

# Using Technology to Monitor Hearing Device Use and Linguistic Environments: Early Intervention Providers' Perspectives

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## Abstract

Early intervention professionals must work with families to optimize children's hearing device use and the linguistic and auditory features of children's environments to improve outcomes for children with hearing loss. Two technologies with potential use in monitoring these domains are data logging and Language Environment Analysis (LENA) technology. This study, which surveyed early intervention providers, had two objectives: (a) to determine whether providers' experiences, perspectives, and current practices indicated there was a need for tools to better monitor these domains, and (b) to gain a better understanding of providers' experiences with and perspectives on use of the two technologies. Most providers reported that they used informal, subjective methods to monitor functioning in the two domains. The providers also felt confident that their methods showed how consistently children on their caseloads were wearing their hearing devices and what their environments were like between intervention visits. Most providers reported limited personal experience with accessing data logging information and with LENA technology. However, many providers reported receiving data logging information from children's audiologists. Providers generally believed access to the technologies could be beneficial, but only if coupled with proper funding for the technology, appropriate training, and supportive administrative policies.

**Acronyms:** CI = cochlear implant; DLP = digital language processor; HA = hearing aid; LENA = Language Environment Analysis; OCHL = Outcomes of Children with Hearing Loss

**Keywords:** cochlear implants, data logging, deaf and hard of hearing, early intervention, hearing aids, LENA technology

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Children with hearing loss are at risk for experiencing delays in spoken language development due to limitations in their ability to fully access the linguistic input in their environments (Moeller et al., 2007). Given recent improvements in early identification of children with hearing loss and in hearing assistive technologies (e.g., hearing aids [HAs] and cochlear implants [CIs]), children with hearing loss should be experiencing consistently improved outcomes. Although this has proven true for many children, the language outcomes of children with hearing loss continue to be widely variable (Geers et al., 2009; Tomblin, Walker, et al., 2015).

Recent findings from the Outcomes of Children with Hearing Loss (OCHL) study indicate that one contributor to the variance in outcomes may be variability in children's access to linguistic input. The research team developed and validated a model in which access to linguistic input was affected by children's aided audibility (access to speech with their hearing aids), duration and consistency of hearing aid use, and characteristics of the caregiver input in their environment. In turn, access to input influenced linguistic uptake and thus, language outcomes (Moeller & Tomblin, 2015). Although children's aided audibility is limited by aspects of their hearing loss and

falls within the domain of the audiologist's influence, the other factors are potentially malleable within the context of early intervention. For early intervention providers to support families' efforts to establish consistent device use and optimize the child's linguistic environment, providers must be able to assess, monitor, and provide families with feedback on their progress in each domain. There are two technologies that may be particularly useful in supporting providers in completing these tasks: data logging and Language Environment Analysis (LENA) technology. In this study, we sought to understand how providers were currently monitoring children's device use and the linguistic and auditory features of their environments, including whether they were making use of these technologies. Additionally, we queried providers on their experiences with and perspectives on use of the technologies.

## Consistent Hearing Device Use

The evidence tying amount of device use to outcomes is robust. Results from the OCHL study indicated that children who are hard of hearing who wore their hearing aids (HA) at least 10 hours a day were more likely to develop age-appropriate language skills than children

who wore their HAs less than 10 hours a day (Tomblin, Harrison, et al., 2015). Similarly, research indicates that for children who use CIs, quantity of device use is positively related to language outcomes (Gagnon et al., 2019; Wang et al., 2011; Wie et al., 2007).

Despite evidence regarding the positive contributions of device use to children's language outcomes, many families struggle in their efforts to establish consistent hearing device use, especially when children are young (Marnane & Ching, 2015; Muñoz et al., 2017; Walker et al., 2013). Studies using objective data logging information from children's HAs indicate that infants and toddlers aged 6 to 24 months wear their HAs an average of less than 4.5 hours per day (Walker, McCreery, et al., 2015). This differs from parent reports, which overestimated child use by an average of 2.43 hours per day. Similarly poor device use has been observed for young children who use CIs (Marnane & Ching, 2015; Wiseman & Warner-Czyz, 2018). Studies that use data logging report that the average amount of time hearing devices are used generally increases with age and degree of hearing loss (Walker et al., 2013). However, results from these objective measures show that few children reach full time device use in the first 3 years of life or in the first year after cochlear implantation (Gagnon et al., 2019; Walker, McCreery, et al., 2015; Walker, Van Voorst, et al., 2015). Potential barriers to device use include caregivers not believing in the importance of device use, situation-specific barriers (e.g., safety of wearing devices when children cannot be closely monitored in the backseat of a car), child behaviors (e.g., children removing the devices frequently), and low caregiver self-efficacy with managing the technology (Moeller et al., 2009; Muñoz et al., 2015, 2016).

### **Linguistic Environments: Linguistic and Auditory Features**

For both children with normal hearing and children with hearing loss, the quantity and quality of linguistic input to which they are exposed during interactions with their caregivers has a strong positive relationship with later language outcomes (Ambrose et al., 2014; Ambrose et al., 2015; Hoff, 2006). However, exposure to linguist input alone does not ensure uptake by the child, especially if the child has limited auditory access to the input. Thus, to optimize the environments of young children with hearing loss, early intervention providers and families must ensure not only that children are exposed to high rates of quality linguistic input, but also that they can access that linguistic input.

Although the use of hearing devices improves children's access to linguistic information, the amount of access is often still not optimal, especially when listening in complex auditory environments (Ambrose et al., 2014). For the purpose of this study, we defined children's linguistic environments as being characterized by both the linguistic input provided by the family and the acoustic characteristics of the environment that may affect a child's ability to access linguistic input (e.g. reverberation, distance between the speaker and listener,

and background noise). Auditory characteristics of the environments of infants and toddlers may be modified to improve access to linguistic input through changes in the physical environment (e.g., additions of carpeting and curtains, closing doors to other areas of the home that are noisy). Parents may also be able to use specific strategies during interactions to improve their child's access to linguistic information (e.g., gaining children's attention prior to speaking to them and being close to children when talking to them). Furthermore, the auditory characteristics of the environment can be improved through addressing sources of background noise in the home, including electronic media (e.g., turning off televisions and radios). Reducing exposure to electronic media may be one of the most accessible and impactful ways of modifying the auditory characteristics of children's linguistic environments. Not only does linguistic input become more audible to children with hearing loss, but caregivers may be able to increase and improve their interactions with their children when electronic media is not in use. Ambrose et al. (2014) found that children with hearing loss who were exposed to more electronic media had lower receptive language scores than children with hearing loss who were exposed to less electronic media. The relationship between electronic media exposure and language outcomes was mediated by the number of conversational turns between caregivers and children, indicating that parents and children had fewer successful language interactions when in the presence of electronic media.

In addition to supporting families in modifying the auditory characteristics of children's environments in ways that reduce barriers to accessing spoken language, early intervention providers must help families optimize the linguistic input they provide to their child. It is especially important for children with hearing loss to be exposed to high rates of quality linguistic input given that their inconsistent access to the input in their environments places them at risk for delays in spoken language development. Optimized input includes being engaged in frequent, high-quality conversations. Additionally, children with hearing loss learn best from interactions in which the parent adopts a responsive, as opposed to directive, interaction style and in which parents use diverse vocabulary and grammatical structures (Ambrose et al., 2015).

### **Assessment, Monitoring, and Feedback Technologies**

For early intervention providers to support families' efforts to establish consistent device use and optimize their child's environments, providers must be able to assess, monitor, and provide families with feedback on their progress toward each goal. Little is known about how early intervention providers currently achieve these tasks.

Specifically, in this study we were interested in the use of two technologies that might support these efforts: (a) data logging in HAs and CIs, and (b) LENA technology. Use of these tools may allow early intervention providers to offer better feedback to parents about their progress

toward the goals. When given access to the information provided by these technologies, as well as coaching regarding the behavior, parents may be able to better set and make progress toward relevant goals.

### **Data Logging**

In their efforts to determine whether children are consistently wearing their devices, both audiologists and early intervention providers frequently ask parents to estimate how many hours per day their children wear their HAs. However, evidence indicates that parents frequently overestimate their children's device use (Moeller et al., 2009; Walker, McCreery, et al., 2015; Walker, Van Voorst, et al., 2015). Data logging is a feature available in most contemporary HAs and CIs. Data logging information is accessed through each manufacturer's proprietary programming software and serves as a tracking tool for device use, including the average number of hours per day that the device was in use since the last programming session. With the advent of data logging, providers have the potential to access objective information regarding children's device use, rather than relying on the subjective information provided by parents. Audiologists have access to data logging information during programming of the devices and may share this information with families to increase awareness of how many hours the child is wearing his or her devices, help the family set and monitor progress toward goals for increased device use, or support maintenance of current use trends. At least one study has demonstrated that audiologists' use of data logging information during counseling can be effective in helping families improve device use (Muñoz et al., 2017). However, traditional counseling sessions with audiologists only occur approximately every 3 to 6 months in the first few years of a child's life. Early intervention sessions are often more frequent and place early intervention providers in a better position than audiologists to continuously monitor and support parents' efforts to establish consistent device use.

### **LENA Technology**

The second monitoring and feedback technology is the LENA system (LENA Foundation, Boulder, Colorado). The system comprises a Digital Language Processor (DLP) and a related software program. The DLP is a digital recording device that can be worn by a child in a pocket on a specially designed piece of clothing to capture up to 16 hours of audio from the child's environment. After the recording is complete, the audio from the DLP can be transferred to the computer for analysis using the associated software. The software analyzes the audio recording to quantify information about the child's environment, including linguistic input (e.g., number of adult words and conversational turns) and presence of specific acoustic characteristics (e.g., background noise and sound from electronic media). LENA technology has been used successfully as a feedback tool with families of children with hearing loss to improve parent-child interactions in intervention studies (Sacks et al., 2014; Suskind et al., 2016).

## **Research Questions**

Although there is evidence of the potential benefits of using data logging and LENA technology as intervention tools, it is unclear the extent to which these technologies are being used in clinical practice. It often takes many years to translate research into clinical practice, which is known as the research to practice gap. This gap is known to be higher in special education than in many other fields (Greenwood & Abbott, 2001). Currently, we know little about how early intervention providers are assessing children's device use and if they are able to access data logging information. Moreover, it is unclear if early intervention providers see utility in having increased access to data logging information for use in early intervention sessions. Similarly, we know little about how providers are monitoring the linguistic and auditory features of children's environments, whether they are using LENA technology, or if they see use of LENA technology as being potentially beneficial for families on their caseloads.

In this study, early intervention providers were surveyed regarding their practices and perspectives regarding monitoring children's device use and linguistic environments. The study posed two research questions:

*1) Do early intervention providers' experiences, perspectives, and current practices indicate there is a need for tools to better monitor children's hearing device use and environments?*

We queried whether providers believed families on their caseloads were already (a) optimizing children's device use and the linguistic and auditory features of their environments, (b) if providers felt confident in their ability to monitor families' progress in these domains, and (c) what tools providers were using to monitor functioning. If providers reported families were already achieving relevant goals and if providers felt confident in their ability to monitor families' functioning with tools already readily accessible to them, providers might be unlikely to see the need for data logging and LENA technology in their practice.

*2) What experiences with and perspectives on use of data logging and LENA technology do early intervention providers have?*

We queried whether providers had first- or second-hand experience with the technologies, what those with experience with the technologies perceived the benefits and barriers of using the technologies to be, the reasons providers had not used the technologies, and whether providers were interested in using the technologies.

## **Methods**

Early intervention providers across the country were recruited to complete an online questionnaire. The questionnaire queried their experiences with and perspectives on monitoring the hearing device use and linguistic environments of children with hearing loss on their caseloads.

## Study Procedures

The questionnaire was hosted on Qualtrics, an online survey software tool. Information about the study and a link to the questionnaire was sent directly to early intervention providers who had participated in the OCHL study and agreed to be contacted for future studies. Additionally, study information and the recruitment link were posted in several social media sites geared toward speech-language pathologists and deaf educators (e.g., the early intervention special interest group of the American Speech-Language-Hearing Association). Recruitment materials invited professionals who were currently providing early intervention services to at least one child with hearing loss to participate. Upon completion of the questionnaire, if participants wanted to be compensated for their time, they could provide a name and physical address and they were sent a \$15.00 Target gift card. The survey remained open for completion from June to October 2016, when the link was closed as the total number of responses desired had been obtained. The project was approved by the Internal Review Board for Boys Town National Research Hospital.

## Study Participants

A total of 163 potential participants began the online survey. Respondents were asked to confirm that they were currently serving at least one family of a child with hearing loss. Two respondents indicated that they were not, and thus were not provided with survey questions. Survey responses were also excluded from the analysis if they were not fully completed; 71 surveys were not completed and therefore excluded from the subsequent analysis. Finally, responses were excluded if participants indicated that their location or professional role was outside the scope of the purpose of the questionnaire. Two surveys were excluded for this reason (one completed by a professional from outside the United States and one completed by an individual who identified their professional role as a president of a state chapter of a parent support organization). Ultimately, 88 questionnaires were completed and included in analyses.

Participants provided early intervention services in 32 states and one U.S. territory. Of the 88 participants, 38 identified as teachers of the deaf, 34 as speech-language pathologists, five as early childhood educators, three as audiologists, and two participants did not indicate how they identified professionally. Additionally, six participants selected the “other” option. The professional identity of these participants was listed as an early childhood special educator, a dual speech-language pathologist and audiologist, a Listening and Spoken Language Specialist certified audiologist, a Listening and Spoken Language Specialist certified Auditory Verbal Educator, a dual speech-language pathology assistant and itinerate teacher of the deaf, and a teacher consultant for children who are deaf or hard of hearing. Participants had an average of 16 years of experience (range 1–50 years).

Participants were employed by a variety of agencies: 34 respondents indicated they worked for a state agency, 17

worked for a school district, 17 worked in an Option school program (a school that is a member of the international, non-profit organization designed to provide programs to educate children with hearing loss in listening and spoken language), 12 worked for private early intervention agencies, and 12 selected “other” and provided an individual response to describe their employment. There were eight settings represented in the 12 responses: hospital ( $n = 3$ ), infant-toddler program provider contracted with the state ( $n = 1$ ), pediatric audiology ( $n = 1$ ), self-employed and private ( $n = 1$ ), hospital home health ( $n = 1$ ), university clinic ( $n = 2$ ), pediatric rehabilitation ( $n = 1$ ), and university and children’s hospital ( $n = 2$ ). Participants indicated that their caseload comprised between 1% and 100% children who have a hearing loss, with an average of 75%.

## Questionnaire

The questionnaire included questions about (a) providers’ educational preparation and current employment, (b) the hearing device use and linguistic environments of children with hearing loss on the provider’s early intervention caseload, (c) providers’ perceptions of the barriers families experienced in establishing consistent hearing device use and optimizing children’s linguistic environments, (d) providers’ experiences with or barriers to using data logging and LENA technology with families of children with hearing loss in an early intervention setting, (e) providers’ opinions on the potential benefits or barriers to the use of these technologies in their current practice, and (f) other aspects of early intervention service delivery that were beyond the scope of the current manuscript. Questions used Likert scale, yes/no, multiple choice, or open-ended responses. After the questionnaire was developed, it was reviewed by research scientists and clinicians with expertise in deaf education and early intervention. The survey was piloted with current early intervention providers and the feedback was used to make changes in the wording and formatting of the questionnaire to ensure clarity of the questions.

## Analysis

Each submitted survey was reviewed to confirm it was complete and not fraudulent. The results were summarized descriptively. Participants’ responses to the open-ended questions were reviewed line by line and coded. For example, if a participant indicated that they had not used a technology in their practice due to the high cost of the system and the lack of training to use the device, these two components of the response were coded with two separate codes (cost and training) under the barriers to use for the technology. Once all the short answer responses were coded, the categories were reviewed and individual codes were collapsed when appropriate (e.g., codes for cost of system and lack of personal funds were combined to be represented under one code for cost). The coding process was inductive and reductive. Both authors reviewed the responses under each code to ensure that the coding system reflected the responses of all participants. Definitions for each code were developed

and all responses were re-coded. Results are presented below.

## Results

### Research Question 1: Do Early Intervention Providers' Experiences, Perspectives, and Current Practices Indicate there is a Need for Tools to Better Monitor Children's Hearing Device Use and Environments?

#### Providers' Perceptions of Families' Functioning

The survey included four questions about providers' perceptions of families' functioning. Providers were asked to consider all families they had served in early intervention over the past five years, but to respond separately for families of children with HAs and families of children with CIs. Responses indicating that the provider did not serve children who used a particular hearing device or did not answer a survey question were not included in the result calculations. The results were calculated based

on the number of individuals who provided answers to the question. Many providers believed that less than 20% of the HA and CI users that they have provided services to over the last five years were unable to establish full-day use in the first year after fitting. Despite reporting that the families they serve experience limited difficulty overall, providers reported that slightly more of the families of children with hearing loss they have served over the past five years had trouble establishing HA use than CI use. Providers shared that most children accepted hearing devices, with a higher percentage of providers reporting that more than 20% of families had more trouble with children accepting HAs than CIs. Providers reported that both parents of children with HAs and parents of children with CIs believed that full-day use of hearing devices was necessary for their child. Providers generally reported a higher percentage of their caseload not believing full-day HA use was important. See Table 1 for detailed results.

**Table 1**

*Percent of Providers who Selected that Each Device Use Item was Applicable to 0-20%, 20-40%, or Greater Than 40% of Their Caseload Over the Past Five Years*

Item	Families of Children with Cochlear Implants			Families of Children with Hearing Aids		
	0–20%	20–40%	> 40%	0–20%	20–40%	> 40%
Family was unable to establish full-day use in the first year after fitting	72	13	15	53	24	23
Family was unable to establish full-day device use by transition out of early intervention	77	13	10	65	21	14
Child did not consistently accept the device	84	11	5	67	21	12

*Note.* Eight participants indicated they did not serve children who use cochlear implants and one participant did not provide answers regarding families of children with cochlear implants for unknown reasons; therefore, for families of children with cochlear implants, percentages for the four questions were calculated based on responses from 79 participants. Additionally, one participant did not provide answers to the second and third questions for families of children with hearing aids for unknown reasons; therefore, percentages for those two questions for families of children with hearing aids were calculated based on responses from 87 participants.

Early intervention providers were asked to indicate the percent of the families on their caseload who had “room to improve” on four aspects of the linguistic environment that are positively associated with child outcomes. More providers reported substantial room for improvement on “responding to children’s verbal and/or nonverbal communication attempts” than other behaviors. The fewest providers noted substantial room for improvement on “becoming less directive with their child and following their child’s lead.” See Table 2 for detailed results.

Providers were also asked to report the percentage of families they have served over the past 5 years who, despite the provider’s counsel, continued to have their child experience one of three less-than-ideal auditory characteristics: noisy home or childcare environments, 30 minutes or more of electronic media per day, and communicating with the child without first getting close

to the child. In each case, at least 50% of the providers responded that more than 40% of the children on their caseload experienced the queried characteristic. Results are displayed in Table 2.

#### Providers' Perceptions of Their Knowledge of Families' Functioning

Providers were asked to report their level of knowledge regarding the functioning of families on their caseloads with respect to device use and two characteristics of the environment: quantity of linguistic input and the auditory environment. Descriptive statistics are reported in Table 3. Most providers reported high confidence with regard to knowing how much each family uses their child’s hearing device(s) on a daily basis, how much each family talks to and interacts with their child between visits, and what each child’s auditory environment is like between visits.

**Table 2**

*Percent of Providers who Selected that each Linguistic Environment Item was Applicable to 0–20%, 20–40%, or Greater Than 40% of Their Caseload over the Past Five Years*

Item	Families on Caseload		
	0–20%	20–40%	> 40%
Family had room to improve with regard to responding to the children’s verbal and/or nonverbal communication attempts	31%	27%	42%
Family had room to improve with regard to increasing and varying their language input to their children	22%	27%	51%
Family had room to improve with regard to increasing their engagement and quantity of interactions with their children	24%	26%	50%
Family had room to improve with regard to becoming less directive with their child and following their child’s lead	14%	37%	49%
Family had their child spend substantial time in noisy home or childcare environments	18%	30%	52%
Family had their child view or listen to 30 minutes or more of electronic media (e.g., TV) per day	3%	23%	74%
Family attempted to communicate with their child without first getting close to the child	17%	33%	50%

*Note.* One participant did not answer this set of questions for unknown reasons; therefore, the percentages are calculated based on responses from 87 participants.

**Table 3**

*Percent of Providers Indicating Each Level of Agreement Regarding Their Knowledge of the Functioning of Families on Their Caseload over the Past Five Years*

	Strongly agree/ agree	Neither agree or disagree	Strongly disagree/ disagree
I know how much each family uses his/ her child’s hearing device(s) on a daily basis.	83%	8%	9%
I know how much each family talks to and interacts with their child between visits.	79%	14%	7%
I know what each child’s auditory environment is like between visits.	66%	23%	11%

*Note.* One participant did not answer this set of questions for unknown reasons; therefore, the percentages are calculated based on responses from 87 participants.

### **Methods Used by Providers to Monitor Functioning**

Providers were asked about the current methods they used to monitor and provide feedback to parents regarding the domains of interest. Responses to the closed-set items are found in Tables 4, 5, and 6 for children’s hearing device use, linguistic input in parent-child interactions, and features of children’s auditory environments, respectively. Additionally, providers were asked to indicate if they used any other methods to assess these domains and, if so, to describe the method. Few alternate responses were gathered from the open-ended option. The responses regarding device use were “lack of progress in data,” “comparing a child’s progress to others,” “asking other teachers,” “daycare checks,” and “judging performance.” The responses regarding linguistic input in parent-child

interactions were “engaging in reflection with the parent at the end of the early intervention session,” “participating in role playing activities with the parent,” “providing real-time or direct coaching to the parent during an interaction,” and “teaching parents how to self-monitor their involvement with their children.” Participants did not indicate that they used any additional methods to assess features of children’s auditory environments.

### **Research Question 2: What Experiences with and Perspectives on Use of Data Logging and LENA Technology do Early Intervention Providers have?**

#### ***Experience with the Technologies***

Early intervention providers were asked about their use of data logging and LENA technology. Only 14% of the providers reported they had personal experience with

**Table 4**

*Percent of Providers Indicating That They Never, Rarely, Sometimes, or Often Used the Specified Methods to Monitor Hearing Device Use*

Technique	Never	Rarely	Sometimes	Often
Using data logging software	61%	11%	14%	14%
Asking the child's audiologist for his/her impressions	11%	11%	30%	48%
Asking the child's audiologist for results from data logging	17%	10%	38%	35%
Having the family keep a regular use log	25%	26%	34%	15%
Asking the family about the child's use <sup>a</sup>	2%	4%	10%	84%
Observing the child's use during sessions	2%	3%	5%	90%

<sup>a</sup>One participant did not answer this question for unknown reasons; therefore, the percentages are calculated based on responses from 87 participants.

**Table 5**

*Percent of Providers Indicating That They Never, Rarely, Sometimes, or Often Used the Specified Methods for Measuring and Providing Feedback on Linguistic Input in Parent-Child Interactions*

Measures	Never	Rarely	Sometimes	Often
Complete and discuss the results of a formal observational measure of parent-child interaction	49%	20%	16%	15%
Informally watch parent-child interaction and take written or mental notes to share with the family <sup>a</sup>	2%	5%	14%	79%
Use LENA technology	76%	13%	9%	2%
Video record the parent and child interacting for co-viewing with the parent	42%	34%	21%	3%

<sup>a</sup>One participant did not answer this question for unknown reasons; therefore, the percentages are calculated based on responses from 87 participants.

**Table 6**

*Percent of Providers Indicating that They Never, Rarely, Sometimes, or Often Used the Specified Methods for Measuring and Providing Feedback on Features of Children's Auditory Environments*

	Never	Rarely	Sometimes	Often
Complete and discuss the results of a formal observational measure of the child's auditory environment	64%	15%	11%	10%
Discuss my impressions of the auditory environment from my informal observations during early intervention sessions	8%	5%	23%	64%
Use LENA technology <sup>a</sup>	79%	9%	10%	2%
Use a sound level meter or other device to measure the noise level in the child's environment and provide results to family <sup>b</sup>	57%	19%	22%	2%

<sup>a</sup>One participant did not answer this question for unknown reasons; therefore, the percentages are calculated based on responses from 87 participants.

<sup>b</sup>Two participants did not answer this question for unknown reasons; therefore, the percentages are calculated based on response from 86 participants.

data logging software. However, 73% of the respondents indicated that they had received data logging information from audiologists. Only 21% of participants reported any experience with LENA technology.

### ***Experienced Providers' Perceptions of the Benefits and Barriers to Use of the Technologies***

Providers who had used either of the two technologies were asked to indicate the benefits and barriers they experienced during use. Providers with experience receiving data logging information on a first-hand or

second-hand basis listed benefits as: information to begin a discussion with the parent regarding amount of hearing device use and barriers to device use, use of the data to inform the clinician about how long hearing devices were in use and in what kinds of auditory environments, and use of the information for tracking hearing device use over time. Providers with first-hand experience with data logging technology shared several barriers to use of the technology in early intervention: “incorrect results due to improper hearing aid use,” “challenging conversations between parents and providers regarding results,” and “lack of correct results.”

Participants with experience using LENA technology shared that they felt the information provided a platform to identify behavioral changes that could be made in the home to support language development. For example, one participant stated, “It’s helpful. It is a visual way to show exactly what’s going on in the home and where the parent could make improvements. It’s a useful tool for helping the parent get a clear understanding of how much time needs to be devoted to achieve the target amount of daily interactions.” Professionals who had used LENA technology also noted some barriers to using the technology, including parents’ fear of being recorded and the need for parents to remember to put the device on their child and to turn it on daily. One participant stated, “Many parents are afraid their family interactions are being recorded and listened to by strangers, being stored on some database, and report that they cannot behave normally when the LENA is there.”

#### ***Non-Experienced Providers’ Reasons for Non-Use of the Technologies***

Participants who reported they did not use data logging or LENA technology were asked to provide a reason. Several reasons were provided for non-use of data logging: outside of their professional responsibilities, lack of access to the technology or software, the information was obtained from another source, lack of benefit, and lack of knowledge. Reported reasons for non-use of LENA technology were lack of access, cost, lack of personal knowledge of the technology, and lack of clear benefit to current practice.

#### ***Non-Experienced Providers’ Interest in Use of the Technologies***

Providers who did not use the technologies were also asked if they were interested in using these technologies in their current early intervention practices. Of the 32 participants who responded about their level of interest in using data logging, 30 participants expressed interest in being able to use data logging themselves and two participants stated that they had no interest in using data logging, citing that the information was available through children’s audiologists. Of the 35 participants who responded about their interest in using LENA technology in the future, 27 participants expressed interest in using the technology and eight participants expressed interest in using the technology if specific conditions were met (e.g., funding, training, increased information concerning the product).

## **Discussion**

Recent research indicates that hearing device use and the linguistic and auditory features of children’s environments contribute to the outcomes of children who are deaf or hard of hearing. However, we know little about how early intervention providers assess, monitor, and provide feedback within these areas for the families they serve, including whether they see a need for access to additional tools for monitoring families’ functioning in these domains. We were specifically interested in providers’ perspectives on two potential tools that could be used to objectively measure functioning in these domains: data logging and LENA technology. This study had two objectives: (a) to determine whether providers’ experiences, perspectives, and current practices indicate there is a need for tools to better monitor these domains, and (b) to gain a better understanding of providers’ experiences with and perspectives on use of data logging and LENA technology.

### **Hearing Device Use and Data Logging**

The majority of providers indicated that they believed that 80% or more of the children on their caseloads were able to establish full-day CI or HA use in the first year after device fitting. This result is in stark contrast with the findings of recent research using data logging to objectively measure device use, which indicate that on average, both young children who use HAs and young children who use CIs wear their devices 5 hours a day or less (Walker, McCreery, et al., 2015; Walker, Van Voorst, et al., 2015). The primary techniques providers reported using for monitoring device use were observing use during sessions and asking parents about device use. Device use during sessions may not be representative of use between sessions. Additionally, research indicates that it is difficult for parents to estimate how much their children wear their devices, with parents having a strong tendency to overestimate use (Walker, McCreery, et al., 2015; Walker, Van Voorst, et al., 2015). Thus, the findings of the current study indicate that providers may benefit from increased access to data logging as a means of ensuring their perceptions of the device use of families on their caseload is accurate. Similarly, given how difficult it is for parents to accurately estimate device use, parents might also benefit from their early intervention providers being able to provide them with objective data on how much their child is wearing his or her devices.

Providers generally felt that data logging information had the potential to be beneficial. However, they typically reported receiving this information from audiologists, as opposed to collecting it themselves, which is likely at least in part due to the numerous barriers that exist to using data logging technology in early intervention settings. Early intervention providers’ familiarity with data logging spoke to the collaborative nature of early intervention services. However, given that audiology visits only occur approximately every 3 to 6 months in the first few years of a child’s life, the frequency with which this data can be



attained is limited if the audiologist is the only one who can access the data. At least one study indicates that access to data logging information between regularly scheduled audiology appointments can be useful in supporting families' efforts to increase HA use (Muñoz et al., 2016). This finding, paired with early intervention providers' interest in collaborating with audiologists to obtain data logging information, indicates that there may be benefits in increasing the accessibility of data logging information. If there was increased access to data logging information, families of children with hearing loss, early intervention providers, and audiologists might have improved capacity to collaboratively develop strategies to help children increase their hearing device use.

### **Linguistic and Auditory Features of Children's Environments and LENA Technology**

Most early intervention providers believed that families had room to improve the linguistic and auditory features of their children's environments. However, the majority also indicated that they were relatively confident that, through use of observation and other objective measures, they were aware of how much each family talked to and interacted with their child between visits and what each child's auditory environment was like between visits. Although use of LENA technology is one potential means of gathering a more objective perspective, most providers reported limited experience with the technology. In addition to providing a tool for monitoring children's environments, LENA technology has potential to be used as a coaching tool. Indeed, in one study by Suskind et al. (2013) the authors reported that after a one-time educational intervention using LENA technology, the number of words spoken by adults in the environments of children with hearing loss increased an average of 31%. The ability for the technology to quantify key aspects of both parent-child interactions and auditory environments, including exposure to electronic media, may be especially valuable, given the interaction between these factors. For example, Ambrose et al. (2014) found that conversational turns between parents and children were less frequent in households with a high degree of electronic media usage than in households with less electronic media usage. Access to objective information regarding the amount of electronic media and conversational interactions in households may allow early intervention providers to identify families with whom having a conversation about the relationships between the auditory environment and parent-child interactions is most important and may allow parents to become more aware of their child's auditory and linguistic environment. Access to this information may also support parents in their efforts to set and monitor their progress toward goals related to media use and their interactions with their child.

### **Implications for Clinical Service**

Many providers stated that data logging and LENA technology could improve their current practice with families. They reported that it could provide data to

begin discussions with families about their barriers to behavioral changes. They also reported that data logging and LENA technology could provide families with a tool for tracking their progress toward consistent device use or optimizing the acoustic or linguistic features of their child's environment. Despite the perceived benefits, providers identified several potential barriers to their use of these technologies; such as lack of access and training, concerns regarding confidentiality and administrative policies or infrastructure, and parents' comfort. To increase use of these technologies in early intervention services, substantial effort will be needed to increase providers' access to the necessary technologies. This will include gathering more evidence on the effectiveness of these technologies, as attaining funding for technology is often dependent upon the evidence base for the technology. Additionally, providers will need support in how to think through issues of privacy, confidentiality, and access to private information. Furthermore, providers will need training in how to talk with parents about the use of these technologies.

Currently, the barriers to directly accessing data logging in early intervention are high. However, children's audiologists are able to easily access this information. Thus, administrators may want to consider methods of ensuring early intervention providers are able to easily communicate with children's audiologists to get this information. Additionally, increased communication will allow audiologists and providers to collaborate on methods for supporting the family in increasing hearing device use. Further, HA and CI manufacturers should consider making this information available to parents through apps or other portals so that parents can monitor their children's device use and share this information with providers as they wish.

### **Conclusions**

Results suggest that these monitoring and feedback technologies have the potential to improve service provision to families of children who are deaf or hard of hearing, but also suggest that they are not currently being used to their full potential in the early intervention setting. Although providers identified potential benefits to incorporating these technologies into their practices, they also identified educational, procedural, and administrative barriers to use of these technologies in early intervention services. These barriers will need to be addressed prior to widespread acceptance and integration of the technologies into early intervention services. Future transition to common use of these technologies may help bridge the research to practice gap and increase the number of effective practices documented for working with children who are deaf and hard of hearing and their families.

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