

# Understanding Limited Use of Amplification in Infants and Children Who Are Hard of Hearing

*Ryan W. McCreery*

Perception and Cognition Laboratory, Boys Town National Research Hospital  
Omaha, NE

*Elizabeth A. Walker*

Department of Communication Sciences and Disorders, University of Iowa  
Iowa City, IA

*Meredith Spratford*

Perception and Cognition Laboratory, Boys Town National Research Hospital  
Omaha, NE

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## **Abstract**

*The effectiveness of amplification for infants and children can be mediated by how much the child uses the device. Existing research suggests that establishing hearing aid use can be challenging. A wide range of factors can influence hearing aid use in children, including the child's age, degree of hearing loss, and socioeconomic status. Audiological interventions, including using validated prescriptive approaches and verification, performing on-going training and orientation, and communicating with caregivers about hearing aid use can also increase hearing aid use by infants and children. Case examples are used to highlight the factors that influence hearing aid use. Potential management strategies and future research needs are also discussed.*

Amplification is the primary means of providing access to the acoustic cues needed to support communication development in children who are hard of hearing. Hearing-aid verification protocols emphasize procedures for maximizing the audibility of speech (American Academy of Audiology, 2013; Bagatto, Scollie, Hyde, & Seewald, 2010), but the benefits of amplification are only achievable if children wear hearing aids consistently. It is within the scope of practice for both pediatric audiologists and early intervention service providers to support consistent hearing aid use (American Speech-Language-Hearing Association, 2004). In order to know what type of support parents and caregivers need, we must first identify the child- and family-related factors that make establishing consistent hearing aid use during infancy and early childhood challenging for many caregivers (Jones & Launer, 2011; Moeller, Hoover, Peterson, & Stelmachowicz, 2009; Muñoz, Preston, & Hicken, 2014; Walker et al., 2013). . In the current article, fixed and malleable factors that influence hearing aid use in young children will be discussed. Strategies for maximizing hearing aid use also will be highlighted. Case studies will demonstrate the impact of hearing aid use on communication outcomes.

## **How Much Do Infants and Children Who Are Hard of Hearing Wear Their Hearing Aids?**

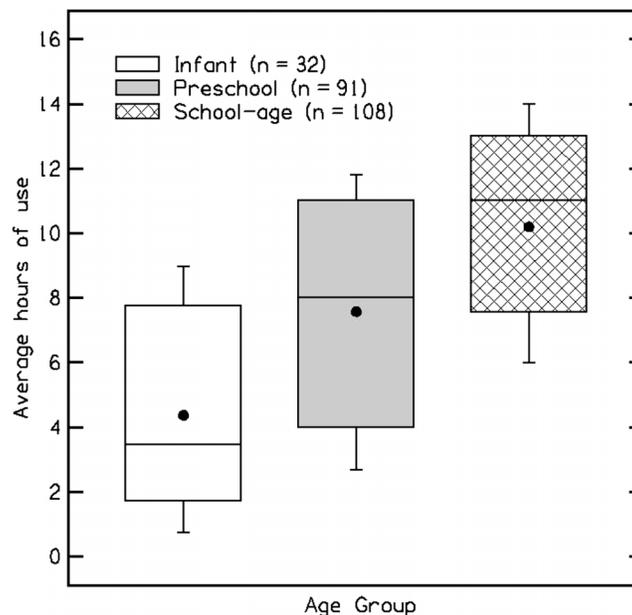
The issue of hearing aid use in children has received limited attention in the research literature until the last 5 years. The recent increase in data regarding infant and children's hearing aid use can be related to several factors. First, universal newborn hearing screening and early

diagnosis of hearing loss has resulted in a new population of infants and toddlers who are fit with amplification at younger ages than in the past. Because hearing aid use can be more difficult to establish at earlier ages, infants wear their hearing aids for fewer hours per day and have more variable use than older children (Walker et al., 2013). The variance in daily use in early-identified children allows researchers to conduct prospective studies and ask questions about the impact of hearing aid use on developmental outcomes. Second, the advent of data logging systems in hearing aids provides an objective method of estimating hearing aid use, as these systems can track and report the average number of hours per day that the hearing aids are powered on. Finally, children with hearing aids continue to show some differences in development compared to peers with normal hearing (Ching et al., 2013; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2014), despite early identification and intervention. As a result, research is shifting from examining the effects of age of identification of hearing loss towards other factors that may impact communication outcomes in children who are hard of hearing. Professionals who serve infants and children who are hard of hearing realize that providing amplification at an early age is necessary, but not sufficient, to support positive developmental outcomes. The culmination of these factors has been an increased interest in documenting the consistency of hearing aid use in infants and children.

Moeller and colleagues (2009) completed one of the first studies of device use in children. Seven children who were identified with hearing loss prior to 6 months of age and received hearing aids by 7 months of age and their mothers participated. A parent questionnaire was used to assess hearing aid use at four different age intervals during early childhood between 10.5 and 28.5 months of age. The questionnaire asked mothers to rate their child's hearing aid use in different listening situations (play time, book reading, in the car, etc.). The data showed several important trends. First, hearing aid use increased as the children grew older. Second, hearing aid use was highly variable across the seven children, depending on the listening situation. The mothers in the study responded to open-ended questions about challenges in establishing hearing aid use; many reported challenges related to different listening situations and their child's temperament. Although this study contained a small number of subjects, it clearly demonstrated the challenges of establishing hearing aid use during early childhood using a longitudinal design.

Data reported by Jones and Launer (2011) also suggested that hearing aid use was not consistent for many children. Hearing aid use increased as a function of age, but 40% of children in their study used their hearing aids for 4 hours or less each day based on a centralized database of data logging measures collected by a hearing aid manufacturer. Similarly, Muñoz and colleagues (2014) reported that the median number of hours of hearing aid use for a group of young children to be approximately 5 hours per day. Data from our own longitudinal study (Outcomes of Children with Hearing Loss; OCHL) from Walker et al. (2013) are also consistent with these estimates (see Figure 1.)

Figure 1. Average Hours of Hearing Aid Use Per Day by Age Group.



Infant (white), preschool (gray), school-age (hatched). The boxes represent the 25th-75th percentiles and the whiskers represent the 5th and 95th percent of the mean.

Challenges in establishing hearing aid use appear to occur most frequently during infancy and early childhood, but there is also significant variability in use among older children.

## Factors That Influence Hearing Aid Use

There are numerous factors that impact hearing aid use in infants and young children. Factors can be separated into two categories based on the ability to influence them clinically. Fixed factors are factors that relate to the child and/or family and cannot be easily addressed through intervention, including age, socioeconomic status, and degree of hearing loss. An understanding of fixed factors can help clinicians to determine which children may be at risk for limited hearing aid use. Malleable factors are factors that can be affected by intervention. For example, the quality of information provided by the audiologist during the hearing aid orientation process may influence the parents' comfort with hearing aid use (Muñoz et al., 2014).

### Fixed Factors

**The child's age.** Hearing aid use varies as a function of the child's age with the amount of hearing aid use generally increasing as children increase in age (Jones & Launer, 2011; Moeller et al., 2009; Muñoz et al., 2014; Walker et al., 2013). The birth-to-two age group is particularly challenging in terms of consistent hearing aid use. Infants have a limited number of waking hours each day, as they sleep 14.2 hours per day on average (Iglowstein, Jenni, Molinari, & Largo, 2003). Thus, children fit with hearing aids before 6 months of age would be expected to have limited hearing aid use. Additionally, Walker and colleagues (2013) reported a decline in hearing aid use between 6 and 12 months, which could potentially be related to the development of the pincer grasp that allows infants to remove their own hearing aids. Understanding and anticipating age-related developmental challenges toward consistent hearing aid use can help providers create practical and realistic goals for the family (Moeller et al., 2009). The age-related increase in hearing aid use can be valuable information to encourage families that early challenges in establishing

consistent hearing aid use are normal and that hearing aid use typically becomes easier as the child gets older. An understanding of the range of hearing aid use that has been reported for different age groups can also help to set expectations for what is reasonable for a child of a specific age. For example, some studies have defined full-time hearing aid use as 12 hours per day; yet, very few of the infants in the OCHL longitudinal study achieved this number of hours during the first year of hearing aid use. Importantly, the amount of hearing aid use observed in recent studies should not necessarily serve as a clinical goal, as practices to support hearing aid use currently vary considerably across clinical settings (Muñoz, Blaiser, & Barwick, 2013). Hearing aid use during all waking hours should continue to be the goal for maximizing auditory experience with amplification. However, recommendations for establishing hearing aid use should take the child's age and specific child- and family-related challenges into consideration.

**Degree of hearing loss.** Children with greater degrees of hearing loss tend to wear their hearing aids for a greater number of hours per day than children with lesser degrees of hearing loss. Specifically, previous research by Walker et al. (2013) and Muñoz et al. (2014) both indicate a greater number of hours of hearing aid use per day in children with moderate or severe hearing loss than in children with mild hearing loss.

Children with mild degrees of hearing loss may not be perceived as having as much difficulty without amplification because of the presence of significant residual hearing. However, evidence suggests that even children with mild hearing loss may be at risk for academic and developmental delays (Đoković et al., 2014; Porter, Sladen, Ampah, Rothpletz, & Bess, 2013). Audiologists should anticipate that children with mild hearing loss may be at risk for limited hearing aid use and counsel parents about the importance of hearing soft or distant sounds and the potential to achieve better language outcomes when well-fit hearing aids are worn consistently over time (Tomblin et al., 2014; Walker, in preparation).

The relationship between degree of hearing loss and hearing aid use creates challenges for determining how hearing aid use can impact outcomes. Children with greater degrees of hearing loss tend to have poorer outcomes (Sininger, Grimes, & Christensen, 2010; Tomblin et al., 2014), but also wear their hearing aids more than children with less hearing loss. If we examine the relationship between hearing aid use and outcomes without accounting for the degree of hearing loss, it could appear that children who wear their amplification more hours have poorer outcomes. These relationships highlight the complexities involved in studying the factors that influence developmental outcomes in children who wear hearing aids.

**Socioeconomic status.** Children from economically disadvantaged backgrounds face challenges in terms of access to services and their overall development (e.g., Boyle et al. 2006). Beyond potentially being identified and fit with hearing aids at later ages, children from lower SES households may also experience limited hearing aid use (Walker et al. 2013). The number of hours of hearing aid use decreases as the family's socioeconomic status decreases (Walker et al. 2013), which may compound the risk for delays in development. Audiologists and professionals who serve children who are hard of hearing and their families should be aware that children with lower socioeconomic status may be at risk for limited hearing aid use and should provide strategic support to increase the likelihood of achieving consistent hearing aid use.

### **Malleable Factors**

**Audiological and other provider interventions.** Audiologists and other professionals who serve children who are hard of hearing and their families can support and positively influence hearing aid use in infants and children. Hearing aid use can be influenced by three key components of audiological intervention: (1) hearing aid verification, (2) hearing aid orientation, and (3) providing feedback on hearing aid use to caregivers and support for overcoming challenges.

**Hearing aid verification.** The purpose of providing amplification to infants and young children is to minimize the negative effects of limited audibility on communication development.

Clinical hearing aid verification protocols measure the audibility of speech to ensure that the child has access to the acoustic cues needed to understand speech and develop language. Hearing aids that provide too little or too much amplification may affect the consistency of device use. Children may have poor audibility from their hearing aids because of their degree of hearing loss. They may also have limited audibility due to audiologists not following best practices for hearing aid verification. Children with poorly fit hearing aids may be less likely to use their hearing aids on a consistent basis. In addition to measuring the audibility of speech, hearing aid verification also allows clinicians to ensure that the maximum output of the hearing aid does not exceed recommended levels for loudness discomfort. Over-amplification could increase the risk that a child will not accept their hearing aids or could even lead to damage to residual hearing (e.g., Macrae, 1995). Performing verification with either real ear (in situ) or simulated real ear measurements with a probe microphone system are the only way to determine that hearing aids provide sufficient audibility for speech and that the maximum output of the hearing aid does not exceed levels set forth by prescriptive approaches.

Rapid growth of the child's ear canal during the first few years of life can change the amount of amplification that is provided to the child, so appropriate verification measures should be completed at least every 3 months for children under 3 years of age and every 6 months for children under 5 years of age.

**Hearing aid orientation.** Parents and caregivers of children who are hard of hearing often have limited experience with hearing loss or management of hearing aids. Muñoz and colleagues (2013) surveyed parents of children who are hard of hearing and nearly half indicated that they received inadequate information and instruction related to the care and maintenance of their child's hearing aids. Another clinical strategy for increasing hearing aid use is to improve the quality and frequency of hearing aid orientation training with parents and caregivers. Because early intervention providers may have more frequent contact with the family, audiologists can partner with early intervention providers to ensure that families receive support and accurate information on an ongoing basis, rather than only at the initial hearing aid fitting. Parents' self-efficacy in managing devices has a positive correlation/relationship with parental report of hearing aid use (Desjardin, 2005). Teaching parents to become independent in managing devices may result in increased hearing aid use. Providing more consistent and ongoing orientation will increase the confidence of parents and caregivers to utilize the child's amplification more frequently and help parents to troubleshoot minor challenges, such as when the earmold becomes uncoupled from the hearing aid. Furthermore, reinforcing the importance of daily listening checks ensures that children are wearing hearing aids that are functioning appropriately.

**Providing feedback about hearing aid use.** The availability of data logging systems in hearing aids provides a new method of monitoring device use in children, but has also raised questions among clinicians about how to share this information with parents and caregivers. Sharing data logging may be particularly challenging in situations where the parent report and data logging are discrepant. Estimates of hearing aid use from parent report and estimates from data logging are largely found to be in close agreement within 2–3 hours per day (Muñoz et al., 2013; Walker et al., 2013). However, Walker and colleagues reported the range of data logging between 2–15 hours per day for parents reporting 12 hours of hearing aid use. Audiologists should anticipate, therefore, that parent report and data logging may not always match. Audiologists and other professionals should approach discrepancies between parent report and data logging cautiously and without assuming that the parent report is inaccurate. The general agreement between parent report and data logging provides some confidence in data logging systems. Yet, there have been no published data that we are aware of that validate the estimates of hearing aid use time provided by data logging. In cases of disagreement between data logging and parent report, discussing the listening situations where hearing aid use is most successful and where hearing aid use is most challenging can help parents to acknowledge challenges and allow collaborative problem solving. Any discussion of limited hearing aid use should occur within a context that acknowledges that establishing hearing aid use can be difficult and should focus on

solutions. Work by Muñoz and colleagues (2014) indicated that some families were able to increase their hearing aid use over time when they were informed about the amount of hearing aid use from data logging and given feedback about realistic expectations for use. These data suggest that providing feedback to parents about the data logging may help to identify challenges related to hearing aid use and set goals for increasing use in cases where full-time hearing aid use is not being achieved.

### Illustrative Case Examples

Two case studies (Child A, Child B) illustrate differences in language outcomes based on varying amounts of aided audibility and hearing aid use. Child A passed newborn hearing screening (NHS) and parents noticed that she was not responding to sound around 27 months of age. Her hearing loss was confirmed at 39 months, and her parents suspected that the hearing loss was progressive in nature. Child B referred twice on the NHS, but the family did not initially pursue diagnostic follow-up. His hearing loss was confirmed at 38 months. Both children were fit with amplification after their third birthdays (A: 40 months, B: 41 months) and had similar degrees of hearing loss by age 7 years (Table 1). Child A had higher maternal education level and family income than Child B.

Table 1. Differences in Outcomes at 7 Years of Age

Child	BEPTA	BESII (Ideal SII)	Rec. Vocab (PPVT-4)*	Exp. Vocab (WASI)*	Morphosyntax (CELF-4)*	Articulation (GFTA-II)	Spelling (WIAT-II)*
A	66.25	73 (70)	84	109	95	Raw 4, SS 100, 28 %ile	114
B	66.25	39 (68)	48	55	55	Raw 47, SS <40 <1 %ile	70

BEPTA = Better-ear pure tone average; BESII = Better-ear aided speech intelligibility index; PPVT-4 = Peabody Picture Vocabulary Test; WASI = Wechsler Abbreviated Scale of Intelligence; GFTA-II = Goldman-Fristoe Test of Articulation; WIAT-II Wechsler Individual Achievement Test

\*= Standard score

At each annual visit for the OCHL study, audiologists documented data logging. In addition, parents reported the average number of hours their child wore the hearing aid on a daily basis. Across visits, Child A had consistent datalogging recordings of 12 hours/day, which corroborated parent report of 12 hours/day since fitting. In comparison, Child B's datalogging recordings varied from 0 to 6 hours across his 7- and 8-year old visits and parents reported daily use between 4–14 hours since hearing aid fitting. Parents reported Child B was allowed time off from wearing the hearing aids for a break at home or days on weekends.

Child A's hearing aids provided consistently better aided audibility over the years in the study compared to Child B (e.g., better-ear speech intelligibility index [BESII] of 73 and 39, respectively, at 7 years of age; see Table 1). Across all visits, Child A's hearing aids were fit closer to DSL targets than those of Child B. The better match-to-targets resulted in Child A receiving audibility more similar to the ideal (amplification perfectly matching DSL targets) than Child B. Compared to the ideal SII values in Table 1, Child A's audibility at age 7 was within 3% of the ideal SII values and Child B's audibility was underfit by 29%. McCreery et al. (2013) has shown that audiologist's verification method contributes to the degree which measured SII matches ideal SII. Child A's audiologist used speechmapping verification with Verifit. It is unknown which verification method Child B's fitting audiologist used. The educational audiologist, who saw Child B approximately 15 times/year for hearing aid and frequency modulation system problems, reported that they did not perform hearing aid verification and did not have verification equipment available in the local education agency.

A comparison of outcomes at 7 years of age demonstrates differences in vocabulary, morphosyntax, articulation, and spelling skills (see Table 1). Child A performed within the average range on all measures except receptive vocabulary. Child B performed well below the average range on all measures. Both children had nonverbal skills (measured with the Wechsler Abbreviated Scale of Intelligence) within the average range, although Child A had a higher standard score than Child B (99 and 88, respectively, with a standard score of 100 representing average performance and one SD equal to 15). Child B had such severe receptive and expressive language delays that the school began using a sign language interpreter in the classroom. In addition, he received services from speech-language pathologists (SLPs), reading and math specialists, and a special education teacher, who became his primary service provider. Child A was in a mainstream classroom, with additional private speech-language services sought by the family.

As part of the OCHL study, the children's service providers (audiologists and school-based providers) completed online surveys following each research visit. At 7 years, Child A's audiologist reported that the family was completely confident managing the devices. Child B's educational audiologist reported that the family was somewhat confident managing the devices and noted a concern about "lack of parental support in hearing aid use and appointment follow-through." Child B's special education teacher also noted a concern with consistency of hearing aid use at home.

The special education teacher reported very little to moderate comfort with skills related to developing spoken language and listening skills for children with hearing loss. Child A's SLP reported mostly expert levels of comfort for skills necessary for working with children with hearing loss. It may be that providers who are comfortable in providing services for children who have hearing loss are more confident emphasizing the link between auditory stimulation and language development and encouraging hearing aid use.

Degree and onset of hearing loss influence speech and language outcomes in children who are hard of hearing, but aided audibility and hearing aid use experience moderate that relationship (Tomblin et al., in submission). Both children had a four-frequency pure tone average of 66.25 at the 7-year visit; however, the exposure to speech and language that Child A had before progression of hearing loss contributed to early acquisition of language fundamentals. Child B, in contrast had a congenital hearing loss, which resulted in limited exposure to sound before hearing aid fitting at 3 years, 5 months. Furthermore, Child A experienced appropriate audibility and consistent hearing aid use over time. After initiating amplification, Child B consistently experienced less than optimal hearing aid fitting, resulting in extremely reduced audibility and limited hearing aid use. Lower socioeconomic status may have also contributed to the low consistency of hearing aid use (Walker et al., 2013), which in turn, may have further impacted auditory access for speech and language development. Despite having school-based providers who were concerned with family confidence managing HAs and low use at home, it is unclear whether or not any of the professionals in this case conveyed their concerns to the family and, if so, how the family interpreted that information. When multiple providers are serving a child, providers should all share the responsibility for educating the family on the importance of auditory access. All providers who serve children who have hearing loss should be confident in their ability to communicate the link between auditory stimulation and language development in a family-centered manner that promotes family investment in promoting hearing aid use.

### **Directions for Future Research**

Although research about hearing aid use in children who are hard of hearing has increased in recent years, many important issues remain unexplored at the present time. Children who are hard of hearing who do not wear their amplification at all will not experience the benefits from amplification, but the amount of hearing aid use that is sufficient to support positive outcomes requires further exploration. Current clinical recommendations suggest that the goal for hearing aid use is during all waking hours. While hearing aid use during all waking hours is an ideal goal, the current data on use suggest that this goal is not achieved consistently, particularly in infants. Data linking the amount of hearing aid use to developmental outcomes may help to define which

children with limited use may be at risk for delays. Further validation of data logging systems should be undertaken to ensure that objective estimates of hearing aid use provided by hearing aids is consistent over time and across different hearing aid manufacturers' devices. Work by Muñoz and colleagues (2014) has explored intervention strategies for increasing hearing aid use in infant and children. Simply informing parents about data logging increased hearing aid use for some of the families in the study. Further intervention research will help to identify practical supportive strategies that will increase hearing aid use and help caregivers to address specific challenges.

## Conclusions

Hearing aid use in infants and children who are hard of hearing is crucial in order for amplification to have a positive impact on developmental outcomes. Many factors that influence hearing aid use during early childhood are not easily addressed through intervention. Infants and young children, those with mild degrees of hearing loss, or children from economically disadvantaged backgrounds may be at particular risk for limited hearing aid use. Audiologists and professionals who serve children who wear hearing aids should be aware of these factors and be prepared to provide strategic support. Ensuring that the child has adequate audibility for speech for their degree of hearing loss is likely to maximize the perceived benefit of the device and promote consistent use compared to devices that do not provide sufficient audibility. Clinicians can also provide strategic support through ongoing hearing aid orientation and providing families with the tools they need for hearing aid care and maintenance to minimize gaps in hearing aid use related to device malfunction. Informing parents about data logging and encouraging progress in hearing aid use over time can also be an effective strategy to reinforce the importance of hearing aid use for achieving good communication outcomes.

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