CHAPTER ELEVEN

What Do We Know About the Fitting and Daily Life Usage of Hearing Instruments in Pediatrics?

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Abstract

This paper describes a national database to track hearing instrument performance and use by children with hearing loss. A data collection system was developed by Phonak was utilized to analyze hearing instrument fittings from 6,696 pediatric patients over 8 years from 44 sites. The system collected specific data including the initial hearing aid fitting gain and output prescriptions, features enabled and fine-tuning changes over time. The pediatric client datalog was also analyzed to describe hearing aid use time, use conditions, programs activated and user controls manipulated. These pediatric hearing aid usage profiles provide information to help audiologists make data-driven decisions resulting in improved and better hearing aid performance and pediatric patient outcomes.

There are powerful examples in medicine of great advances in care and outcomes being achieved through a dogged and detailed analysis of the current state of care. This continuous evolution of a best practice clinical pathway is a moving target and can only be achieved with a perpetual, high resolution lens by which to track and understand conditions, treatments and outcomes. Such a lens was developed in the early 1960s, with the introduction of the national database for cystic fibrosis. This pool of data was established to track treatments and outcomes for all patients treated in centers across the United States. The ability to aggregate and analyze a multitude of variables, interventions, and outcomes allows clinicians and researchers to connect these dots in meaningful ways and supports the development of best practices. It has resulted in substantial improvements in life expectancy for individuals with cystic fibrosis. At the inception of the database, the average life expectancy for a patient with cystic fibrosis was less than three years of age. Today cystic fibrosis patients are expected to live into their forties (Gewande, 2007).

Until now, we have had no database or archive that allows us to track hearing instrument performance and usage by children with hearing loss. This lack of visibility into the clinical pathway, prescribed hearing instrument parameters and device usage diminishes the audiologist's potential for data-driven clinical decision making. For example, when a parent of a twelve month-old child with severe congenital sensorineural hearing loss returns to the clinic six months following the child's initial hearing aid fitting, data logging from the hearing instruments might reveal that the aids are worn on average 4 hours per day. At the same time, the parent is concerned with the child's progress. The audiologist's inclination is to advise the parent that more use is likely to result in better hearing performance and outcomes. At this time we do not have published data definitely showing by age what average use per day is or should be. Nor can we connect patterns of auditory exposure to degree of loss and auditory outcomes. Furthermore, we have little insight into specific acoustic properties of the listening environments of children or the hearing instrument performance under these conditions. This information would be highly important in order to better understand how to optimize the hearing instruments for better meet the real-life listening needs of the children.

The project described in this paper is intended to provide that lens into pediatric hearing instrument fitting and usage of hearing instruments in daily life environments to support evidence-based clinical decision making and counseling, and eventually the evolution of more informed clinical pathways to support best outcomes for children with hearing loss.

Tools and Method

"Cuper" is a data collection system created by Phonak (Figure 1). This database warehouses hearing instrument fittings from multiple work stations and aggregates the data for later analysis. Individual clinicians must first consent to share their data by activating the fitting logging in their Target ™ software. The data package is anonymized and made HIPAA compliant on the clinician's work station before it is transferred to the server. Two types of data are included for each patient. The client fitting log is all information pertaining to the hearing instrument fitting: what is the age of patient, what is the patient's hearing loss, how many visits were logged, what was gain and output prescribed, what features were enabled and how was the device fine-tuned from the default settings over time. Every mouse click is logged in order to create a picture of the fitting and the clinical journey. A second stream of data, the client datalog, is coming from the hearing instruments through Target™ software. The hearing instruments are constantly accumulating data including use time, use conditions, programs activated, and user controls manipulated. Once the clinician agrees to participate in fitting logging, s/he must enter a unique identifier code in the software. This engages the process and at pre-set intervals, the anonymized data is streamed to a central server where fittings can be filtered and analyzed. For this report, there were 44 unique sites supplying fitting data. This included 36 pediatric clinics and 6 school-based audiology clinics. 6,696 patients were included in the data analysis over a time period of eight months. Data in this paper are often described as a function of three age ranges: Infants and young children (0-4 years), young school-aged children (5-8 years), and tweens and teens (9-18 years). These age groupings represent the three Junior Modes available in Target.™ The modes are designed to support streamlined, evidence-based fittings and to minimize time spent behind the computer, so clinicians can spend time in direct care and conversation with families.

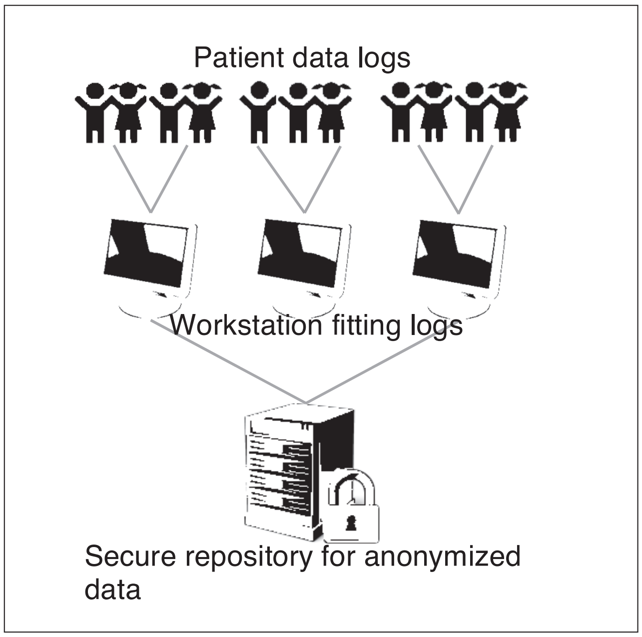

Figure 1. Illustration of the data flow included in this project. Datalogs that accumulated on pediatric hearing instruments were read into fitting stations, where they were combined with fitting logs that were sent to the central data repository, Cuper. Queries were then developed to facilitate better understand ing of current pediatric hearing instrument fitting and usage patterns.

Patient Profiles

Across the 44 sites, a programming session during the study timeframe triggered a patient's inclusion in the data set. The distribution of patient ages can be seen in Figure 2. Depending on age, 80-90% of fittings were based on hearing loss that was purely sensorineural in nature. This is consistent with the audiometric findings for adult fittings in Cuper. The prevalence of conductive hearing loss would be somewhat higher than indicated here because this data only accounts for losses fitted with air conduction devices.

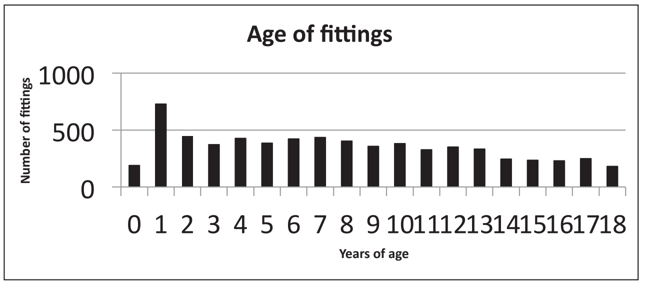

Figure 2. Distribution of hearing instrument fittings by age from the Sound Foundations Cuper 2013 project. This data set includes fittings from 44 unique pediatric sites throughout the United States.

Cuper shows that most children are fitted to the Desired Sensation Level (DSL) 5.0a Pediatric fitting formula (Scollie, et. al., 2005) and a majority of adults are fitted to the Phonak Adaptive Digital targets. DSL was prescribed in 83 percent of pediatric hearing instrument fittings. This is not a surprising finding since DSL is the Target™ software default for fittings when the entered birthdate qualifies the patient is 18 years or younger. Since children are often unable to provide adequate feedback about the hearing instrument settings, it is imperative that real ear or simulated real measures are used to verify that the settings maximally support auditory access and comfort. This is most easily done by using an evidence-based, independent prescription that can also be generated in the real ear system software. Since it is based on data describing speech sensation levels associated with comfortable listening levels, the DSL method aligns well to the goal of pediatric amplification supporting speech and language development. The Adaptive Phonak Digital Formula was chosen in 15 percent of pediatric fittings in general and 19 percent of teen fittings. It is unclear if clinicians are verifying settings with speech mapping to assess audibility and comfort. Of the adults fitted at the pediatric centers included in this study, 50 percent were fitted with Phonak Digital Formula. National Acoustics Lab Non-Linear Fitting procedure (NAL-NL1; Keidser, 2011) was applied in 26 percent of adult fittings.

Use of Hearing Instruments

While using an audibility-based prescriptive method is an important first step in providing adequate auditory exposure, the amount of time that the instruments are in use and the performance of those instruments in typical pediatric environments are equally critical factors for successful communication. The data loggs collected from the hearing instruments when in real life situations give us specific insight into how children wear the devices. The data logs are downloaded into Target™ software each time an aid is hooked up for re-programming. These logs are embedded in the fitting sessions and sent to the Cuper database, allowing us to understand hearing instrument use for different listening environments in the context of age, hearing loss and device parameters. The initial review of the data revealed that children were using their instruments for approximately four to five hours per day depending on age. This seemed low compared to our current understanding of hearing aid use. For example, Walker et. al. (2012) surveyed parents about hearing instrument use in children 8 months to 8 years old. In this study, parents reported an average of 10.8 hours of use per day during the week. Data logs from the hearing instruments worn by these children documented an average of 8.2 hours of use per day. The Cuper data was reanalyzed without the logs from patients who were essentially "non-users." By age range, the percentage of "non-users," defined as children who presented with less than 30 minutes of hearing aid use per day, can be found in Figure 3. The spike in teens re-

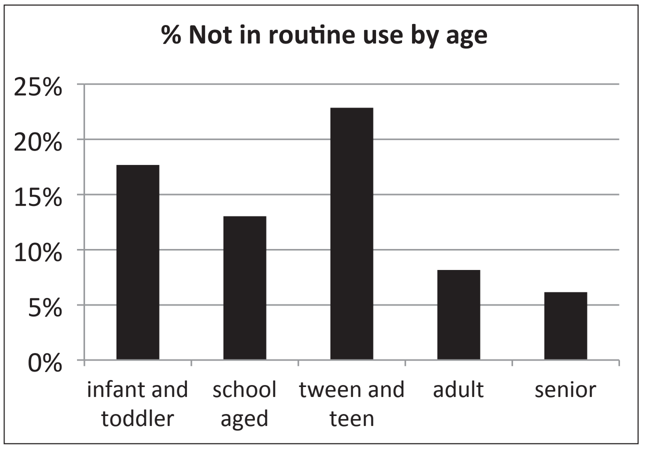

Figure 3. Percentage of devices by age which were not in routine use. Routine use is defined as more than 30 minutes of average use time per day.

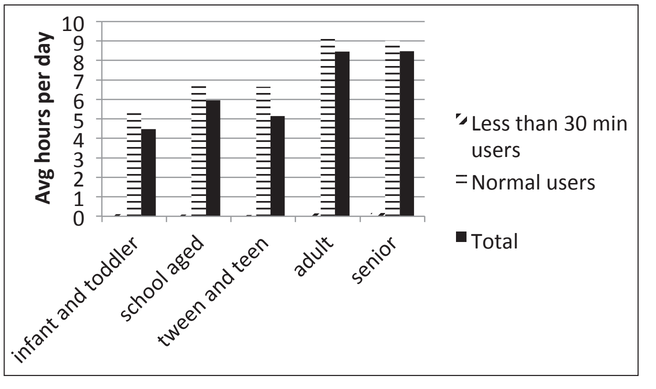

Figure 4. Average use time by age for normal users and non-users of hearing instruments. Children use hearing instruments about 5-7 hours per day on average, less than what is typical for adult and senior users.

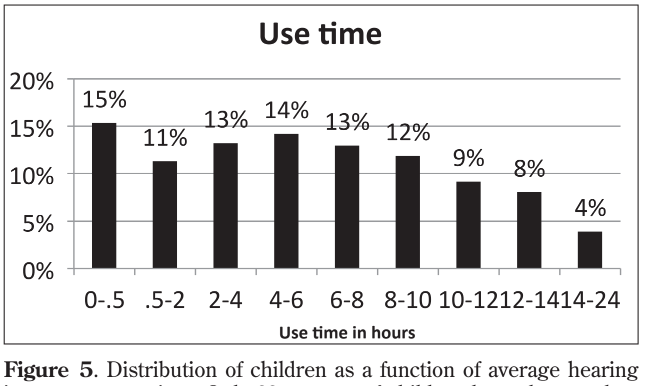

Figure 5. Distribution of children as a function of average hearing instrument use time. Only 33 percent of children logged more than eight hours of average hearing instrument use time per day.

jecting the use of technology when academic rigors are typically increasing and academic performance has the strongest impact on future academic and career choices is concerning. Excluding non-users, the remaining children aid users, wore devices an average of 6.1 hours per day. This is still somewhat less than described by Walker et. al. The use time for infants and toddlers averaged 5.5 hours per day, slightly less than school – aged children and teens who accumulated almost 7 hours per day on average (Figure 4). By comparison, adults logs showed an average of use time 9 hours per day. Only 33 percent of children in our sample wore hearing instruments for more than 8 hours per day (Figure 5). The relatively light pediatric hearing instrument usage is somewhat concerning and certainly poses a challenge to pediatric fitters and manufacturers alike. In order to ensure best outcomes, we need to understand how use patterns correlate with speech and language development, academic success, and social and communicative ease. If our assumption that more is better proves true, then we now need to understand what are the barriers to more use and how can we overcome them.

Application of Styles and Features

There are a multiple factors that influence the level of technology selected for children beyond the family budget. Many children in the United States with hearing impairment qualify for Medicaid, which dictates by state the type and cost of hearing aids covered. Twenty states have provisions insurance coverage for pediatric hearing instruments and these mandates include varying amounts of coverage or reimbursement that also dictate or affect the device selected. (State Insurance Mandates, 2014). The devices that were available in the study market comprised three levels of technology. Table 1 summarizes the technologies typically included in each product segment at the time of this analysis. In our sample 63 percent of children under age nineteen were fitted with standard level products. This is exactly what was reported three years ago by Jones & Launer (2010). Advanced level devices were dispensed to teens more often than younger children. Advanced products comprised 20% of devices dispensed to teens. Still, children, including teens, are rarely fitted with premium technology, with these products comprising barely 2 percent of pediatric fittings. These product selections reveal that while all children in this sample had access to a directional microphone, non-linear frequency compression and a basic automatic, the use time were typically not provided ear to ear streaming (called DuoPhone) for improved understanding on phones, a base program for music to improve music appreciation or steerable directionality (ZoomControl, Auto ZoomControl).

As would be expected, most children are fitted with behind-the-ear (BTE) style devices (Figure 6). Almost 17% of teens were fitted with RIC or custom products. While this is far lower than what is seen in the adult market, it is up from only 6% three years ago (Jones & Launer, 2010). 13% of all pediatric fittings included a non-traditional BTE coupling including a slim tube, external receiver or custom shell. Non-traditional fittings jump to 26% of the solutions fitted to 9-18 year olds. By comparison, these coupling solutions comprise 45% of adult fittings.

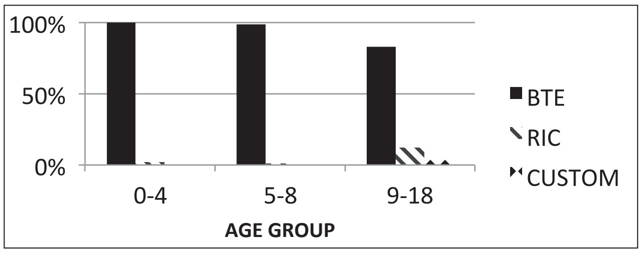

Figure 6. Hearing aid fitting of device style by age group.

	Standard	Advanced	Premium
Directional microphones	Front facing directionality	Steerable directionality	Automatic 360˚ directionality
Super directionality	No	No	Yes
Ear to Ear phone streaming	No	No	Yes
Automatic program selection	2 base programs	3 base programs	4 base programs
Non-linear frequency compression	Yes	Yes	Yes
Digital noise reduction	Yes	Yes	Yes
Wind noise reduction		Yes	Yes
FM/Roger/Wireless compatibility	Yes	Yes	Yes
Adjustable channels	6	16	20

Table 1. Typical feature allocation across the three technology levels represented in data set.

When evaluating the use of features, it is important to understand where overt decisions were made versus a passive acceptance of Junior defaults. Table 2 depicts the default settings by age, showing that controls are disabled until nine years of age and infants and young children are given a single FM ready- calm situation program. At age nine, the controls are reactivated and the start-up program transitions to SoundFlow, the automatic mode. Surprising to the authors, clinicians frequently changed these default settings. For all ages, the program toggle was activated more than half of the time (Figure 7), indicating that even very young children are provided with multiple program options.

Program structure	0-3 years	4-8 years	9-18 years
Start-up	Roger/FM+M	Roger/FM+M	SoundFlow
Rx formula	DSL 5 Peds	DSL 5 Peds	DSL 5 Peds
Soundflow	Disabled	Disabled	Enabled
Push button	Disabled	Disabled	Enabled
Volume control	Disabled	Disabled	Enabled

Table 2. Phonak Target™ Junior Mode default Settings.

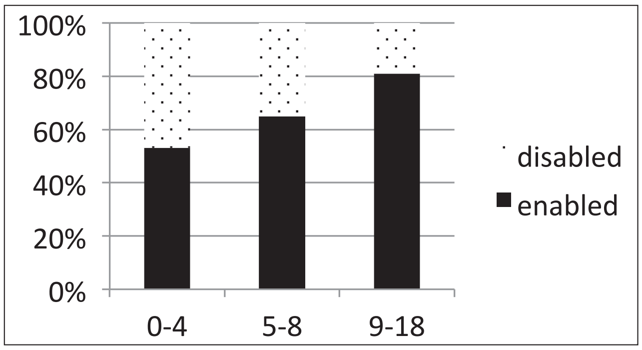

Figure 7. Percentage of time as a function of age that the program toggle was enabled in pediatric hearing instrument fittings.

While there is some evidence (Ricketts, 2010) that directional microphone programs might have more benefit than detriment for children, there is not conclusive evidence that automatic program switching can improve listening comfort and comprehension for children. However, these data show that SoundFlow, the Phonak multi-base automatic program, was the most frequently chosen start-up program for children (Figure 8). This finding reveals that clinicians believe that a single program does not sufficiently meet children's listening needs and that an automatic will select the optimal program a given for situation more reliably than a child will. While, according to Cuper data, an automatic is used by 90% percent of adult hearing aid users, it is less well understood how well the behavior of these devices meets the needs of the typical pediatric use cases and listening intentions of children.

In order to better understand the behavior and success of automatic program selection for students at school, one of the authors has begun a project to record the environments encountered by children throughout the day and track those environments in a time-locked way while simultaneously logging the behavior of the automatic functionality and a recording a child's listening intent.

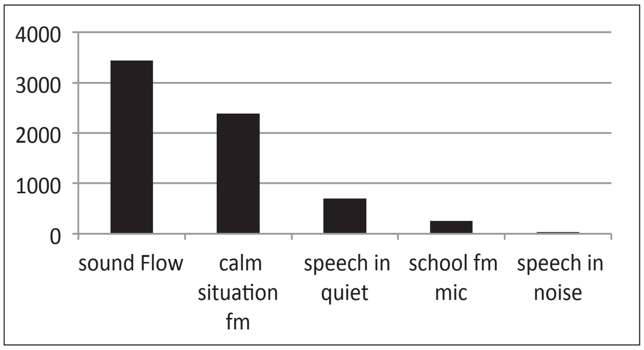

Figure 8. Distribution of start-up programs chosen in pediatric hearing instrument fittings.

The premium tier of the current Phonak automatic classifier incorporates 5 base programs and the system can define the scene as any one of these environments: calm, noise, speech in noise, speech in loud noise, or music. The system can also blend the characteristics of these programs when the environment warrants such a combination. In order to best understand if there are opportunities to optimize the behaviors of the system for children, we have undertaken a project to analyze the output of the SoundFlow system for children over the course of the school day. In this project, an audio recorder is time-locked with the behavior of the actuators in the classifier. Later interviews with students allowed the investigators to further understand the students' listening intent and judge the performance of the devices in this environment. This comprehensive approach to gaining authentic understanding of pediatric listening environments and pediatric listening intent as it relates to classifier behavior will allow us to further optimize this feature, already popular among pediatric audiologists, to meet the specific needs of children. Additionally, it will help us to better understand the characteristics of the listening environments children encounter in their daily life and to better counsel the care takers involved about the listening needs of the children.

Other Phonak advanced features can be tracked through Cuper such as non-linear frequency compression, known as Sound Recover. Cuper allows us to study how and when SoundRecover is engaged. The data show that depending on age, SoundRecover was activated in 65-70 percent of children. This rate is similar to usage in the adult population and less than what is seen in the elderly population (Figure 9). Since SoundRecover was developed in response to the literature revealing that the bandwidth of hearing instruments may not be sufficient for optimal speech and language development in children (Stelmachowicz, 2004; Pittman, 2008), this finding is somewhat surprising as clinicians tend to disable it for milder hearing losses. There is some support from Wolfe (submitted, 2013) that SoundRecover may results in improved perception of /s/ for individuals with mild hearing loss, however, the clinical reticence to apply it in these cases highlights a need for additional evidence in this area.

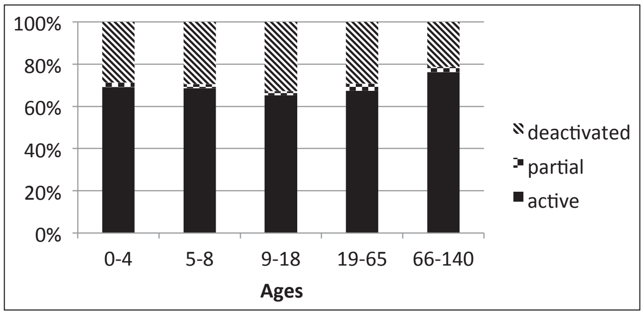

Figure 9. Percentage of patients for whom SoundRecover is activated, partially activated, and deactivated.

WorkFlow

The analysis of Cuper data gives us specific insight into the workflow of the audiologist and the clinical pathway and management of children with hearing loss. Both for pediatrics and adults, first fittings take about 14 minutes to complete in Target™ software. Assuming most appointments are booked for an hour, this means that there is a substantial amount of time remaining for counseling, real ear verification or further testing in the booth. Duration of follow up programming sessions, consistent with adult follow ups, average 10 minutes of programming time. We can also see that fewer than 10% of fittings included an entered real-ear-to-coupler difference (RECD). However, this may be because clinicians are aware than an age-based average RECD is automatically applied by the software whenever a child's age is into the client profile. To improve the accuracy of the fitting, the average values can be overwritten by entering the child's own measured RECD. In the 0-4 age range, a measured valued was entered 7% of the time. For young school-aged children, 5% of fittings included a measured value and for teens, 3% of fittings were based on an entered RECD. Since measured values provide a much more accurate fitting (Bagatto, et.al., 2002), it is presumed that clinicians are measuring this value more often than is represented by Cuper, but perhaps making a fine tuning adjustments in the software to match targets in the real ear system, rather than improving the first fit with the measured values. The decrease in measured RECD with age is consistent with the assumption that as a child becomes more cooperative with age, the clinician will transition from simulating real-ear measure with the RECD to performing actual real ear measures, rendering RECD measurement unnecessary. This disconnect between fittings software and real ear measurement equipment presents an opportunity to streamline and improve the pediatric fitting process.

Conclusions

The Cuper database provides us with a window into pediatric fittings and hearing instrument usage in daily life environments. By studying the behaviors of fitters and users, we can gain specific insights about what is well accepted and working well and where there exists opportunities for further improvement. For example, in this sample we observed that there are age and hearing loss specific use patterns in some cases that less than expected. This finding challenges us to determine what the barriers are to full time use and amend our counseling, change our fitting parameters or search for a less intrusive design to provide more consistent amplification for children. A next step might be to determine what factors or parameters separate the full time users from the light users. This would allow us to start understanding the factors that result in successful hearing instrument use. Cuper also allows us to see trends such as a greater adoption of non-traditional styles in the teen population. If the better cosmetics of the RIC and custom products improve compliance, then these trends could be important to improving outcomes.

SoundRecover remains a very successful strategy especially for moderate to profound hearing losses is applied in most fittings for these hearing instrument categories. However, we saw a trend of decreasing SoundRecover use, particularly with mild hearing loss. This spurs us to further our investigation of the benefits and limitations of this technology and continue to innovate in this area to develop the solutions that allow children to live a life without limits. To improve the power of this data collection system, we need to connect these findings to outcomes measured in clinical practice and daily life. This is a critical next step in applying this data to strengthen our evidence-based approach to pediatric hearing loss management.

Acknowledgments

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