
Application of The University of Western Ontario Pediatric Audiological Monitoring Protocol (UWO PedAMP)

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Background

The primary goal of Early Hearing Detection and Intervention (EHDI) programs is to provide effective intervention by six months of age to maximize the infant's natural potential to develop language and literacy skills (Joint Committee on Infant Hearing [JCIH], 2007). Intervention with hearing aids is a common choice among families and pediatric audiologists have access to scientifically-based strategies and clinical tools to ensure the hearing aids are fitted appropriately to the infant (e.g., Bagatto, Scollie, Hyde & Seewald, 2010). Outcome evaluation is a key component of the pediatric hearing aid fitting process, however, there is little research related to what a typical outcome might be for an infant who wears hearing aids and how to systematically track the child's auditory development and performance over time. This is in part due to the lack of well-normed and validated outcome measures available for use with infants and children who wear hearing aids. Supporting outcome evaluation for pediatric patients who wear hearing aids could be addressed by a well-validated, clinically feasible monitoring protocol to track auditory development and performance. Known clinical tools with good normative properties, validity, feasibility, and utility would support the development of an evidence-based outcome evaluation guideline for pediatric audiology programs. Additionally, indicators to track clinical process outcomes, such as the appropriateness of the hearing aid fitting, are needed so that the functional outcomes can be appropriately interpreted.

Recently, the University of Western Ontario Pediatric Audiological Monitoring Protocol (UWO PedAMP) was developed (Bagatto, Moodie & Scollie, 2010; Bagatto, Moodie, Malandrino, Richert, Clench & Scollie, In press-a). This outcome evaluation guideline consists of several tools that aim to measure auditory-related outcomes in infants and children who have permanent hearing loss and may or may not wear hearing aids.



The guideline includes tools that assess the following dimensions: 1) subjective assessment of early auditory development; 2) subjective ratings of auditory performance in daily life; 3) acceptance and use of hearing aids; and 4) effectiveness of service delivery. The caregiver-report functional outcomes are supported by each child's hearing aid fitting information (i.e., real-ear-to-coupler difference (RECD), Speech Intelligibility Index [SII]). Caregiver-report functional outcome tools were targeted in the first version of the UWO PedAMP because objective measures of speech detection and recognition may be difficult to obtain in cases of children with complex factors (e.g., difficult to test due to developmental level). Coincidentally, it is these same children who may also present assessment and/or management difficulties more generally. Focusing on objective strategies as the primary strategy for outcome evaluation, therefore, is not likely to be successful on those very cases in which outcome measures are needed the most. Caregiver reports (i.e., subjective outcome measures) can be completed by the parent regardless of the child's developmental level and provide rich and important real-life information that can support the more objective tests that clinicians may perform as well as being more applicable to children with complex needs. Therefore, this initial work focused on the evaluation of subjective outcome evaluation tools that assess auditory-related behaviors in infants and children. This article will describe the outcome evaluation tools included in the UWO PedAMP Version 1.0. A description of how the guideline is administered as part of a complete pediatric hearing aid fitting protocol will be provided in the context of a case example. The UWO PedAMP has been implemented with children of varying ages, developmental abilities and degrees of hearing loss and the impact of these variables on outcome have been presented elsewhere (Bagatto et al, In Press-a).

Development of the UWO PedAMP

Using a knowledge-to-action (KTA) approach (Graham, Logan, Harrison, Strauss, Tetro, Caswell & Robinson, 2006) a critical review of available outcome evaluation tools for infants and children aged birth to six years within the category of caregiver-report questionnaires was conducted (Bagatto, Moodie, Seewald, Bartlett & Scollie, In Press-b). This allowed for an appraisal of the current tools to eliminate the need for developing new tools. Through the critical review process, there was an attempt to include tools with good statistical properties and available norms and avoid tools that were too lengthy or complicated in favor of those that had good clinical feasibility and utility (Andresen, 2000).

Following the critical review, the UWO PedAMP was developed and members of the Network of Pediatric Audiologists of Canada were invited to review the proposed outcome evaluation tools and provide objective and subjective feedback regarding the components of the guideline (Moodie, Bagatto, Seewald, Kothari, Miller & Scollie, In Press). Their feedback was also requested regarding barriers and facilitators to implementing outcome evaluation tools within the contexts in which they worked. This provided an opportunity to use an engaged community of practice with a shared understanding of the knowledge and clinical needs. It also allowed the authors of the UWO PedAMP to strike a balance between creating an evidence-based guideline, which can be rigid and complex, with a more actionable, flexible guideline through the development of clear and specific tools (Bhattacharyya, Reeves & Zwarenstein 2009).

Content and Clinical Application of the UWO PedAMP

The UWO PedAMP consists of the:

- Hearing Aid Fitting Summary
- Aided Speech Intelligibility Index (SII) Normative Values
- LittleEARS[®] Auditory Questionnaire (Tsiakpini, Weichbold, Keuhn-Inacker, Coninx, D'Haese & Almadin, 2004; Copyright MED-EL, 2004)
- Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Rating Scale (Ching & Hill 2005a; Copyright Australian Hearing, 2005)
- Ontario Infant Hearing Program (OIHP) Amplification Benefit Questionnaire

The UWO PedAMP is intended to be used with children with permanent childhood hearing impairment (PCHI) from birth to age six years who wear hearing aids. Monitoring children with PCHI who do not wear hearing aids is also considered an important use of the UWO PedAMP. The proposed use may change as the guideline evolves through systematic evaluation and clinical implementation. Information about where each tool can be located is found in Appendix A.

Clinical application of the UWO PedAMP will be explained in this document through the use of a case example: David was identified with a moderate rising to mild bilateral sensorineural hearing loss and fitted with binaural hearing aids when he was eleven months old. The reason for the delay in hearing aid fitting was due to parental indecision in the early stages. David was born full term and does not have any other medical issues besides hearing loss. The following sections

describe each outcome evaluation tool in the UWO PedAMP and provide results for the case example.

Hearing Aid Fitting Details

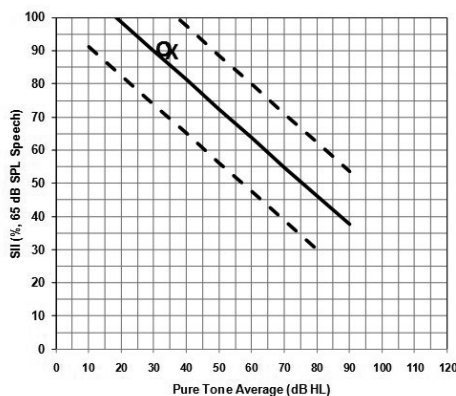
Evidence-based pediatric hearing aid fitting protocols were followed in order to ensure that David’s hearing aids will positively impact his ability to develop auditory skills in daily life (e.g., American Academy of Audiology [AAA], 2003; Bagatto, Scollie et al, 2010). Outcome evaluation is designed to be completed following the hearing aid verification stage of the fitting process as it allows one to measure the impact of the fitting. Since positive outcomes infer good hearing aid fittings, it is important to monitor factors associated with ‘typical’ hearing aid fittings as part of the UWO PedAMP. Monitoring hearing aid fitting details allows the clinician to determine whether an *individual child’s fitting* is providing a typical degree of audibility. In addition, this information provides monitoring *at the level of the program* as a whole. The brief fitting details gathered in this protocol will help to determine, for example, the typical rate at which RECD measures are made, or the typical amount of audibility provided by hearing aids. Health care programs that receive government funding are increasingly being pressured to document that the services are of high quality. As part of the UWO PedAMP, two tools have been provided to monitor hearing aid fitting details and include: 1) the Hearing Aid Fitting Summary; and 2) Aided SII Normative Values. Used together, they provide helpful information for the audiologist, caregivers, and health policy-makers about the hearing aid fitting as part of this outcome evaluation guideline.

Simulated (or predicted) real-ear measurements of hearing aid performance are the preferred method of verification for infants and young children and are recommended by several pediatric hearing aid fitting protocols (e.g., AAA 2003; Bagatto, Scollie et al, 2010). The real-ear performance of the hearing aid is predicted from coupler measures of speech inputs using the infant’s RECD (Seewald, Moodie, Sinclair & Scollie, 1999). The hearing aid’s maximum power output (MPO) is verified using narrowband stimuli. Functional outcome evaluation of the hearing aid fitting will be measured through the use of questionnaires within the UWO PedAMP. In this guideline, the aim is to minimize the time needed to capture the hearing aid fitting details. For this reason, the exact fit-to-targets at each frequency and test level are not documented. Instead, the fit-to-targets are assessed by the clinician and the overall amount of audibility provided for low and moderate level speech (via the Speech Intelligibility Index [SII]) and whether or not key protocol elements were measured for each

fitting (RECD, MPO) are monitored. A complete Hearing Aid Fitting Summary includes details about the RECD (Measured, Predicted, Used other ear values, Previously measured) and the MPO as well as SII values for soft and average speech inputs (zero to 100).

The SII is a value representing the proportion of speech that is heard by the listener through the hearing aids (American National Standards Institute [ANSI] S3.5 1997). It is an acoustic measure, not a behavioral prediction. This means that the SII represents the audibility of speech, and is not a prediction of speech recognition scores. The SII provides a value that clinicians, caregivers, and teachers can use to conceptualize the proportion of speech that is available to the child. SII values are provided from hearing aid verification systems (e.g., Audioscan Verifit®, Interacoustics Affinity®) for various speech inputs. If a clinician has performed multi-level speech-based real-ear verification of the young child’s hearing aids, the associated SII values for these measurements would also be provided.

Recently, normative data relating the specific SII values for acceptable hearing aid fittings became available (Moodie 2009, 2010). These were derived from pediatric fit-to-target data from 161 ears. From these data, the SII values were extracted to develop norms by pure-tone average (PTA) for use in the UWO PedAMP (see Appendix A). Tracking this



Hearing Aid Fitting Detail	Right Ear	Left Ear
Real Ear to Coupler Difference (RECD)	<input checked="" type="checkbox"/> Measured <input type="checkbox"/> Predicted <input type="checkbox"/> Used other ear values <input type="checkbox"/> Used previously measured values	<input type="checkbox"/> Measured <input type="checkbox"/> Predicted <input checked="" type="checkbox"/> Used other ear values <input type="checkbox"/> Used previously measured values
Maximum Power Output (MPO)	<input checked="" type="radio"/> Yes No	<input checked="" type="radio"/> Yes No
SII Soft Value (55 dB SPL)	91	94
SII Average Value (65 dB SPL)	91	90

Figure 1: Hearing Aid Fitting Details and Aided SII values for Case Example: David. SII values (y-axis) for an average speech input are plotted for the right (O) and left (X) hearing aid fittings by David’s PTA (x-axis). Since the symbols fall within the 95% confidence intervals (dashed lines), it can be concluded that David’s hearing aid fitting is providing a typical degree of audibility for his degree of hearing loss, in both ears.

clinical process outcome is important for interpreting scores on the functional outcomes such as the LittLEARS and the PEACH. The hearing aid fitting details and SII values for David's hearing aid fitting are summarized in Figure 1. It can be noted that the RECD and MPO were measured and the SII values for an average speech input were 91% for the right ear and 90% for the left ear. This indicated typical audibility in both ears for David's degree of hearing loss (PTA Right = 33.8 dB HL, PTA Left = 36.7 dB HL). SII values for a soft speech input also indicated typical audibility in both ears.

The LittLEARS Auditory Questionnaire

The purpose of the LittLEARS Auditory Questionnaire is to assess the auditory behavior of infants with PCHI who wear hearing aids or cochlear implants (Tsaikpini et al, 2004; Coninx, Weichbold, Tsiakpini, et al, 2009). The 35 items in the LittLEARS questionnaire assess auditory development during the first two years of hearing in the real-world and tap into receptive and semantic auditory behavior as well as expressive-vocal behavior. The questions are listed in an age-dependent order and are in a yes/no format. The total of all 'yes' answers provide a score that can be compared to average and minimum age-dependent values. These values are provided in one-month age categories based on normative data (Coninx et al, 2009).

A longitudinal intervention study was conducted using the LittLEARS as part of the UWO PedAMP (Bagatto et al, In Press-a). Through this work, it was reported that caregivers and clinicians found it feasible to complete clinically (Moodie et al, In Press). In addition, the questionnaire has been shown to be sensitive to other medical issues besides hearing loss (Bagatto et al, In Press - a). The LittLEARS has been shown to be useful for monitoring the progression of auditory development in infants and young children who have normal hearing and aided PCHI. As part of version 1.0 of the UWO PedAMP, the LittLEARS can be used for children from birth to approximately 48 months of age, depending on their score on the tool. A close look at the items on the LittLEARS and the PEACH, which has items more appropriate for older children, indicate a stopping rule was needed to make the application of these tools feasible to utilize in a clinical population. Therefore, when a minimum score of 27 or better is achieved on the LittLEARS, the child's performance is considered to be at a ceiling score. If ceiling is reached, the tool should no longer be administered. Instead, the clinician can begin to administer the Parent's Evaluation of Aural/Oral Performance in Children (PEACH), either at that appointment or at the next follow-up visit. Children who are younger than 24 months of

age and achieve the ceiling score on the LittLEARS may not yet be in the developmental range of the PEACH. The clinician may want to continue to administer the LittLEARS until the child is 24 months of age, or interpret low scores on the PEACH knowing the child may not yet be within the developmental range of the tool as supported by recent work (Bagatto et al, In Press - a).

At David's hearing aid fitting appointment, David's mother completed the LittLEARS Auditory Questionnaire to obtain a description of his auditory development without experience with hearing aids. The total 'yes' score of 14 was plotted to intersect at age eleven months and revealed that David was not meeting auditory development milestones for his age without hearing aids (Figure 2). After three months of hearing aid use (David was 14 months of age), the score on the LittLEARS was 20 indicating that he was meeting minimum auditory development milestones for his age when wearing the hearing aids. Another hearing aid review appointment

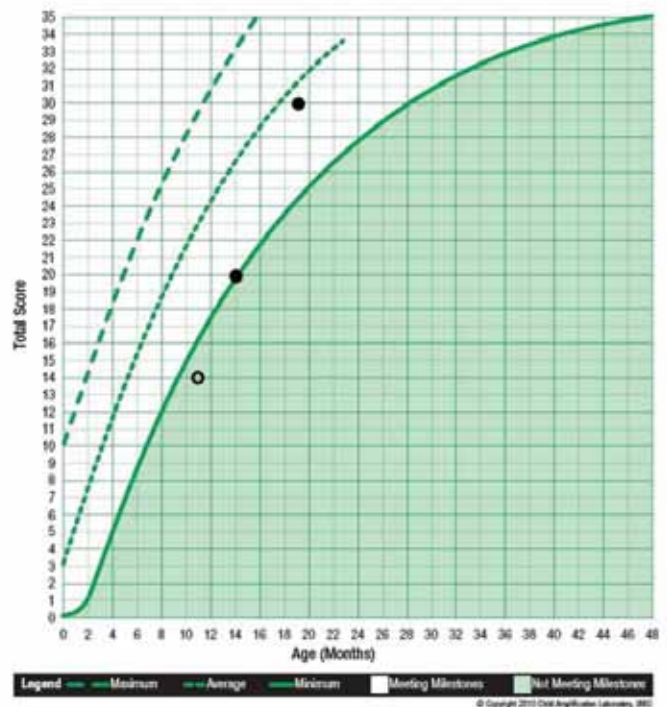


Figure 2: LittLEARS score sheet for Case Example: David. The solid line indicates the minimum expected score, the small dashed line indicates the average expected score and the large dashed line indicates the maximum expected score from the German-derived norms. Circles represent the LittLEARS Score (y-axis) plotted by the child's age in months (x-axis). The open circle is the unaided score and the filled circles represent scores in the aided condition. Scores in the non-shaded region indicate the child is meeting auditory development milestones for his age and scores in the shaded region indicate the child is not meeting auditory development milestones for his age. David was not meeting minimum auditory development milestones for his age prior to being fitted with amplification. While wear the hearing aids, David's scores improved to where he was showing progress and meeting auditory development milestones for his age.

revealed responses on the LittLEARS that totaled 30 at age 19 months. This score was plotted on the LittLEARS scoresheet (see Figure 2) and indicates that David was meeting auditory development milestones for his age after about 8 months of hearing aid use.

Parent’s Evaluation of Aural/Oral Performance of Children (PEACH)

The PEACH in its original diary form is conducted using a structured interview format and has questions that address quiet and noisy situations, as well as hearing device and telephone usage (Ching & Hill 2005b). The PEACH Diary requires caregivers to observe their child for at least one week and record their observations for the 13 scenarios over that time period. They are also asked to rate the frequency of each behavior and provide examples of when the child did or did not exhibit a particular response. After the observation period, the audiologist meets with the caregiver to address each item in a face-to-face interview. The interview is structured in order to solicit detailed information from the caregiver, rather than yes/no answers.

This observation and interview process required for the PEACH Diary was found to be heavy in administrative and respondent burden as reported in a research study (Golding, Pearce, Seymour, Cooper, Ching & Dillon, 2007) and through the Network of Pediatric Audiologists of Canada (Moodie et al, In Press). A Rating Scale version of the PEACH (Ching & Hill, 2005a) has been made available and includes most of the scenarios from the original PEACH Diary (Ching & Hill, 2005b). The PEACH Rating Scale appears to be more acceptable by clinicians and caregivers because the respondent and administrative burden have been reduced (Moodie et al, In Press). The PEACH Rating Scale has been selected for use in version 1.0 of the UWO PedAMP, with children who have attained ceiling performance (i.e., total score of 27 or greater) on the LittLEARS Auditory Questionnaire. The instructions ask caregivers to recall their child’s behavior in everyday life over the past week and rate their child’s hearing performance across a range of hearing and communication scenarios. The nature of the rating scale allows it to be answered by the caregiver during an appointment with guidance from the clinician. The overall score is summed, along with summed scores for the quiet and noise subscales. Each sum (overall, quiet, noise) is converted to a percentage. An accompanying score sheet was developed as part of the UWO PedAMP and provides assistance with interpretation of individual scores (see Appendix A and Figure 3).

The PEACH assesses functional auditory performance in quiet and noisy situations. Using the newly-developed score sheet, scores can be compared to scores derived from children with PCHI who wear hearing aids. This tool can assist in identifying whether a child is or is not performing typical auditory behaviors. Results to date indicate that the PEACH Rating Scale is appropriate for use within the UWO PedAMP with children who wear hearing aids after they have met a certain criteria on the LittLEARS Questionnaire (Bagatto et al, In Press-a).

Since David’s recent score on the LittLEARS exceeded 27, the PEACH Rating Scale was administered at his next follow-up appointment (22 months of age) where new earmolds were provided. Audiometry was repeated using the new earmolds coupled to insert earphones and the RECD was measured using the new earmolds. Upon verification of the performance of the hearing aids, it was noted that the SII values for soft and average speech inputs were not significantly different from previous assessments. The MPO was measured in both ears. Responses from his mother on the PEACH revealed that David was demonstrating typical auditory performance in both the Quiet (91.7%) and Noise (70.0%) subscales (see Figure 3). His overall score was 81.8%.

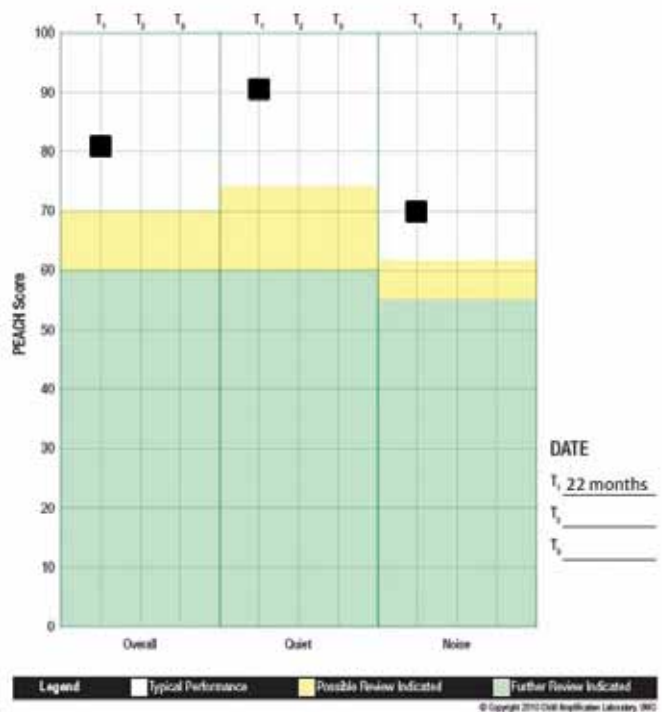


Figure 3: PEACH score sheet for Case Example: David. The PEACH percentage scores (y-axis) are plotted within each subscale (x-axis) for this case example. Results indicate the David is demonstrating typical auditory performance while wearing the hearing aids.

The OIHP Amplification Benefit Questionnaire

The OIHP Amplification Benefit Questionnaire is an eleven-item questionnaire that was developed jointly by the OIHP and the members of the Child Amplification Laboratory at the University of Western Ontario (see Bagatto, Moodie & Scollie, 2010). Using a five-point rating scale, this tool addresses acceptance and use of hearing aids, auditory performance for different levels of sound, effectiveness of service delivery and overall satisfaction. The final question is open-ended and asks the caregiver about how hearing aid services could be improved within the OIHP. It is recommended that the questionnaire be answered by the caregiver after their child has worn hearing aids for *three months or more* so as to give the caregiver a chance to become accustomed to and comfortable with their child's hearing aids and the services offered by the EDHI program. It should be readministered at follow-up visits thereafter (see Figure 4).

Initial responses from David's mother on the OIHP Hearing Aid Benefit Questionnaire revealed one to three hours of hearing aid use per day and some willingness of the child to accept his hearing aids. David's mother reported good responses to sound and a level of comfort troubleshooting the hearing aids. She reported feeling as though the hearing aids were 'worth the effort' and that she was satisfied with the hearing aid services she was provided. More recent responses on the OIHP Hearing Aid Benefit Questionnaire revealed an increase in daily hearing aid use to four to eight hours per day and the child being slightly less willing to accept the hearing aids. Other items on the questionnaire remained similar.

		Appointment Type (Aided)							
		Initial Assessment	Pre-fitting	Initial fitting	30 Day Recheck	3 months Recheck	6 months Recheck	Yearly Rechecks	Event Driven
Outcome Evaluation Tool	Hearing Aid Fitting Details	X	X	✓	X	✓	✓	✓	✓
	WFL Hearing Aid Benefits	X	X	X	X	✓	✓	✓	✓
	EDHIARS	Establish Unaided Baseline: Administer at one of these appointments			✓ [Score <20, WFL PEACH, WFL PEACH]	✓ [Score <20, WFL PEACH, WFL PEACH]	✓ [Score <20, WFL PEACH, WFL PEACH]	✓ [Score <20, WFL PEACH, WFL PEACH]	✓
	PEACH	X	X	X	↓	↓	↓	↓	✓

Figure 4: Administration guidelines for children with hearing loss who wear hearing aids. The top row specifies the appointment type and the far left column indicates the outcome evaluation tool within the UWO PedAMP that should be administered. Within the grid, '✓' and 'X' designates when an outcome evaluation tool should or should not be administered at a particular appointment.

Strategies to support the child's acceptance of the hearing aids were discussed with David's mother. A summary of each outcome measure within the UWO PedAMP and administration guidelines are provided in Figure 4.

Summary

The UWO PedAMP consists of several outcome evaluation tools that assess auditory development (LittleEARS) and performance (PEACH) in children with hearing loss. It also includes tools to track important hearing aid fitting details as well as an index of the appropriateness of the hearing aid fitting (e.g., SII) to assist with the interpretation of scores on the functional outcome questionnaires. Finally, this outcome evaluation guideline includes a tool that assesses overall service delivery and caregiver satisfaction with hearing aid services for their child. The OIHP Amplification Benefit Questionnaire provides a way to measure how an EHDI program is doing overall. The use of the KTA process framework and The Network of Pediatric Audiologists of Canada facilitated the development of the UWO PedAMP. The end result of this process is a guideline that is balanced in statistical properties as well as in clinical feasibility, utility and acceptability. The UWO PedAMP can be used in the final stage of the pediatric hearing aid fitting process where it facilitates the evaluation of the impact of the hearing fitting. Access to visual tools to permit rapid scoring supports clinical feasibility and implementation on a regular basis. The UWO PedAMP will evolve through clinical implementation, and a continued community of practice is considered important for its success. ■

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