Alberta College of
Speech-Language Pathologists
and Audiologists

Protocol:

Pediatric Amplification

November 2021;
February 2025 – addition of Supplement 3

Clinical Guide

for use by ACSLPA regulated members for fitting amplification to all children with permanent hearing loss including those followed by the Alberta Early Hearing Detection and Intervention (EHDI) Program.

Acknowledgements

This document is built on the established 2019 amplification protocol of the Ontario Infant Hearing Program (IHP). Alberta Health Services Allied Health Professional Practice and Education, the Alberta College of Speech-Language Pathologists and Audiologists, and the Alberta Early Hearing Detection and Intervention (EHDI) Program recognize the exceptional work of those involved with the development and implementation of the Ontario IHP Program. With permission, the Ontario IHP amplification protocol has been adopted and, where required for an Alberta context, adapted to support the needs of the pediatric amplification component of the Alberta EHDI program and pediatric audiologists in general. Heartfelt thanks are extended to the following audiologists working in AHS, ACSLPA, and private practice in Alberta who contributed their time, knowledge and experience to the development of this provincial audiology clinical practice guide and protocol: Anne Woolliams, Ashlea Andres, Brian Schmidt, Cheryl Blair, Elizabeth Leonard, Karin Bork, Kathleen Jones, Kelly-Ann Casey, Marion Zeeman, Mayuri Hirani, Raeanne Rowswell, and Tanis Howarth. Specific acknowledgement and appreciation are extended to Dr. Marlene Bagatto and Dr. Susan Scollie, School of Communication Sciences and Disorders and National Centre for Audiology, Western University, London, Ontario, for their expertise and input.

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Protocol: Pediatric Amplification Protocol

Consistent with Competency Profiles for the professions, a protocol outlines the specific clinical criteria, activities, and procedures that should be adhered to by regulated members in the provision of specific professional services. Protocols are evidence informed.

Introduction

This Protocol addresses the provision of amplification, by registered Audiologists, to infants, children and youth (birth to 18;0 years) who present with permanent hearing loss, including those that are part of the Alberta Early Hearing Detection and Intervention (EHDI) Program pathway.

For the purposes of this protocol, providing amplification includes the process of prescribing a hearing aid based on appropriate assessment information, verification that the specified acoustical performance targets have been achieved, fitting the device on the child, and evaluation of device effectiveness in daily life. Dispensing includes obtaining ear impressions for earmold fabrication, electroacoustic analysis of the prescribed hearing aids, and adjustment of the hearing aids to the settings prescribed by a registered Audiologist, and hearing aid orientation.

This document specifies context and procedures for the provision of Amplification, including specification of key procedures and equipment requirements.

Purpose & Scope of this Document

Audiologists who are providing amplification services to children from birth to 18 years, should adhere to the Protocol described in this document.

It is recognized that special circumstances may indicate the need for departure from the procedures specified in this protocol. This does not mean that this protocol is generally discretional. Every reasonable effort should be made to comply with this Amplification Protocol, in the interest of quality of care, consistency of care (equity), and evaluability of overall program performance and outcomes. Departures from this protocol should be documented in the child's clinical chart including rationale and evidence.

Supporting Documents and Resources

All AHS documents referred to in this protocol and posted on the ACSLPA website as a resource are versions of the documents at the time of posting (December 2021).

- *Behavioural Assessment in Pediatric Audiology*
- *Audiological Management for Infants and Children with Middle Ear Dysfunction Associated with Otitis Media AHS Clinical Reference*
- *Pediatric Diagnostic ABR Assessment Procedures and Protocols: Clinical Guide*
- *Identification Intervention and Follow-Up for Children with Mild Bilateral Hearing Loss*
- *Identification Intervention and Follow-Up for Children with Permanent Unilateral Hearing Loss*
- https://www.alberta.ca/infection-prevention-and-control.aspx
- *AAA Clinical Practice Guideline for Remote Microphone HAT for Children and Youth from birth to 21 including Supplement A (2011)*
- *Supplement B: Classroom Audio Distribution Systems – Selection and Verification (2011)*

Document Development

This protocol is a joint undertaking between ACSLPA and AHS. Both organizations share the common goal of providing high quality, standardized, evidence-based amplification practices for infants and children. All regulated audiologists in Alberta should follow this protocol when fitting amplification to any child with permanent hearing loss. There are additional requirements when regulated audiologists are seeing children who are part of the EHDI program (e.g., data submission). For these requirements, refer to Supplement 1.

The contents of this document are based on the 2019 Ontario Infant Hearing Program (IHP) Protocol. The Ontario IHP Protocol is based on: (i) numerous and ongoing reviews of scientific and clinical literature; (ii) ongoing protocol reviews and consultations with leading experts worldwide; (iii) extensive experience with infant hearing aid fitting; and (iv) feedback from program professionals.

This Clinical Protocol was developed by a Pediatric Amplification working group comprised of registered audiologists in public and private practice from across Alberta, all of whom possess expertise in pediatric amplification. The document was developed in partnership across several agencies, including ACSLPA, Alberta Aids to Daily Living (AADL), AHS Health Professions Strategy and Practice, and the Alberta EHDI program.

This protocol will be reviewed and updated every five years, or as required, based on substantial practice changes in pediatric amplification. For further information, or to request revisions or review, contact ACSLPA's Audiology Practice Advisor at audiology@acslpa.ca.

This Amplification protocol is evidence-based. Evidence will be reviewed by the joint ACSLPA and AHS Pediatric Amplification Advisory Committee on an ongoing basis. This may result in specification of procedures that differ from information in published journals. A registered audiologist may bring any significant procedural concerns to the attention of the ACSLPA Audiology Practice Advisor. These concerns will be brought forward to the Pediatric Amplification Advisory Committee for review. Substantive issues will be addressed by new evidence review, re-examination of existing evidence, and/or provincial consensus development.

Pediatric Amplification Foundations

Amplification Candidacy

Amplification provided to children birth to 18;0 years in Alberta should be prescribed, dispensed, and fitted by audiologists registered with ACSLPA.

For infants and children to be considered a candidate for amplification, permanent hearing loss will have been identified through a pediatric diagnostic audiological assessment. Please refer to the following AHS Audiology Practice guides accessed through the ACSLPA website: *Pediatric Diagnostic ABR Assessment Procedures and Protocols: Clinical Guide, Behavioural Assessment in Pediatric Audiology, Audiological Management for Infants and Children with Middle Ear Dysfunction Associated with Otitis Media AHS Clinical Reference*.

The primary goal of diagnostic audiological assessment is to determine the absence or presence, and extent, of permanent hearing loss. If permanent hearing loss is present, the goal is to provide sufficient audiometric information to initiate service options for a family; to improve hearing and communication development as soon as is reasonable after identification of permanent hearing loss and, in the case of

infants, before six months corrected age[1]. The assessment will result in valid and accurate estimates of ear-specific and frequency-specific thresholds to the fullest extent possible.

Infants and children who have bilateral permanent hearing loss of moderate or greater degree are unequivocally audiological candidates for binaural amplification, unless there is a clear, documented contraindication. See Appendix A: Degrees of Hearing Loss for a description of the threshold values and ranges associated with the severity of hearing loss descriptors.

Children with a permanent hearing loss greater than 20 dB HL may be candidates for amplification and/or personal FM systems. Refer to *Identification Intervention and Follow-Up for Children with Mild Bilateral Hearing Loss* for information about managing children with mild bilateral hearing (MBHL) loss.

Children identified with permanent unilateral hearing loss (PUHL) may be candidates for amplification. Evidence suggests that amplification recommendations based on the level of hearing loss in the affected ear must be individualized for infants and children with permanent UHL. Refer to *Identification Intervention and Follow-Up for Children with Permanent Unilateral Hearing Loss* for information about factors to be considered in making the determination of when a child with PUHL is a good candidate for amplification.

The AHS MBHL and PUHL clinical guides referenced in the supporting documents and resources section should be followed in the determination of a child's candidacy for amplification. Once candidacy is determined, Appendix B outlines the amplification options for children with MBHL or PUHL.

Infants who have been identified as having definite or probable Auditory Neuropathy Spectrum Disorder (ANSD) based on ABR findings should be evaluated behaviourally, as soon as developmentally appropriate, to define perceptual thresholds. A trial with amplification can only begin once consistent elevated behavioural responses are obtained, ideally ear-specific thresholds. Refer to Diagnostic Pediatric ABR Assessment for information about early follow-up and management of infants and young children with ANSD.

If amplification is indicated and elected by the family after review of the options and information, the process of Amplification needs to be undertaken in a timely manner. See the section *Timing of Amplification* below.

The provision of amplification to an infant or young child with permanent hearing loss is not an event, but a process. Even if complete and accurate audiometry is obtained at three months of age, periodic follow-up audiometry is required to confirm the early measurements, refine threshold estimates, and/or detect and quantify possible changes in hearing and hearing aid settings. Any changes to the child's auditory thresholds are applied to the hearing aid prescription as needed.

[1] Calculating Corrected Age for Preterm Infants from AHS (2018) Growth Chart Use Protocol:

Corrected Age is based on 40 weeks gestation, and it used until 24 months corrected age.

(Step 1) Calculate # weeks pre-term: 40 weeks – gestational age at birth (completed weeks)

(Step 2) Calculate corrected age: Chronological age - # weeks preterm

Example: A baby born at 34 weeks is now 6 months, 3 weeks chronological age (postnatal age)

(Step 1) 40 weeks – 34 weeks = 6 weeks preterm

(Step 2) 6 month;3 weeks – 6 weeks = 5 months;1 week Corrected Age

Registered Audiologists

Goals of Amplification

The main goals of Amplification are to:

- Provide an amplified speech signal that is consistently audible across levels;
- Avoid distortion of varying inputs at prescribed settings for the user;
- Ensure the signal is amplifying sounds in as broad a frequency range as possible; and
- Include sufficient electroacoustic flexibility to allow for changes in the required frequency/output characteristics related to ear growth or changes in the auditory characteristics of the infant.

Timing of Amplification

ACSLPA supports the Alberta EHDI Program target of prescribing and verifying amplification by no later than six months corrected age, as recommended by the Joint Committee on Infant Hearing (JCIH, 2019). Research indicates early hearing aid fitting (e.g., at three months of age) is associated with improved global language scores, especially for greater degrees of hearing loss (Ching et al, 2018). The interpretation of the JCIH recommendation is not prescription of a hearing aid at six months but a completed process of prescription, verification and adjustment, if necessary, by six months.

Accounting for practical considerations of early hearing aid fitting, it is reasonable to expect infants to be fitted with hearing aids between three to six months corrected age.

While review by an otolaryngologist by three months is ideal, it is recognized that this may not be possible, and should not delay the hearing aid fitting.

Some children with complex situations (i.e., illness, active middle ear disorders, audiometric uncertainty, or family context), may take longer to receive their hearing aids which is not unexpected. Reasons for delayed hearing aid fitting are to be documented by the Registered Audiologist in the child's clinical record.

Definition of Amplification Devices

For the purposes of this document, a 'hearing aid' is defined as any electronic device fitted to the ear designed to amplify and deliver sound to the ear in an individualized way for a person's hearing loss. This protocol focuses on the fitting and verification of behind-the-ear hearing aids and the verification of personal remote microphone hearing aid technology. The candidacy, fitting and verification of bone conduction hearing devices and cochlear implant technologies are outside the scope of this protocol. Children for whom these are considerations may be referred to the specialty programs that provide these services in the province.

Remote microphone hearing assistance technologies (RM-HAT) are devices for mitigating the impact of distance, noise, and reverberation. They can be worn with or without hearing aids and a verification protocol is described in this document.

Instrumentation and Calibration

Amplification services shall be conducted using equipment that is capable of meeting the specifications necessary to meet the requirements described in this protocol. Clinical instrumentation requirements are listed in Appendix C.

Routine calibration checks of real-ear hearing aid test systems are necessary for appropriate operation of the system and shall be completed by the audiologist on a weekly basis, at minimum. These systems are to be calibrated on an annual basis, as scheduled by the facility.
Ongoing calibration and maintenance (including software updates) are the responsibility of the clinic providing services.

Infection Control

Infection prevention and control practices are governed by regulatory, site-specific, and/or institutional-specific protocols and are outside the scope of this document. For further information, refer to the ACSLPA Advisory Statement: Infection Prevention Control: Reusable and Single-use Medical Devices.

Amplification Funding

Amplification devices for pediatric clients (birth to 18 years) are fully or partially funded through AADL or NIHB as eligibility criteria permits. To be eligible for AADL funding, assessment for the purpose of amplification, amplification prescription, dispensing, fitting, verification, and validation must be conducted by an audiologist who is registered with ACSLPA. Amplification benefits funded by the AADL Program to children birth to 18;0 years are to be provided in adherence to this Amplification Protocol. In addition, to access AADL funding, the audiologist must be designated an approved Specialty Assessor with the AADL Program. To access NIHB funding, the audiologist must have a provider number with NIHB. Audiologists providing amplification need to contact AADL and NIHB to confirm eligibility criteria to provide services.

Hearing loss threshold criteria for funding eligibility is outlined in the AADL Program Policy Manual. Audiologists fitting and dispensing amplification need to stay abreast of current AADL Program requirements and refer to the most current AADL Policy Manual posted online.

Clinical Records and Reports

All Amplification records are to be maintained according to ACSLPA's Standard of Practice 4.3 Documentation and Information Management. Further information regarding record keeping is available in ACSLPA's Guideline: Clinical Documentation and Record Keeping.

The infant's audiological record of amplification should include the following:

- Audiological assessment results;
- Amplification prescription (make, model, earmold specifications, non-electroacoustic characteristics);
- Date of fitting and serial number(s);
- Hearing aid verification data (including RECD values and fit-to-targets);
- Documentation of hours of use (e.g., data-logging and/or parent report);
- Verification of activated advanced features (e.g., noise reduction, frequency lowering, etc.);
- Hearing aid orientation with caregivers;
- Outcome measurements (e.g., SII, Amplification Benefit Questionnaire, LittlEARS, PEACH); and
- When RM-HAT technology is provided, the equivalent of that described above for hearing aids will be documented.

The clinical records need to be sufficient to facilitate consultative, clinical review, and case conferencing. To ensure records are complete, the Hearing Aid Fitting and Verification Checklist found in Appendix D should be completed and kept on record.

Personal Health Information

Management of all personal health information arising from the Amplification process is to comply with relevant ACSLPA Standards of Practice, Advisory Statements and current Government of Alberta legislation.

Overview of Amplification Process

Required Components of the Amplification Process:

The amplification process should include the following:

1. Child and family-centred care, collaborative goal setting, and shared decision making
    - Client-centered services refer to "a partnership between a team of health providers and a client where the client retains control over their care and is provided access to the knowledge and skills of team members to arrive at a realistic team shared plan of care and access to the resources to achieve the plan".
    - Collaborative goal setting with the family, inclusive of shared decision-making, to support the family in their choice of communication outcome for their child, and their choice to include or not include amplification as part of that desired outcome.
2. Audiological and otological assessment
    - A complete description of the audiometric thresholds for both ears.
    - Consultation by an otolaryngologist.
3. Selection of Amplification
    - Otoscopy
    - Accurate ear impression(s) for the purposes of fabricating an earmold
    - Determination of non-electroacoustic characteristics
    - Electroacoustic Characteristics
    - Device selection
    - Assistive technology
4. Fitting and Verification of Amplification
    - Real-ear-to-coupler difference (RECD) measurement for infants and young children using the child's earmold, if available;
    - DSL m[i/o] v5 Child target ear canal sound pressure levels (SPL) for the amplified long-term average speech spectrum for speech at soft, conversational, and loud levels for each hearing aid to be fitted;
    - DSL m[i/o] v5 Child target ear canal SPLs for defining the maximum power output of each hearing aid to be fitted;
    - Electroacoustic verification in the coupler using test signals that align with prescriptive targets (i.e., speech, narrowband);
    - Verification that the electroacoustic characteristics of the hearing aid(s) adequately match the auditory needs of the infant, child, or youth; Simulated measurements of the real-ear aided response (REAR) should be completed across test levels for speech and maximum output (RESR); and
    - Application of signal processing (e.g., noise reduction, frequency lowering) as indicated.

5. Information and Orientation for the Family
    - Instruction and counseling sessions with the parent/caregiver when the hearing aid(s) are first fitted and at subsequent follow-up visits.
6. Outcome Evaluation
    - Follow-up schedule as per protocol;
    - Follow-up visits as required for adjustments to the amplification; and
    - Outcome measures that provide an evaluation of the outcome of the intervention.

Audiological and Otological Assessment

Audiometric Thresholds (Minimum Requirements)

Before initiating the process of providing amplification, threshold measurements for at least 500, 2000, and 4000 Hz will be obtained in each ear for air conducted stimuli and at 500 and/or 2000 Hz, as applicable, for bone-conducted stimuli. Threshold estimates at 1000 Hz are recommended, but not required for the initial provision of amplification.

Refer to Appendix E for additional information on auditory assessment, including what to do when no response is indicated on the ABR Assessment.

Consultation by an Otolaryngologist

When a child is identified as having a permanent hearing loss, referral to an otolaryngologist for medical consultation is required. Often this referral is made by the audiologist who identified the hearing loss. The referral to otolaryngology has the main goal of obtaining a broad review of the child's health status in light of the hearing loss, and may include radiologic, serologic, and ophthalmologic tests, as well as genetic review and other cross-referrals.

When a family elects to proceed with amplification, it is important to confirm that a referral to an otolaryngologist has been made or will be initiated.

Other Supports

With their decision to proceed with amplification, families continue to need various supports to help them through the process of acceptance and adaptation to the hearing loss and the device(s). Audiologists shall aim to facilitate information-sharing and a plan for supporting the family's goals for their child. The audiologist will offer a family with a child newly diagnosed with permanent hearing loss the opportunity to connect with other parents of children who have permanent hearing loss. If a family needs additional support such as connecting with other professionals or community services, helping with transitions to childcare and school, etc., the Audiologist will arrange for the services that are needed. When indicated, they will make a referral to a Social Worker.

Second Opinions

Second opinions may be initiated by the parent/caregiver of the child with PCHL if they believe that such a review may materially improve the accuracy or effectiveness of the overall Amplification.

Selection of Amplification

Otoscopy

Cursory otoscopy should be conducted at the start of any amplification appointment. Its main purpose is to detect foreign bodies, canal occlusion, and/or any physical condition of the ear that would warrant a referral to a physician.

Ear Impressions

The ear impression(s) should be conducted by a registered audiologist, or under the clinical supervision of a registered audiologist as outlined in the *Speech-Language Pathologists and Audiologists Profession Regulation*. Audiologists should also refer to the ACSLPA Audiologist Restricted Activities Competency Profiles. Ear impressions will be obtained from each ear for fabrication of personal earmolds when behind-the-ear (BTE) hearing aids are to be provided. The fabrication order form shall include length of canal and helix, material (silicone, etc.), tubing type, shell style, vent (if possible), and options. Some earmold characteristics will be limited by the size of the infant's ear.

Earmold(s) for infants and young children should be made of a soft material for comfort, safety, and retention. Also, softer material reduces the possibility of acoustic feedback from the BTE hearing aid(s). The advantages and disadvantages of various earmold materials should be weighed for each individual infant and young child. The cost and need for frequent replacement of earmolds to prevent acoustic feedback should be explained to the caregiver. The audiologist will select the appropriate ear mold material for an older child or youth and is not limited to choosing soft materials for the earmold.

Refer to Appendix F for additional information on pediatric ear impressions and earmolds.

Non - Electroacoustic Characteristics

Audiologists should consider non-electroacoustic characteristics of the prescribed hearing aid(s). Ear coupling for retention, monaural versus binaural fitting, ability to deactivate advanced features, remote microphone hearing assistance technology compatibility, and tamper resistant battery doors are all important considerations.

The unique needs of infants and young children should be considered when selecting non-electroacoustic features of the hearing aid(s). Tamper-resistant battery doors are required; hearing aid batteries are toxic if ingested. Disabling the volume control and the program button will ensure that the infant is wearing the hearing aids at the prescribed settings at all times. Pediatric ear hooks should also be used for filtering acoustic output, as well as for loss prevention/retention. The device should have a battery that is capable of lasting the entire school day including power needed to couple to remote microphone technology; ideally the battery will last all waking hours within a single day.

Audiologists should consider non-electroacoustic characteristics of the prescribed hearing aid for older children and youth. Ear coupling for retention, monaural vs binaural fitting, ability to deactivate features, RM-HAT compatibility, and tamper resistant battery doors are still important considerations. As a child ages, depending on their cognitive capacity and/or family-led decision making, these features

may be adjusted as needed. The device should have a battery that is capable of lasting all waking hours, including power needed for all wireless accessories.

Refer to Appendix G for additional information on non-electroacoustic characteristics.

Electroacoustic Characteristics

The use of a systematic, objective approach to electroacoustic characteristics that incorporates age-dependent variables into the computations for prescribing a hearing aid needs to be considered.The formula that should be used for all children from birth to 18.0 years to develop the appropriate electroacoustic characteristics is the Desired Sensation Level Method® m[i/o] v5 (Scollie et al, 2005). If another formula is used in the case of older children and youth, the rationale should be documented. DSL v5 provides targets that vary depending on the type of fitting, specifically, targets for pediatric patients (i.e., congenital hearing loss) and for adult patients (i.e., acquired hearing loss). For the purposes of this Protocol, clinicians should use the DSL m[i/o] v5 'Child' targets within the real-ear hearing aid test system. A conductive correction within the DSL formula for conductive or mixed losses (air-bone gap of 10 dB or greater) should be applied. Coupler targets for the amplified long term average speech spectrum (65 dB SPL), soft speech (55 db SPL), loud speech (75 dB SPL), and maximum power output (MPO) across frequency for each ear requiring amplification should be documented.

When prescribing amplification for an infant, the selection of electroacoustic characteristics should include the following:

1. Sufficient gain, level-dependent processing, and frequency shaping to allow the hearing aid to be adjusted to a child's individualized DSL v5 prescription using the procedures described in this document.
2. The hearing aid(s) selected should avoid unnecessary distortion.
3. The hearing aid(s) selected should provide electroacoustic flexibility to accommodate anticipated changes in ear canal growth, changes in hearing threshold level if known or suspected, and anticipated needs for coupling to external sound sources or for advanced signal processing.

Device Selection

Once the non-electroacoustic and electroacoustic characteristics of the potential hearing aid(s) have been identified, the audiologist discusses the features, price and funding with the family. Using a child and family-centred approach, the Audiologist together with the family choose a hearing aid. Earmolds and hearing aids are to be ordered, with a request for pediatric filtered ear hooks, tamper proof battery door, and pediatric care kit.

Assistive Technology

Infants may be candidates for assistive listening technologies and devices in addition to, or instead of, personally-worn hearing aids. It has been well documented that the use of remote microphone hearing assistance technology (RM-HAT) by children in educational settings is an effective strategy for improving listening in environments with poor signal to noise ratios, great distance between listener and talker, and highly reverberant rooms. While a remote microphone technology (RM-HAT) system may not be used in the first few months of life, when the infant becomes a toddler, more difficult listening situations will develop. The child may be at a distance from the primary caregiver or talker and in highly reverberant environments. In addition, use of this technology may increase the rate of language acquisition (Benítez-Barrera et al, 2018; 2019; Moeller et al, 1996).

If the audiologist determines that the infant is a candidate for other assistive technology, such as remote microphone hearing assistance technology, the audiologist should explain the option to the family and facilitate careful consideration and informed choice.

Wireless Accessories

RM-HAT is essential for older children and youth. The following two documents are comprehensive and provide evidence-based guidance for RM-HAT in school-aged children and youth:

- *AAA Clinical Practice Guideline for Remote Microphone HAT for Children and Youth from birth to 21including Supplement A (2011)*
- Supplement B: Classroom Audio Distribution Systems – Selection and Verification (2011)

Children and youth may also be candidates for wireless accessories beyond the use of RM-HAT described in the Assistive Technology section of the Pediatric Amplification Protocol. In discussion with the family and when the child/youth is ready, remote controls, cell phone apps, wireless phone adapters, amplified telephones, wireless TV adapters/TV listening devices, and/or T-coil compatible accessories can all be considered.

Other Assistive Technology

As children become more independent discussing alerting devices, amplified alarm clocks, bed shakers, and/or visual aids for the doorbell, fire alarms, and household appliances may apply. The Registered Audiologist should explain the options to the family and facilitate careful consideration and informed choice.

Refer to Appendix L for additional information on remote microphone hearing assistance technologies.

Fitting & Verification of Amplification

Real-Ear-to-Couple-Difference (RECD)

The real-ear-to-coupler difference (RECD) measurement procedure was developed to determine an individualized acoustic transform for use with the Desired Sensation Level (DSL®) Method (see reviews in Bagatto et al., 2005; Moodie et al., 2016; Seewald & Scollie, 1999). The individual's RECD is used to obtain SPL thresholds, generate the appropriate gain and output response for a hearing aid, and has been shown to be highly repeatable and valid. RECD values are known to be highly variable among children of the same age (Feigin et al., 1989; Seewald & Scollie, 1999; Bagatto et al, 2002; Bagatto et al, 2006), for this reason, it is best practice to measure the individual infant's RECD so optimal amplification can be provided.

RECD Measurement

The RECD measurement is a required element in this protocol. RECD measurements will be obtained following the procedure described by Moodie and colleagues (1994; 2016) and. RECD values, tester, coupling type (earmold, foam tip, immittance tip), coupler type (HA-1, HA-2, HA-4), ear, and test date are to be documented and retained on file.

In the event that the individual RECD measurement cannot be obtained, age-related predicted values should be applied. The predicted values used are to be specified (i.e., age, coupling type), documented, and retained on file. The current age-related predicted values are derived from data collected from infants and children of varying ages and are provided for foam tip and earmold coupling (Bagatto et al, 2005) and may use software-assisted corrections to convert individual RECDs between foam tip and earmold formats when necessary (Moodie et al, 2016).

RECD Measurement and New Earmolds

The acoustic properties of an infant's or young child's personal earmold should be taken into account through the use of RECD measurements or age-appropriate predicted values. Whenever a new earmold is obtained, an RECD measurement should be collected using the earmold and applied in the calculation of prescriptive targets. Thus, the prescriptive targets are to be updated with the new RECD measurement when a new earmold is obtained. The verification procedures described in this document should be carried out every time the prescriptive targets have been updated.

RECD Measurement and Auditory Thresholds

When comparing audiometric thresholds for the same infant over time, it is important to take into account the changes in individual ear canal acoustics. RECD measurements should be applied so that the thresholds are represented in either real-ear SPL or equivalent adult hearing level, because both of these scales allow appraisal of threshold changes independent of ear canal acoustic changes.

For example, when comparing visual reinforcement audiometry (VRA) thresholds completed at nine months of age to ABR threshold estimations collected at three months of age, the RECD should be applied to both sets of thresholds to obtain an individualized and more accurate threshold representation. If ear canal acoustics are not considered when making this comparison, what appears to be a change in hearing threshold sensitivity may in fact be a result of changes in ear canal acoustics due to ear growth. These calculations are commonly automated in many commercial hearing aid analyzers.

Refer to Appendix H for additional information on RECD measurement, including the RECD procedure and considerations regarding measuring an infant RECD and the changing acoustics of the ear canal.

Electroacoustic Verification

Prior to being fitted to the infant, the prescribed hearing aid(s) should be adjusted by the audiologist to approximate the target electroacoustic values for gain and maximum output that were specified according to the components detailed in the steps of the protocol related to the selection of amplification. All verification curves, in SPL, and final hearing aid settings should be documented and dated for each ear requiring amplification. Simulated real-ear measurements of the real-ear aided response (REAR) are to be performed for each device and the hearing aid(s) adjusted to provide a match to targets through the use of test box measurements within real-ear hearing aid test systems.

As children develop and age, in-situ real ear measurements are the preferred method of electroacoustic verification. For Real Ear Unaided Gain (REUG) measurements, the measurement azimuth (0, 45, 90 degrees) should be specified in the real ear and hearing aid test system.

The prescribing audiologist is responsible for verifying the match to targets prior to the initial fitting of the devices to the child and following any returns from repair. It is important to check for feedback from the aid once it has been placed on the infant's ear. When it becomes developmentally possible, in-situ real ear measurements (vs. simulated) become the preferred method of electroacoustic verification.

Verification Stimuli

Verification of hearing aid performance across average (65 dB SPL), soft (55 dB SPL), and loud (75 dB SPL) speech input levels as well as MPO will be conducted in the coupler to determine the audibility and compression characteristics of the device. Verification of speech targets should be completed using pre-recorded, calibrated speech test signals. Maximum output characteristics for most hearing aids will be verified using narrowband stimuli at a high-test level (85 to 90 dB SPL).

Refer to Appendix I for a detailed description of the electroacoustic verification procedure.

Application of Additional Signal Processing

Automatic feedback management technologies may be applied if feedback is noted when the hearing aid has been placed on the infant's ear following verification. Prior to applying feedback management strategies, however, every attempt should be made to reduce feedback through other methods (i.e., good earmold fit, use of lubricant).

If feedback suppression is applied, then verification of the aid is to be conducted following application of these technologies. The application of feedback suppression is to be reassessed whenever new earmolds are obtained. Feedback suppression technology is to be deactivated when not required.

Additional signal processing, such as automatic noise reduction, automatic program switching, and frequency lowering processors are continuously evolving. As new technologies and new evidence emerges, clinicians are encouraged to use technologies that meet the listening needs of their patients. Specific evidence review and protocols have been developed for frequency lowering, noise management, and remote microphone hearing assistance technologies and are included within this document.

Refer to Appendix J for a detailed description of the frequency lowering procedures

Refer to Appendix K for a detailed description of the noise management strategies and procedures

Refer to Appendix M for a description of the remote microphone technology verification procedure

Orientation for the Family

The provision of hearing aids should include explanations of the use, care, and maintenance of the devices provided in a clear and understandable way and supplemented by appropriate resources and information. A complete list of topics for clinicians to share information about and discuss with families is included in *Appendix N*.

Infants are not able to report if their hearing aids are malfunctioning. Consequently, family vigilance is required and a care kit should be provided. Supportive information and instruction for the family/ caregiver should be given at the time of the initial fitting of the hearing aid(s), and a follow-up visits.

In addition to the topics in *Appendix N*, inclusion of the following topics for older children and youth, and their families is important:

- Use of wireless technology.
- Use of other assistive technology.
- Changes in funding supports at 18;0 years.
- Transition of care and supports related to changing education and/or occupation needs.

Outcome Evaluation

Follow-up Schedule

Follow-up to the initial hearing aid fitting should be carried out on a regular schedule, with accommodation for individual needs as required. The audiologist prescribing, fitting, and verifying the hearing aid(s) should see infants and young children and family for at least one follow-up visit within the hearing aid trial period, and for one follow-up visit at the end of the trial period. For pediatric clients birth to 6;0 years of age, it is recommended that a trial period of 60 days be provided.

The schedule of amplification follow-up visits following completion of the trial period should include visits every three months for one year after the fitting of amplification, a minimum of every six months for the second year through to age 6;0 years, and annually thereafter. The growth of the head and ear canal during early childhood require regular measurement of a child's external ear canal acoustics. These measurements are an important component of providing consistently accurate amplification.

For infants and young children regular audiological monitoring of unaided hearing thresholds should occur every three months in the first-year post-diagnosis, and then every six months thereafter to 6;0 years, unless changes occur that would require more frequent monitoring.

For infants and young children identified as having a progressive or fluctuating hearing loss or auditory neuropathy spectrum disorder (ANSD), the regular schedule is especially important. The schedule should be re-assessed on an ongoing, individual basis considering the need for new ear molds or diagnostic assessment, with documentation when the standard follow-up schedule described above is not followed.

For older children and youth, follow-up to the initial hearing aid fitting should be carried out on a regular schedule, with accommodation for individual needs as required. The audiologist prescribing, fitting and verifying the hearing aid(s) should see the child or youth for at least one follow-up visit within the hearing aid trial period, and for one follow-up visit at the end of the trial period. For children and youth 6;1 to 18;0 years of age it is recommended that a trial period of 60 days be provided.

The schedule of amplification follow-up visits following completion of the trial period should include annual visits with more frequent visits as required.

Regular audiological monitoring of unaided hearing thresholds should occur annually unless changes occur that would require more frequent monitoring of unaided hearing thresholds.

Follow-up Visits

At the follow-up visits, an incremental history should be obtained from the family. Use, care, and maintenance of the hearing aids should be discussed as parents' questions arise, or as re-instruction is required. Otoscopy, middle-ear analysis, and assessment of hearing levels (typically behaviour-based) using the child's earmolds connected to the insert earphone transducer should be completed for infants and young children (see *AHS Behavioural Assessment in Pediatric Audiology*). Earmolds should be assessed for appropriate fit and new earmolds obtained when required. For infants and young children, an RECD should be re-measured with the new earmolds to account for growth and development, or if there has been a change in middle ear status. An electroacoustic analysis of the hearing device(s) to ANSI standards and a listening check of the hearing aids should be conducted to evaluate sound quality and the need for further assessment or repair. Subsequent adjustments should be made to the hearing aids as needed and an evaluation of the need for additional technologies (e.g., remote microphones, noise reduction, frequency lowering) should be conducted through counseling and outcome measures.

Outcome Measures

For infants and young children validation of the fitting should be done using procedures outlined in the Pediatric Amplification Outcome Measurement Protocol described in Appendix O and Appendix P. In brief, the systematic, evidence-based protocol includes tools that assess the following dimensions:

- Subjective assessment of early auditory development;
- Subjective ratings of auditory performance in daily life;
- Acceptance and use of hearing aids; and
- Parent/caregiver experience with pediatric amplification service delivery.

For children and youth 6;0 to 18;0 the following outcome measures may be considered:

Preschool to School-age	• Auditory Behavior in Everyday Life (ABEL) • Children's Outcome Worksheets (COW) • Meaningful Auditory Integration Scale (MAIS) • Parents' Evaluation of Aural/Oral Performance of Children (PEACH) • Teacher's Evaluation of Aural/Oral Performance of Children (TEACH)
School-age	• Children's Home Inventory of Listening Difficulties (CHILD) • Listening Inventories for Education (LIFE) • Listening Situations Questionnaire (LSQ) • Screening Instrument for Targeting Educational Risk (SIFTER)
Older School-age	Self-Report Outcome measures, including the • Client Oriented Scale of Improvement (COSI) • Abbreviated Profile of Hearing Aid Benefit (APHAB) • Satisfaction with Amplification in Daily Life (SADL)

Data Submission to the EHDI Program

Audiologists are expected to collect and submit data to the EHDI program ONLY for children aged 0-6 years who are followed through the EHDI pathway. Collection and submission of data to the EHDI program supports outcome measures and informs program development, research, improvement, and funding. See Supplement 1.

APPENDIX A: Degrees of Hearing Loss in Children

For this protocol, audiologists should use the following severity (degree) of hearing loss descriptors and associated dB HL ranges when describing hearing loss.

Degree of Hearing Loss	Hearing Loss Range (dB HL)
Normal	-10 to 15
Near Normal/Slight	16 to 20
Mild	21 to 40
Moderate	41 to 55
Moderately-Severe	56 to 70
Severe	71 to 90
Profound	91+

Adapted from ASHA, Degree of Hearing Loss

APPENDIX B: Management of Mild Bilateral and Unilateral Hearing Loss

Prior to determining the type of amplification that will be fitted for children with mild bilateral hearing loss (MBHL) and/or permanent unilateral hearing loss (PUHL), this protocol requires that the audiologist providing amplification follows the clinical guidance and recommendations in the AHS MBHL and UHL clinical guides to determine candidacy for amplification.

Conversations with the family are paramount in the shared decision as to when to fit amplification for a child with a mild or permanent unilateral hearing loss. It is crucial that families are informed of options and are highly engaged in the decision-making process. Family readiness and motivation are fundamental to proceeding with fitting amplification on a child with mild bilateral and unilateral hearing loss. Shared decision making is an important element of family-centred care where the audiologist supports the family in making a decision that is consistent with the values of the family and considers their expectations. Hearing aid candidacy, fitting and evaluation for these types of hearing losses need a multi-disciplinary approach. Determination of both need for and benefit with amplification require information and understanding of the child's hearing, speech and language development, academic development (if school-age), behavioral development, listening effort, and social and emotional impacts. Communication with the family and between all professionals and caregivers involved with the child and family is important to ensure parents are clear on the management options and plan for their child. Poor communication and/or mixed messages between professionals creates frustration and confusion for parents.

Once candidacy for a child with MBHL and/or PUHL is determined as per the clinical guides above, then the following tables should be used to assist in determining the type of amplification that is optimal for an individual child and family.

Amplification Options for Mild Bilateral Hearing Loss (MBHL)	
Mild Degree of Hearing Loss (21 to 40 dB HL)	
Air Conduction Hearing Aid **or** Softband Bone Conduction Hearing Device (BCHD) **AND** Personal Remote Microphone Hearing Aid Technology (RM-HAT)	• Detection of sound is improved. • RM-HAT reduces the negative impacts of noise, distance and reverberation. • RM-HAT supports vocabulary and language development. • See Appendix L and Appendix M for detailed information on RM-HAT. • Softband BCHD is an option for infants and young children with a predominantly conductive MBHL who are not suitable candidates for air conduction hearing aids. This includes hearing loss secondary to microtia/atresia.

Amplification Options: Permanent Unilateral Hearing Loss (PUHL)

In alignment with the SAC 2020 Position Paper on Unilateral Hearing Loss in Children (December 2020), this protocol recommends the provision of a hearing aid for children with PUHL when the degree of hearing loss on the affected side permits the child to receive appropriate speech audibility from either an air or bone conduction hearing aid. Typically, depending on the frequencies affected, mild to severe degrees of sensorineural hearing loss receive appropriate audibility with an air conduction hearing aid. A remote microphone system is recommended in combination with a hearing aid, especially for preschool, early education, or classroom settings. Consistent with any hearing aid fitting, appropriate gain, output, frequency bandwidth, and sound quality should be considered.

Mild to Severe Degree of Hearing Loss (21 to 90 dB HL)	
Air Conduction Hearing Aid **or** Softband Bone Conduction Hearing Device (BCHD) **AND** Personal Remote Microphone Hearing Aid Technology (RM-HAT)	• Detection of sound is improved. • RM-HAT reduces the negative impacts of noise, distance and reverberation. • Decisions regarding RM-HAT use for a child with UHL should be made on an individual basis. • Considerations include the child's age, the degree and configuration of hearing loss in the poorer hearing ear, whether the child uses personal amplification, and where the RM-HAT will be used. • When deciding whether to fit a receiver to the poorer hearing ear, it is important to consider aided speech discrimination ability; if significantly poorer than in the normally hearing ear, it is possible that RMS input to the personal amplification device might not improve outcomes. • Softband BCHD is an option for infants and young children with a predominantly conductive PUHL who are not suitable candidates for an air conduction hearing aid. This includes hearing loss secondary to microtia/atresia.
Profound (*equal to or greater than 91 dB HL with sufficient residual hearing to support speech intelligibility*)	
Air Conduction Hearing Aid fitted to ear with hearing loss **AND** Personal Remote Microphone Hearing Aid Technology (RM-HAT)	• This is the optimal choice when restoration of hearing is the goal • Need to consider the amount of residual hearing that the child can benefit from if amplified. • Use Speech Intelligibility Index (SII) as a decision tool to determine if this option is an appropriate choice of amplification. • RM-HAT is fitted to better ear based on speech discrimination scores, when a child is developmentally capable of participating in this task. • Occlusion of the normal hearing ear is to be avoided.
Softband Bone Conduction Hearing Device (BCHD) **AND** Personal Remote Microphone Hearing Aid Technology (RM-HAT)	• When an air conduction hearing aid is contra-indicated, a referral to a bone conduction amplification program may be considered on a case-by-case basis. • For profound PUHL, the softband BCHD would primarily act as CROS; refer to sections below for considerations.

Profound *(no residual hearing measured or hearing loss unaidable due to very poor speech discrimination or intolerance of amplified sounds or restoration of hearing is not a goal)*	
Personal Remote Microphone Hearing Aid Technology (RM-HAT) only	• If the affected side is profound in degree, and the ear is unaidable, then RM-HAT alone is an option. • Addresses effects of noise, distance, and reverberation on speech understanding.
Contralateral routing of sound (CROS) hearing aid **and** Personal Remote Microphone Hearing Aid Technology (RM-HAT)	• When there is no expected benefit from fitting amplification to the affected ear, then this option can be considered as there is potential to: ○ improve detection of speech on side with UHL in quiet; ○ improve speech understanding in noise when speech is the dominant signal on the side with PUHL; or ○ reduce speech understanding when noise is the dominant signal on the PUHL side. • For successful use and to minimize deleterious effects, a child should have the skills needed to use CROS technology in a noisy listening environment, including the ability to: ○ orient their head to avoid a noise source; and ○ manage their location or environment to position themselves such that noise sources are not directed towards the PUHL side. The inability to perform these skills has the potential to negatively impact overall speech discrimination. As such, consider: ○ the need to avoid occluding the normal hearing ear by providing a large vent or open fitting; or ○ CROS and RM-HAT will improve hearing ability in noisy listening situations, especially in preschool and educational settings
Bone Conduction Hearing Device (BCHD) on a soft headband.	• A BCHD coupled to a soft headband would primarily act as a CROS system. • The literature on the benefits of BCHD on a soft headband is not clear for this purpose. • Referral to a bone conduction amplification program for exploration may be considered on a case-by-case basis, especially when a conventional CROS hearing aid offers little to no benefit. • This is typically not recommended as a standard of practice until a child is of school age.

Note: *In some jurisdictions, cochlear implant candidacy is an option for children with single-sided deafness. This option is not available in Alberta at this time.*

APPENDIX C: Clinical Instrumentation

In addition to hearing aid programming software, sites providing pediatric amplification for infants and children must have access to real-ear and hearing aid test systems that provide specific functions to support the entirety of hearing aid evaluations and verification procedures described in this protocol. These include the required functions defined below.

1. **Desired Sensation Level (Dsl) V5.0a Child Prescriptive Targets**
   The DSL Method v5.0 (Scollie et al., 2005) is used to develop the appropriate electroacoustic characteristics for each infant and child requiring air conduction hearing aid amplification. The hearing aid test system is used to provide DSL targets for every frequency at which audiometric data has been entered. Preferably, the system should interpolate for targets in between frequencies at which audiometric data has been entered.
2. **Fitting Parameters**
   (a) Age
   The real-ear and hearing aid test system must allow the end user to enter the age or birth-date of the patient, or read this information in from Noah or other similar database. This variable will affect the calculation of predicted age-related transforms within DSL (the real-ear-to-coupler difference (RECD) and the real-ear unaided response (REUR).
   (b) Client Type
   The real-ear and hearing aid test system must require the end user to choose whether the DSL prescription is based on pediatric hearing loss.
   (c) Circuit Type
   The real-ear and hearing aid test system must define whether the targets are displayed for linear or wide dynamic range compression. Alternatively, if only one circuit type is used, the targets should be displayed for wide dynamic range compression.
   (d) Prescription Type
   The DSL Method v5.0 calculates different prescriptions for use in quiet or in noise environments. This variable creates two different prescriptions: the DSL-noise prescription uses less gain and output. It is recommended that the real-ear and hearing aid test system provides the DSL Quiet and Noise environment listening targets.
   (e) Transducer Type
   The real-ear and hearing aid test system must require the end-user to define the transducer used for audiometry from the following list:
   - Insert earphone + foam tip
   - Insert earphone + custom mold
   - TDH phone
   - Frequency specific diagnostic pediatric ABR assessment results in eHL.
3. **Data Entry and Data Display**
   (a) Acoustic Transforms
   The real-ear and hearing aid test system must prompt the end user to either enter values for, or measure directly the following transforms: RECD measurements, the coupling type (foam tip, ear-mold) and coupler type (HA-1, HA-2 or HA-4) should be specified. If the end user does not provide entered or measured data for any transform, the DSL age-predicted values should be used. The real-ear and hearing aid test system should display onscreen the chosen RECD measurement option (from the list of 4 above) for the end user to see.

(b) *Audiometric Data*
The real-ear and hearing aid test system must allow the end user to enter frequency-specific measures of the patient's air conduction thresholds and bone conduction thresholds for each ear requiring a hearing aid.

(c) *Verification Displays*
The real-ear and hearing aid test system must support hearing aid verification either when the hearing aid is coupled to the ear, or when the hearing aid is attached to a coupler. The system must provide appropriate corrections when coupler-based verification is used (accounting for both microphone location effects and the RECD). Testing with calibrated running speech must be provided in both the 2cc coupler and REAR displays, with analysis of the hearing aid in 1/3 octave bands both for percentile analysis and for the long term average speech spectrum. Running speech test signals may include the ISTS signal or any signal that provides equivalent test results. Percentile analysis should be offered for the 99th and 30th percentiles at a minimum. The speech test signals must be equivalent in spectral and dynamic range properties to the ISTS.

(d) *SPL-ogram*
The real-ear and hearing aid test system must display and correctly label either the REAR90/OSPL-90 and/or the predicted or measured UCL values onscreen. The system must display and correctly label the patient's hearing thresholds, converted to SPL using the DSL transforms. These variables must be displayed together with the DSL targets and hearing aid verification curves. An analysis of the Speech Intelligibility Index (SII) must be displayed for each verification curve performed with running speech.

(e) *Evaluations of accessories and signal processing*
The system must provide support for assessment of external microphone systems (e.g., FM systems and similar) as well as assessment of noise reduction, frequency lowering, noise floor, and any other test abilities required by this protocol.

Many pieces of verification equipment meet the requirements outlined above. This includes, but is not limited to, the Verifit and, more recently, the Verifit 2. The Verifit 2 has transitioned to the use of a 0.4cc coupler for the measurement of a wideband RECD (wRECD) up to 12,500 Hz. Since coupler type now differs between systems it is necessary to indicate which coupler type was used to measure the RECD/wRECD. This can be entered in the drop-down menu shown in the Figure 1 below.

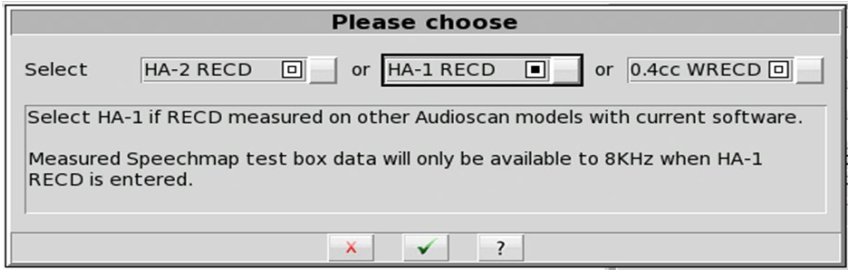

Figure 1: RECD coupler selection screen on the Audioscan Verifit 2
(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

In determining which coupler was used for measuring an RECD, the Audioscan® software version must be considered. HA-2 RECD must be selected when the RECD was measured with software versions prior to 3.12, HA-1 RECD for versions 3.12 and above, and 0.4cc WRECD for Verifit2.

Further information on this topic visit http://canadianaudiologist.ca/issue/volume-2-issue-6-2015/column/science-matters. Instructional videos on RECD measurement can be found on the Audioscan website or at https://youtu.be/p57vcjTUGYA

APPENDIX D: Hearing Aid Fitting and Verification Checklist

This checklist provides a list of amplification details to be considered when performing a new hearing aid fitting or an adjustment. Check all that apply and provide comments on bottom/reverse if necessary.

This checklist is a guide for key quality indicators that can be subject to review. To ensure records are complete, the Hearing Aid Checklist found in Appendix D is to be completed and kept on record.

Description of Ear Canal Acoustics

Transducer used to assess hearing thresholds:				
☐ insert earphones + personal earmold	☐ insert earphones + foam-tip	☐ Other: _____		
RECD for verification:	☐ new	☐ previously measured	☐ Based on Other Ear Value	☐ Used previously Measured Value
RECD Coupler:	☐ HA-1	☐ HA-2	☐ 0.4cc WRECD	
RECD Coupling type:	☐ foam-tip	☐ personal earmold		

If predicted RECD used, provide reason: _____

Electroacoustic Verification of Fit-to-Targets and SII values (see Appendix I)

Soft level of speech (55 db SPL)				
	within ±5 dB of DSL targets	over targets	under targets	SII within normative range
R ear	☐	☐	☐	☐
L ear	☐	☐	☐	☐
Average level speech (65 dB SPL)				
R ear	☐	☐	☐	☐
L ear	☐	☐	☐	☐
Loud level speech (75 dB SPL)				
R ear	☐	☐	☐	☐
L ear	☐	☐	☐	☐
Maximum power output (MPO)				
R ear	☐	☐	☐	☐
L ear	☐	☐	☐	☐

Consideration of Advanced Amplification Technologies

Noise management (see appendix K)			
Candidate?:	☐ yes	☐ no	
Feature Enabled?:	☐ yes	☐ no	
Verification Documented?	☐ yes	☐ no	_____ dB of noise reduction

Frequency lowering (see Appendix J)		
Candidate?:	☐ yes	☐ no
Feature Enabled?:	☐ yes	☐ no
Verification Documented?	☐ yes	☐ no

Remote microphone (see Appendix L&M)		
Candidate?:	☐ yes	☐ no
Feature Enabled?:	☐ yes	☐ no
Verification Documented?	☐ yes	☐ no

Feedback suppression (see Appendix K)		
Candidate?:	☐ yes	☐ no
Feature Enabled?:	☐ yes	☐ no
Verification Documented?	☐ yes	☐ no

Directional microphone				
Microphone mode selected:	□ pinna matched		□ fixed	□ adaptive
Date-logging Feature Enabled?	☐ yes	☐ no		hrs/day of use: _____
Considered status of earmold(s) New earmold(s) required?	☐ yes	☐ no		

Comments:

APPENDIX E: Auditory Assessment Considerations

For infants under six months of age and for some older infants, assessment is based primarily on objective tone-pip ABR physiologic measures to provide accurate, frequency and ear-specific estimates of behavioural thresholds. These estimates can be used to inform the fitting of amplification. Refer to the AHS document *Pediatric Diagnostic ABR Assessment Procedures and Protocols: Clinical Guide,* The ABR-based thresholds are reported in estimated hearing level (eHL), which represents an estimated behavioural threshold. The hearing aid prescription should be calculated using the eHL data obtained during the tone-pip ABR assessment (Bagatto et al, 2005).

Estimated Hearing Level (eHL) & Hearing Aid Fitting

Tone-pip ABR thresholds are measured in dB nHL and are converted to estimates of true perceptual threshold by applying a correction factor to the dB nHL value. dB HL and dB nHL are not equivalent. They are defined with reference to adult norms. To adjust to estimates of true perceptual (behavioural) thresholds in dB HL, correction factors are applied based on empirical, longitudinal validation studies. Correction factors are available at 500, 1000, 2000, and 4000 Hz for air-conducted stimuli and 500 and 2000 Hz for bone-conducted stimuli. ***These corrections are applied by the AHS Audiologist who has confirmed PCHL on the diagnostic ABR assessment. The resulting thresholds are referred to as 'Estimated Hearing Level' (eHL) thresholds, with units dB eHL.***

For the purposes of calculating the hearing aid prescription, the audiologist prescribing, fitting and verifying the amplification should enter the eHL values directly in applications of DSL v5 in their real-ear and hearing aid test system as well as hearing aid programming software. The eHL option is often found in the 'Transducer' section of the system when DSL v5.0 Child Targets are chosen. Choosing eHL indicates that the ABR thresholds have been corrected, as described above, and no further correction will be applied by the system.

When a present response is reported at the minimum test level for any frequency (i.e., ≤25 dBeHL), 25 dB eHL should be inputted into fitting and verification software as the threshold. Note that levels below 25 dB are not assessed on ABR assessment. Confirmation of threshold below this level will be done during behavioural assessment and fitting can be adjusted when specific threshold information becomes available.

For children over the age of six months, visual reinforcement or play audiometry is appropriate and will provide ear- and frequency-specific information. Auditory characteristics for this age group should be defined following procedures as outlined in *AHS Behavioural Assessment in Pediatric Audiology – A Guide for Clinicians.* The availability of frequency-specific threshold data is important for the prescription of amplification. If the presence of PCHL has been confirmed, the process of amplification may proceed on the basis of minimum ear-specific threshold estimations for air and bone conducted stimuli (*see section on Audiometric Thresholds Minimum Mandatory Requirements above*). Delay in the process pending the collection of discretional thresholds is not warranted at this stage. There will be cases where full audiometric information is not available. In these instances, the audiologist should make a best estimate, based on the thresholds provided as well as additional clinical and/or familial information, of the residual hearing across the frequency range important for speech. For these cases, the decision to begin the process of obtaining amplification is at the audiologist's discretion in consultation with the family.

For infants in whom no response (NR) is indicated on the ABR and ANSD has been ruled out, amplification should be provided cautiously. If NR was obtained on the ABR at any frequency, an eHL value will be provided by the AHS audiologist who conducted the ABR assessment. No responses will be reported as “>X”.

Where “NR” values are reported, amplification should still be considered as an option and is required as part of a cochlear implant candidacy assessment. For hearing aid fitting, thresholds reported as >X should be entered in the fitting and verification software at 5 dB above the highest intensity where no response was reported.

For example, if the 2000 Hz AC threshold was reported as >90 dBeHL, 95 dBeHL will be entered into the fitting and verification software. In cases of no measured responses on the ABR Assessment, measured RECDs, continued observation, and assessment of the infant are crucial.

APPENDIX F: Pediatric Ear Impressions and Earmolds

Procedure For Obtaining Ear Impressions

Instruct parent regarding the procedure, including positioning and child control. Some bracing of the head and torso may be necessary during insertion of impression material. In rare circumstances, when bracing is insufficient for earmold impressions to be obtained safely the audiologist may need to consider coordinating the taking of impressions with other procedures that use sedation.

Follow ACSLPA's Advisory: Infection Prevention Control: Reusable and Single-use Medical Devices infection control guidelines and https://www.alberta.ca/infection-prevention-and-control.aspx.

Perform an otoscopic examination to ensure that there are no conditions that would preclude taking an earmold impression (e.g., discharge from the ear, excessive cerumen). Make an estimate of ear canal size and length.

The following guidelines may be used when inserting the otoblock. Measure and mark earlight using the following general guidelines:

- <6 months – mark earlight for approximately 10 mm from ear canal entrance
- >6 months – mark earlight for 10-15 mm from ear canal entrance, depending on ear size and age.

Note: If infant is premature, has Down syndrome, low birth weight, etc., insertion depth may need to be reduced.

Using the earlight, insert the oto-block gently into the ear canal so that the marked position on the earlight is at the ear canal entrance (see #3 above). Examine the depth and position of the oto-block with the otoscope. When satisfied with the placement, wrap the string from the block over and around the infant's ear.

With the child still, place the tip of the impression syringe down the ear canal as close to the oto-block as possible. Do not pull on the patient's ear, as this will change the shape of the ear canal.
Depress the plunger slowly and move the syringe out as the canal fills. Keep the tip of the syringe in the impression material at all times. Once the canal is full, move out into the concha, filling in as much as possible without removing the syringe from the impression material. Next, fill in the helix area and then the rest of the concha.

Allow the impression material to harden. Time will vary depending on the material and proportions used. Quick drying material is desirable for active children. It is desirable to protect the impression to prevent it from being misshapen with movement. When your fingernail can be pushed on the material without leaving an indentation, then the material is set.

To remove the impression, pull gently on the pinna to loosen the impression in the infant's ear. Then, carefully peel out the concha portion without bending the canal; at the same time remove the helix portion. When the concha portion is about a third of the way out, gently rotate the impression forward (towards the patient's nose) and remove the canal portion of the impression.

Perform an otoscopic inspection of the ear canal to ensure removal of the oto-block and earmold material, and to evaluate the status of the ear canal.

Inspect the impression for quality and completeness.

1. Mark the canal for appropriate length and complete the earmold order form.

Earmold Material and Style

Although earmold labs have a variety of brand names for their products, 2 main choices of pliable earmold material should be considered for children: Silicone or vinyl/formaseal.

For very young children (<12 months corrected), the size of the ear canal may limit the diameter of the sound bore and how completely the earmold can be tubed. If the earmold material is too pliable, a small ear canal could constrict or close off the un-tubed portion of the sound bore. In this case, it is possible to connect a smaller diameter of tubing (#16) to the standard tubing diameter (#13). Hard wall tubing is ideal to avoid constriction, and may be modified as shown in figure 4. The final configuration will be dependent on a variety of factors.

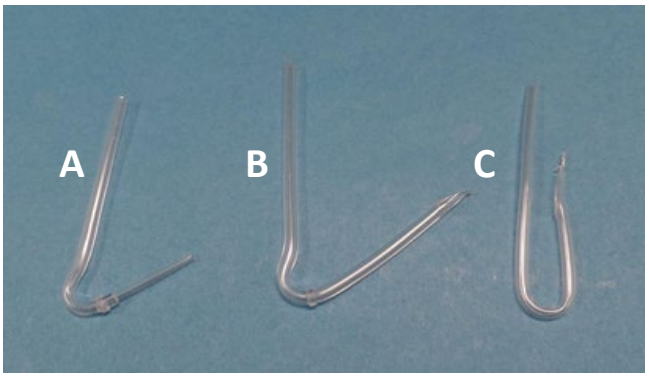

Figure 4: Earmold tubing styles A: #13 to #16 with tube lock; B: #13 with tube lock; C: #13 without tube lock
(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Silicone materials do not accept glue and usually require the use of a tube lock or tubing retention ring to hold tubing in place. This can distort the shape of the earmold in small ear canals, causing irritation or even feedback. Vinyl or formaseal material accepts tubing glue and is somewhat stiffer in shape than silicone; therefore it may be a better option for children under 6 months of age, or for children with unusually small ear canals.

Earmold venting should be considered when possible, being cautious that it does not cause acoustic feedback with the fitting. The size of an infant's ear canal will often limit the ability to add a vent, but it can provide important acoustic modifications for the fitting.

Shell-style earmolds are the standard style recommended for children, because of retention and feedback-prevention. Helix locks may improve earmold retention, but parents should be carefully instructed on inserting them correctly to prevent irritation or feedback from a helix lock that is not placed properly.

APPENDIX G: Non-Electroacoustic Characteristics

Behind-the-ear (BTE) hearing aids are the most appropriate choice for the majority of infants for the following reasons:

1. Many infants are born with well-developed pinna and ear canals to accommodate the signal processor connected to a personal earmold;
2. Rapid growth of the outer ear requires frequent earmold remakes which are less costly and more convenient than custom (i.e., in-the-ear, in-the-canal) hearing aids;
3. Custom products are more prone to feedback due to the close proximity of the receiver and microphone;
4. BTEs allow for greater electroacoustic flexibility; Direct audio input capabilities are more compatible with the target population;
5. During out-of-office repairs of the BTE, a similar device can be coupled to the child's earmold so the child is not without amplification.

Infants with confirmed permanent hearing loss in both ears should be fitted with bilateral air conduction hearing aids unless contraindicated. Many studies have demonstrated the benefits of bilateral hearing (Hawkins & Yacullo, 1984; Valente, 1982a, 1982b). Additionally, auditory deprivation in children with unilateral amplification has been reported (Boothroyd, 1992; Hattori, 1993).

Hearing aids must be compatible with remote microphone hearing assistance technologies (i.e., FM/DM). Tamper resistant battery doors shall be included on hearing aids for infants. A deactivation or locking system for the volume control and advanced signal processing (e.g., noise management, frequency lowering, data logging) features shall be available on the hearing aids.

Pediatric-Sized Filtered Earhooks

Manufacturers routinely send pediatric-sized filtered earhooks when BTE hearing aids are ordered for a child. A pediatric-sized earhook will allow the BTE to stay situated on the infant's ear. In addition, unfiltered earhooks will add resonant peaks to the output response of the hearing aid, possibly causing feedback and making adjustment to MPO targets difficult. A filtered earhook will smooth the response and allow for a better match to targets with less chance of feedback (Scollie & Seewald, 2002).

APPENDIX H: Real Ear to Coupler Difference (RECD)

RECD Procedure

1. The HA-2 or HA-4 coupler is connected to the coupler microphone of the unit and a transducer is coupled to the other end of the coupler.

2. A stimulus generated by the probe microphone system is delivered into the coupler and the coupler response is measured by the microphone.

3. Once the coupler measurement has been obtained, a foam ear tip or personal earmold is coupled to the transducer and inserted into the infant's ear along with the probe tube.

Coupling selection should be made in congruence with the coupling method used to obtain audiometric thresholds. For example, if VRA was conducted to obtain thresholds using an insert earphone coupled to the child's personal earmold, then RECD measurement should also be made using the earmold. When this is not possible, some verification systems offer a correction factor in the event of a mismatch between audiometric thresholds and RECD transducer couplings (Glista, 2016; Moodie et al, 2016).

Age Appropriate RECD Predicted Values

Using an age appropriate predicted RECD value is more desirable than using an average adult value for infants. However, age-appropriate average values in current use have some limitations. First, the average RECD values were derived from infants and children with normal middle ear status. Therefore, the predicted values will not reflect any acoustic changes that a fluid-filled or perforated eardrum will display. Second, individual real-ear SPL values may differ substantially from group average values, even in age-matched groups. When applying RECD predicted values for ear tips, one can expect to fall within a range of ±5.6 dB (at 500 Hz) at best and ±10.9 dB (at 6000 Hz) at worst for children 24 months of age and younger. Predictions of earmold RECDs can span a range of accuracy from ±6.7 dB (at 2000 Hz) to ±12.4 dB (at 6000 Hz) for children 36 months of age and younger. An RECD measurement should therefore be attempted whenever possible. However, when these values cannot be obtained, age-appropriate predicted values found in applications of DSL m[i/o] v5 should be applied.

Infant RECD Measurement

Consistent probe tube placement or prevention of slit leak venting can be difficult to obtain during RECD measurement in infants. It may be helpful to couple the probe tube to an immittance or OAE tip with plastic wrap (i.e., moisture guard or soft surgical tape) for very small ear canals. Ensure the probe tube extends approximately 2-4 mm past the opening of the tip to obtain appropriate insertion depth (Bagatto et al, 2006). This technique is helpful in coordinating insertion and ensuring a constant depth placement. The same stimulus is presented via the probe microphone system and insert earphone/custom earmold coupling, and the real-ear response is measured. The difference between the real-ear response and the coupler response is obtained. This difference is the individual transfer function designated as the RECD and will be applied throughout several stages of the amplification process.

There are several challenges that should be taken into account when considering providing amplification to an infant less than three months of age. For example, the first three months of life is a period of plasticity and rapid change in the acoustical and physical properties of the external meatus. This can cause difficulty in achieving a satisfactory and stable earmold fit, and may necessitate many follow-up

visits) for adjustment, repeat RECD measures and ear impressions to reduce acoustic feedback from the hearing aids (e.g., follow-up visits every 2 to 4 weeks until approximately 3 months of age).

Rapid anatomical maturation coupled with small and diverse ear canal volumes in neonates affect real-ear SPLs and have implications for the accuracy of prescriptive parameters based on group norms as well as for the stability of real-ear measures over time. There is also rapid maturation of both the middle ear and the afferent auditory pathways, and these may cause changes in hearing as well as increase the possibility of audiometric error.

As the infant's external ear canal grows, the acoustic properties of the ear will change substantially, especially in the first year of life. This change in ear size will necessitate a new earmold. Whenever a new earmold is made, an RECD measurement should be obtained and applied in the calculation of prescriptive targets for the hearing aid(s). Thus, the prescriptive targets should be updated with a new RECD measurement when a new earmold is obtained. The verification procedures described above should be carried out every time the prescriptive targets have been updated.

APPENDIX I: Electroacoustic Verification Procedure

1. Use the measured RECDs (or the average when required).
2. Follow the verification instructions and prompts to enter the following information: age of the child; ear; transducer type, DSL (child) fitting formula; hearing thresholds, and conductive component (when required).
3. Place selected hearing aid in the test box coupled to the HA-2 or HA-4 coupler.
4. In the simulated (test box) real-ear section of the system, choose a calibrated speech stimulus. Select a level of 65 dB SPL and measure a simulated real-ear aided response.
5. Adjust the aid to provide a close match to the average speech targets for 65 dB SPL and store the curve.
6. Choose a high-level (85 – 90 dB SPL) narrowband stimulus and adjust the hearing aid so it approximates the DSL v5.0 MPO targets and does not exceed the UCL targets. Store the curve.
7. Choose the same standard speech stimulus as in Step 2 above, and proceed to select a level of 55 dB SPL to verify soft speech targets and then a level of 75 dB SPL to verify loud speech targets.
8. Adjust the hearing aid to the soft and loud targets and store the curves.

   NOTE: Do not compromise your fit to targets for average speech or MPO to obtain a better match for soft or loud speech. A close match to average conversational speech and maximum output targets of the hearing aids are to be given priority when verifying hearing aids for infants and young children.
9. Repeat the verification procedure for average and MPO if you made adjustments in Step 6.
10. Repeat steps 1 through 7 with the other hearing aid for binaural hearing aid fittings.
11. Save the final settings to the hearing aid(s) and record the verification data from the real-ear and hearing aid test system and the hearing aid fitting software for the patient's chart.

Aided sound field threshold testing can be useful for counseling and educational purposes, it is not the recommended procedure for verifying amplification for infants in this protocol.

APPENDIX J: Frequency Lowering Procedures

The rationale for using frequency lowering is equivalent to the rationale for using extended bandwidth in hearing aids: to provide access to the high-frequency sounds of speech. The sounds /s/ and /ʃ/ receive particular emphasis because they have been studied extensively, /s/ plays a strong grammatical role in the English language, and frequency lowering can lead to spectral overlap and perceptual confusion of these two sounds.

The Ontario Infant Hearing Program (2019) protocol for frequency lowering procedures in hearing aid fittings provides evidence-based support to assist audiologists in determining when and how to apply frequency lowering in hearing aids for children. It is adopted in full for use in this protocol and is reprinted with permission below.

In addition to the Ontario IHP guidelines for frequency lowering, the following additional comments and recommendations based on evidence published in the past three years are provided:

A review of the most recent research on the topic of frequency lowering in the pediatric population revealed no clear recommendations for use of frequency lowering in the pediatric population (Akinseye 2018, Alexander 2019, Brennan et al 2017, Glista et al 2019, Glista et al 2018, Wolfe et al 2017). Some researchers have found benefits to the use of this technology, others have not, and some have identified adverse effects. There may be several reasons why there is a lack of consistency in findings to date, including the fact that the majority of research on this topic has been conducted using older versions of frequency lowering technology. It is important to note that manufacturers update their processing algorithms for these types of technologies and over time new studies may provide a clearer picture. In the meantime, these findings do not deter or contraindicate the use of frequency lowering in situations where high frequency sounds are not accessible using conventional amplification. These findings do support the best practice to be one ***that strongly encourages individual fine-tuning, as well as diligent post-fitting monitoring and use of post-fitting supports***.

In cases where frequency lowering technology has been implemented, verified, and fine-tuned to meet the individual child's needs, a plan for post-fitting monitoring should be planned and outlined. The Ontario IHP protocol for frequency lowering addresses this requirement. The pediatric amplification protocol outlined in this document includes an additional recommendation for the continued use of objective validation measures when possible. The Ling Six Sound Test can be completed with babies (looking for signs of detection), as well as older children (identification and reproduction of the sounds). This test may be completed as a baseline, to validate fittings, confirm adjustments, as well as monitor acclimatization. Feedback should be sought from parents, caregivers, speech-language pathologists, and others regarding the success of fittings, or any adjustments using frequency lowering technology. Subjective benefit questionnaires will be helpful in obtaining this feedback.

The provision of frequency lowering technology to children requires close monitoring to ensure that the goal of amplifying high frequency sounds is being achieved. When using frequency lowering, individual verification, validation, and fine tuning is important.

Candidacy For Frequency Lowering

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Children require audibility of a broad bandwidth of speech for optimal access to high-frequency speech cues (Stelmachowicz, Pittman, Hoover, Lewis, & Moeller, 2004). Audibility to 9000 Hz has been shown to improve word learning rates in children, when compared to audibility to only 4000 Hz (Pittman, 2008). Furthermore, speech production development is affected by hearing loss, particularly for affricate and fricative speech sounds (Moeller et al., 2007). Despite recent improved feedback management and extended bandwidth processing in current hearing aid technology, gain and/or feedback constraints continue to limit our ability to provide audibility of high-frequency speech sounds. Clinically available hearing aids have begun to offer processing that lowers certain high-frequency sounds, presenting them to the listener at a lower frequency. Perceptually, this can be defined as high-pitched sounds that have been processed to be played at a lower pitch. If the original frequency is not audible, we might expect that frequency lowering may present the sound at a pitch where the listener has (a) better hearing thresholds; (b) more hearing aid gain and output; or (c) both. These effects may allow for benefit of high-frequency sound detection or recognition.

Within the literature, several articles offer a review of the rationale and evidence on frequency lowering devices for managing high-frequency hearing loss (Alexander, 2013; McCreery et al., 2012; Simpson, 2009). Early evidence in older children suggests that frequency lowering hearing aid technology can increase the audibility of high-frequency speech sounds (e.g., /s/, /ʃ/) and can improve speech sound recognition ability for children with high-frequency hearing loss, when compared to conventional hearing aid fittings (Auriemmo et al., 2009; Glista et al., 2009; 2012; Wolfe et al., 2010). Studies of frequency lowering in children report benefit for listeners with hearing levels ranging from a moderate hearing loss by pure tone average (Wolfe et al., 2010; McCreery et al., 2014) to a severe to profound high-frequency hearing loss (Glista et al., 2009; 2012). In the study by Glista et al. (2009), children with a greater degree of hearing loss experienced greater benefit from frequency compression than did those with lesser degrees of loss. Therefore, it is difficult to determine a strict candidacy criterion for frequency lowering in children based on current findings regarding degree of hearing loss presented in the literature. Recalling that children demonstrate greater need for audibility of high-frequency cues in speech (see review by Stelmachowicz et al, 2004), caution should be used when interpreting adult candidacy as a predictor of pediatric candidacy for either frequency lowering or extended bandwidth technologies. Within the IHP, one goal of amplification is to support spoken language development (when spoken communication development is supported by the family). Therefore, it is reasonable to **consider frequency lowering as a means to provide access to high-frequency sounds, when these cannot be provided via conventional amplification**. As conventional amplification advances, it may be possible to amplify a broader bandwidth of sound without the use of frequency lowering technology. A summary of these factors is provided below (Figure 1).

Candidacy Factors for Frequency Lowering:

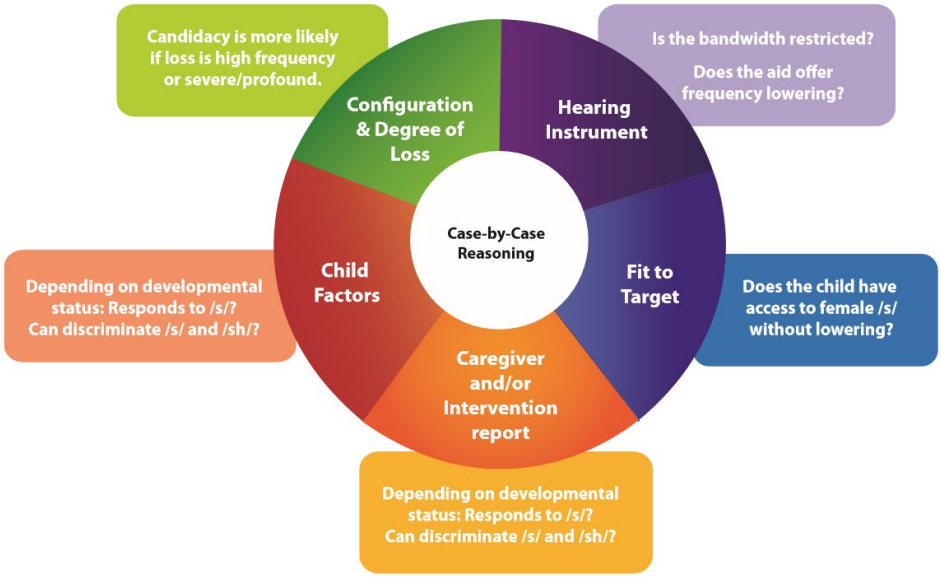

Figure 1. ***Factors to consider when determining candidacy for frequency lowering devices***
(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Overview: Frequency Lowering & The Maximum Audible Output Frequency (Maof)

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Current clinical guidelines recommend that the Audiologist maximize the output bandwidth available to the listener prior to activating frequency lowering through the use of validated prescriptive targets (AAA, 2013). The Audiologist can then determine the frequency at which the output of the hearing aid falls below audibility for a given audiogram; this has been referred to as the MAOF: maximum audible output frequency (McCreery et al., 2014; McCreery et al, 2013). In this protocol, we verify the hearing aid with a running speech signal, to determine a "range" to use when fitting according to the MAOF. Specifically, the MAOF range spans from the point at which the long-term average speech spectrum (LTASS) crosses the hearing threshold line to the point at which the peaks of speech cross threshold (Figure 2). This range can be used as a target region for frequency lowered stimuli when fine-tuning fittings and can be highlighted in some hearing aid test systems.

Specific stimuli and procedures integrating the MAOF concept are recommended in this protocol (Glista, et al., 2016; Scollie et al., 2016). A display of peak and valley measurements for the LTASS is needed when identifying the MAOF range.

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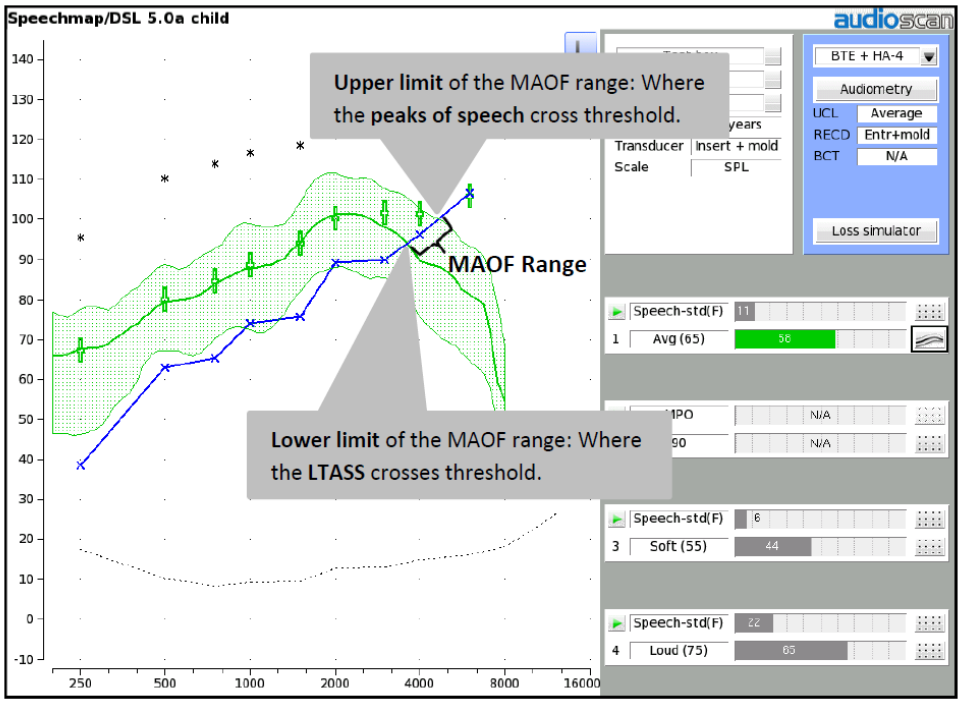


Figure 2. An Audioscan® Verifit2 test box screen measurement of the LTASS (with peak and valley measurements displayed) in reference to the hearing threshold line for an average level presentation level. The MAOF range extends from the point where the LTASS crosses threshold to the point where the peaks of speech cross threshold. *Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification*

Case Example A: Overview of Fitting Frequency Lowering

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

This case illustrates a typical fitting for a child presenting with severe high-frequency hearing loss. With frequency lowering off (Figure 3), the hearing aid response meets DSL targets within 5 dB up to 3000 Hz. Therefore, audibility of average level speech (green) is not available above 4000 Hz; the audible bandwidth is further reduced for soft speech. Audibility for high-frequency speech sounds was assessed using the calibrated /s/ stimulus. Without frequency lowering, the /s/ (including the upper shoulder) falls outside of the MAOF range and below the hearing threshold line (pink); /s/ is not audible without frequency lowering (Figure 3). With frequency lowering enabled (Figure 4), the upper shoulder of the /s/

stimulus falls within the MAOF range and above the hearing threshold line; /s/ is audible with frequency lowering enabled (pink). This fitting uses a weak frequency lowering setting, placing the /s/ near the upper limit of the MAOF range. A listening check revealed good sound quality and discrimination between /s/ and /ʃ/.

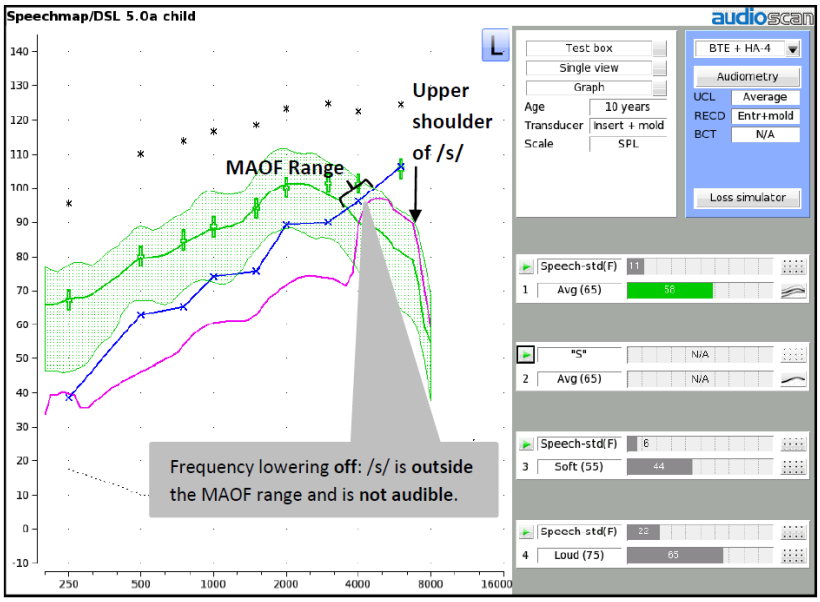


Figure 3. Text box measurement of an /s/ spectrum in reference to the MAOF range measured with frequency lowering turned off and at a presentation level of 65 dB SPL. *Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification*

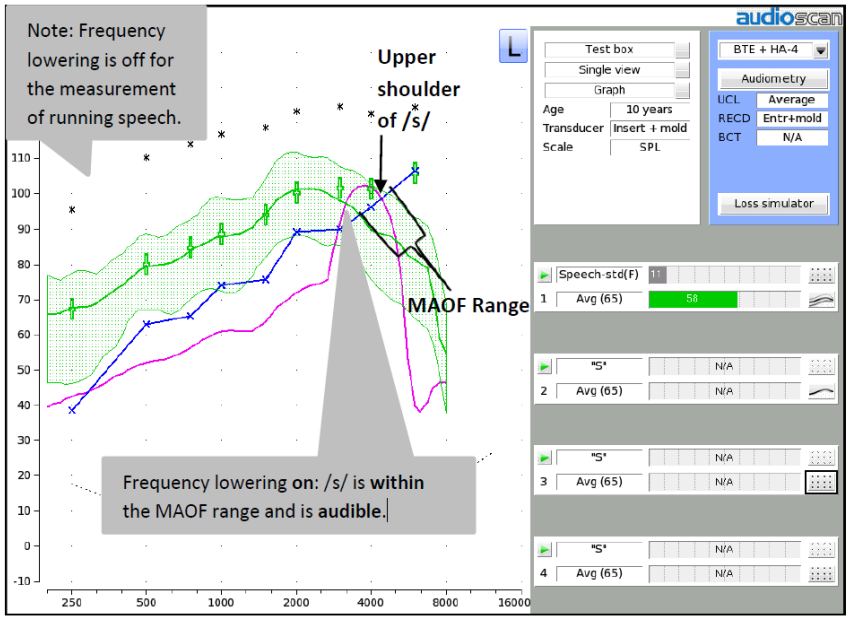


Figure 4. Text box measurement of an /s/ spectrum in reference to the MAOF range measured with frequency lowering turned on and at a presentation level of 65 dB SPL. *Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification*

Recommended Protocol

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

The Ontario Infant Hearing Program (2019) protocol for verifying frequency lowering hearing aids provides evidence-based support to assist audiologists in determining when to use frequency lowering with children. It is adopted in full for use in this protocol and with permission is reprinted below:

1. **Verify the shape and gain of the hearing aid fitting without frequency lowering.**
   Begin by verifying and fine-tuning the hearing aid to optimize the fitting without frequency lowering. Ensure that the aided speech spectra meet DSL prescriptive targets and provide a broad bandwidth of audibility for multi-level speech and when assessing MPO.

2. **Determine candidacy for frequency lowering.**
   In addition to the candidacy factors stated above, this step allows you to determine if electroacoustic verification suggests that frequency lowering may improve high-frequency audibility. This requires the fitter to assess audibility of the /s/ stimulus with and without frequency lowering enabled.

   ✓ With frequency lowering OFF and noise reduction OFF, measure the calibrated /s/ at 65 dB SPL. Determine if the calibrated /s/ is audible and if the upper shoulder falls within the MAOF range. If it does not, the candidacy criterion for frequency lowering has been met.

3. **Enable frequency lowering and adjust to optimize.**
   Start by enabling the manufacturer default setting in the hearing aid. The final setting should use the least amount of frequency lowering needed to obtain audibility of /s/.

   ✓ With frequency lowering ON, measure the response for the calibrated /s/ at 65 dB SPL. Assess whether the /s/ is audible and falls within the MAOF range. Pay special attention to whether or not the full spectrum of the /s/ is audible, using the upper shoulder of /s/ to assist with the assessment.

   ✓ Fine-tune the frequency lowering setting until the upper shoulder of /s/ falls within the MAOF. It is recommended that the final setting employ the weakest possible settings, placing the /s/ stimulus at the upper edge of the MAOF range and as close to the peaks of speech.

   ✓ Optimize frequency lowering settings for each ear individually
   (see FAQ for more information).

   ✓ Assess /s-ʃ/ overlap
      i. Measure the aided /ʃ/ to make a descriptive measure of the frequency separation between /s/ and /ʃ/. This measure may help with counselling or troubleshooting difficulty with discrimination between /s/ and /ʃ/. Because the fine-tuning steps above, the weakest possible setting of frequency lowering has already been determined and therefore the separation between /s/ and /ʃ/ is likely already maximized. Listening checks are also useful for these purposes and should be completed after frequency lowering is verified.

   ✓ Complete Validation*
      i. For younger children use the LING 6, and as the child develops consider use of the CNC monosyllabic word recognition test based on developmental ability of the child.

**Alberta modification to the 2019 Ontario IHP Protocol for the Provision of Amplification*

5. **Provide post-fitting supports.**
    a. Provide information to parents, therapists, and others who may do a listening check on the hearing aids with frequency lowering enabled. Sound quality may differ from conventional hearing aids, and parents, caregivers and professionals may require support on this topic. One approach is to alert caregivers or therapists that sound quality may differ from previous hearing aids and/or with the same fitting without frequency lowering enabled. Having the caregiver perform a listening check at the fitting appointment will allow them to better understand what they should be listening for on a daily basis.
    b. As the infant or child embarks on a program of oral language development, incorporate feedback from therapists. For example, if the child cannot functionally detect /s/, the fitting may need to be adjusted to provide more gain or output (e.g., within the fitting software or via new earmold), and/or by adjusting the frequency lowering settings. Some fitting cases can provide additional challenges in this regard, so feel free to request fitting support if needed.

Upon completing of this fitting protocol, re-enable noise reduction if this is a component of the fitting.

Case Example B: Effects of Fine-Tuning on /s/

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

To illustrate the effects of fine-tuning, Case A was verified with both stronger and weaker frequency lowering settings. This hearing aid uses frequency compression and settings have been selected using the combined slider tool to modify compression ratio and cut-off frequency together. The fine-tuned setting used a 3200 Hz cut-off and 3.3:1 compression ratio. The calibrated /s/ was measured and can be seen below in pink (Figure 5). Using the weakest possible frequency lowering setting, we can achieve a fine-tuned setting where the upper shoulder of /s/ falls at the upper edge of the MAOF range.

For illustrative purposes, the strength of the cut-off and compression ratio were increased from the fine-tuned setting and /s/ was re-measured (blue). The overall sensation level of the /s/ has increased, but the upper shoulder of /s/ is now at the lower edge of the MAOF range. This is not an optimal setting since a weaker frequency lowered setting is possible. We would hypothesize that a stronger setting such as this one would cause increased /s-ʃ/ overlap which is undesirable.

The strength was then decreased from the fine-tuned setting and /s/ was re-measured (yellow). This created a fitting where the /s/ fell outside the MAOF range, resulting in reduced audibility (approximately 1 dB SL). This would not be considered an optimal setting.

Overall, this exploration of settings illustrates the need to fine-tune each child's frequency lowered fitting based on a valid approach. The recommended protocol ensures consideration of the child's hearing loss, ear canal acoustics and the response of the chosen hearing device when choosing a frequency lowering setting.

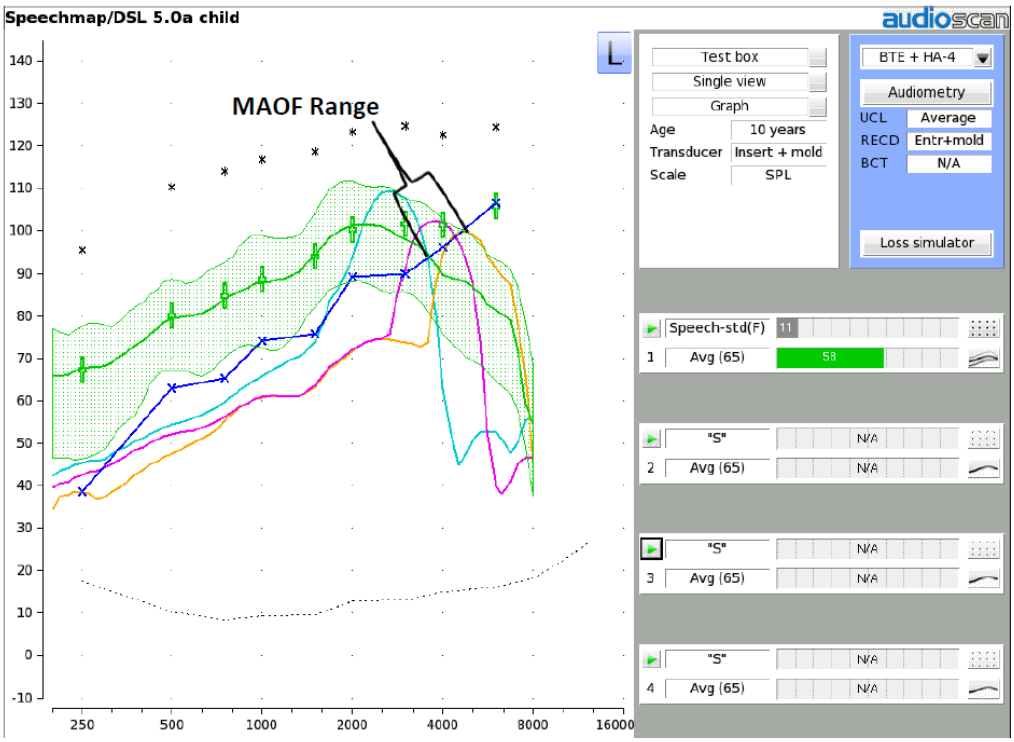


Figure 5. Measurements of the /s/ spectra, relative to the MAOF range, for the fine-tuned setting (pink), a stronger setting (blue) and a weaker frequency lowered setting (yellow).
Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification

Case Example C: Optional descriptive measures of /ʃ/

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

A calibrated /ʃ/stimulus is provided for optional use in description of fittings or troubleshooting. Because frequency lowering can increase spectral overlap, which can in some cases result in /s-ʃ/ confusion. This is more likely when the frequency separation between these two sounds is very small.

To illustrate this, the response for /ʃ/was measured to describe spectral separation between /s/ and /ʃ/. The electroacoustic results depicted here (Figure 6) matches with the listening check, in which the clinician could clearly discern the two fricatives. Both /s/ and /ʃ/ were also measured at the stronger frequency lowered setting (Figure 7). We can see that, compared to the fine-tuned setting, the /s-ʃ/ overlap has been increased. This may result in poorer sound quality and less ability to discriminate between the fricatives for the child.

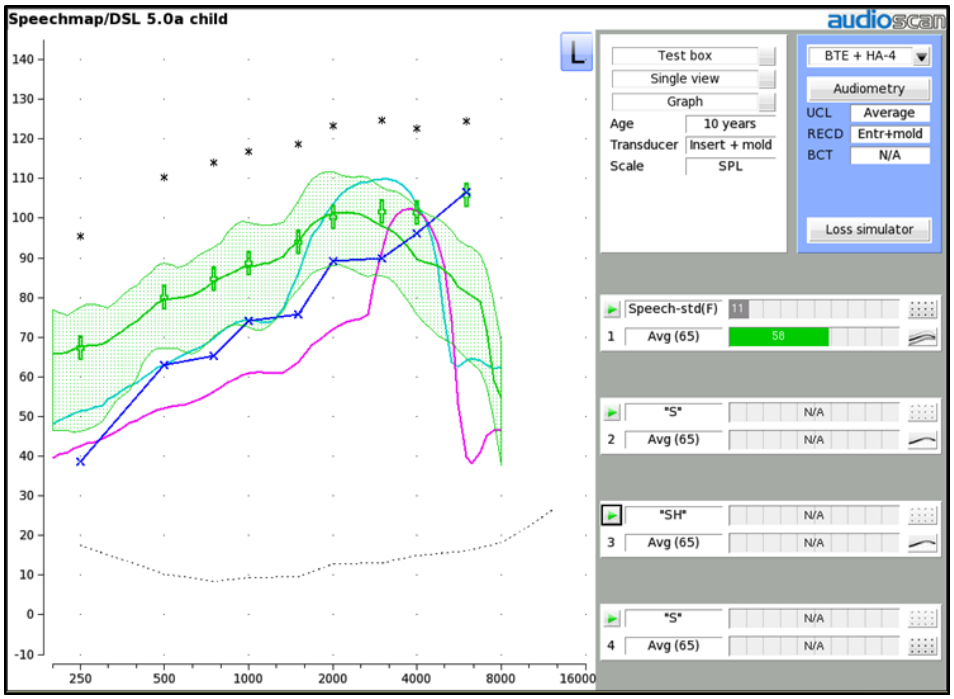


Figure 6. Text box measurements of the LTASS (green) and /s/ (pink) and /ʃ/ (blue) at the fine-tuned setting, for a presentation level of 65 dB SPL. *Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification*

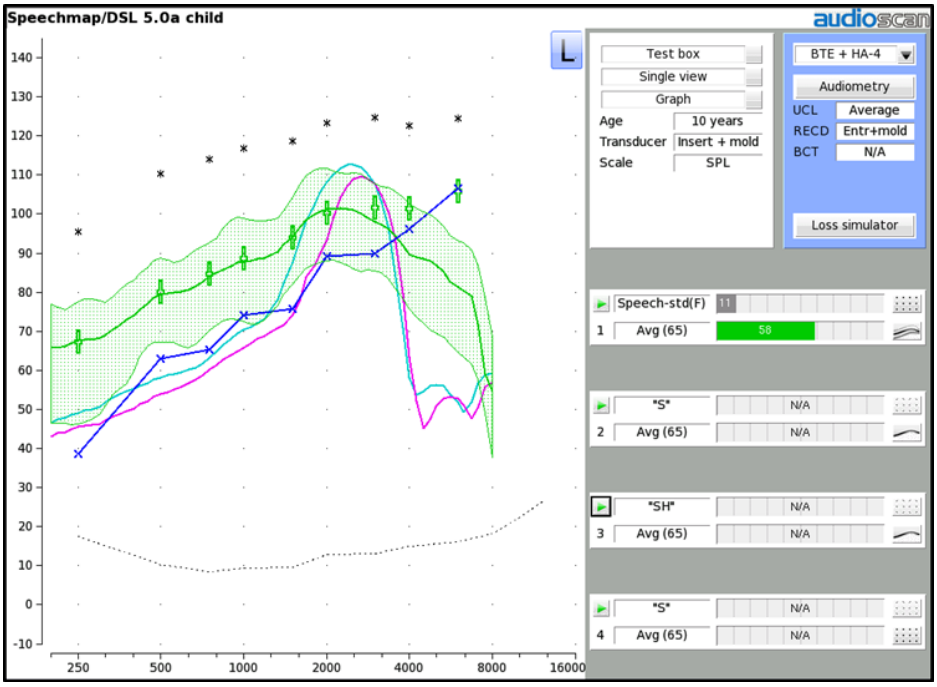


Figure 7. Text box measurements of the LTASS (green) and /s/ (pink) and /ʃ/ (blue) at a stronger setting, for a presentation level of 65 dB SPL *Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification*

Case Example D: Illustrating the Challenges of Partial Audiometric Data

(Adapted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

This eight-month-old was assessed via behavioural audiometry. Results revealed a severe sensorineural hearing loss in both ears. Threshold estimates in the left ear were 75 and 85 dB HL at 500 and 2000 Hz (Figure 8). Results were not yet obtained at other test frequencies. The infant's family elected to pursue a hearing aid fitting prior to obtaining full results; the measurement of this infant's hearing thresholds at other frequencies is an ongoing goal for future appointments.

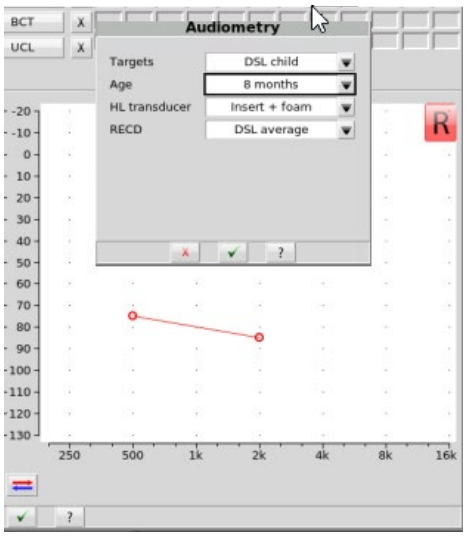


Figure 8. Hearing threshold information for Case D entered into the Audioscan® Verifit 2.

The initial fitting of the hearing aid is shown below (Figure 9). The fit to target for soft and average speech is acceptable, though targets could not be reached for loud speech due to the limitations of the device. It is likely that the hearing loss will slope and therefore the loss above 2000 Hz is equal to or poorer than the loss at 2000 Hz as demonstrated by the dotted line extrapolating our estimation of the threshold. Using this estimation, we can speculate that average speech sounds above 2000 Hz are not audible and soft speech is not audible above 500 Hz.

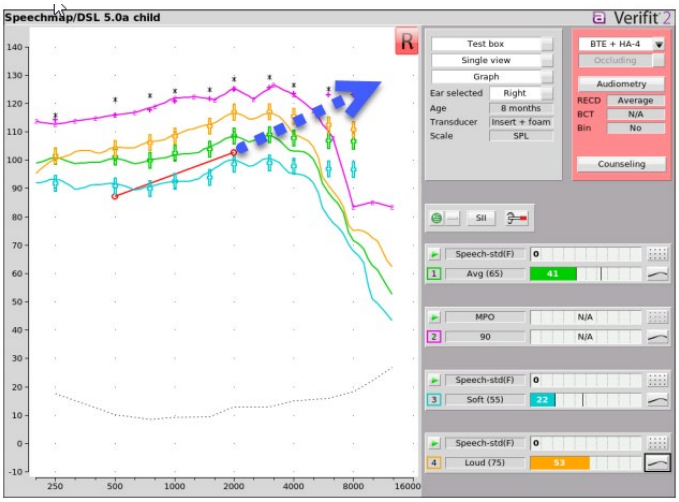


Figure 9. Text box measurements of soft (blue), average (green) and loud (yellow) and for the MPO (pink) measured at a presentation level of 65 dB SPL.

Candidacy for frequency lowering was determined using the calibrated /s/ (blue) with frequency lowering off (Figure 10) and on (Figure 11). By extrapolating the hearing thresholds in the high-frequencies (dotted blue line), we estimate that the /s/ is not audible without frequency lowering activated, indicating that this infant is a candidate for frequency lowering. When activated, the /s/ is lowered to a region where the signal is likely audible. A listening check was completed to assess sound quality and phoneme discriminability. Further exploration using the calibrated /ʃ/ speech signal could be used for counselling purposes. Evaluation of efficacy of this setting can be determined at follow-up appointments with use of caregiver reports and/or outcome measures. Once a more detailed audiogram is available, these settings can be re-evaluated.

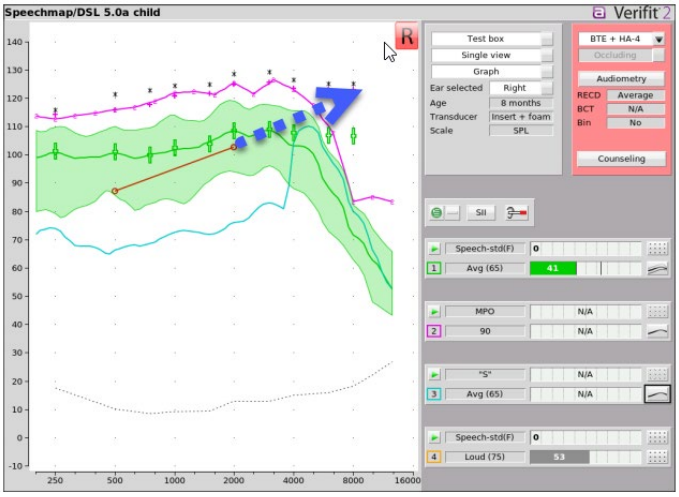


Figure 10. Measurement of the /s/ spectrum, relative to the MAOF range using extrapolated hearing thresholds, with frequency lowering OFF.

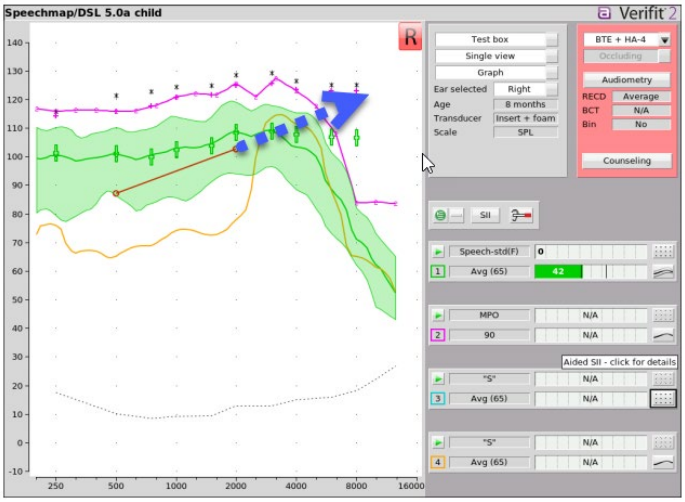


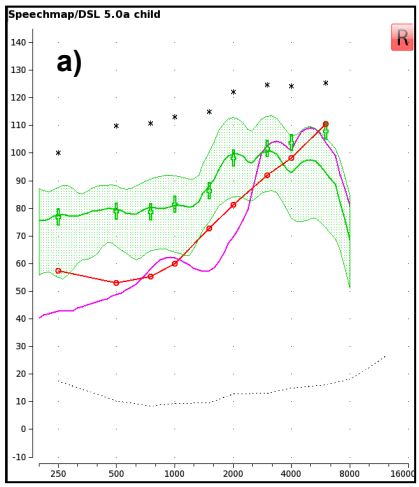
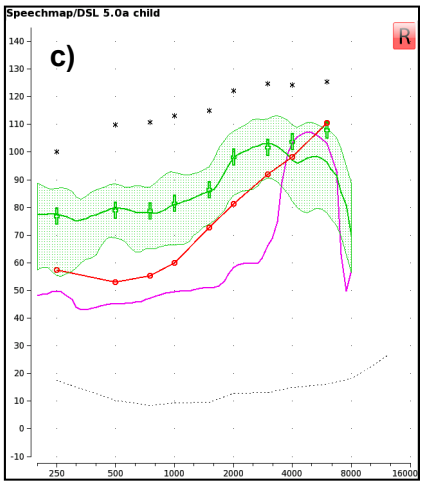
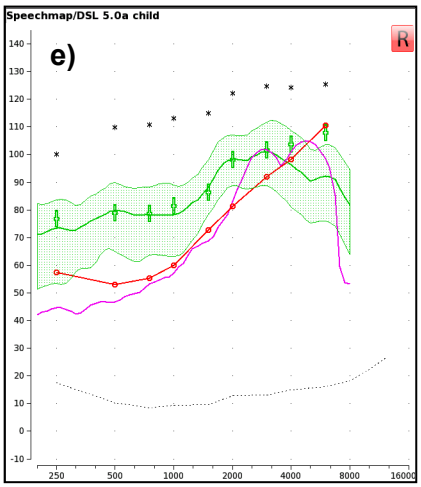
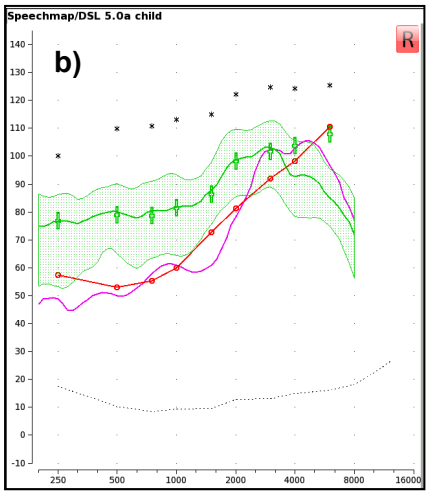
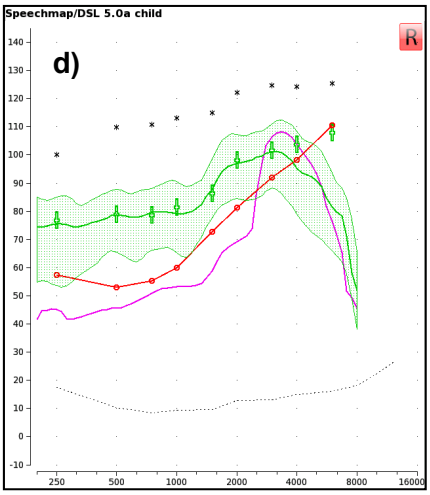
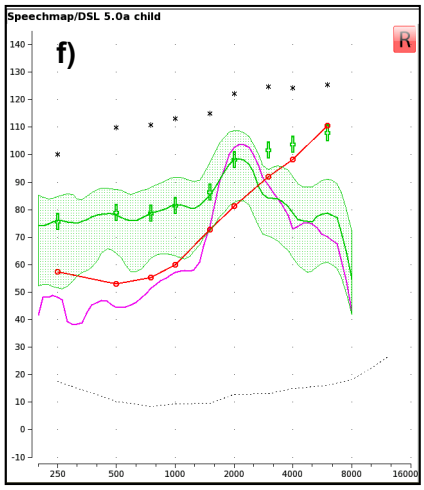
Figure 11. Measurement of the /s/ spectrum, relative to the MAOF range using extrapolated hearing thresholds, with frequency lowering ON.

Case Example E: Illustrating Differences in Frequency Lowering Technologies

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

This section presents six different types of frequency lowering fitted to the same hearing loss. The calibrated /s/ was not audible in any of the fittings without frequency lowering activated. Each frequency lowering technology was verified following the suggested frequency lowering protocol described above. Resulting settings are illustrated below (Table 1). Note: The terminology used in the fitting software to describe the settings and parameters for each type of frequency lowering differs across manufacturers. Although different frequency lowering setting were used to achieve each of the measurements presented in Table 1, the results are all considered acceptable. This is due to differences in the nature of the signal processing associated with each type of lowering.

Table 1. Repeated measurement of the LTASS and /s/ stimulus for the same case study fitted with various types of frequency lowering. *(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)*

Frequency Composition	Frequency Compression	Frequency Translation
		
Adaptive Frequency Composition	**Adaptive Frequency Compression**	**Frequency Transposition**
		

Why do the measurement results look different across frequency lowering types?

These differences are mainly due to the frequency response of the device in combination with the nature of the frequency lowering signal processing associated with each device. A brief description of some of the differences between frequency lowering technologies is provided below.

Composition: Frequency composition is available in non-adaptive and adaptive forms – refer to a) and b) in Table 1 for the corresponding measurements. Both produce an /s/ signal that appears double peaked and broader in comparison to some of the other examples. This is due to the lowered signal being superimposed on the original signal, resulting in a double-representation of the /s/ signal. The lowered /s/ has been placed within the MAOF range (with the lower peak as the reference), using the weakest possible setting for both types of frequency composition. This type of lowering is currently available in Bernafon and Oticon devices.

Compression: Frequency compression is also available in non-adaptive and adaptive forms – refer to c) and d) in Table 1. Both produce an /s/ signal that is narrower in comparison to some of the other types of frequency lowering. For this type of lowering, high-frequency information of the signal is being compressed to a smaller bandwidth. In the examples above, this device is set to the weakest possible setting where the /s/ still falls within the MAOF range. This type of lowering is currently available in Phonak devices.

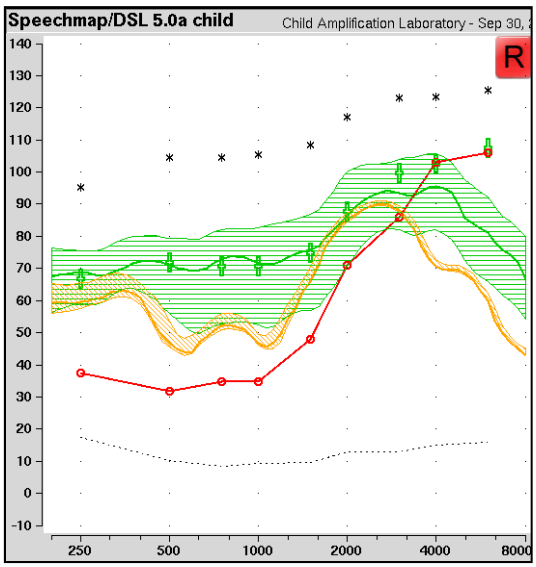
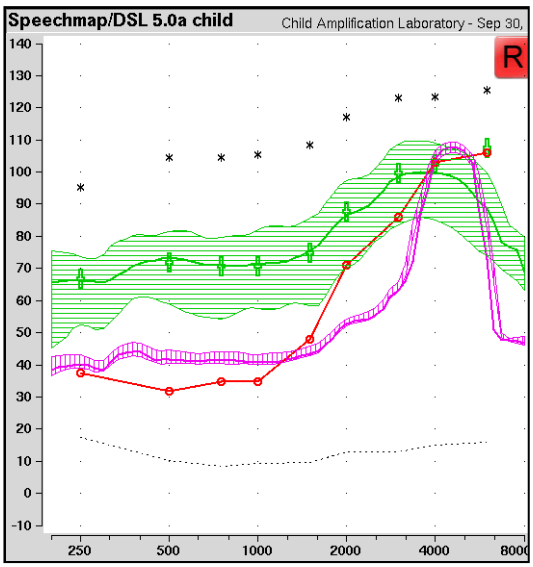
Translation: Frequency translation uses an adaptive form of lowering – refer to e) in Table 1. This type of lowering produces an /s/ stimulus with a double peak. This is because the original signal remains along with the frequency-lowered signal, thus both signals are being represented in the measurement. When verifying frequency translation, ensure that the lower peak of the signal falls within the MAOF range. In this case, the setting selected was the weakest available so the lower peak could not be increased in frequency to fall within the MAOF range. However, activation of frequency translation at its weakest setting made the /s/ audible. This type of lowering is available in Starkey devices.

Transposition: This type of technology uses linear frequency transposition to lower a high-frequency portion of the signal – refer to e) in Table 1. The /s/ stimulus in this example appears narrower than some of the other examples as it captures the lowered signal only; the high-frequency information above as well as the original signal is filtered out. Frequency transposition has been applied using the weakest possible setting, while still placing it within the MAOF range. This type of lowering is available in Widex devices.

The nominal settings chosen in the manufacturer fitting software to produce the examples above differed greatly across the types of lowering. To demonstrate this further, the value of the start frequency for frequency transposition and the cut-off frequency for frequency compression were both set to 4000 Hz (note: both the cut-off and start values denote the starting point for frequency lowering). Differences in the signal processing used to achieve lowering for transposition versus compression would suggest that a set value of 4000 Hz would yield differing results. The spectrum of the calibrated /s/ signal was measured, as shown on the next page (Table 2):

Table 2. Measurements of the LTASS and /s/ stimuli for a hearing loss fitted with frequency transposition and frequency compression, along with the nominal settings chosen for illustrative purposes.

(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Frequency Transposition	Frequency Compression
	
Start Frequency: 4000 Hz	Cut-off: 4000 Hz

In this example, frequency transposition has lowered the peak of /s/ to approximately 3000 Hz whereas frequency compression is lowering to around 5000 Hz despite both using a setting of 4000 Hz. Due to the processing applied to the signal, frequency transposition appears to provide more lowering than frequency compression at the
same setting.

The purpose of this case is to illustrate that these three types of frequency lowering technologies produce different effects on the aided response of the hearing aid. Summary points are:

1) All technologies provide measurable amounts of frequency lowering.
2) Choosing similar nominal settings for start/cutoff/target frequency does not result in similar amounts of frequency lowering between frequency transposition, compression and translation.
3) Frequency composition and translation may create a double peaked /s/ stimulus. The lower peak is to be fine-tuned.
4) Frequency transposition appears to provide a stronger frequency lowering effect than other processors.
5) Processors should not be compared based on nominal software settings (e.g., “4000 Hz”) because these programming handles have different meanings for different processors.

For individual cases, choice of frequency lowering settings for frequency composition, transposition, translation or compression should be based on electroacoustic evaluation of audibility as per this protocol, and should not be based on comparison of nominal settings across technology.

This case does not address whether one type of frequency lowering may be more beneficial for this hearing loss. Experimental studies comparing benefit in children across types of lowering are not available at this time.

Frequently Asked Questions

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

1) When should I enable frequency lowering in a fitting?

   - Determine if the listener is receiving a broad bandwidth of audibility without frequency lowering activated by assessing audibility of high-frequency phonemes. If the signal is either inaudible or not falling outside of the bandwidth of the device, complete further assessment with frequency lowering activated. It is recommended that these measurements be completed using an average presentation level.
   - In the case that the listener is having difficulty understanding soft speech, consider measuring the calibrated /s/ at 55 dB SPL and assessing audibility. Decisions regarding activation of frequency lowering in this case are at the discretion of the audiologist and should consider caregiver reports.

2) When should I turn frequency lowering off?

   - Child and caregiver reports should be monitored for any indication that frequency lowering may be hindering/disrupting performance. These indicators may include a change in speech production related to slurring of /s/ and /ʃ/, decreased use of the device, the child's reluctance to wear the device, or reported complaint about sound quality.
   - In a case discussed by Scollie, Glista & Richert (2014), a child who was an experienced frequency lowering user, was refitted with new hearing aids which had increased bandwidth. Objective and subjective tests suggested good and equal performance either with frequency lowering enabled or disabled. Since the child had no preference for either setting, frequency lowering was disabled (Scollie et al, 2014).

3) Should we be providing asymmetrical frequency lowering settings?

   - A study by John et al (2013) found that adults with asymmetric hearing loss received equal benefit from symmetrical and asymmetrical frequency lowering settings. This study spanned six weeks so acclimatization effects may be a factor. Similar studies have yet to be completed on a pediatric population.
   - In a case discussed in by Scollie et al. (2014), a child was fitted with asymmetrical frequency lowering settings. The child reported a remarkable increase in audibility of sounds suggesting an asymmetrical fitting did not diminish perceived benefit for this case (Scollie et al, 2014).

4) Can frequency lowering be enabled for mild to moderate hearing losses?

   - There is no reported evidence at this time that frequency lowering should or should not be used in cases of mild hearing loss across frequencies. Further research is needed on this topic. However, studies do show that individuals with a mild to moderate PTA and with more severe high-frequency hearing loss have received benefit from frequency compression.
   - Wolfe et al. (2010) reported improved speech recognition when frequency compression was activated for individuals with moderate to moderately-severe hearing loss. As always, the use of frequency lowering is at the discretion of the audiologist and should be determined on a case-by-case basis following candidacy guidelines reported in this document (See question #1).

5) Is there a certain amount of audibility I should be achieving?

- No. The goal of this protocol is to make /s/ audible at the weakest possible setting. By creating a fitting where /s/ falls within the MAOF range and/or within the band-pass of the device and audibility of /s/ is maximized.
- If the hearing loss is too severe and the /s/ signal cannot be made audible within the MAOF range, increase the strength of frequency lowering to the weakest setting where audibility is achieved.

6) Which type of frequency lowering should we use?

- A brief description of the different types of frequency lowering is provided above. It is unknown whether the different types of frequency lowering technologies provide similar benefit, or if candidacy would interact with magnitude and configuration of hearing loss in a similar way across the different available technologies. To date, there are no studies that directly compare hearing aid performance across frequency lowering types.

7) What about acclimatization or training?

- The studies summarized above provide evidence that some time may be needed to maximize benefit from frequency lowering technology. A study by Glista, Scollie and Sulkers (2012) looked at acclimatization effects associated with the use of frequency lowering in an older pediatric population. The study revealed that most subjects showed significant acclimatization trends after six to eight weeks without any auditory training. Changes over this time period were either gradual or sudden, and varied across children and outcome measures.
- Measuring a baseline at time of initial fitting, and then repeating that measure within 6 to 8 weeks, will provide information about an acclimatization effect for that child.*
- Consider the use of parent observational reports (e.g., Have you noticed any changes in your child's vocalizations? Or production of high frequency speech sounds?)*
- Interaction with speech-language pathologists can be a rich source of information as to whether a child is learning to use the frequency-lowered sound and may be able to provide some intervention to improve acclimatization to frequency lowering.
- Key topics for inter-professional discussion could include whether the child responds to certain speech sounds, whether certain speech sounds can be discriminated, and whether speech sound confusions are encountered.

*Alberta modification to the 2019 Ontario IHP Amplification Protocol

APPENDIX K: Noise Management in Hearing Aid Fittings

The rationale for providing noise management in hearing aids is to reduce the occurrence of excessive loudness for a child who uses hearing aid(s).

The Ontario Infant Hearing Program (2019) protocol for noise management in hearing aid fittings provides evidence-based support to assist audiologists in determining when to use noise management in hearing aids with children. It is adopted in full for use in this protocol and with permission is reprinted below:

What is the Rationale for Noise Management?

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification

Children and infants experience a wide range of auditory environments in their daily lives. Many of these environments include high levels of speech, background noise, and/or reverberation (Crukley, Scollie, and Parsa, 2011) and may be louder than desired for children and infants who wear hearing aids even if loudness is normalized on formal loudness rating tasks (Ching et al, 2010; Crukley & Scollie, 2012; Scollie et al., 2010a;b). In addition, some children (and adults) experience significantly higher loudness perception than do others with similar hearing losses and similar amplification. Excessive loudness may be associated with fewer hours of daily hearing aid use in both adults and children, and may therefore limit benefit through inconsistent access to amplified sound (Humes, Wilson, & Humes, 2003; Ching et al., 2010).

Determination of Candidacy for Noise Management

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Evidence-based rationales for providing noise management are to: (1) provide aided listening levels for the child that are comfortable across a wide range of environments, and (2) prevent excessive loudness percepts from limiting daily use of hearing aids. Trials with noise management are warranted on a case by case basis and at the clinician's discretion. Indicators of need for noise management include: (1) the child is regularly in noisy situations; (2) the child or caregiver reports limited hearing aid use attributable to noisy or loud environment limitations; (3) the child or caregiver reports loudness discomfort in any situation. Considerations for candidacy are summarized in Figure 1, along with device-specific considerations that dictate how noise management may be provided; these device considerations are discussed further below.

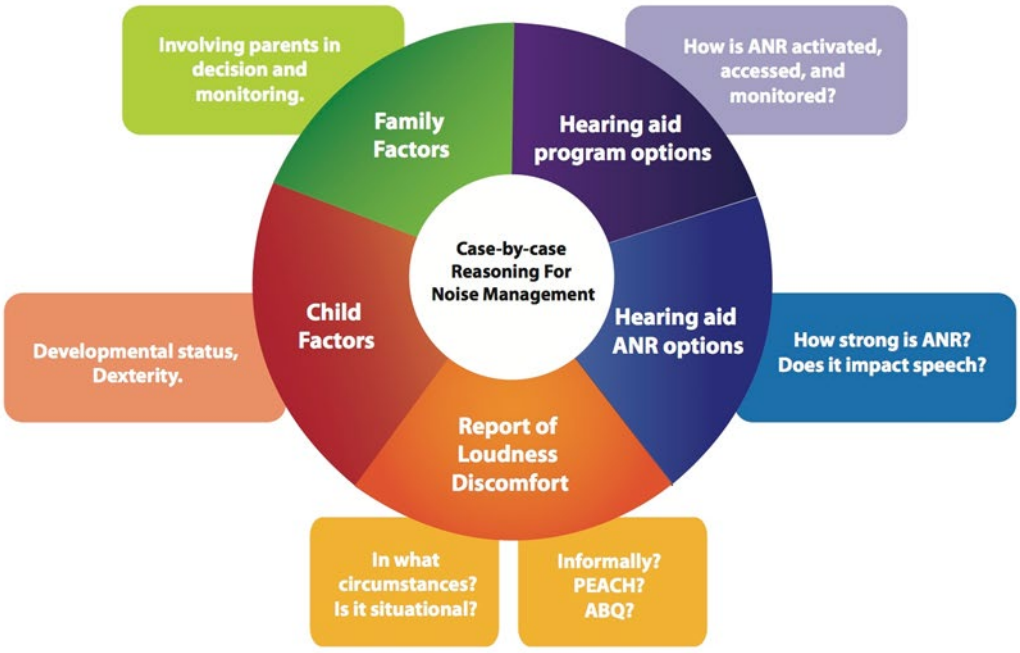


Figure 1. Candidacy and Device Considerations in Noise Management for Children who use Hearing Aids
(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

What are the types of noise management signal processing?

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Modern hearing aids currently offer three main options for managing listening in noise. Directional microphone systems use more than one microphone to reduce the amplification of sounds coming from non-frontal locations. Adaptive noise reduction (ANR) involves digital signal processing to identify and minimize unwanted noise in the hearing aid's output. Frequency-gain shaping is the adjustment of the amount of amplification provided across the frequency and input range. Automatic switching between alternate programs within the hearing aid is also a common feature in modern hearing aids.

Directional Microphones

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Directional microphones can be beneficial for children or adults if the listener's head is pointed at the target talker, and the competing signals are from other directions (e.g., Crukley & Scollie, 2014). However, children have a low rate of accurate head orientation toward target talkers, and orientation away from a target talker can have deleterious effects on speech recognition when directionality is used (Ching et al., 2009; Ricketts & Galster, 2008). Although there appears to be a directional advantage when the signal of interest is in front of the listener, there is also a clear directional disadvantage when the listener is not facing the sound source (Ching et al., 2009; Ricketts et al., 2007). Children rely on non-frontal listening and over-hearing for incidental language learning and for hearing the talker in home and daycare environments (Akhtar, 2005; Akhtar, Jipson, & Callanan, 2001).

Full time use of directional microphones is not recommended for infants and young children, because they are unlikely to orient to the target talker, and because reduction of sounds from the side and back may impair learning

through overhearing (AAA, 2013). Part time use can be considered on a case by case basis, particularly if improvement of SNR is an aim of the directional strategy (AAA, 2013), with monitoring for benefit and appropriate use. Use of directional microphones may be less likely to impair overhearing if the directional profile is matched to that of a normal pinna, based on studies in adults (Keidser, et al., 2009). However, auditory localization continues to develop through childhood, with significant developmental trends to age 6 y and continued development through adolescence (Kuhnle et al., 2012). Evidence on directional microphone use, spatial hearing, and benefit in real world environments is lacking at this time. Use of directional microphones in children older than the IHP age range may have a different use and benefit profile than described here. Training on correct directional microphone use may be needed to ensure appropriate use of these systems (Pittman & Hiipakka, 2013).

Adaptive Noise Reduction (ANR)

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Research with adults has shown no improvement in speech recognition performance with the use of ANR (e.g., Bentler & Chiou, 2006; Bentler et al., 2008). The use of ANR in children's hearing aids does not affect speech recognition (Crukley & Scollie, 2014; McCreery et al., 2012; Pittman, 2011b; Stelmachowicz et al., 2010). One study found that medium-strength ANR provides some loudness reduction when speech is presented in babble, but also that this effect varies across children (Crukley & Scollie, 2014). Stelmachowicz et al. (2010) evaluated ANR in children across a range of speech recognition tasks in noise. Overall, this study found no significant effect of ANR. However, individual results with 5 to 7 year old children indicated more variability in this group, with some children showing benefit or decrement with ANR. The authors interpreted the results, overall, as indicating a neutral effect for the ANR system tested, and suggested that fitting practices that preserve speech audibility may help to avoid negative impacts of ANR use. Another recent study found increased rates of novel word learning with ANR in older children, but not with younger children (Pittman, 2011a). Pittman speculated that this was due to improved ease of listening, which is consistent with a recent study in adults (Sarampalis et al., 2009), and that older children were better able to take advantage of this versus younger children. More recently, children's performance and preference with directional-ANR systems was assessed, and in general, children preferred systems that helped them perform well, including those with ANR activated (Pittman & Hiipakka, 2013). These children were 8 and older, and were able to indicate which memory they preferred in a lab demonstration of multiple memories in a hearing aid.

ANR systems differ, providing more or less noise reduction across devices and settings (AAA, 2013). Provided that a given hearing aid's ANR does not reduce audibility for speech in quiet, it may be activated in hearing aids for infants and young children. Counselling around expectations should reflect whether the child's specific ANR strategy can reduce steady state noises and/or multi-talker speech.

Frequency-Gain Shaping

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Another option for providing improved loudness comfort in noisy environments is the use of less gain and output, either in the hearing aid's main program or in a second program, or by means of a volume control.
The most recent version of the Desired Sensation Level Method (v5.0; Scollie et al., 2005) includes an alternate prescription for use in noisy situations (Scollie et al., 2005). The noise prescription was designed to maintain audibility of the frequency regions of speech believed to contain acoustic cues most important for speech intelligibility based on the Speech Intelligibility Index (SII, ANSI S3.5, 1997). This prescription was designed to manage loudness comfort in noisy environments without degrading speech recognition abilities (Scollie et al., 2005). Evaluations in children have found that an alternative hearing aid program using either NAL-NL1 or the DSL v5 noise program can alleviate excessive loudness for noisy environments or for high-level signals (Crukley & Scollie, 2012; 2014; Ching et al., 2010; Quar et al., 2013).

On average, using less gain in a noise program does not affect speech recognition in quiet, although some individual children may experience some decrement in speech recognition (Crukley & Scollie, 2012; Scollie et al., 2010b). Children appear to prefer using higher gains for quiet, communication intensive situations, particularly for children who have greater degrees of hearing loss (Quar et al., 2013; Scollie et al., 2010a). Use of a validated lower-

gain prescription can alleviate noise tolerance issues in children who are more susceptible to loudness tolerance problems (Ching et al., 2010; Crukley & Scollie, 2012; 2014; Quar et al, 2013). Older children may actively switch between memories, although this has not been tested in younger children or in a broad clinical population that includes children with medical or developmental challenges. Validated prescriptions that have been evaluated in children include the DSL5-Child Noise target and the NAL-NL1 target. These options are available in some hearing aid verification systems.

Automatic Program Switching

(Adopted from the 2019 Ontario IHP amplification protocol)

Some hearing aids provide automatic switching between programs, allowing the audiologist to configure environment-specific programs for different listening scenarios (e.g., quiet, noise, remote microphone, phone). These hearing aids monitor the ongoing acoustic environment, classify it by acoustic features, and switch to the program that is associated with that environment. Although little research is available on the use of these features in infants and young children, it stands to reason that manual switching is not feasible in this population. Trials of automatic program switching should be explored at the clinician's discretion, if this feature assists in the development of a monitored noise management strategy.

Are There Electroacoustic Measurements of Adaptive Noise Reduction (ANR) Processing? (Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

There are many different signal processing strategies for adaptive noise reduction (ANR) and these may vary in strength, defined as amount of noise decreased (dB), and time to activation/deactivation(s). ANR creates a reduction in gain when ongoing noises are present in the environment. This reduction may act quickly or take up to 20 seconds to activate fully. It may act over all frequencies or be shaped in frequency.
Currently, noise reduction technologies in hearing aids can be verified in the test box using three different 'noisy' signals (Air Conditioner, On the bus, and Vacuum within the Audioscan Verifit system and Speech Noise, Vacuum, and Babble within the Aurical system).

For testing to be reliable, the noise signal must play for 30 seconds to allow all manufacturer's ANR strategies to activate to full strength and to produce replicable results. Therefore, it is necessary to **use a timer** to ensure accurate recording time for accurate data collection. A test level of **85 dB is recommended**. In the example below, the hearing aid provides an overall attenuation between 0 and 17 dB, depending on the setting:

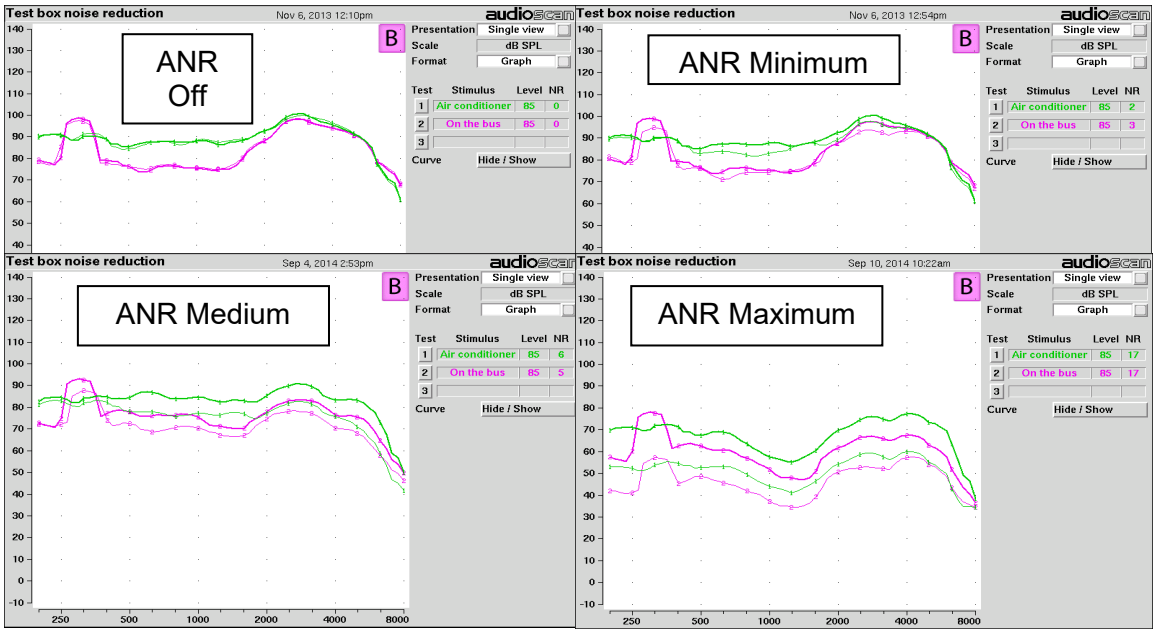


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Figure 5. Test results for ANR strength testing across processor settings.

Typical Performance Ranges for ANR Processing

As shown in the case above, ANR processing varies with the nominal strength of the processor chosen in the software. It also varies across brands. A representative sample of hearing aids was tested at all possible settings, and the results of the "Noise Reduction" tests at 85 dB were noted, for the amount of attenuation (dB) provided over 30 seconds (Scollie et al, 2016)

The results indicated that some brands of hearing aids have stronger or weaker ANR systems. The nominal settings in software are correlated with these performance categories, but brand variation also exists. Software settings that are labelled as "Off" have 0-4 dB attenuation, in contrast to software settings that are labelled as "On" or "Medium" or similar, which offer 0-8 dB attenuation (mean 4 – 6 dB), and software settings that are labelled as "Maximum" or "Strong" or similar, which offer 3-16 dB of attenuation (mean 8-9 dB).

Audiologists are advised to consider the objectively measured strength of ANR systems when interpreting whether a noise management strategy has or has not been effective for an individual child.

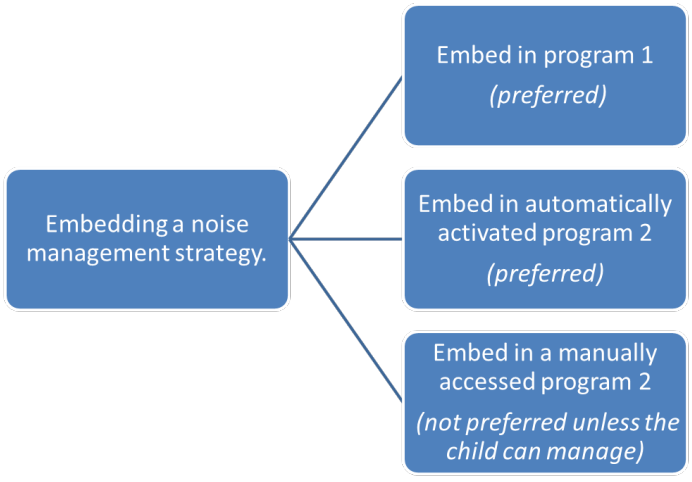
Practical Considerations in Building a Noise Management Strategy

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Because different brands of hearing aids provide noise management options in different ways, having flexibility in how to build a noise management program is important. The considerations below summarize these choices in current products:

1) Embedding The Strategy in a Program.

Some hearing aids provide environmental classification and switching between programs, while others do not. For this reason, the noise management strategy may be embedded in an automatically accessed second program, or it may be embedded in the hearing aid's main program. Either of these options allow access to the noise management strategy without requiring the child to make the switch. Pilot evaluations of a broad range of hearing aids indicate that either strategy provides both activation and de-activation of the noise management processing when the hearing aids are exposed to high- and mid-level speech in quiet and in a variety of background noises (work in progress).



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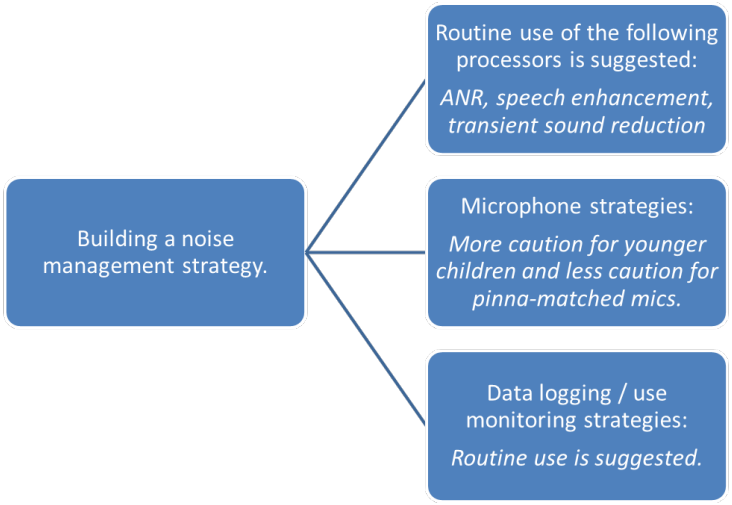
2) Adding Signal Processing to The Program.

Adaptive processors that act to reduce noisy signals, attenuate transient signals, and enhance speech-only signals are all versions of Adaptive Noise Reduction (ANR). These are generally recommended for use in children, although they should not be expected to improve speech recognition in noise (AAA, 2013). They are recommended to improve comfort when used in noisy environments. Some evidence exists that loudness is reduced for many (but not all) children with these processors (Crukley & Scollie, 2014). Therefore, trials with processors at known strengths can determine if a child is receiving benefit from the processors.

Directional programs may be trialed with young children, but caution is suggested for younger infants and children especially with full-band directionality (AAA, 2013)

3) Verification Considerations

Verification of noise management is needed to ensure that it does not attenuate speech in quiet, and to verify that the noise management processing actually reduces noise. In the protocol below, a baseline measurement will allow the audiologist to know the strength of the noise reduction, so that this information is available for ongoing monitoring. For example, if the initial noise reduction strength is mild, and insufficient benefit is achieved, a stronger noise management strategy could be added to the hearing aids.



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Recommended Protocol

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

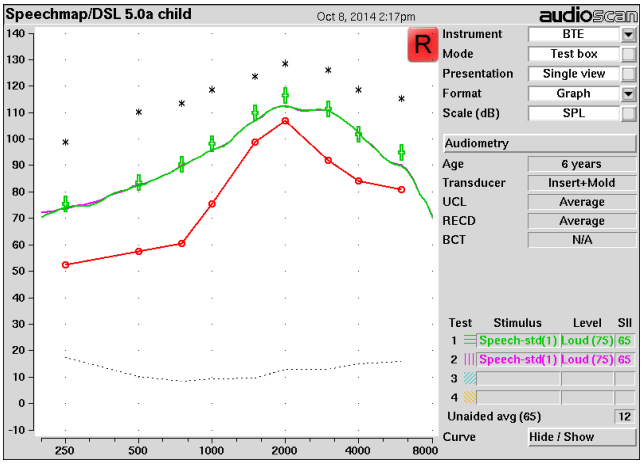
1) Consider the candidacy factors for noise management.
   - **a.** Does the child or caregiver report any loudness discomfort, either informally or formally (on the PEACH or IHP- ABQ)? Under what circumstances does loudness discomfort occur?
   - **b.** Is the hearing aid use time per day limited, and if so, is it limited because of loudness and/or noise issues? Under what circumstances does loudness discomfort occur?
2) Consider practical factors in planning a noise management strategy.
   - **c.** Child Factors: Does the child have the cognitive/developmental/dexterity abilities to monitor his or her own environment and manually choose between hearing aid programs?
   - **d.** Family Factors: Involve the caregivers in choosing to provide noise management in order to facilitate their awareness, engagement, and monitoring.
   - **e.** Hearing Aid Options: What noise management features does the hearing aid offer? How strong is the noise reduction, and how can it be accessed (via automatic or manual programs?) and monitored (via data or use monitoring?).
3) Verify the shape and gain of the hearing aid fitting without ANR.
   - **f.** Begin by verifying and tuning hearing aid to optimize the fitting without ANR. Ensure that the aided speech spectra meet DSL prescriptive targets and provide a broad bandwidth of audibility.
   - **g.** Check whether the Loud and/or MPO response is on target. If the hearing aid is over target, this may be impacting the child's loudness comfort in daily use.
4) Enable the noise management program. How will the child access the noise management strategy?
   - **h.** Can you embed it within the hearing aid's only program?
   - **i.** Can you embed it in an automatically accessed second program?
   - **j.** Can you embed it in a manually accessed program?
5) Program the noise management strategy, by adding features to the noise management program.
6) Verify the noise management strategy: Does it attenuate speech in quiet?
   - **k.** Run a 75 dB SPL speech signal to the hearing aid, with and without the noise management strategy enabled.
   - **l.** The two curves should be highly similar.
   - **m.** *Because this step rarely produces any concern, it is sufficient to run this when learning a new make/model/processing scheme, and does not need to be performed on a case by case basis unless there are concerns.*
7) Verify the noise management strategy: Does it attenuate high-level noise?
   - **n.** Measure a noise reduction signal such as "Air Conditioner" or "Vacuum" in the Noise Reduction tests for 30 seconds. Note the overall amount of attenuation provided as a measure of strength of processing.
   - **o.** Consider strengthening the processor if the tests provide fewer than 3 dB of attenuation.
8) Counsel on appropriate use and monitor outcomes at the next visit.
   - **p.** Does hearing aid use increase, including in situations of concern?
   - **q.** Does loudness discomfort decrease, including in situations of concern?
   - **r.** Steps to consider if problems are not resolved:
     - **i.** Consider a stronger noise management setting or an automatically accessed gain-reduced noise program fitted either to DSL5-noise or NAL-NL2-child.
     - **ii.** Consider a trial with a loaner aid that offers stronger noise management.
     - **iii.** Request further support from the IHP.

Case Example A: Illustrating the Fitting Protocol

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

The following case illustrates a fitting for a child who is a full-time user, and for whom a noise management strategy was created. The hearing aid's adaptive noise management feature was enabled in the main program of the hearing aid together with an omnidirectional microphone. Verification indicates that the noise management strategy reduces the level of noises by 6 dB, while leaving speech in quiet unaffected. Monitoring plans include software-supported hearing aid use logging, evaluation of use on the IHP-ABQ, and continued monitoring of reports of loudness comfort in loud environments on the IHP-ABQ and by caregiver report. Any changes in these outcomes may inform the clinician about the real-world effectiveness of the strategy.

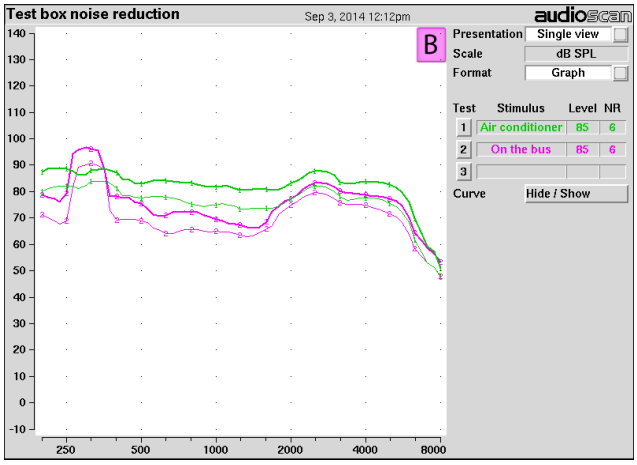
When a loud speech input is delivered to the hearing aid with noise management, the hearing aid maintains a good fit to DSL targets. Therefore, the noise management strategy does not impact the audibility of speech in quiet:



When the noise management strategy is enabled, an average of 6 dB noise reduction is noted when 'Air conditioner' and 'On the bus' signals are delivered to the hearing aid. Other noise reduction stimuli available in this system include 'Vacuum' and 'Multi-talker Babble'.

Test 1: ANR Off
Test 2: ANR On

Thick line: at onset of signal.
Thin line: after 30 seconds.



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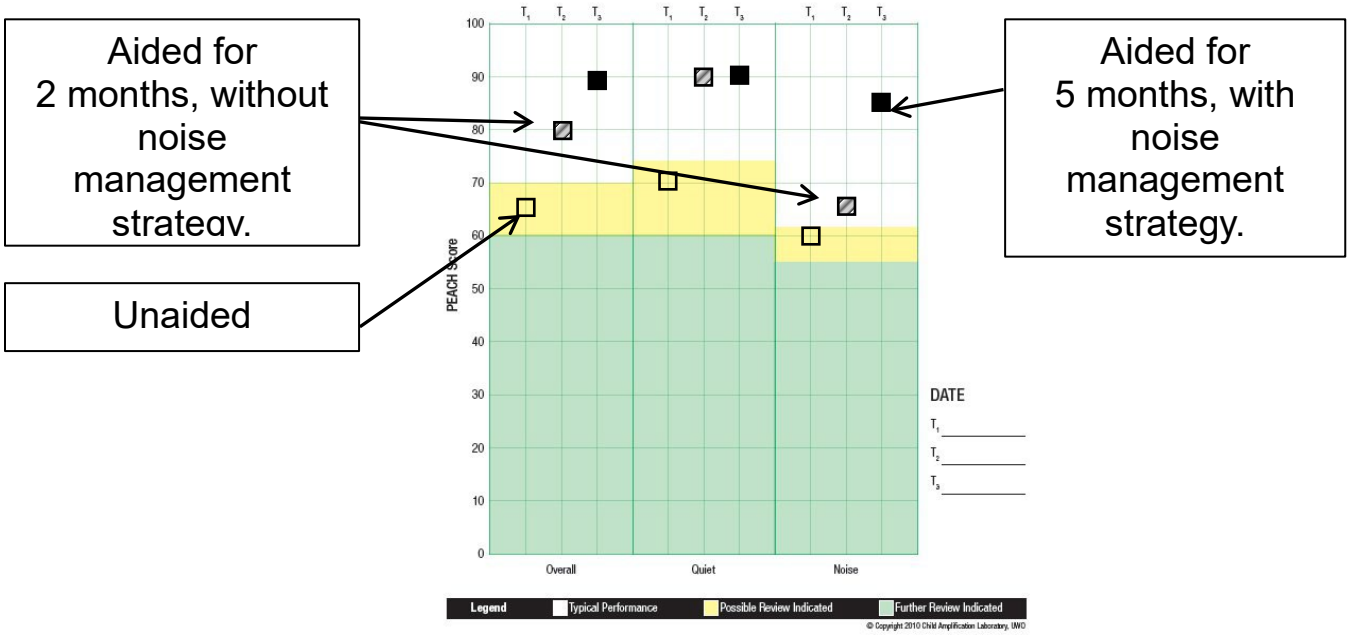
Case Example B: Illustrating the Role of Monitoring and Follow Up

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

In this example, a child with normal developmental status was fitted with hearing aids at 4.5 years of age. She has a bilateral moderately-severe hearing loss and was fitted late due to lack of parental follow-up. Noise management strategies were not initially activated in the hearing aids. Prior to being fitted with hearing aids, the mother completed the PEACH, as recommended by the IHP Outcome Measurement Protocol (2010). Scores ranged from 65%, 70%, and 60% for the Overall, Quiet and Noise subscales respectively for the unaided condition. After two months of experience with the hearing aids, the child's scores on the PEACH increased to 80%, 91%, and 65% for the same subscales. Items in the noise subscale were discussed with the family and the need for a noise management strategy for certain situations was identified. Therefore, a noise management strategy in a second manually-accessible program was applied in consultation with the parents and child. This included adaptive noise reduction and omni-directional microphones. At the follow-up appointment, scores improved to 88%, 91%, and 85% on the Overall, Quiet and Noise subscales respectively. An improvement in the noise score likely coincided with the introduction of the noise management strategy.

This demonstrates that the PEACH is sensitive to auditory performance in the unaided and aided condition and shows progression in scores with more experience with hearing aids as well as the application of noise management strategies. In this case, a positive outcome with intervention was documented by systematically tracking the child's auditory performance over time.



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APPENDIX L: Remote Microphone Hearing Assistance Technologies

It has been well documented that the use of remote microphone hearing assistance technology (RM-HAT) by children in educational settings is an effective strategy for improving listening in environments with poor signal to noise ratios, great distances between listener and talker, and highly reverberant rooms (AAA, 2013). While a remote microphone technology system may not be used in the first few months of life, when an infant becomes a toddler, more difficult listening situations will develop. The child may be at a distance from the primary caregiver or talker and in highly reverberant environments.

Recent research (Benítez-Barrera et al, 2018;2019; Curran et al, 2019; Thompson et al, 2020; Walker et al, 2019), while tentative, indicates preschool children who use RM-HATs at home have improved access to both child-directed speech, as well as overheard speech. While RM-HAT use does not result in increased vocabulary or grammar, it correlates with significant improvements in higher-level language skills. Further research on these topics is still required. For these reasons, it is recommended that RM-HAT be discussed with the family during amplification appointments and provided early in the amplification process.

The *AAA Clinical Practice Guideline for Remote Microphone HAT for Children and Youth from birth to 21including Supplement A (2011)* and Supplement B: Classroom Audio Distribution Systems – Selection and Verification (2011) are comprehensive, evidence-based documents.

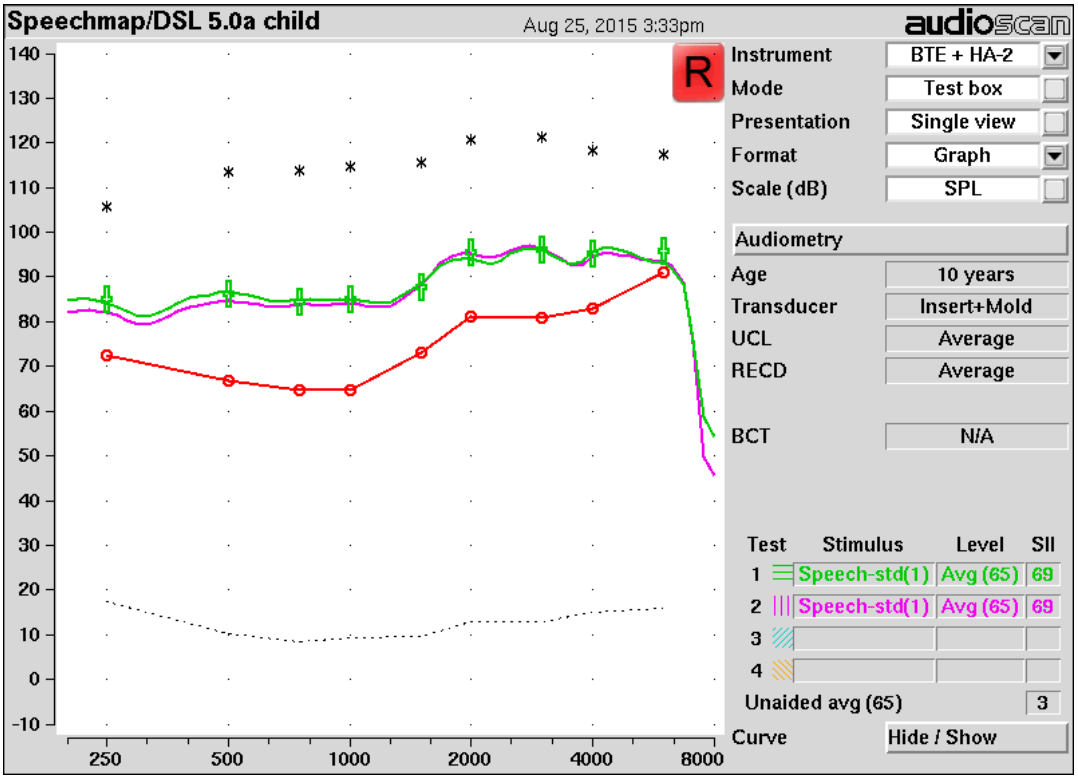
For quick reference, the following sections of the *AAA Clinical Practice Guideline for Remote Microphone HAT (CPG RM-HAT) for Children and Youth (2011)* are highlighted based on their relevance for Audiologists managing infants and young children with permanent hearing loss.	
Key Sections	Content
Section 5. • Remote Microphone HAT Candidacy, Implementation and Device Selection Considerations (pp. 7-18)	• Relevant to the majority of infants and young children with HL.
Section 6. • Fitting and Verification Procedures (pp. 18 -19)	• Overview of Remote Microphone HAT fitting goals.
Section 10. Supplement A: • Fitting and Verification Procedures for Ear-Level FM (pp. 48-49)	• General verification information and terminology.
Section 10. Supplement A1: • Fitting and Verification Procedures for Children and Youth with Hearing Loss (pp. 50 – 64)	• Step-by-step verification instructions outlined. • Refer to Appendix M of this document for a visual example of the electroacoustic verification "transparency protocol. • Behavioural verification procedures are not feasible for infants and very young children, and are considered optional for this age group.
Section 10. Supplement A3: • Fitting and Verification Procedures for Children and Youth with Normal Hearing Sensitivity and special listening requirements. (pp.71 – 75)	• Applicable for children with unilateral hearing loss when an ear-level FM is desired for the normal hearing ear.
Section 10. Supplement A: • Quick reference summary of verification steps (pp. 76-77)	• An at-a-glance summary of the electroacoustic, behavioural and real ear evaluation steps for verification of ear-level FM Systems.

APPENDIX M: Remote Microphone Hearing Assistance Technology Verification

Remote Microphone HAT Verification

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

For personal HAT systems coupled to hearing aids, the AAA Guideline (2011, Supplement A) recommends a “transparency protocol” in which the output of the hearing aid and HAT system (HA+HAT) combined is matched to the output of the hearing aid alone. These measures are performed with a moderate input signal, such as speech at 65 dB SPL. This “transparency protocol” has been endorsed by training programs and major manufacturers of FM/DM/RM-HAT systems for several years, and is likely not new to most pediatric amplification sites. It is important to contact the manufacturer of a specific remote microphone HAT for their verification protocols for their technology. Their instructions will provide guidance on factors that may change over time as different products are released (such as placement of microphones in verification test boxes, for example). A visual example of this "transparency protocol" is shown below for a system that meets the fitting requirements outlined in the AAA Guideline (2011, Supplement A).



Example of the HAT Transparency Verification Protocol

(Reproduced with permission from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Most children with permanent hearing loss are candidates for remote microphone HAT to be used in conjunction with hearing aids. The AAA Guideline (2011, Supplement A) for selecting and fitting these devices on children and youth provides evidence-based support for pediatric audiologists who work with this population. This protocol endorses the AAA Guideline (2011, Supplement A) to guide candidacy and device selection and verification support for Audiologists considering remote microphone HATs for their young patients.

APPENDIX N: Hearing Aid Orientation Information for the Family

Hearing Aid Orientation Checklist

The following topics should be discussed, demonstrated and/or practiced with the parent or caregiver during the initial hearing aid orientation and follow-up appointments.

Ear Molds

- □ Insertion and removal
- □ Earmold tubing attachment to hearing aids
- □ Life expectancy of molds
- □ Trial period

Hearing Aids

- □ Parts of hearing aid (microphone ports, ear hook, etc.)
- □ Insertion and removal
- □ Turning hearing aid on and off
- □ Extra user controls, if active
- □ Extra connectivity if applicable (e.g. telecoil/Bluetooth)
- □ Trial Period, manufacturer warranty and insurance information
- □ Loss & Damage insurance
- □ Life expectancy of hearing aids

Retention Techniques

- □ Importance of retention and loss prevention (insurance)
- □ Use of earmold lubricant
- □ Tips and tricks for keeping the hearing aids on
- □ Demonstration of retention clips, double-sided tape, retention cap/bonnet, headband, etc.

Batteries

Disposable

- □ Safety
- □ Battery size
- □ Insertion and removal
- □ Tool for opening locking mechanism if applicable
- □ Checking battery levels
- □ Battery indicator options (if available and/or appropriate)

Rechargeable

- □ Orientation of charger
- □ Information on charging times
- □ Battery level indicators

Care & Maintenance Kit

Demonstration of equipment found in the care and maintenance kit

- □ Battery tester
- □ Stethoscope for daily listening check
- □ Earmold blower for removing moisture and debris
- □ Dry Aid Kit for removing moisture from the hearing aid(s) and earmold(s)
- □ Battery door opener tool, where applicable
- □ Cleaning brushes
- □ Instruction manuals
- □ Items not covered above (e.g. other cleaning tools, informational brochures, videos, books, stickers and carrying case.)

Routine Maintenance

- □ Inspection of hearing aids, earmolds and tubing for dirt and debris
- □ Techniques for cleaning earmolds and hearing aids
- □ Demonstration of a daily inspection of ear canal, and daily listening check of the hearing aids.
    - Sound quality (weak, distorted, clear)
    - Ling 6
    - Ensure user controls are active and working properly
- □ Check battery and replace if necessary
- □ Check for moisture problems

Troubleshooting

- □ Discussion and demonstration of troubleshooting techniques and solutions.
- □ Understanding and combating feedback
- □ Protecting the hearing aids from potential hazards (e.g., moisture, pets)
- □ Troubleshooting techniques
- □ E.g. no sound, static, intermittent, charging issues, broken housing
- □ Plans for repair of malfunctioning hearing aids
- □ Loaners/backup hearing aids and equipment

Educational & Community Support

- □ Educational Support
- □ Local & non-profit organizations

Use of Hearing Aids & Expectations

- □ Aided audibility and implications for speech and language development
- □ Behaviour monitoring and what to observe (positive responses & negative responses to sound)
- □ Impact of noise and distance (i.e., home, car, public places) – expectations and management strategies
- □ Wear Time: Hours of daily use
    - Incorporating use of hearing aids into the child's routine
    - Sharing the importance of wear hours as it relates to language outcomes
    - Data logging

Follow-up Plan

- □ Plans for documenting experiences with hearing aids – hearing aid diaries could be provided or recommended
- □ Observation of child's interactions (acceptance) of hearing aids
- □ Plans for follow-up contact between the family and clinician

APPENDIX O: Outcome Measurement Protocol

Pediatric Amplification Outcome Measurement Protocol

(Adapted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

At follow-up visits, it is important for the audiologist to talk with parents and caregivers about the fit of the hearing aids, the infant and child's use of them, auditory development and to measure these. Use of a systematic, evidence-based outcome measurement protocol for children who wear hearing aids supports optimal amplification for the child with permanent hearing loss. The UWO Pediatric Audiological Monitoring Protocol (UWO PedAMP), (Bagatto et al., 2011) was developed to allow monitoring of hearing aid details and hearing abilities of children aged 0-6 years.

The outcomes of children with permanent hearing loss who are fit with amplification should be measured using components of the UWO PedAMP Protocol.

Assessment of the quality of the hearing aid fitting and parent-report questionnaires are a routine part of the Provision of Amplification. The quality of the hearing aid fitting is assessed by the reporting of RECD activities (measured or predicted) and comparing the Speech Intelligibility Index (SII; ANSI S3.5 – 1997 [R2012]) to normative values based on pure tone average hearing loss in pediatric hearing aid fittings (Moodie et al, 2017). Parent questionnaires (LittlEARS, PEACH, and EHDI Program Amplification Benefit Questionnaire) are administered and scored at regular intervals. The application of the results of the Outcome Measurement tools are used to inform audiological management of the child and continuous improvement of the delivery of pediatric amplification services within the Alberta EHDI Program Pathway.

The following table describes the outcome measurements that should be gathered in all cases. Where children are part of EHDI pathway, these measures should be reported as part of the required data collection and submission for EHDI. The audiologist prescribing, fitting and verifying the amplification will provide the Hearing Aid Fitting Summary information to the EDHI Program.

Tool	Purpose	Description
Amplification Benefit Questionnaire	- Acceptance & use of hearing aids - Parent/Caregiver Experience with hearing aid services	15 items
Hearing Aid Fitting Summary	- Quality of hearing aid fitting	15 items (excluding demographic information)
LittlEARS Auditory Questionnaire *(Tsiakpini et al, 2004)*	- Receptive & semantic auditory behaviour - Expressive vocal behaviour	35 yes/no response items
Parent's Evaluation of Aural/Oral Performance of Children (PEACH) *(Ching & Hill, 2005)*	- Communication in quiet & noise - Responsiveness to environment	13 items

The details of each of these are described in the Appendices that follow.

APPENDIX P: Clinical Application of the Outcome Measurement Protocol

The administration of each outcome tool is based on the following schedule. Check marks indicate when a particular tool should be administered in relationship to the assessment and follow-up appointments. A ***blue box*** indicates when data should be submitted to the EHDI Program for children who are in the EHDI pathway.

	Audiological Assessment Threshold Data	**Hearing Aid Fitting Summary**	**Parent Questionnaire** LittleEars or PEACH *If score ≥27 & ≥ 24 months, Stop using LittlEARS and use PEACH*	**EHDI Program Pediatric Amplification Benefit Questionnaire**
Year One: First Year of Hearing Aid Use				
Initial Audiological Assessment PCHL confirmation	✓		✓ Administered & submitted once before child starts to use hearing aids	
Hearing Aid Evaluation				
Initial Fitting		✓		
HA Recheck 30 days post-initial fitting		✓		
HA Recheck 3 months post-initial fitting		✓		✓
Behavioural Ax @ 6 months of age	✓		✓ Administered & Submitted once at 6 months	
HA Recheck 6 months post-initial fitting		✓		
Behavioural Ax @ 9 months of age	✓			
HA recheck 9 months post-initial fitting		✓		
Behavioral Ax @ 12 months of age	✓		✓ Administered & Submitted once at 12 months	
HA check (annual) 12 months post-initial fitting		✓		✓
	Audiological Assessment Threshold Data	**Hearing Aid Fitting Summary**	**Parent Questionnaire** LittleEars or PEACH If score ≥27 & ≥ 24 months, Stop using LittlEARS and use PEACH	**EHDI Program Pediatric Amplification Benefit Questionnaire**
Second Year of Hearing Aid Use through to age 6;0 years*				
Ongoing Amplification Recheck every 6 months		✓	✓ Administered & Submitted once a year	✓ Administered & Submitted once a year
Ongoing Behavioral Ax every 6 months	✓ Measured & submitted once a year			

Application of the Outcome Measurement Protocol

(Adapted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

Clinical application of the outcome measurement protocol is explained through the use of a case example.

Case: Cyrus was identified with a moderate rising to mild bilateral sensorineural hearing loss and fitted with hearing aids binaurally when he was eleven months old. The reason for the delay in hearing aid fitting was related to parental readiness early in the process. Cyrus was born full term and does not have any other medical issues besides hearing loss. The following sections describe each outcome measurement tool in the protocol and provide results for Cyrus.

Hearing Aid Fitting Details & Summary

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

The outcome measurement protocol is followed to ensure that Cyrus' hearing aids are providing the necessary access to speech for his degree of hearing loss. **Outcome evaluation is designed to be completed following the hearing aid verification stage of the fitting process to measure the impact of the fitting**. An appropriate hearing aid fitting is associated with positive outcomes. Monitoring hearing aid fitting details allows the audiologist 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 *EHDI Program as a whole*. The 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 given a specified hearing loss.

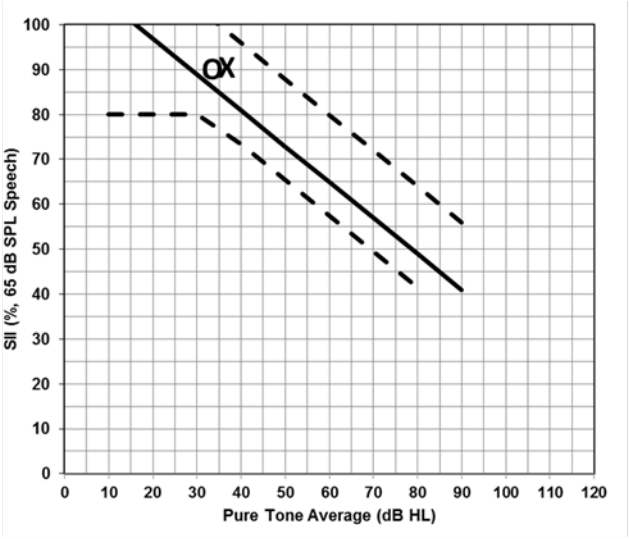
As part of this protocol, the Hearing Aid Fitting Summary is used to monitor the quality of the hearing aid fitting, and to provide helpful information for the audiologist, parents, and the EHDI Program about the hearing aid fitting.

In this protocol, in order to minimize the time needed to capture the hearing aid fitting details, the exact fit-to-targets at each frequency and test level are not documented. Instead, the fit-to-targets are assessed by the audiologist 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 recorded and 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). EHDI Program data forms are used to document these details.

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 [R2012]). 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 test 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. Normative data relating the specific SII values for acceptable hearing aid fittings are available (Moodie et al, 2009; 2017) and can be found in some hearing aid test systems (see Verifit 2 sample below). 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 current protocol.



Tracking this 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 Cyrus' hearing aid fitting are summarized on the right. 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 Cyrus'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.

Hearing Aid Fitting Detail	Right Ear	Left Ear
Real Ear to Coupler Difference (RECD)	☑ Measured ☐ Predicted ☐ Used other ear values ☐ Used previously measured values	☐ Measured ☐ Predicted ☑ Used other ear values ☐ Used previously measured values
Maximum Power Output (MPO)	(Yes) No	(Yes) No
SII Soft Value (55 dB SPL)	91	94
SII Average Value (65 dB SPL)	91	90

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LittlEARS Auditory Questionnaire

(Adopted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

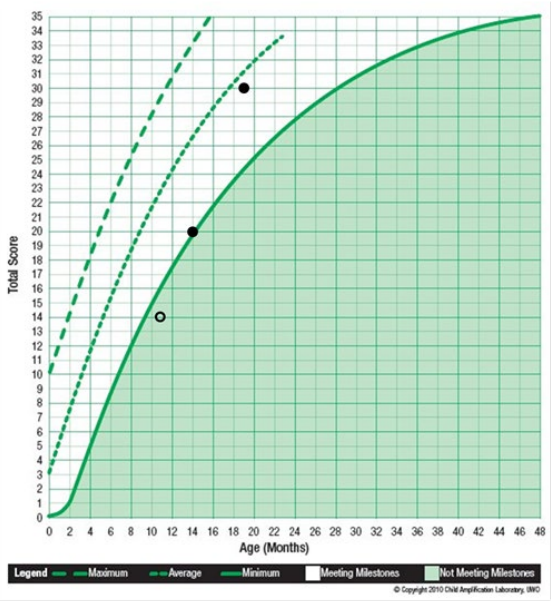
The purpose of the LittlEARS Auditory Questionnaire is to assess the auditory behaviour of infants with PHL who wear hearing aids or cochlear implants (Tsaikpini et al, 2004; Coninx et al, 2009). The 35 items in the LittlEARS questionnaire assess auditory development during the first two years of hearing 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). *Note: The LittlEARS Tool should be purchased from Med-El who holds the copyright permissions.*

A longitudinal intervention study was conducted using the LittlEARS as part of the UWO PedAMP (Bagatto et al, 2011; 2016). Through this work, it was reported that caregivers and clinicians found it feasible to complete clinically (Moodie et al, 2011). In addition, the questionnaire has been shown to be sensitive to other medical issues besides hearing loss (Bagatto et al, 2011; 2016). 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 PHL. As part of this protocol, 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 and the child is 24 months of age and older, 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 should 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, 2011).

At Cyrus' hearing aid evaluation appointment, his mother completed the LittlEARS Auditory Questionnaire to obtain a baseline 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 Cyrus was not meeting auditory development milestones for his age without hearing aids.

After three months of hearing aid use (Cyrus 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 revealed responses on the LittlEARS that totaled 30 at age 19 months. This score was plotted on the LittlEARS scoresheet (see right) and indicates that Cyrus was meeting auditory development milestones for his age after about 8 months of hearing aid use.



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

(Adapted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

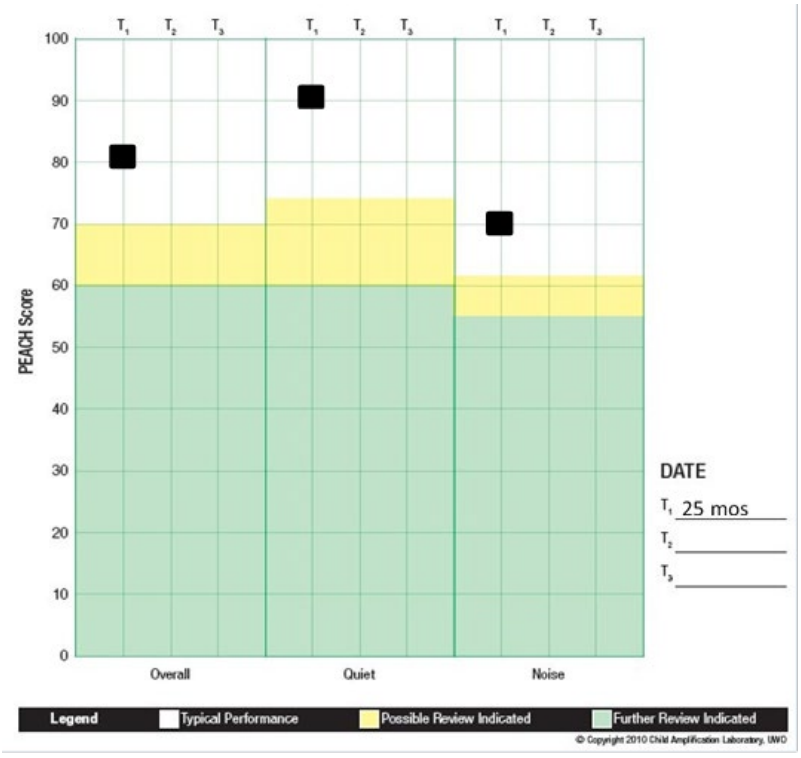
The PEACH Rating Scale has been selected for use in the current protocol, with children who have attained ceiling performance (i.e., total score of 27 or greater) on the LittlEARS Auditory Questionnaire.

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. A score sheet was developed as part of the UWO PedAMP and provides assistance with interpretation of individual results and is available on the Child Amplification Lab, National Centre for Audiology website at https://www.dslio.com/?page_id=283

The PEACH assesses functional auditory performance in quiet and noisy situations. Using the UWO developed score sheet, scores can be compared to scores derived from children with PHL 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 IHP Outcome Measurement Protocol with children who wear hearing aids after they have met a certain criteria on the LittlEARS Questionnaire (Bagatto et al, 2011).

Since Cyrus' recent score on the LittlEARS exceeded 27 and he was older than 24 months of age, the PEACH Rating Scale was administered at his next follow-up appointment (25 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 Cyrus was demonstrating typical auditory performance in both the Quiet (91.7%) and Noise (70.0%) subscales (see right). His overall score was 81.8%.



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The EHDI Amplification Benefit Questionnaire

(Adapted from the 2019 Ontario IHP Protocol for the Provision of Amplification)

The EHDI Amplification Benefit Questionnaire is a questionnaire that was developed by the EHDI Pediatric Amplification working group. Based on the Ontario IHP Amplification Benefit Questionnaire and patient experience questionnaires such as the Pediatric Measures of Processes of Care. This tool addresses acceptance and use of hearing aids, auditory performance for different levels of sound, and family experience of service delivery. The tool makes use of Likert type rating scales and two open-ended questions.

It is recommended that the questionnaire be answered by the caregiver after their child has worn hearing aids for *three months or more* to give the caregiver a chance to become accustomed to and comfortable with their child's hearing aids and the services offered by the IHP.

Initial responses from Cyrus' mother on the Amplification Benefit Questionnaire at three months post-hearing aid fitting revealed one to four hours of hearing aid use per day and some willingness of the child to accept his hearing aids. This was verified by checking internal data logging within his hearing aids. Cyrus' 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. Her responses at 6 months post-hearing aid fitting revealed an increase in daily hearing aid use to four to eight hours per day and Cyrus being slightly less willing to accept the hearing aids. Other items on the questionnaire remained similar. Strategies to support the child's acceptance of the hearing aids were discussed with Cyrus' mother.

APPENDIX Q: Amplification Benefit Questionnaire

Note: As of the release of this first version of the protocol. The exact content and process for administration of the amplification benefit questionnaire is a work in progress.

Thank you for completing this survey.

Please take a moment to think about your child's recent audiology and hearing aid appointments that focused on your child's amplification, then provide your answer to these questions.

Your feedback will help us to improve care.

1. **When was your child first fit with their PRESENT Hearing Aids?** Month | Year

2. **How much does your child wear their hearing aids in a typical day?**

Not Applicable	Not at all	Less than 1 hour a day	1 to 4 hours per day	4 to 8 hours per day	More than 10 hours per day
☐	☐	☐	☐	☐	☐

	Not Applicable	Not at all	To a very small extent	To a small extent	To a moderate extent	To a fairly great extent	To a great extent	To a very great extent
3. Is your child happy wearing their hearing aids?								
4. Can you tell when the hearing aids are not working? (e.g., whistling, no sound)								
5. Do you know how to check problems with the hearing aids when they occur? (e.g., dead battery or wax in earmold tubing)								
6. Considering everything, do you think the hearing aids are worth the effort?								

At your child's recent audiology appointments that included activities or discussions about amplification, to what extent did the people who worked with you:

	Not Applicable	Not at all	To a very small extent	To a small extent	To a moderate extent	To a fairly great extent	To a great extent	To a very great extent
7. Provide you with clear written, verbal or visual information about your child's hearing?	☐	1	2	3	4	5	6	7
8. Listen to your concerns?	☐	1	2	3	4	5	6	7
9. Answer your questions?	☐	1	2	3	4	5	6	7
10. Help you understand the results?	☐	1	2	3	4	5	6	7
11. Provide you with information about next steps?	☐	1	2	3	4	5	6	7

12. Overall how would you rate the hearing aid services you have received for your child?

Very Negative				Neither Positive nor Negative					Very Positive
1	2	3	4	5	6	7	8	9	10

13. Do you have any recommendations to improve your experience?

_____

_____

_____

_____

14. Do you have any other comments you want to share about your experience with hearing aid services for your child?

_____

_____

15. At what site/clinic did your child receive their hearing aid services? _____

16. What is your postal code? _____

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SUPPLEMENT 1:

Alberta Early Hearing Detection & Intervention (EHDI) Program Context

ACSLPA endorses the principles, mandates, and requirements of the Alberta EHDI Program. When a registered audiologist is following a child who is part of the EHDI Program pathway, the ACSLPA Pediatric Amplification Protocol is inclusive of the requirements specific to the EHDI Program. ACSLPA endorses the collection and submission of data to the EHDI Program for children identified with PCHL ad data informs practice, research, and funding.

EHDI Program

Alberta's EHDI Program is a family-centred, comprehensive and coordinated population-based screening program focused on early detection, diagnosis, and intervention for infants with screen detected permanent congenital hearing loss (PCHL) and their families. The EHDI Program ensures that PCHL is identified as early as possible in an infant's life, and that follow-up and support can be provided as timely as possible to improve language, learning, and developmental outcomes for infants with PCHL. The Provincial EHDI Program is responsible for the coordination and continuous improvement of the system of EHDI services, which assures that the provincial EHDI goals are met.

EHDI Program Goal

The primary goal of the Alberta EHDI program is to minimize the effects of undiagnosed permanent congenital hearing loss in Alberta infants through early detection, diagnosis, and intervention. All infants whose screening indicates potential hearing loss have access to physiological diagnostic audiological assessment to assess hearing status no later than three months corrected age. All infants with confirmed permanent congenital hearing impairment are to receive intervention services as soon as possible after diagnosis and no later than six months corrected age.

EHDI Program Intervention Principles

Amplification is to be provided in accordance with the Alberta EHDI Program Intervention Principles:

- Parent perspectives and choices are honoured; Providers are guided by what matters to families.
- The team works collaboratively, with the family as the central member.
- Services honour diversity and respond to cultural and spiritual needs.
- Information shared is accurate, comprehensive, and unbiased.
- Access to intervention is early, coordinated, and equitable, regardless of the type and degree of permanent hearing loss.
- Intervention supports family interaction, optimizing language, literacy, learning environments, and social development.
- Families are connected to social and emotional supports,
- Services are evidence informed and standardized.
- Providers have specialized competencies to engage families and to optimize family well-being and developmental outcomes of children who are Deaf or Hard of Hearing.
- EHDI Program, child and family data, and outcomes, are systematically monitored to guide decision-making and quality improvement.
- Albertans participate in EHDI design.

EHDI Program Target Disorder

The Alberta EHDI Program target disorder includes any PCHL for which there is reasonable evidence that the hearing loss will compromise auditory communication development and speech perception, in the absence of intervention. The target PCHL includes conductive impairment associated with structural anomalies of the ear, and Auditory Neuropathy Spectrum Disorder (ANSD).

Hearing loss is considered permanent if it is irreversible, or if it is likely to be sustained for six months or more. This includes all unilateral and bilateral sensorineural loss and most conductive loss that has a structural cause, such as ear canal atresia or middle-ear malformation.

When providing Amplification services to children who fall in the EHDI Program (i.e., infants and children with screen detected permanent congenital hearing loss) the following are additional required elements as detailed in the AHS Pediatric Amplification Protocol for use in the EHDI program.

- EHDI Program specific components
- EHDI Data Submission requirements
- Use of the EHDI Program Foundational Conversation Guide for Providers.

For children who are part of the Alberta EHDI pathway, amplification will be prescribed, dispensed and fitted by Registered Audiologists who are members in good standing with ACSLPA and who are required to:

- Complete the required standardized education and learning as set out by this protocol;
- Participate in the Pediatric Amplification Community of Practice and ongoing education opportunities that are offered related to this protocol;
- Meet the criteria to be recognized by the EHDI program as a provider of pediatric amplification in the EHDI care pathway;
- Participate in the EHDI Program quality assurance program which includes the submission of data related to Amplification as described in the protocol and pediatric amplification practice audits; and
- Register as Specialty Assessors with the Alberta Aids to Daily Living (AADL) program if authorizing or fitting hearing aids. All Amplification benefits funded by the Alberta Aids to Daily Living (AADL) Program to children birth to 18;0 years are to be provided in adherence to this Amplification Protocol.

The rationale for the above requirements includes:

- The practice of pediatric amplification for infants and children under 6;0 years contains elements that may be outside the conventional and everyday experience of an audiologist.
- Initial and ongoing specialized training is required to maximize and maintain understanding, and to fulfill a highly specific standard of care with many mandatory elements.
- Quality assurance (QA) and continuous quality improvement (QI) are part of the Alberta EHDI program. The QA/QI program for EHDI targets all major components of the EHDI program pathway, including pediatric amplification.
- Providers should be registered with the AADL program to receive funding for amplification services.

Foundational Conversations with Families in the EHDI Program Pathway

Foundational conversations facilitate consistent, family-centred, and evidence-informed sharing of information. These conversations are essential to optimally engage, empower, and support families. They occur during the diagnostic and intervention stages of the program pathway. Foundational conversations may be applicable both at early and later stages of intervention, given the fluid nature of individualized intervention approaches, goals, and decision-making. Foundational conversations may be supplemented with information provided in other formats, as appropriate, and based on family needs and preferences.

The AHS EHDI Program Foundational Conversations Guide (FC Guide; release date pending) supports service providers in early conversations with families. The FC Guide provides information on the guiding principles and content of foundational conversations, as well as strategies, supporting evidence, and recommended resources. Within the EHDI program pathway, it specifically pertains to the stages of diagnostic hearing assessment and intervention services. The guide integrates family perspectives, literature, expert consensus, and stakeholder input specific to the Alberta EHDI Program. All communication with families should reflect the principles of AHS and the Alberta EHDI Program.

Standardized Education and Learning for Audiologists Delivering Amplification Services to Infants and Young Children in the EHDI Program Pathway

Audiologists who are prescribing, fitting, verifying, and validating amplification on infants and young children birth to 6;0 years who are followed in the EHDI Program pathway are required to participate in a standardized education program as a part of this protocol. This requirement assures the establishment of uniform knowledge and understanding of this protocol and supports standardized execution of a highly specific standard of care with many mandatory elements.

Standardized education will involve learning opportunities and supports that include: self-study, formal learning with academic experts, and a pediatric amplification community of practice.

Recognition as Audiologist Providing Pediatric Amplification in the EHDI Program Pathway

To be recognized as an audiologist who is identified as a provider of pediatric amplification services to an infant or young child within the Alberta EHDI Program Pathway, an audiologist is required to:

- Be employed currently in AHS or in a Private Practice in Alberta;
- Be a member in good standing with ACSLPA;
- Be registered as a provider (specialty assessor or authorizer) with the Alberta Aids to Daily Living Program;
- Commit to follow this protocol;
- Commit to participate in both initial and ongoing specialized standardized education as set to maximize and maintain understanding of, and to fulfill a specific standard of care as set out in this protocol;
- Commit to participate in the EHDI Pediatric Amplification Community of Practice;
- Commit to submit standardized data to the EHDI Program as detailed in Appendix Q and when requested as protocols and procedures change;
- Agree to participate in EHDI Program quality assurance initiatives, including file audits; and
- Use a real-ear and hearing aid test system that meets the technical requirements described in Appendix C of this protocol.

SUPPLEMENT 2:

Child & Family-Centred Care

ACSLPA defines client-centred care as “a partnership between a team of health providers and a client where the client retains control over their care and is provided access to the knowledge and skills of team members to arrive at a realistic team shared plan of care and access to the resources to achieve the plan”.

Child & Family Centred Care

Patient and family centred care (PFCC) is a healthcare approach that recognizes that patient care is improved when families and healthcare providers work together. PFCC is defined by four core concepts: Respect and Dignity, Information Sharing, Participation, and Collaboration (as per the Institute for Patient-and Family Centred-Care). PFCC aligns with AHS’ foundational Patient First Strategy, which aims to improve the patient experience by ensuring patients and families are at the centre of all health care activities, decisions, and teams. Given the context of this guide, PFCC is rephrased as “child” and family centred care. To facilitate child and family centred care, providers seek out, work with, and value the child and their family/caregivers as partners in designing and carrying out care services (CIHC, 2010). As outlined in the Interprofessional Competency Framework (CIHC, 2010), this requires that providers:

- Support the participation of families as integral partners;
- Share information in a way that is respectful, understandable, encourages discussion, and enhances participation in decision-making;
- Ensure that appropriate education and support is provided to families and others involved;
- Listen respectfully to the expressed needs of all parties in shaping and delivering services; and
- Acknowledge the importance of emotional, social, and developmental support.

The Alberta EHDI program identifies five essential aspects of child and family centred care for children who are deaf or hard of hearing. These are adapted from the 10 guiding principles presented in Best Practices in Family-Centred Early Intervention for Children Who are Deaf or Hard of Hearing: An International Consensus Statement (Moeller et al., 2013).

- Emotional Support
- Relationship Building/Family and Provider Partnerships
- Individualized Approach and Attention to Readiness
- Informed Choice and Unbiased Information
- Socially, Culturally and Linguistically Responsive Practices

Emotional Support

Family well-being is critical to child development, and service providers have a pivotal role in recognizing the need for and providing emotional support to families of children with hearing loss. The family may experience strong emotions, such as grief, especially at time of diagnosis; however, emotional support may be an initial, ongoing, or variable need (Scarcini et al., 2018; Gilliver et al, 2013). It is important for the provider to be aware of the variables that contribute to a family's emotional stress, acknowledge that families may experience fluctuating grief due to their child's hearing loss, and be competent in engaging in supportive and empathetic conversation in which the audiologist is responsive and sensitive through active listening. Providers can assist families in accessing additional supports, such as family support groups and other professionals, as needed.

Informed Choice and Unbiased Information

Informed choice is "the process wherein families gain the necessary knowledge, information and experiences to make fully informed decisions" (Moeller et al., 2013). Families make decisions based on (Young, et al., 2005):

- Information received
- Family values, beliefs, and culture
- Priorities and interests
- Availability and access to services
- Family economic or social circumstances

After a hearing loss diagnosis is received, families require a good foundation of knowledge and skills which help them make decisions and manage their child's needs. To best support families in making an informed choice, information shared by service providers should be evidence-based, accurate, well-balanced, and comprehensive (Muse et al., 2013). Families desire comprehensive information that is clear and consistent across providers (Russ, et al., 2004; Scarcini et al., 2018). Comprehensive means that all options should be discussed, with explanation of advantages, limitations, any uncertainties, and requirements for best outcomes (Jackson, 2011). This information should be conveyed in a straightforward manner and without judgement. Best practice is based on current knowledge, including published studies and outcomes research that supports evidence-based practice, understanding of child development, and intervention practices (ASHA, 2008a).

Providers should take care to avoid any bias in the presentation of information, as this can strongly influence family opinions and their future decisions (Matthijs et al., 2012). The presentation of bias can be reduced by providing information from a variety of sources, including written information, visual aids, and decision support tools, as well as encouraging family discussions with other qualified providers and other families of children with hearing loss (Matthijs et al., 2012; Porter et al., 2018). When there is a family need for information outside the provider's area of expertise, the provider will acknowledge this and guide the family in obtaining the needed information from other providers and/or resources.

Relationship Building/Family and Provider Partnerships

Building relationships with families is fundamental to developing family-provider partnerships that foster engaged, confident, and well-informed families. Family-provider partnerships encourage shared goal setting and decision-making, which leads to better quality of care for the child, as well as satisfaction and self-confidence amongst parents (Elwyn et al., 2012; Legare et al., 2008; Montori et al, 2017). It is critical that providers support families in their choice of communication outcome for their child and their choice to include or not include amplification as part of that desired outcome.

Partnerships can also strengthen family capacity to foster child development (Moeller, et al., 2013). Providers should recognize that a family's acceptance of a child's hearing loss diagnosis and confidence in their ability to support their child using learned skills influences their involvement in the intervention process (Meibos et al., 2016). Providers may need to adjust expectations of family engagement based on each family's unique circumstances and challenges, which may impact their capacity to be involved in intervention (ASHA, 2008a).

In all interactions with a family, the audiologist demonstrates empathy, responsiveness, and sensitivity through active listening and open-ended questions (ASHA, 2008b; Muse et al., 2013).
As described by Moeller and colleagues (2013), family-provider partnerships require:

- That family-identified needs, priorities, goals, and desires are understood, acknowledged, and supported;
- Open communication, information exchange, and the sharing of tasks;
- Maintaining trust, respect, honesty, and transparency; and
- Ongoing care and attentiveness.

Individualized Approach and Attention to Readiness

It is important to recognize that family experience and diversity (i.e., social, cultural, and linguistic) influences their perspective on hearing loss, their child's abilities, relationships with professionals and involvement in their child's intervention (Moeller et al, 2013; Sass-Lehrer, 2012). To best meet a family's needs, service delivery needs to be individualized. It is important to recognize that family circumstances vary, and some families may require additional or different supports through the intervention process. Steps should be taken to support these needs. For example, frequent follow-up appointments may be challenging for families to attend, so it may be helpful to check-in with families to see if scheduling those appointments in advance is preferred or if certain appointments may be carried out virtually.

Families value continued relationships with providers and individualized information and coaching that:

- Meets their perceived needs (which may change over time);
- Is evidence based, positive, and realistic based on their child (i.e., degree of hearing loss, additional challenges, etc.); and
- Enhances their confidence and competence and builds practical skills
  (Gilliver et al., 2013; McCracken et al., 2008; Fitzpatrick et al., 2008; Moeller et al., 2013).

Active listening and open-ended questions assist in the identification of family concerns, priorities and needs, and inform the timing, quantity, and detail of information provided (Luterman, 2006).

A provider's attention to family readiness is essential to providing information and initiating discussions about choices. To support readiness, encourage family-driven conversations, which allow them to share their perspective, ask questions and lead where the discussion goes (ASHA, 2008a).

Information provided and intervention options vary depending on the child's individual profile, and therefore should be tailored as appropriate. When sharing information:

- Ensure that the family has everything they need to receive the information (e.g., people present, pen and paper, etc.);
- Check-in with the family as they receive information. Use their feedback to guide your pace, timing, and amount/detail of information shared. Address emotions and concerns (Bosteels et al., 2012; Munoz et al., 2015); and
- Actively listen to the family, check for understanding, and allow them time to reflect on the information received (Munoz et al., 2015).

Families benefit from being offered information in various formats to suit their preferences. For example, instruction on hearing aid care may be provided using a written checklist, a checklist with visuals, demonstration, and/or video links for later viewing.

Socially, Culturally, and Linguistically Responsive Practices

Recognition of social, cultural, and linguistic diversity is important to provide appropriate, respectful, responsive, and inclusive services to all families. The quality of care and quantity of information provided should not vary due to factors of diversity, which include, but are not limited to (ASHA, 2017): age, disability, ethnicity, gender identity/expression, sex, sexual orientation, national origin (includes culture and language), race, or religion. Factors of diversity may influence behaviours and attitudes of both families and service providers, which can impact interactions, family-provider relationships, and service delivery.

Providers should be aware of any of their own biases and how they might influence service provision when working with families from similar or different cultural backgrounds (ASHA, 2017). This awareness allows the provider to reflect and take action to minimize any bias. Responsive practices may include being open and flexible in care, respectful of family choices, and ensuring accessibility of supports and resources.

Providers demonstrate respect of diversity and inclusivity by using people-first and bias-free language (AHS, n.d.). For example, the description "child with hearing loss" is preferred over "hearing impaired child" because it is people-first language.

When a provider is not proficient in the language of the family, interactions should involve a professional interpreter.

SUPPLEMENT 3:

Pediatric Amplification Collaboration between Public and Private Practice

Should your area have public and private audiologists following the same child, the below minimum communication points are recommended to ensure appropriate collaboration.

Communication should occur when:	Public Responsibility	Private Responsibility
New Diagnosis **Whoever diagnoses should make referrals:** **ENT, SLP, educational audiology, etc., and communicate with other parties using appropriate consent to disclose documentation, as needed**	Contact family for confirmation of private clinic and fax full report including: • History • Tympanometry • Ear-specific audiometry with air (and bone, as needed) • Frequency-specific findings (500, 2000, & 4000 Hz minimum) • Recommendations (if the date of next assessment is known, then share with private) • If any assessment components are missing, please provide an explanation of why	Contact public if no results received
Monitoring Assessment	Fax to private each time	Fax report/audiogram to public with frequency/ear-specific findings to avoid duplication. If assessment is overdue, or a need is identified for a sooner next appointment, contact public
A significant change in hearing	Immediate communication	Immediate communication
Concern with change in hearing	Immediate communication	Immediate communication
When a new test is needed for AADL purposes		Communicate with public
Financial issues surrounding or outside of 3rd party funding	Social worker to assist	Communicate with public; they can include the social worker to assist
Fitting		Let public know date of fitting and follow-up visits, if booked
Purposefully not fit to target		Communicate with public
Found to be below target	Communicate with private	
Broken equipment	Communicate with private	
Datalogging	Communicate	Communicate
Validation Measures/Questionnaire	Complete and fax to private	
Family concern with public care		Phone public
Family concern with private care	Phone private	
Discharge from the public audiologist/transfer of care	Fax report with detailed plan AND encrypted email to private to confirm transfer of care, as appropriate	Confirm transfer of care and receipt of all pertaining documents
AHS Community Audiology care is required following discharge from GRH/Stollery/ACH	Communicate transfer of care plan with private and make referral, as needed	Make referrals, as needed