



Washington State EHDDI Learning Community
Best Practices for Audiologic Assessment of
Infants and Young Children

2020

Purpose of guidelines

The purpose of this document is to provide best practice guidelines to support pediatric audiologists and other stakeholders in Washington State in accurate and timely assessment of hearing of infants and young children. These guidelines expand previous [2012 WA EHDDI Diagnostic Audiology Guidelines](#) and incorporate [2019 Guidelines from the Joint Committee on Infant Hearing \(JCIH\)](#). These guidelines were developed with a work group of WA state audiologists as well as input from a larger group of EHDDI stakeholders. These guidelines address the assessment of infants and children who have not passed newborn hearing screening or child hearing screening, who are at risk for hearing loss, and who are identified with permanent or temporary hearing loss. The goal of these guidelines is to provide helpful ideas for audiologists, but not to provide requirements for competent professionals.

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Principles of Care

- Audiologic assessments are provided by audiologists in Washington State and surrounding communities who have training, expertise and appropriate equipment to accurately assess the hearing of infants and children, maintain consistent practice in pediatric audiology, and provide family-centered care and access to appropriate referrals and resources.
- Families are supported with services in audiology centers that provide an environment that is welcoming and designed to minimize barriers to care. Interpreters are provided for all communication with the family in the language chosen by the family, as needed.
- Audiologists and EHDDI stakeholders strive to ensure that children benefit from timely screening, diagnosis and intervention. Historically JCIH guidelines have promoted the “1-3-6” timeline with the goals of screening by 1 month, diagnosis by 3 months, and intervention by 6 months. The new JCIH guidelines still support this timeline, but also recommend that states that are meeting these benchmarks should aim for a “1-2-3” timeline.
- Early hearing detection goals are to identify the hearing loss as close to onset as possible using a variety of methods to identify hearing loss across childhood. Newborn hearing screening detects most congenital hearing losses, but children with congenital mild or isolated hearing loss may pass newborn hearing screening. Some children who do not pass NHS may be lost to follow-up. Lastly, children can develop hearing loss at any age and ongoing screenings and hearing assessments are crucial for optimizing early detection.
- Audiologists use evidence-based guidelines to guide their pediatric audiology practice and use measures that have research evidence of accurate diagnosis of hearing in infants and children.
- Audiologists use equipment that is calibrated annually and monitored with daily biologic and listening check of all transducers. All assessments are conducted in full compliance with infection control policies and standards, and support cleaning procedures for equipment and examiners that are in direct contact with the child.
- Audiologists approach each assessment with an individualized plan for assessment measures and incorporate input from the family in developing the assessment plan.
- Families may decline screening and follow-up assessment and intervention.

Screening

Screening

- Refer to [WA State Newborn Hearing Screening guidelines](#) for detailed guidance.
- Newborn hearing screening (NHS) should be performed prior to discharge from the birth hospital, or no later than one month of age.
- No more than two attempts should be made to complete an initial NHS.
- Babies who did not receive a hospital NHS should have opportunities for outpatient NHS.
- Well-baby nursery NHS use either otoacoustic emissions (OAE) or automated auditory brainstem response (ABR), whereas NHS in the NICU must include ABR screening.
- When babies are transferred between hospitals during the neonatal period, the discharge summary should indicate if NHS was or was not performed. Recipient hospitals should complete screening if not completed previously or if a new risk factor for hearing loss develops.

Rescreening

- Infants who have not passed an initial newborn hearing screening should receive a rescreening about two weeks later but before one month of age. Rescreening should occur during an outpatient appointment and the family should have an appointment for the rescreening before discharge from the birth hospital.
- Rescreening should include both ears, even if the child did not pass the initial screen in one ear.
- Rescreening can be completed with either OAE or automated ABR for babies who have not spent time in a NICU. NICU graduates who did not pass ABR NHS should be scheduled for a diagnostic ABR evaluation with an audiologist.
- If rescreening is performed by an audiologist, the testing should proceed to diagnostic testing within the same visit, if possible.
- If the child needs to be referred to another facility for a diagnostic audiologic evaluation, newborn hearing screening programs should identify a referral pathway for each child to ensure that each child has access to an audiologist.

Assessment protocol

Arrange assessment

Scheduling

- If a baby does not pass newborn hearing screenings, the baby is scheduled for a comprehensive diagnostic evaluation with an audiologist. Having two assessments scheduled within a few weeks can ensure that all information can be obtained across the two assessments, if both visits are needed.
- Clinics provide families with specific verbal and written instructions before the appointment to maximize the child sleeping for the ABR assessment (e.g., “Please bring your child to the appointment tired and ready to take a nap as the testing must be completed when a child is asleep. Please prevent your child from sleeping on the car ride and limit sleep several hours prior to the appointment.”).

Timing

- For babies who do not pass newborn hearing screenings, audiologists strive to complete the initial diagnosis by 2 to 3 months of age and minimize the number of evaluations to determine a diagnosis.
- When ABR evaluations are conducted within the first 3 months, assessments capitalize on infants participating in the evaluation under natural sleep. Learning about the child’s hearing starts the intervention process that maximizes child development.
- Babies with prolonged NICU stays over 3 months benefit from early identification of hearing loss with audiologic evaluation prior to discharge from the NICU whenever possible.

Sedation

- Clinics with the resources to do so, provide sedation for ABR assessment for older infants and children who have not had successful assessments during natural sleep AND are not developmentally able to provide reliable responses to sound for determining hearing levels. Due to the risks of sedation, sedated ABR assessment is recommended only if the results will change the course of treatment. Sedation protocol of the institution is followed to ensure safety.

Develop assessment plan

Goals

- For infants and children being seen by an audiologist for an audiologic assessment, the goal of the assessment is to determine the child's hearing levels for the purposes of diagnosis, to share the new information with the family and provide intervention options. Audiologists strive to obtain adequate information for a diagnosis in one session with the expectation that confirmation and additional information will be obtained at upcoming evaluations.

Strategies

- The assessment strategies, order of assessments, and number of assessment measures is determined by the purpose of the assessment and the child's risks for hearing loss, but the purpose can be expanded to be more detailed as the assessment proceeds.

Order

- The audiologist determines the order of assessment measures with the most valuable measures conducted first and with the expectation that not all measures may not be completed due to the child awakening or habituating. Measures of behavioral hearing thresholds provide the greatest diagnostic strength and, as such, rare recommended as the first measure, if the child is developmentally ready to participate and, if not, ABR testing is used to estimate hearing levels based on ABR thresholds. The order of the assessment is modified based on the child's disposition; if a child arrives asleep, testing should quickly proceed to ABR testing, if indicated based on age. Measures that can trigger children to be upset and fearful, such as immittance and OAE testing, are typically not completed prior to behavioral assessment, as the child's participation in behavioral assessment may be adversely impacted. In addition, knowledge of OAE and middle ear measures prior to conducting behavioral or ABR assessment may bias the audiologist during the behavioral/ABR assessment or dissuade the audiologist from persisting with behavioral/ABR testing. Children who show middle ear fluid/involvement are candidates for ABR/behavioral testing; documenting hearing levels is crucial in managing the middle ear issue as well as determining if permanent hearing loss is also present.

Cross-check

- The audiologist incorporates the cross-check principle into the assessment and uses multiple measures to strengthen the diagnosis. Additional measures both strengthen the diagnosis, and rule out additional disorders.

Family input

- The audiologist incorporates family priorities into the assessment plan by querying family's objectives and identifying the important questions the family would like to be answered by the assessment.

Conduct case history

- Audiologists ensure access to the child's pertinent medical records and review these records prior to the appointment. Audiologists access newborn hearing screening/rescreening findings in medical records and the WA EHDDI database prior to the appointment.
- Audiologists conduct a detailed case history with family at each appointment, covering the topics below, if not covered previously. The conversation is opened by the audiologist providing a clear, concise overview of the purpose of the assessment (Why are we here?) as well as a summary of past assessments of the child's hearing (What do we know about the child's hearing so far?). Audiologists use both yes/no questions as well as open-ended questions to facilitate discussion. Case histories that flow in a conversation and discussion format will facilitate a family's engagement rather than an interview style.
- Case history from records and from the family should cover the following topics:
 - Hearing history: previous hearing screenings and audiological evaluations
 - Perinatal/Neonatal history: including gestation, NICU stay, ototoxic medication, hyperbilirubinemia with exchange transfusion, asphyxia, hypoxic ischemic encephalopathy, ECMO treatment
 - Congenital infection (cytomegalovirus, Zika, rubella, herpes simplex, toxoplasmosis, syphilis)
 - Medical: postnatal infections (meningitis, mumps, measles), head trauma, chemotherapy
 - Craniofacial malformations (ear dysplasia, microcephaly, hydrocephalus)
 - Syndrome: characteristics of a syndrome that can include hearing loss
 - Family history of childhood hearing loss
 - Middle ear history: ear fluid and infection, ear tubes, drainage, ear pain
 - Developmental progress in hearing and communication
 - Parent impression of child's hearing
- The audiologist determines if the child has any risk factors for progressive hearing loss and incorporates these risks in providing recommendations for monitoring hearing; see [monitoring hearing guidelines](#).
- For children with permanent hearing loss and hearing technology, case history questions focus on family goals and actions to support goals, technology use and issues, access to support services, developmental progress, follow-up with referrals, as well as a general discussion of family concerns and need for resources.

Maximize validity of assessment measures

- The audiologist selects assessment measures and test parameters that are appropriate for the child's age/developmental level and implements measures using appropriate methodology; refer to Method section for detailed guidelines for:
 - 0-6 months: [ABR](#)
 - 6-24/30 months: [VRA](#)
 - 24/30 months to 5/8 years: [CPA](#)
 - 5/8 years to 21 years: [Conventional Audiometry](#)
 - [Speech Audiometry](#)
 - [Middle Ear Measures](#)
 - [Outcome Questionnaires](#)
- The audiologist maximizes the child's participation in each assessment measure using strategies that improve both validity of the measure as well as the completeness of the measure.
 - For infant assessment, strategies to ensure that the child is quiet and not moving during ABR and OAE testing are crucial for obtaining valid measures. The child should be either held or laying in a safe bassinet/seat determined by the parent to be the position that is most familiar to the child. Swaddling the baby in a blanket can be used to encourage sleep and decrease movement during sleep.
 - For young children, the quality of recording OAE and tympanometry responses are maximized by strategies to prevent the child from removing the ear probe as well as distracting the child by looking at a toy or test assistant/parent. Parents are instructed to use a passive restraint "hug" to reduce the child's movement during the procedure.
 - For behavioral assessment using VRA and CPA, a test assistant is crucial for maximizing the validity of threshold measures. Clinics that offer pediatric audiologic assessment are encouraged to train an audiology assistant or staff member or use another audiologist as the CPA/VRA test assistant. The VRA/CPA test assistant has a crucial role in reducing false responses and promoting participation for an extended period so that a complete assessment of threshold levels can be completed in one test session. In addition, the assistant can quickly change transducers and work with the parent to maximize the child's participation in the assessment. For CPA, some clinics may have access to portable audiometers that allow the audiologist to also function as the test assistant with the child.

Determine the child's current hearing levels

1. What are the child's crucial hearing levels? Establish crucial thresholds.

- a. The audiologist measures behavioral hearing thresholds or ABR thresholds for a high and low frequency stimulus in each ear (e.g., 2 kHz and .5 kHz).
 - No response ABR: If there is no response or poor waveform morphology for ABR at equipment limits, the audiologist determines if hearing loss is a profound SNHL vs auditory neuropathy spectrum disorder (ANSD) by measuring ABR responses to high-level (e.g., 90 dBnHL) clicks to determine if cochlear microphonic response is present/absent in each ear: [see ABR method section](#).
 - Soundfield (SF) VRA: If earphone testing is not possible for VRA assessment based on the child's refusal, the audiologist measures crucial thresholds in soundfield. If behavioral thresholds are elevated using soundfield stimuli, unmasked bone conduction testing is adequate for comparison to AC SF thresholds.
 - SAT VRA: If behavioral responses to frequency-specific stimuli using VRA are inconsistent despite multiple conditioning trials, the audiologist provides conditioning with a speech stimulus and determines [speech awareness threshold \(SAT\)](#). If SAT is established, return to testing with frequency-specific stimuli.
 - CPA or VRA: If responses during CPA testing are inconsistent despite multiple conditioning trials, the audiologist changes testing to VRA and provides VRA conditioning to obtain frequency-specific thresholds.
- b. If hearing/ABR thresholds are elevated, the audiologist measures 2kHz-evoked bone conduction thresholds in each ear. Masking in the contralateral ear is needed for behavioral measures and may be needed for ABR testing. If masking cannot be conducted, unmasked bone conduction thresholds in children with symmetrical hearing across ears have validity. For a child, whose type of hearing loss (conductive, sensorineural, neural) has been established previously and the child shows stable hearing thresholds, repeating BC testing is not necessary.
- c. If the audiologist questions the validity of threshold measures, the audiologist:
 - re-checks thresholds that have questionable validity or are "outliers" compared to other thresholds.
 - cross-checks frequency specific thresholds with a speech detection measure using SAT or SRT; SRT/SAT threshold should be within 10 dB of the child's lowest frequency-specific threshold.

2. What are the child's broad hearing levels? Establish a broad range of thresholds.

- a. The audiologist obtains hearing/ABR thresholds across a broad frequency range in each ear using a pediatric-based frequency order (e.g., (.2, .5), 4, 1, 8, .25, 6 kHz) as well as alternating ears to maximize obtaining the information for diagnosis and providing recommendations.
 - AC thresholds in each ear at .5 and 2 kHz are the minimum information needed for a diagnosis. The diagnosis is strengthened with thresholds at 4 kHz in each ear. Click-evoked ABR thresholds can be used as a cross-check, if needed for poor waveform morphology, but are not used for determining the configuration of the hearing loss.
- b. The audiologists obtains bone conduction thresholds for each ear at additional frequencies with elevated AC thresholds, using masking in the contralateral ear.

Assess the function of the peripheral auditory system

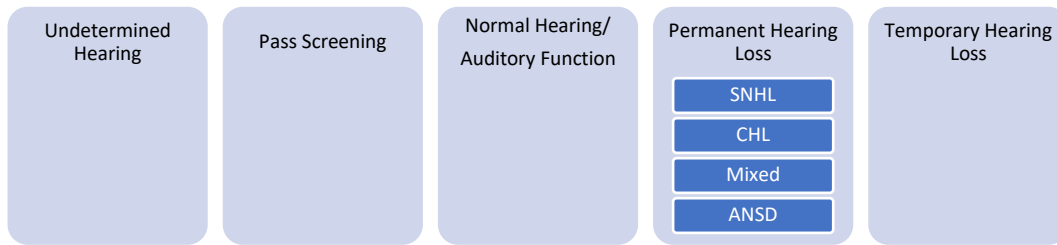
- Middle ear measures
 - The audiologist measured middle ear function using stimuli and Interpretation based on age-appropriate guidelines/norms. Use [middle ear measures method section](#) for specific guidelines.
 - The audiologist completes otoscopic inspections of each ear.
- OAE measures
 - The audiologist obtains DPOAE or TEOAE responses in each ear using appropriate stimuli and interprets using age-appropriate guidelines/norms. Use [OAE method section](#) for specific guidelines.

Assess functional hearing

- The audiologist measures speech recognition using appropriate speech stimuli based on the child's developmental level. Refer to [speech audiometry method](#) for specific guidelines.
- The audiologist implements family outcome questionnaires to assess the family's perspective on the child's functional communication at home and in the community. Refer to [outcome questionnaire section](#) for appropriate questionnaires across age levels.

Interpret findings and provide recommendations

Determine the diagnostic category for the child



- **Undetermined hearing levels**
 - **Definition:** A diagnosis is not obtained at the visit; the child’s hearing status is undetermined.
 - **Examples:**
 - a child not sleeping or adequately quiet for quality ABR recording
 - a child shows behavioral hearing responses that are inconsistent across level and valid hearing thresholds are not established
 - limited information is obtained and does not qualify as “pass screening” or “normal hearing”
 - **Recommendations:** For children with incomplete assessment, the timeline for the follow-up assessment and the type of assessment (ABR-natural sleep, ABR-sedated or behavioral) is determined by a number of factors including the child’s risk factors for hearing loss and the likelihood of the child participating in the type of assessment, as well as the family’s availability.

- **Pass screening**
 - **Definition:** the child passes the hearing screening, but a full diagnosis is not completed
 - **Examples:**
 - A child shows present otoacoustic emissions in each ear across the frequency range. Based on present OAE responses, a mild hearing loss and ANSD have not been ruled out and the findings should not be interpreted as indicating normal hearing/auditory function but should be interpreted as “passing a screening”. OAE screening alone is not adequate for assessment of hearing of children who have not passed newborn hearing screening and rescreening.
 - A child shows normal soundfield behavioral hearing thresholds to frequency-specific stimuli. When no individual ear measures are obtained, significant unilateral hearing loss cannot be ruled out.
 - **Recommendations:** The timeline for further assessment for children who pass a screening with an audiologist should be determined by the child’s risk for hearing loss and hearing history as well as the [monitoring hearing guidelines](#).

- **Normal hearing**
 - **Definition:**
 - Normal hearing is determined when ear-specific, frequency-specific thresholds are obtained at levels of 0 to 20 dBHL/dBeHL across the frequency range in each ear via either behavioral assessment or ABR and based on a minimum of thresholds for both a low and high frequency (.5 and 2 kHz) in each ear.
 - The diagnosis of normal hearing is strengthened by including thresholds at additional frequencies, particularly 4 kHz. Isolated hearing losses can be ruled out when thresholds are obtained for additional frequencies (.25, 1 kHz, etc.).
 - The diagnosis of normal hearing is strengthened by peripheral auditory system measures (middle ear and OAE measures).

- Recommendations for continued monitoring of children with normal hearing are determined by the child's risk for hearing change: see [monitoring hearing guidelines](#).
- Temporary hearing loss
 - Definition: A diagnosis of temporary hearing loss is supported by evidence of blockage in the outer and/or middle ear and evidence of conductive hearing loss.
 - Otitis media and associated conductive hearing loss is the most common cause of temporary hearing loss in young children. Close monitoring and medical management of the conductive hearing loss associated with otitis media minimizes the impact on children's development.
 - Recommendations:
 - When a significant temporary hearing loss is identified, follow-up audiological monitoring should be scheduled to allow adequate time for resolution but also a short enough time period to identify chronic issues, typically in 4 to 6 weeks.
 - Children who show persistent middle ear fluid and/or recurrent ear infections for 3 months or more should be offered an evaluation with an otolaryngologist for medical management and consideration for tympanostomy tubes. All children should receive a post-tubes hearing evaluation to monitor effectiveness of the treatment and to determine if any permanent hearing loss exists.
 - Children who have additional risk factors should be referred to an otolaryngologist for evaluation and management on a shorter time frame: permanent hearing loss, craniofacial abnormalities, syndromes with high risk for middle ear issues, or children with speech and language delays.
- Permanent hearing loss
 - Permanent hearing loss is determined when air conduction ear-specific, frequency-specific thresholds are obtained at levels of 25 to 115+ dBHL/dBeHL across the frequency range in each ear using either behavioral or ABR assessment.
 - A complete diagnosis of permanent hearing loss is based on thresholds for a low and high frequency (.5 and 2 kHz) in each ear. The diagnosis of permanent hearing loss is strengthened by including thresholds at additional frequencies, particularly 4 kHz. The configuration of the hearing loss is more detailed when thresholds are obtained at additional frequencies (1, 8, .25 kHz, etc.).
 - Responses to bone conduction stimuli in each ear are crucial for determining type of hearing loss.
 - The diagnosis of permanent hearing loss is strengthened by peripheral auditory system measures (middle ear and OAE measures) and should be included in an initial diagnosis.
 - Measures of functional hearing using speech recognition measures and family questionnaires provide additional information about the impact of the hearing loss and are completed, if possible, given the child's developmental level.
 - Types of permanent hearing loss
 - Sensorineural: hearing loss isolated to the cochlea/inner ear
 - a. Air conduction thresholds at levels of 25 to 115+ dBHL/dBeHL
 - b. No significant gap between air conduction and bone conduction thresholds
 - c. Normal outer/middle ear function
 - d. Absent otoacoustic emissions at frequencies with HL > 30 dB
 - e. Absent acoustic reflexes with HL > moderate

- Conductive: Permanent conductive hearing loss due to outer/middle ear malformation
 - a. Air conduction thresholds at levels of 25 to 70 dBHL/dBeHL
 - b. Bone conduction thresholds at levels of 0 to 20 dBHL/dBeHL
 - c. Outer/middle ear function
 - i. Cannot test due to atresia of ear canal
 - ii. Abnormal: reduced or high compliance of the middle ear system
 - d. Absent otoacoustic emissions and absent acoustic reflexes
- Mixed
 - a. Some children show a hearing loss that has both sensory and conductive components that are both permanent.
 - b. Some children show a permanent hearing loss as well as a temporary conductive overlay.
 - c. Air conduction and bone conduction thresholds show a significant hearing loss from both sensory and conductive types.
- Auditory Neuropathy Spectrum Disorder (ANSD)
 - a. Absent ABR or abnormal waveforms with no repeatable wave V responses
 - b. Present cochlear microphonic and present otoacoustic emissions
 - c. Absent acoustic reflexes
 - d. Behavioral hearing thresholds vary across individuals with ANSD with thresholds from the normal to the profound range
- Recommendations:
 - Recommendations: [see provide options and referrals for details](#)
 - Audiological monitoring: For children with permanent hearing loss, the goal of ongoing assessment is to monitor the child's hearing/ABR thresholds across a broad frequency range and provide additional information as the child develops and is able to participate in more detailed assessment. Hearing technology is adjusted based on ongoing assessment, if used. At each assessment, order of ear and frequency is determined based on missing information from most recent assessments as well as data that is most valuable in setting hearing aids, if used. Children with permanent hearing loss are seen for audiologic assessments on a schedule of:
 - Every 3 months in the first year of life
 - Every 6 months from 1 to 5 years of age
 - Yearly over the age of 5
 - More frequent evaluations if there is concern for hearing change or child progress.

Communicate with families

[See WA EHDDI Family-Centered Care Best Practices for detailed information.](#)

- Conversations with families involve sharing information, but audiologists also use skills of active listening to attend to family questions, concerns, and comments and provide emotional support. Supporting families with collaborative, informed decision-making is crucial as families need to make a number of decisions in the early stages of learning about their child's hearing, as well as on-going decisions over the child's life. Informed choice does not just mean that the audiologist provides neutral information, but also draws attention to the benefits, risks, and family responsibilities that are associated with decisions and choices.
- In the early stages of learning about a child's hearing, there may be limited information based on only screening information or diagnostic evaluations with inconclusive findings. Families can be frustrated with the lack of information and the burden of multiple appointments. Audiologists can support families by acknowledging the family's frustration and committing to providing more conclusive information about the child's hearing with timely and accurate follow-up assessment. Audiologists should have a mechanism in place to track follow-up appointments for children who need ongoing audiological monitoring, so that if appointments are missed the family is contacted to reschedule and the primary care physician is notified.
- When a child has been identified as deaf or hard of hearing (DHH), the audiologist is responsible for describing the impact of the hearing levels on the child's language, learning, and social-emotional development. Audiologists are most effective when conversations include family-friendly terminology and provide the amount of detail that the family needs at the moment, based on their questions and comments. Audiologists recognize that diagnostic test details that are important to the audiologist are not necessary details for the family in the early stages of learning about their child's hearing; families are more interested in what the child can and cannot hear and how hearing loss can impact a child's communication and development. Families benefit from a balance between realistic expectations that their child will be impacted by hearing loss along with realistic hope for their child's development. Lastly, audiologists provide a clear explanation about referrals and what will happen next.

Document findings

- Clinical reports include:
 - demographics: name, medical record number, birth date, date of test, and place of test
 - case history including: perinatal, medical, middle ear, hearing, family childhood hearing loss, current interventions, current hearing technology
 - test details with graphs, waveforms, tracings
 - diagnosis and supporting interpretation of each audiological test
 - documentation of testing that was attempted, but could not be completed and reason
 - interpretation of discrepancies across audiological tests
 - description of impact hearing loss may have on communication and development
 - follow-up plan and recommendations
 - contact information (phone and email) and credentials of the audiologist
- Clinical reports are shared with family and team members by mail, email, or fax, protected by secure methods that ensure privacy and with appropriate signed consent.

Provide options and referrals

Children who are deaf or hard of hearing (DHH) and their families benefit from early identification of childhood hearing loss and opportunities to address communication as early as possible. When families are provided with information about the importance of early intervention, they can take immediate steps to choose options of communication modes and hearing technology that support their goals for their child. All children benefit from early identification and intervention, regardless of other medical or developmental conditions.

Hearing Technology

- For families wishing to pursue hearing technology, EHDDI stakeholders strive to maximize early access, with a goal of fitting hearing technology within one month of identifying the hearing loss.
- Children have access to hearing technology that is appropriate for their hearing loss and age. Loaner hearing technology is offered to maximize the child's early auditory access, if needed.
- Children need medical clearance from an otolaryngologist prior to fitting, in accordance with [Washington state guidelines](#). Children and their families benefit from care coordination between audiologists and otolaryngologists in the community as well as high-priority expedited scheduling to ensure hearing technology fitting is not delayed.

Otologic Evaluations

- Children who are identified as DHH are referred for a comprehensive otologic evaluation with an otolaryngologist to determine the etiology of the hearing loss, if supported by the family, with testing for the most common causes of sensorineural hearing loss including genetic testing and testing for congenital cytomegalovirus, as well as the options of a cardiac evaluation (electrocardiogram) and vision evaluation.
- If there is evidence or concern for a treatable audiologic issue, audiologists refer children immediately to an otolaryngologist for treatment. Audiologists ensure that a follow-up hearing evaluation is scheduled at the time of referral to an otolaryngologist to ensure that the child receives timely follow-up assessment.

Family and Educational Support Services

- When an audiologist identifies a child under the age of 3 as DHH, the audiologist refers the family to Part C Birth to 3 services, preferably within 48 hours of diagnosis, per JCIH, or within 1 week of diagnosis, per Part C guidelines. Referral to services should not be delayed until hearing aid fitting or confirmation of the hearing loss. Audiologists document and report to WA EHDDI when families decline Part C referrals. Audiologists use the WA EHDDI database for submitting a referral and also send audiologic records to the family resources coordinator (FRC) at the time of referral.
- When an audiologist identifies a child age 3 to 5 years as DHH, audiologists help families access preschool services by referring the family to the Child Find program within their local school district.
- When an audiologist identifies a child over the age of 5 who is DHH, the family is provided with information about accessing appropriate accommodations and support services in the public school and family consent is obtained for the audiologist to communicate and share findings with the school district audiologist and/or the school nurse.

Family Support

- Families benefit from meeting with adults who are deaf or hard of hearing. The WA Office of Deaf and Hard of Hearing Family Mentor program can be contacted at familymentorcoordinator@gmail.com
- Families benefit from contact with other parents of children who are DHH. Washington Hands and Voices offers trained parent-to-parent support and families can be referred or contact the WA Hands and Voices Guide by Your Side program at 425-268-7087 or GBYS@WAhandsandvoices.org

Collaborate with EHDDI Stakeholders

- Collaboration in the WA EHDDI system involves sharing information with members of the team involved in the child's care: family of the child, primary care physician, otolaryngologist, family resource coordinator, Birth to 3 services provider, WA EHDDI system, school audiologist/team, as well as other professionals.
- Stakeholders share findings of screenings and audiological diagnoses with the WA EHDDI system in a timely manner after each screen and diagnostic assessment through the online database, hearing screening cards, or by fax.
- Collaboration involves discussion in-person or via phone/videoconferencing.

Provide Resources

Audiologists offer resources to all families whose children have been identified as DHH in an accessible format and language. Resources include information about all communication approaches and hearing technology options.

- Resources about newborn hearing screening
 - Newborn Hearing Screening Brochure: [English \(PDF\)](#), [Spanish \(PDF\)](#), and [Russian \(PDF\)](#).
 - [Video about newborn hearing screening](#)
- Resources about the early identification of hearing loss
 - [Family video on importance of early detection](#)
- Resources for families whose children have not passed newborn hearing screening
 - [Clinics in WA state and surrounding areas that offer diagnostic audiologic assessment](#)
 - Brochure for Rescreen: [English \(PDF\)](#).
 - Learning about Hearing Loss - A Roadmap for Families: [English \(PDF\)](#), [Spanish \(PDF\)](#), [Mandarin \(PDF\)](#), and [Russian \(PDF\)](#).
 - Brochure for Audiology Referral: [English \(PDF\)](#), [Spanish \(PDF\)](#), and [Russian \(PDF\)](#).
 - WA EHDDI Mini-notebook about hearing assessment and hearing loss for Parents in [English \(PDF\)](#) and [Spanish \(PDF\)](#)
- Resources for families with children who have been identified as deaf or hard of hearing
 - Resource Notebook for Families of Children who are Deaf or Hard of Hearing: [English \(PDF\)](#), [Spanish \(PDF\)](#), [Mandarin \(PDF\)](#), [Russian \(PDF\)](#), and [Somali \(PDF\)](#). Please contact the EHDDI program for hard copies in English and Spanish: ehddi2@doh.wa.gov

Monitor Hearing

All children should receive ongoing screening and assessment to monitor hearing levels and development of communication skills. All children are at risk for hearing change and should have regular monitoring of hearing and language development. Monitoring guidelines are based on 2019 JCIH¹.

- All children who have passed NHS and have a **“high” risk of hearing change** should have an audiological evaluation of hearing **within 3 months after the occurrence** of the following risk factors:
 - Congenital cytomegalovirus (CMV) infection; monitor with yearly hearing evaluations until age 3.
 - Extracorporeal membrane oxygenation (ECMO): monitor with yearly hearing evaluations until school-age.
 - Bacterial and viral meningitis or encephalitis; monitor with yearly hearing evaluations until school-age.
 - Head trauma involving basal skull/temporal bone
 - Chemotherapy
 - Children with congenital Zika infection (Zika virus laboratory evidence in mother and infant with or without clinical finding) should have an ABR hearing rescreen at 1 month and a ABR evaluation at 4 to 6 months or a behavioral hearing evaluation by 9 months.

- All children who have passed NHS and have a **“medium” risk of hearing change** should receive an audiological evaluation of hearing **by 9 months of age**. “Medium” risk factors include:
 - Family history of childhood hearing loss. Additional monitoring frequency based on family history.
 - NICU stay greater than 5 days
 - Hyperbilirubinemia with exchange transfusion
 - Aminoglycoside treatment more than 5 days
 - Asphyxia or hypoxic ischemic encephalopathy
 - In utero infection of herpes, rubella, syphilis, or toxoplasmosis
 - Craniofacial malformations (ear dysplasia, microcephaly, hydrocephalus)
 - Characteristics of a syndrome that includes hearing loss

- All children who have who have passed NHS and have a **“low” risk for hearing change** or are identified as “high” or “medium” risk that have completed recommended monitoring above should have regular child hearing screenings both in the medical home and in the public schools.
 - All children should receive child hearing screenings at well-child visits at age: 4, 5, 6, 8, 10 years, once between 11 and 13 years, 15 and 17 years, and 18 and 21 years. All children enrolled in public school should receive school hearing screenings at the following grades: K, 1, 2, 3, 5, 7.
 - All children should receive monitoring of communicative development with the following monitoring schedule at well-child visits:
 - Surveillance of communication skills at: 1, 2, 4, 6, 12, 15, 24 months, and yearly at 3 to 21 years of age.
 - Developmental screening at: 9, 18, and 30 months or a caregiver or provider concern.
 - Risk assessment for hearing at every well child visit from 1 month to 3 years of age.
 - If a child does not pass a hearing screening and/or the communication screening or if the provider or family has a concern regarding hearing or language, the child should be immediately referred to an audiologist for assessment and for a speech-language evaluation.

Method for Assessment

Method: Auditory Brainstem Response (ABR)

- Preparation of infant: The audiologist cleans each site on the child's head (high forehead, low mastoids) with an abrasive skin prep gel. Earlobe placement may be elected instead of mastoid and may be beneficial during BC testing. To maximize a high-quality recording, electrode impedance should be less than 5 kOhms at each site and within 2 kOhms of each other. The child should be either held or laying in a safe bassinet/seat determined by the parent to be the position that is most familiar to the child. Swaddling the baby in a blanket can be used to encourage sleep and decrease movement during sleep. The audiologist may have limited access to monitoring the transducer of the ear the baby is sleeping on; it may be beneficial to rotate the child gently to optimize visual monitoring of the earphone of the test ear.
- Transducer:
 - Insert earphones are used for ABR assessment with the exception of those with outer ear anomalies where use of a circumaural TDH earphone is needed. To retain the insert in the ear while the baby moves during the session, secure with tape across the pinna.
 - For bone conduction (BC) ABR testing, the audiologist or assistant holds the BC oscillator in place on the superior/upper part of the infant's mastoid with the index finger pressing the oscillator firmly on the mastoid and thumb and middle finger on either side of the lead/cord. Insert earphones do not need to be removed during BC testing. BC testing of each ear should be completed with the BC oscillator on the test ear mastoid and not on the contralateral mastoid.
- Stimuli:
 - Tone burst stimuli: 2, .5, 4, 1 kHz tone bursts, Blackman-gated tone burst stimuli with 2 cycle rise/fall and no plateau at a rate of 33.3/sec or 39.1/sec.
 - Masking: The audiologist uses appropriate masking for air conduction with > 60 dBHL difference between ears and during bone conduction testing, recognizing that due to the structure of the infant skull, less crossover is likely.
- Method:
 - Data collection: For each stimulus condition, the audiologist collects a minimum of 2 responses/replications, each comprised of 1000 to 2000 sweeps, and obtains a 3rd replication if there is not agreement between the 2 responses or to reduce uncertainty. Filter settings: 30 to 1500/2000 Hz with no notch filter. Time window: 25 msec.
 - Noise reduction: The audiologist pauses data collection based on child's movement on EEG and monitors the level of noise in the recording, with responses with noise levels of less than 25nV. Impedance of the electrodes is periodically checked during the session.
 - Steps: use a 20 dB down/10 dB up step size to maximize the number of thresholds. For children using hearing technology, a 5 dB step size is helpful in setting hearing aids.
- Interpretation
 - Wave V is identified as a peak within the expected latency range, typically followed by a negative peak/trough (V'/SN10); for low amplitude responses, the SN10 response may be crucial for identifying a response. The audiologist classifies the responses at each stimulus condition as "present" if wave V is identified, "absent" if wave V is not present, or "inconclusive" if noise in the response interferes with the identification of presence or absence of wave V.

- To assist in evaluating the validity of the responses, the audiologist compares wave V latency across test levels both intra-aurally and inter-aurally to verify that latency of wave V is consistent. The audiologist compares the child’s latency values to normative latency values for the stimulus condition.
- Care should be used in interpreting responses to 500 Hz stimuli as it may be more challenging to obtain responses within the normal hearing range due to challenges with fit of the earphone.
- ABR threshold is determined at each stimulus condition, indicated by the lowest level at which responses the child demonstrates consistent wave V responses. ABR threshold in dBnHL values are converted to dBeHL using correction factors established within the clinic or using published guidelines, as suggested in the table below⁴. Normal hearing function is defined as ABR thresholds at levels of 0 to 20 dBeHL.

ABR	500 Hz	1000 Hz	2000 Hz	4000 Hz
Normal range of dBnHL thresholds	35-45 dBnHL	20-30 dBnHL	15-25 dBnHL	10-20 dBnHL
dBnHL to dBeHL correction for AC	-15 dB	-10 dB	-5 dB	0 dB
dBnHL to dBeHL correction for BC	+10 dB		0 dB	
Normal range of dBeHL thresholds	0 -20 dBeHL	0 -20 dBeHL	0 -20 dBeHL	0 -20 dBeHL
Expected latency values for infants	12-16 msec	10-14 msec	8-11 msec	7-10 msec

- For infants who show no response or poor waveform morphology to tone burst stimuli up to maximum output levels of the equipment, the audiologist assesses responses to click stimuli at a slow rate (13.3/sec) at 90 dBnHL to both rarefaction and condensation stimuli as well as to a control run at 90 dBnHL with the earphone tube clamped closed. If an infant has ANSD, the child will show a cochlear microphonic (CM) response but will show no CM on the control run. A stimulus artifact will be present on both control and stimulus runs and should not be interpreted as a CM.
- Other evoked potentials including ASSR and ABR with pure-tone and chirp technology are emerging as alternative methods for assessing hearing function. Several manufacturers offer chirp stimuli for ABR assessment. Use of these stimuli should be approached with caution as age-dependent normative data for children with hearing loss and agreement with ABR chirp thresholds and behavioral pure tone thresholds have not been established. JCIH guidelines¹ suggest further evaluation of these methods to determine if they meet criteria to be included in best practices.

Method: Behavioral Hearing Assessment: Visual Reinforcement Audiometry (VRA)

- Age: VRA is appropriate for infants and children age 6 months to 30 months developmental age.
- Transducers: Insert earphones are preferable for assessment of infants and toddlers to maximize fit and head-turns. Children with atresia should have air conduction thresholds measured with circumaural headphones. Soundfield testing may be elected due to the child's rejection of the earphone. Bone conduction should be used with a pediatric headband that holds the bone oscillator in the appropriate position with adequate tension.
- Equipment/support needed: a variety of centering toys as well as simple holdable toys that can be sanitized and a trained VRA test assistant.
- Stimuli:
 - Use frequency-specific pulsed stimuli: pure-tones or narrow-band noise stimuli. Use either narrow band noise or FRESH noise (FREquency Specific Hearing assessment noise); young infants may be more responsive to noise stimuli. Frequency-specific stimuli in soundfield must be narrow band or warbled/frequency-modulated.
 - Speech stimuli (live voice) are used for children having difficulty conditioning to frequency-specific stimuli or for a cross-check of frequency-specific thresholds; see speech awareness threshold in [speech audiometry](#)
- Conditioning trials: At the beginning of the test session, the audiologist pairs the stimulus and the reinforcer at an audible level (20 dB above presumed threshold or at 50-80 dBHL for unknown hearing status).
 - Conditioning with frequency-specific stimuli is preferable, but a speech stimulus is used if the child cannot be conditioned with frequency-specific stimuli.
 - The level, ear, and frequency of the conditioning stimulus is adjusted to ensure that conditioning and probe trials are audible.
 - Re-conditioning may be needed later in the test session if the child habituates and no longer responds to audible stimuli.
 - Vibrotactile conditioning may be needed for children with profound hearing loss, by conditioning with a low frequency stimulus at maximum output of the bone oscillator.
 - Probe trials: The audiologist presents a stimulus at the same level used during conditioning trials to determine if the child is conditioned. Threshold search begins after a response on a probe trial; if no response, conditioning trials continue.
- Control trials: The audiologist may measure the child's responses during control/silent trials to determine the child's rate of false responses. Valid testing occurs when the false-positive rate is <30%.
- Toss trials: if child is not ready to listen during a test trial, the audiologist does not record the child's response, and repeats the trial.
- Inter-stimulus intervals: The audiologist varies the time between stimuli (inter-stimulus interval) to avoid a pattern that promotes false-positive responses.
- Reinforcement: Audiologists use a variety of reinforcement with mechanical lighted toys as well as video reinforcers to maintain the child's interest. The reinforcer should be on the same side of the room as the ear/speaker for the stimuli (e.g., right insert, right reinforcer). Social reinforcement by the test assistant is added if visual reinforcement is minimally rewarding for a child.
- Response: The audiologist determines if a head turn response occurs during a 4 second response window: 2 seconds during the stimulus presentation and 2 seconds after the stimulus, to observe off-responses/late responses. For children with motor delays, an expanded response window may be needed.
- Steps: The audiologist uses a 20 dB down/10 dB up step size for children whose hearing levels are unknown and uses 10 dB down/5 dB up for children who have hearing loss.
- Stopping rule/threshold level: Threshold is defined as the lowest level where the child shows a minimum of 2 responses/or responses to >50% of the trials. A screening level of 20 dBHL may be elected due to a child's noise.
- Worksheet: Due to the variability in young children's responses to sound, audiologists may record every trial, indicating if the child responded or did not respond; a VRA worksheet or audiogram can be used with symbols:

+ for head turn, 0 for no head turn, C for conditioning trial. Examples of VRA worksheets are available in the [Appendix 1 of the Ontario Assessment Guidelines](#)

- VRA test assistant: Use of a trained test assistant for VRA is crucial in maximizing the validity and completeness of testing.
 - Ready to listen: The VRA test assistant uses a centering toy to maintain the child in a ready to listen position to minimize false-negative and false-positive responses.
 - If child is too engrossed in a centering toy that impacts attention to listening, the assistant changes the toy to something simpler or decreases the intrigue of the toy.
 - If a child has frequent false responses, the assistant increases the interest of the centering toy.
 - No cueing: It is crucial for the VRA test assistant to not provide any indication of the presence of the auditory stimuli. The assistant should not pause the movement of the centering toy or look at the child during stimulus presentation, as the child may use these cues to provide false responses.
 - Shaping: The assistant may need to help the child turn his head by following the centering toy during conditioning. The assistant does not provide shaping during the threshold search phase.
 - Social reinforcement: For children minimally rewarded by the VRA reinforcers, the audiologist instructs the assistant to provide social reinforcement after the visual reinforcer is activated.
 - Holdable toy: The assistant may need to offer a child a toy to hold if the child shows frustration/reaching for centering toy that is negatively impacting listening behavior or to occupy the child's hand and prevent the child from removing the transducer.
 - Facilitate parent behavior that supports testing: The VRA test assistant instructs the parent to not talk during the test session, and to not cue the child if the parent hears a stimulus. The parent holds the child's arm to prevent/reduce the child's removal of the transducer.
- Interpretation
 - Threshold: Behavioral hearing thresholds are determined as the lowest level where the child consistently responds for each stimulus condition.
 - If responses at a stimulus condition are scattered across a range of levels, threshold is not established and is not recorded on the audiogram; the responses are recorded as "undetermined hearing level" or "could not establish threshold".
 - If the audiologist questions the reliability of a threshold for a particular stimulus condition, the audiologist re-checks the threshold. Some children's responses during testing may be elevated and inconsistent during times of learning the task or during times of inattention and these test conditions are re-evaluated during the test session, if possible.

Method: Behavioral Hearing Assessment: Conditioned Play Audiometry (CPA)

- Age: Between 24 and 36 months developmental age, most children are able to participate in CPA testing. For this age group, the advantage of using CPA over VRA is that children provide more responses with CPA and testing is more complete. Research shows that some children at a developmental level of 24 to 27 months can learn CPA and most children can learn by 30 months developmental age³. CPA can be used into early school-age, as many children ages 5 to 9 years of age benefit from the rewards of playing a game to maintain focus and motivation.
- Transducers: Appropriate transducers for CPA testing include insert or circumaural earphones and bone conduction. Soundfield testing is appropriate for aided testing or if earphones are rejected.
- Equipment/support needed: a child-size table and chair and a variety of engaging CPA games (e.g., peg in board, toy in bucket, connect4, coin in bank, etc.) that can be easily accessed. Children will need a number of different games to maintain engagement throughout the session: see the [WA EHDDI CPA toolkit](#) for ideas. A trained CPA test assistant is needed; some clinics may have access to portable audiometers that allow the audiologist to also function as the CPA test assistant with the child.
- Stimuli
 - Frequency-specific stimuli: Audiologists use a “pediatric order” of test stimuli, varying across ears and across the frequency range to ensure adequate information is obtained prior to the child habituating: e.g., 2, .5, 4, 1, 8, .25, 6 kHz. The order of ear/frequency is adjusted based on the specific child and the audiologist’s determination of importance based on past assessment data. Thresholds at mid-octave frequencies are measured if >20 dB between octaves.
 - Speech stimuli are used as a cross-check of frequency-specific stimuli using a measure of speech reception threshold: [see speech audiometry](#)
- Conditioning trials: At the beginning of the test session, the audiologist presents stimuli at an audible level and instructs the test assistant to condition (see test assistant role below). Re-conditioning may be needed later in the test session if the child habituates. Conditioning occurs at 10-20 dB above presumed threshold or at 50-80 dBHL for unknown hearing status. The level, ear, and frequency of the conditioning stimulus is adjusted to ensure audibility.
- Probe trials: After conditioning, the audiologist presents an audible stimulus to determine if the child is conditioned. The audiologist states that the trial is a probe and the assistant does not cue during a probe trial. Threshold search begins after a correct response on a probe trial; if no response, conditioning trials continue.
- Response: The child completes the CPA task: puts peg in board, coin in bank, etc.
- Steps: The audiologist uses a 20 dB down/10 dB up bracketing procedure for children whose hearing levels are unknown and will elect to switch to 10 dB down/5 dB up bracketing procedure for children who have hearing loss.
- Threshold/Stopping rule: lowest level with 2 out of 3 responses/>50%. A screening level of 20 dBHL may be elected due to child’s activity and noise or for the purposes of rapid screening.
- Inter-stimulus intervals: audiologist varies the time between trials (inter-stimulus interval) to avoid a pattern that promotes false-positive responses.
- Masking: The audiologist uses contralateral masking for AC testing at test frequencies with >50 dB difference between ears and for all BC tests, using plateau or other appropriate method to determine adequate masking.
- Audiogram: The audiologist records thresholds on an audiogram using conventional symbols; indicating method, transducer, and reliability.
- CPA Test assistant
 - Instruction: The CPA test assistant provides brief instruction of the listening game prior to putting earphones on the child (e.g., “We’re going to play a listening game....wait for the sound and then you can take your turn with the game when you hear the sound”).

- Ready to listen: The CPA test assistant helps the child to get in a ready to listen position during each trial to reduce false-negative responses (i.e., the child not being ready to listen).
- Conditioning: During the conditioning phase only, the CPA test assistant shapes the child's motor response with a hand over hand method by placing the assistant's hand over the child's hand and guiding the child to complete the CPA task. Some children may do better with a visual prompt instead of hand over hand.
- Reinforcement: During the conditioning phase, the CPA test assistant provides 100% positive and 100% negative reinforcement. During the testing phase, the assistant provides intermittent positive reinforcement and 100% negative reinforcement. Negative reinforcement for false-positive responses include a head shake, "no sound, listen again" and the assistant returns the CPA game token to the child to try again. Positive reinforcement for true-positive responses include a head nod, thumbs up, "Good listening", "You're working hard". The CPA test assistant does not ask the child "do you hear it?", as this query promotes false responses.
- Managing challenging behavior
 - Maintain child's motivation: The audiologist advises the CPA test assistant to vary the CPA game to maintain child's motivation and interest and reliability of responses. The CPA test assistant provides verbal encouragement to encourage the child to persist: "You're almost done, 3 more".
 - Reluctant responder: When a child is reluctant to participate in CPA, the audiologist and CPA test assistant provide additional conditioning trials to give the child time to warm up, perhaps having all the adults (parent, assistant) play the CPA game with the child during conditioning.
 - False responder /impulsive responder: The CPA test assistant reminds the child to wait for the stimulus and uses negative reinforcement described above. The assistant may change the CPA game to a game in which the audiologist/assistant controls the reward like pushing a large button to activate a video or mechanical toy.
 - Could not condition: After a number of conditioning trials, if the child cannot be conditioned to provide reliable responses during CPA testing, the audiologist will elect to assess hearing using VRA.
- Interpretation
 - Threshold: Behavioral hearing thresholds are determined as the lowest level where the child consistently responds for each stimulus condition.

Method: Behavioral Hearing Assessment: Conventional Audiometry

- Age: conventional audiometry is appropriate for children age 6 years+
- Transducers: Appropriate transducers include insert earphones, circumaural earphones and bone conduction
- Stimuli: Pure tone pulsed stimuli: 1, 2, 4, 6, 8, .5, .25 Hz. Test mid-octaves if slope of HL is > 20 dB/octave.
- Conditioning:
 - Conditioning: Instruct the child/teen to push the button/raise hand in response to tonal stimuli
 - Probe trials: present audible stimulus to determine if the child is conditioned
- Response: hand raise or button push
- Steps: Use a down-10/up-5 dB bracketing procedure.
- Threshold/Stopping rules: lowest level with 2 out of 3 responses/>50%.
- Inter-stimulus intervals: Audiologist varies the time between trials (inter-stimulus interval) to avoid a pattern that promotes false-positive responses
- Masking: use contralateral masking for AC with >50 dB difference between ears and for all BC tests.
- Audiogram: Record thresholds on audiogram using conventional symbols; indicate method and reliability

Method: Speech Audiometry

- Speech Awareness threshold
 - Definition: lowest level that child can detect a broadband speech stimulus
 - Purpose: cross-check for frequency-specific thresholds and/or to establish conditioning in a child who is not able to learn the task to frequency-specific stimuli.
 - Stimuli: live voice (“hi...bye-bye...peek-a-boo...uh-oh)
 - Method: use a 20 dB down/ 10 dB up threshold search
 - Response: head turn using VRA
 - Interpretation: SAT should be within 10 dB of the pure-tone average.

- Speech reception threshold (SRT)
 - Definition: lowest level that child can currently identify spondee words
 - Purpose: cross-check for frequency-specific thresholds and/or to establish conditioning in a child who is not able to learn the task to frequency-specific stimuli.
 - Stimuli: Pediatric spondee modified word list
 - Method: use a 20 dB down /10 dB up bracketing procedure: if child responds correctly, decrease 20 dB; if child does not respond correctly, increase 10 dB. SRT is defined as the lowest level patient correctly responds at least 50% of the words.
 - Response: Child repeats word; child points to toy or picture
 - Interpretation: SRT should be within 10 dB of the pure-tone average.

- Ling sound detection
 - Definition/purpose: detection of range of recorded speech stimuli, typically to determine aided benefit or to evaluate impact of hearing loss with unaided measures
 - Stimuli: a, ee, u, s, sh, m
 - Response: head turn with VRA or CPA task
 - Method: determine if child is able to detect 6 Ling sounds at conversational speech level (50 dBHL) and soft speech level (35 dBHL)

- Informal speech discrimination: Use body parts or toys that are in the child’s receptive vocabulary. Have the child point to object named. Report scores as number correct (e.g., 7/10) not as percentage. For children < 3 years.

- Speech recognition
 - Definition: measure of ability to recognize words, phrases, sentences at a suprathreshold level in quiet and noise
 - Response: child points to picture or toy/body part or repeats word
 - Stimuli: see [speech audiometry table](#) for age-appropriate speech recognition stimuli
 - Method: Present a 25-word list for each condition, preferably using recorded speech stimuli
 - Purpose
 - Evaluate the impact of hearing loss:
 - Measure speech recognition in soundfield for soft speech stimuli (35 dBHL) and conversational speech (50 dBHL) in quiet and in noise. For children with unilateral hearing loss, compare speech in noise measures with 2 conditions: words from speaker on the side of the ear without hearing loss and noise from opposite speaker, compared to the opposite configuration.
 - Measure the child’s signal to noise level (SNR) loss using the Bamford-Kowal-Bench Speech-in-Noise (BKB-SIN) test or the Hearing in Noise Test for Children (HINT-C).

- Determine the child's candidacy for hearing technology:
 - Measure speech recognition in each ear at 40 dB above the pure tone average.
- Evaluate benefit from hearing technology:
 - Measure aided soundfield speech recognition at a conversational level of 50 dBHL and a soft speech level of 35 dBHL in quiet. Measure aided speech recognition in noise, with multi-talker babble from the opposite speaker, resulting in SNRs of -5, 0, and +5.
- Interpretation
 - Interpret speech recognition measures:
 - 90-100%=excellent
 - 80-90%=good
 - 70-80%=fair
 - 50-70%=poor
 - <50=very poor
 - Using 25 words lists, significant differences between conditions =>20% difference.
 - Interpret SNR Loss measures (BKB-SIN, HINT-C)
 - Use age-matched corrections based on test guidelines
 - Interpret SNR loss
 - 0-3 dB Normal/near normal performance in noise
 - 3-7 dB Mild SNR loss; mild difficulties in noise
 - 7-15 dB Moderate SNR loss: significant difficulties in noise
 - >15 dB Severe SNR loss; severe difficulties in noise

Speech Audiometry Table

Test	Language Age	Description
Ling 6 Sound Test	6 months-3 years	Detection of recorded phonemes /a/ /i/ /u/ /s/ /sh/ /m/
ESP Early Speech Perception Test	2 years +	Closed set: Spondees and words, Detection, pattern perception, word identification
O&C Open and Closed Test	2 years +	Closed and open set picture identification
NU-CHIPS Northwestern University Children's Perception of Speech	2.5-5 years	Closed set (4), picture identification
WIPI Word Intelligibility by Picture Identification	3.5-6 years	Closed set (6), picture identification
PSI Pediatric Speech Intelligibility Test	3-10 years	Closed set, verbal response, quiet and noise
MLNT/LNT (Multisyllabic) Lexical Neighborhood Test	3 years +	Open set: Multisyllabic and monosyllabic words. Lexically easy/difficult
UWO Plurals Test	4 years +	Closed set: picture response
PB-K Phonetically Balanced Word Lists-Kindergarten	5 years +	Open set Monosyllabic words
Az Baby BIO Sentence Test	5 years +	Open set sentences
W-22 (Central Institute for the Deaf list W-22)	8 years +	Open set: monosyllabic words
NU-6 (Northwest University Auditory Test #6)	12 years +	Open set: monosyllabic words
Listening Comprehension Test	6-17 years	Open set
SNR LOSS MEASURES		
Phrases in Noise Test (PINT)	3 years +	Closed set sentences in varying SNRs with recorded classroom noise
BKB-SIN (Bamford-Kowal-Bench Speech in Noise)	5 years +	Open set sentences in varying SNRs with multi-talker babble both on Ch1
HINT-C Hearing in Noise Test-Children	5 years +	Open set sentences in varying SNR with speech-shaped noise
WIN Words in Noise	6 years +	Open set monosyllabic words in a range of SNRs with multi-talker babble
SPIN Speech Perception in Noise	Teen-adult	Sentences in noise
Quick-SIN Quick Speech in Noise	Teen-adult	Sentences in multi-talker babble in varying SNRs
SPRINT Speech Reception in Noise	Teen-adult	Words in noise

Method: Middle Ear Measures

- **Otoscopy:** The primary purpose of an otoscopic exam is to determine if there is any blockage in the ear canal and if there is an abnormal shape of the pinnae, presence of skin tags or pits, or other craniofacial abnormalities. Assessment of the tympanic membrane is noteworthy for presence of a tube, perforation, or abnormal color.
- **Tympanometry**
 - **Probe tone:**
 - A 1kHz probe tone is used for infants 0 to 9 months of age. If a measure of the ear canal volume is needed, a 226 Hz probe tone must be used to measure ear canal volume.
 - A 226 Hz probe tone is used for older infants and children older than 6 months.
 - Wideband immittance uses a broadband stimulus.
 - **Method**
 - Obtain a seal in the ear canal with an appropriate size probe tip, pull up and back on the pinna if needed, to open the canal. Use passive restraint by parent to reduce movement. Repeat the measure if noise or movement interferes with a quality recording. Obtain a repeat measure if the response is difficult to interpret.
 - **Expected normal range**
 - Age guidelines: young infants age 0 to 6 months, older infants/toddlers age 7 months to 3 years, children age 4 to 18 years.
 - Compliance:
 - Young infants with 1kHz probe tone: positive compliance relative to the end pressure points of the curve OR static admittance of >0.6mmho, compensated from the negative tail.
 - Older infants/toddlers: .2 to .7 ml
 - Children: .4 to 1.4 ml
 - Wideband immittance: maximum absorbance in the 1 to 4kHz range
 - Ear canal volume:
 - Infants: .2 to .7cc
 - Toddlers/Young children: .3 to 9cc
 - Older children: .6 to 1.4cc
 - Pressure
 - peak pressure= > -100 daPa
 - Tympanometric width/gradient
 - Infants/toddlers=100-200 daPa
 - Children=50-150 daPa
 - **Interpretation**
 - Normal outer/middle ear function
 - Abnormal outer/middle ear function: immittance: high or low, earcanal volume: high or low
 - Could not evaluate (noisy, not testable due to atresia or drainage, child refuses)
- **Acoustic Reflex (AR)**
 - **Stimuli**
 - Broadband noise (BBN) stimulus for infants
 - Pure-tone stimuli for children
 - **Method**
 - Pressurize with appropriate probe tone stimulus. Present BBN or pure-tone stimulus starting at lowest level of expected range and increase in 5 dB steps until a response is identified.
 - **Expected normal range**
 - BBN stimulus: 65 to 90 dBHL
 - Pure-tone stimuli: 70 to 100 dB HL
 - **Interpretation**
 - Presence of the AR can strengthen the interpretation of tympanometry.
 - Presence of AR along with present OAEs and absent ABR responses, strengthens the diagnosis of ANSD.

Method: Otoacoustic Emissions

- Method

The audiologist selects an appropriate tip size for a tight fit deep in the canal. The probe is stabilized by clipping the cable close to the child's head. The probe may be more stable when an infant is laying with the test ear towards the ceiling. The audiologist inserts the tip by lifting the pinna up and back and turning the probe tip. Maintaining a secure probe fit and low child noise throughout testing is crucial for obtaining a valid OAE measure. In addition, the audiologist ensures that occlusion of the ear canal or the probe assembly does not impact the validity of the measure.

- Stimuli

- Distortion product (DPOAE): 65 dB SPL (F1), 55 dB SPL (F2)
- Transient evoked (TEOAE): 80 dB SPL for infants; 84 dB SPL for children

- Expected normal range of responses

- DPOAE: SNR of 3 to 6 dB and a minimum DP amplitude of -8 dB in at least 3 frequency bands
- TEOAE: Reproducibility > 70% for at least 3 frequency bands with minimum 3 dB SNR in at least 3 bands

- Interpretation

- Strengths of OAE testing as part of an audiologic test battery:
 - cross-check of other audiological measures
 - combined with measure of CM with ABR testing, distinguishes between sensory and neural HL; children with ANSD show present OAE responses
 - detects CHL/SNHL as a screening tool; children with CHL/SNHL >25 dB show absent OAEs
- Limitations of OAE screening alone:
 - OAE testing alone is not an adequate evaluation of auditory function in infants/children who have not passed screening and rescreening
 - degree/type/configuration of HL cannot be distinguished
 - misses minimal SNHL and ANSD when used in isolation
 - not a test of hearing

Method: Outcome Questionnaires

Outcome questionnaires are used as a structured method for evaluating family input on the child’s listening and communication. Family members as well as older children/teens and educators can complete these measures. Outcome questionnaires can be used to provide family’s input on the impact of the hearing loss for children who are DHH, both those who use hearing technology and those who are not using technology.

FAMILY OUTCOME MEASURES	TARGET AGES	FORMAT
ELF Early Listening Function	5 mos-3 years	Observation of 12 activities
LittIEARS LittIEARS Auditory Questionnaire	1 mo-2 years	35 item, yes/no; Age-specific norms chart
Auditory Skills Checklist	5mos-5 years	3-point scale
IT-MAIS and MAIS (Infant/Toddler) Meaningful Auditory Integration Scale	5 mos-3 yrs- IT-MAIS; >3 yrs- MAIS	10 questions, 5-point scale,
CHILD Children’s Home Inventory for Listening Difficulties	3-12 years	15 questions, 8-point scale, parent and child versions
PEACH Parent’s Evaluation of Aural/oral performance of Children	3-7 years	13 items, 5-point scale; norms chart
SSQ Speech, Spatial and Quality of Hearing Questionnaire	4 years +	8 situations parent and child versions
P-APHAB Pediatric Abbreviated Profile of Hearing Aid Benefit	10-17 years	24 items, 7-point scale; parent and child versions
HEARQL Hearing Environments and Reflection on Quality of Life	8-12 years	35 items
SAC-A Self-Assessment of Communication-Adolescent	Teens	12 items, 5-point scale
SCHOOL-BASED OUTCOME MEASURE	TARGET AGES	FORMAT
SIFTER Screening Instrument for Targeting Educational Risk Preschool SIFTER, SIFTER and Secondary SIFTER	3-5 yrs-P-SIFTER 5-12 yrs-SIFTER 12-18 yrs-S-SIFTER	15 questions covering 5 content areas: teacher questionnaire
LIFE-R Listening Inventory for Education-Revised	8-18 years	15 items; teacher and student questionnaires
TEACH Teacher’s Evaluation of Aural/oral performance of Children	3-7 years	11 items teacher questionnaire
CHAPS Children’s Auditory Processing Performance Scale	7-16 years	35 items teacher questionnaire
CPQ Classroom Participation Questionnaire	9 years+	16 questions student questionnaire

References

¹Joint Committee on Infant Hearing 2019 Guidelines

²Washington State EHDDI Best Practices for Family-Centered Care and Communication

³Assessment of Hearing in Infants and Young Children: Clinical Guidance Document from the American Academy of Audiology 2020

⁴Ontario ABR Assessment Guidelines 2018

⁵Minnesota Infant Audiologic Assessment Guidelines 2018