DEPARTMENT OF HEALTH

—EARLY HEARING DETECTION AND INTERVENTION—

EARLY HEARING DETECTION AND INTERVENTION (EHDI) GUIDELINES

FOR AUDIOLOGISTS

Last Revision Approved: November 2018

A complete guide to newborn hearing diagnosis, amplification, and referral to early intervention and family support. Minnesota specific background, state system details, and best practice elements are focused on reducing variability in outcomes for children and on accountability for meeting state EHDI program goals.

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Minnesota Newborn Screening Program
(800) 664-7772
www.health.state.mn.us/newbornscreening
https://www.health.state.mn.us/people/childrenyouth/improveehdi

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DEPARTMENT OF HEALTH

OVERVIEW OF EARLY HEARING DETECTION AND INTERVENTION

A section of the Early Hearing Detection and Intervention (EHDI) Guidelines for Audiologists

Last Revision Approved: November 2018

BACKGROUND

During the 1960s, state public health programs developed systems to screen infants for a number of different genetic and congenital conditions. The factors necessary to add conditions to the newborn screening panel included that the condition:

- must not be clinically evident in the newborn period until after significant harm to the infant had manifested
- be treatable in the newborn period, and
- the benefits to babies and society outweigh the risk and burden of screening and treatment.

Congenital hearing loss is one of the most common congenital conditions, with an estimated incidence of one to three per thousand births. This far exceeds the combined incidence of other conditions for which newborns are routinely screened. Since existing state-based newborn screening systems already had the capacity for high volume tracking, quality assurance, and follow-up, state programs ultimately became the platform that enabled newborn hearing screening to become truly universal beginning in the late 1990s. State-based newborn screening systems also provided an avenue for creating greater uniformity in practices at the state and national levels.

HISTORY OF NEWBORN HEARING SCREENING IN THE UNITED STATES

In 1965, the Babbidge Report to the Secretary of Health, Education, and Welfare, recommended the development and nationwide implementation of universal procedures for early identification and evaluation of hearing loss. This resulted in the development of a high-risk registry in 1967 to facilitate early identification of hearing loss. The weakness inherent in the high-risk registry was that it was only able to identify half of children with congenital hearing loss.

By 1988, the average age of identification for profoundly deaf children in the United States remained at 2 ½ years of age. This prompted former Surgeon General, C. Everett Koop, to issue a goal that by the year 2000, 90% of children with significant hearing loss be identified by 12 months of age.

Meanwhile, the development of new automated hearing screening technologies continued to provide more accurate, objective, and cost effective methods with which to screen newborns. In 1993, the National Institutes of Health issued a recommendation that all newborns be screened for hearing loss before

leaving the hospital. Following this, in 1994, the Joint Committee on Infant Hearing (including representatives from audiology, otolaryngology, and pediatrics) also endorsed universal newborn hearing screening. The committee further recommended that hearing loss be diagnosed before three months of age and that early intervention be initiated by six months of age.

There was also growing evidence (Yoshinaga-Itano, Sedey, & Coulter, 1998) that early diagnosis of hearing loss resulted in significantly improved educational outcomes for children. All of these factors led to a proliferation of voluntary hearing screening programs in hospitals around the country, and by 2004, it was estimated that 90% of newborns were receiving newborn hearing screening.

MINNESOTA NEWBORN HEARING SCREENING AND FOLLOW-UP

Newborn hearing screening in Minnesota became mandated in 2007. Minnesota Statutes (Revisor of Statutes, State of Minnesota, 2016: 144.125, 144.128, 144.966, and 144.1251)[1] outline the responsibilities for both healthcare providers and the Minnesota Department of Health (MDH) for all conditions included on the newborn screening panel. This includes requirements for parent education, reporting of results, and follow-up services. All infants born in Minnesota should receive hearing screening prior to discharge unless a parent refuses in writing.

Minnesota's newborn hearing screening program, along with hospitals, midwives, primary care providers, audiologists, otolaryngologists, and local public health care providers across the state, help ensure that infants who do not pass their newborn hearing screening receive an early and definitive diagnosis of hearing status. When permanent hearing loss is diagnosed, family support, genetics, ophthalmology, and early intervention resources continue to support the child's development toward improved health and educational outcomes.

MINNESOTA NEWBORN HEARING SCREENING ADVISORY COMMITTEE

Minnesota Statute 144.966[1] established a Newborn Hearing Screening Advisory Committee to assist and advise Minnesota Departments of Health and Education in all aspects of program design, implementation, and evaluation for continuous quality improvement. This twenty-member panel is appointed by the Commissioner of Health and is called to meet at least quarterly. Membership includes stakeholders from various health, education, and parental groups and is outlined in the statute.

MINNESOTA EARLY HEARING DETECTION AND INTERVENTION (EHDI) SYSTEM AT-A-GLANCE

Since newborn hearing screening became mandated in 2007, Minnesota has continued to increase the percentage of newborns screened. More than 98% of babies are screened before 1 month of age (Minnesota Department of Health, 2014a). Statewide REFER rates (the percent of infants who do not pass newborn hearing screen at hospital discharge) meet or fall very near the recommended benchmark rate of ≤ 4%, indicating effective screening practices and an appropriate number of infants who are referred for outpatient follow-up. The percentage of infants who

REFER and have a complete diagnosis by three months of age showed steady improvement from 23% in 2010, to 40.5% in 2014. Close to 90% of children with confirmed permanent loss enroll in early intervention services through the Individuals with Disabilities Act (IDEA) Part C. Minnesota Hands and Voices (MNHV) parent-to-parent support continues to contact about 90% of families, with nearly half contacted within the first month following diagnosis. Nearly 90% of children are connected with at least three of the following stakeholders: audiology, MNHV, IDEA Part C, and/or local public health. Additional detailed benchmark data are collected to track progress and need areas. A current summary of Minnesota EHDI system data can be found at https://www.health.state.mn.us/people/childrenyouth/improveehdi along with other resources and tools for health care providers, educators, and parents. Data are used to evaluate program outcomes and for planning continuous quality improvement.

See Appendix for the MDH timeline that describes MDH follow-up and connection to resources from birth to diagnosis and beyond.

MNSCREEN

MNScreen is a secure system for electronic reporting of hearing screening results in Minnesota. The system is designed to improve demographic data integrity and the efficiency of follow-up care coordination for children who do not pass newborn hearing screening.

MNScreen will allow both MDH program staff and birth facilities to monitor their own screening programs on an ongoing, real-time basis, which will help improve services for all Minnesota newborns. In the future, outpatient providers may also be able to use MNScreen to report diagnostic test results and refer newborns for other early interventions as needed, helping to improve access and reduce disparities in care.

This document was peer reviewed by a team of Minnesota EHDI stakeholders, and both clinical and educational audiologists.

DEPARTMENT OF HEALTH

SECTION 1: GUIDELINES FOR INFANT AUDIOLOGIC ASSESSMENT

A section of the Early Hearing Detection and Intervention (EHDI) Guidelines for Audiologists

Last Revision Approved: November 2018

INTRODUCTION

This document provides recommended guidelines for early diagnosis of hearing loss in infants who do not pass their newborn hearing screening. It is intended to promote a more standardized approach to follow-up hearing care to ensure consistency in outcomes. This document describes optimal processes based on current evidence and combined clinical experience.

Expanded guidance is included on several topics that have been large contributors to variability in the accuracy, completeness, and timeliness of audiological assessments. This includes:

- Use of evidence-based electrophysiologic assessment parameters, calibration data, and correction factors normed on children with hearing loss (pages 10-11)
- Use of efficient test methods and protocols (pages 11-12)
- Use of criterion based strategies for auditory brainstem response (ABR) waveform interpretation (pages 13-14)
- Use of effective bone conduction ABR techniques to document type of hearing loss (pages 14-15)

Because of the importance of early identification of hearing loss, all screening, follow-up, and tracking procedures must, at a minimum, be consistent with the national Early Hearing Detection and Intervention (EHDI) goals of providing audiological diagnosis (type and degree of hearing loss) by no later than three months of age and with current MDH statutory requirements. Resources are available from the MDH–EHDI Program to assist with program support, implementation, and quality assurance.

BACKGROUND

Hearing loss is one of the most common congenital conditions with an estimated incidence of one to three per 1000 births. Nearly 95% of congenitally Deaf/Hard of Hearing (DHH) children are born to two typical hearing parents. Without early diagnosis of hearing loss, DHH children are at risk for delays in a variety of developmental areas including vocabulary, articulation, intelligibility, social adjustments, and behavior.

The goal of an EHDI program is to promote effective communication for all children through the early identification of hearing loss and to initiate appropriate intervention services as early as possible. Early identification and intervention can substantially reduce or even eliminate developmental delays that often stem from a late diagnosis of hearing loss. For many children with hearing loss, early identification and intervention enables them to perform at the same level on language assessments as their peers with typical hearing and similar cognitive ability (Yoshinaga-Itano, Sedey, & Coulter, 1998).

Many different healthcare professionals and entities play a role in the hearing screening and follow-up process. Each hand-off between care providers creates the possibility for a child to fall through the cracks. Following a standard process that parents and providers understand helps minimize possible loss to follow-up or confusion. Minnesota hospitals and out-of-hospital birth providers are required to screen all infants for hearing loss and report results to the family, primary care provider, and MDH. At the first well-child visit primary care providers are expected to review newborn hearing screening results for all infants in their care and ensure that an outpatient follow-up visit is scheduled if the final newborn screen was a REFER result.

Audiologists play a critical role in the EHDI process by:

- ensuring that screening and rescreening occurs by one month of age
- promptly referring for or completing diagnostic hearing evaluation by three months of age
- fitting amplification when chosen by the family for infants with confirmed permanent hearing loss
- connecting those with confirmed permanent hearing loss to early intervention services and family support by six months of age, or as soon as possible after diagnosis

Minnesota data indicate that community EHDI systems that complete rescreening as early as two weeks and begin diagnostic assessment as early as four to eight weeks of age have the highest success rate in providing a definitive diagnosis in a timely manner. This helps avoid the need for sedated procedures and the possibility of either a late diagnosis or becoming "lost to follow-up." With prompt referral and follow-up, children have the opportunity to receive life-changing care and services even earlier than state and national guidelines prescribe.

CHILD AND FAMILY CENTERED COMMUNICATION

In family centered care, families are recognized as the experts in determining what is best for their children and families. No one understands their child's needs more than the parents do. Family centered care is a crucial component of best clinical practice (English, et al., 2016; Gravel, 2002) and is beneficial to children and their families. Clinicians are encouraged to use a teach-back method to ensure parental understanding of test results and recommendations. When communicating a diagnosis of hearing loss to families,

an awareness of cultural differences is important (world heritage and religious cultures as well as Deaf culture). Sharing results and recommendations in an unbiased manner that recognizes each family's unique situation and background helps support parents to make the best choices for their child and family. Professionals should deliver information in a positive manner with sensitivity to the emotional needs of the parent.

FACILITY AND PERSONNEL CONSIDERATIONS

Hearing diagnosis includes assessment of type and degree of hearing loss in each ear. Audiologists are expected to follow their professional code of ethics regarding their capability to provide thorough pediatric audiologic assessments. If a facility does not have the equipment or staff with appropriate training and experience to conduct the described pediatric audiological evaluations, the infant should be referred to a pediatric audiologist.

EQUIPMENT CALIBRATION

Audiometric equipment must be calibrated in accordance with current American National Standards Institute (ANSI) Specifications for Audiometers (American National Standards Institute, 2010). Immittance equipment must be calibrated according to ANSI Specifications for Instruments to Measure Aural Acoustic Immittance (American National Standards Institute, 2012). There is not currently an ANSI standard for calibration of auditory brainstem response (ABR) equipment or otoacoustic emissions (OAE) equipment, therefore current international standards are used for factory default settings (e.g. ISO389-6 for ABR) (International Organization for Standardization, ISO; 2007; Richter & Fedtke, 2005).

INFECTION CONTROL

All assessments should be conducted in full compliance with facility infection control policies and standards. Policies should outline cleaning procedures for anything that will be in direct contact with the infant, including assessment equipment and the examiner. When an individual facility does not have a written standard in place, then generally accepted standards should be followed. Resources for standard infection control precautions, including documents from the World Health Organization (WHO) and Center for Disease Control (CDC), can be found on the MDH webpage https://www.health.state.mn.us/facilities/patientsafety/infectioncontrol/guidelines.html

OUTPATIENT RESCREENING

Some community EHDI systems include one additional outpatient rescreening in the primary care or audiology clinic prior to scheduling a full audiological assessment. This visit should ideally be scheduled at about two weeks of age. Healthy newborns can be rescreened with either otoacoustic emissions (OAE) or automated auditory brainstem response (AABR) technology regardless of what was used at birth, in accordance with national guidelines. Infants who still do not pass the initial outpatient rescreening should promptly be scheduled for complete audiological assessment to include diagnostic ABR. Diagnostic evaluation should not be delayed solely due to middle ear dysfunction. Pediatric audiology centers have greater success in completing diagnostic evaluations in a single session when infants are first seen at a younger age (see Target age for initial diagnostic assessment section).

If a passing OAE follows an abnormal AABR result,

there is a risk that auditory neuropathy spectrum disorder (ANSD) can go undetected. The prevalence of ANSD is 0.03% or less in the well baby population (Korver, van Zanten, Meuwese-Jongejeugd, van Straaten, & Oudesluys-Murphy, 2012). The preferred method would be to retest AABR refers using AABR, if available. Testing with acoustic reflexes can be included with passing OAE results to screen for ANSD if AABR is not available at the rescreen appointment. Patient history and careful review of test results should be included in determining a follow-up plan. Parent education should include a discussion of speech/language milestones.

NICU Infants

NICU infants who do not pass an AABR screening should not be rescreened and passed by OAE alone. JCIH guidelines recommend that NICU infants who do not pass hearing screening be scheduled with an audiologist for a comprehensive evaluation, ideally prior to the infant's discharge from the hospital and/or as soon as medically feasible. General outpatient rescreening for NICU infants is not recommended.

SCHEDULING TACTICS

Infants approaching three months of age often require more than one visit to complete a full diagnostic audiological evaluation due to their decreasing sleep time. Facilities are encouraged to utilize creative scheduling tactics for older infants (e.g. scheduling two diagnostic appointments a week apart) to allow for rapid completion of unfinished assessments. See www.improveaudiology.org[8] for more suggestions.

PEDIATRIC TEST BATTERY

Target age for initial diagnostic assessment

The target age for the initial diagnostic assessment is four to eight weeks of age. Diagnostic evaluation should not be delayed solely due to middle ear dysfunction. Minnesota data show that following this practice improves the likelihood that type and degree of hearing loss can be determined before three months of age (or when medically feasible for NICU graduates) even when multiple diagnostic visits are necessary. For NICU infants, complete audiological work-up should be completed prior to discharge whenever possible.

Test Battery Approach

When evaluating infants and young children, it is necessary to cross-check results by using a battery of electro-physiologic tests to correlate with behavioral findings when age-appropriate. It is also important to seek information from and listen to parents/caregivers and intervention specialists who can provide valuable information about the child's functional use of hearing and about their speech/language and developmental progress. A complete evaluation should include a battery of physiologic tests that define type, degree, and configuration of hearing loss for each ear. The following

components are typically part of a diagnostic infant hearing evaluation.

Case History

Providers should document a full medical and developmental history of the child including:

- Prenatal history—significant pregnancy complications
- Perinatal history—TORCH infections (toxoplasmosis, other infections, rubella, cytomegalovirus, or herpes simplex)
- Ototoxic medication exposure
- Family history of childhood hearing loss, syndromes, or other disorders associated with hearing loss
- Behavioral history including auditory responsiveness, speech-language development, and other developmental milestones
- Review of child's motor milestones (may point toward vestibular dysfunction related to hearing loss)
- Review of any prior hearing screening or audiological testing
- Review of risk factors for hearing loss or delayed onset hearing loss

Otoscopic exam

The primary purpose of an otoscopic exam is to rule out any obstruction or debris that could impact the audiological assessment and might warrant referral to a physician prior to the evaluation. Shape of pinnae, presence of skin tags or pits, or other craniofacial abnormalities may also be noted during this exam.

Tympanometry

A 1000Hz probe tone should be used for infants younger than six months corrected age (American Academy of Audiology, 2012; Joint Committee on Infant Hearing, 2007[2]). Test results should be interpreted using available normative data (Kei, et al., 2003; Margolis, Bass-Ringdahl, Hanks, Holte, & Zapala, 2003). The Ontario Infant Hearing Program 2016 Guideline, (Hyde, et al., 2016)[3] suggests abnormality criterion of peak compensated static admittance of < 0.6mmho, compensated from the negative tail -400 daPa. For infants six months corrected age and older, a 226 Hz probe tone is appropriate. Completion of immittance testing either prior to or after other testing during the diagnostic session is at the discretion of the audiologist. Knowledge of middle ear status prior to the completion of ABR testing can help make decisions about the most likely diagnostic outcome, and therefore help plan for the most efficient ABR test protocol.

Acoustic Reflex

Acoustic reflex testing (especially when reflexes are present) may play a role in cross-checking reliability of other diagnostic findings, or to assess the possibility of ANSD if ABR testing is unavailable. Since methods for testing middle ear function are constantly evolving, audiologists are encouraged to regularly review current literature. For infants less than six months of age, the recommended procedure is high frequency probe tone (0.66 to 1 kHz) with ipsilateral stimulation using broadband noise or tones (1 or 2 kHz) at levels not to exceed 105 dB SPL (Hunter & Blankenship, 2017). Reflex presence can be shown with repeatable deflections that are negative or positive from baseline (Kei, 2012). National/international guidelines generally say acoustic reflex testing is discretional, in part because absence of reflexes in newborns is not always clinically significant (British Columbia Early Hearing Program, BCEHP; 2012)[4].

Otoacoustic Emissions

Otoacoustic Emissions (OAE) testing is an established hearing screening technology and is helpful as a cross-check procedure in a diagnostic test battery. When present, OAEs provide some information about cochlear outer hair cell function and can be helpful when assessing for ANSD. When absent, other audiological tests are needed for definitive diagnosis.

For reporting purposes, responses interpreted as present, but abnormal or absent should both be recorded in the MDH–EHDI system as a REFER result. This is necessary so that ongoing follow-up is prompted when necessary and so that abnormal responses are clearly conveyed to all providers. Only present and normal should be recorded in MDH–EHDI as a PASS result.

Transient evoked otoacoustic emissions (TEOAEs) and distortion product otoacoustic emissions (DPOAEs) are thought to have largely independent cochlear mechanisms of generation. Abdala, Winter, & Shera (2017) suggest clinicians might get a more comprehensive picture of cochlear function if both types are used.

Transient Evoked Otoacoustic Emissions (TEOAE)

- Sample Stimulus: 80-84 dB peSPL broadband click (AAA, 2012; Abdala, Winter, & Shera, 2017)
- Present response: Signal to Noise Ratio (SNR) > 6 dB at majority of frequencies with 70% overall wave reproducibility
- Interpretation: See other state, national, and international pediatric diagnostic guidelines (AAA, 2012; BCEHP, 2012;[4] Coalition of Ohio Audiologists and Children's Hospitals (COACH), Ohio Department of Health, 2017) for discussion about evidence-based normative data and sensitivity/specificity of criteria for interpretation of test results.

Distortion Product Otoacoustic Emissions (DPOAE)

- Sample Stimuli: Paired tones with ratio of 1.22, where L1/L2 = 65/55 dB SPL, with several f2 frequencies tested between 2000-6000 Hz and other frequencies if deemed appropriate
- Present response: Stimulus intensity is within +/- 3 dB of target levels across frequencies; response is replicable with sufficient SNR (> 6 dB) at most frequencies and amplitude (DP level) in the normal range (see below for more discussion)
- Interpretation: See other state, national, and pediatric diagnostic guidelines and articles (AAA, 2012; BCEHP, 2012;[4] Coalition of Ohio Audiologists and Children's Hospitals (COACH), Ohio Department of Health, 2017; Gorga, et al., 2005; Hyde, et al., 2016[3]) for discussions about DP amplitude, SNR, evidence-based normative data and sensitivity/specificity of criteria for interpretation of test results. Research with young infants suggests DP amplitudes are higher than adult subjects. Because of this, some suggest that cut-off criteria for DP amplitudes judged as normal should be higher than those of adults (Blankenship, et al., 2018).

Diagnostic ABR

Suspected middle ear fluid should not keep audiologists from proceeding with diagnostic ABR testing to determine hearing status. It is necessary to rule out (or confirm) underlying sensorineural loss early using bone conduction ABR procedures despite persistent middle ear effusion that may exist. Using an efficient sequence that provides information about the type of impairment is imperative. For example, when an air conduction threshold is elevated in one

ear, is the other ear also elevated or within normal limits? If a conductive component is suspected, spending time collecting additional air conduction threshold information is less useful than obtaining bone conduction results (because the air conduction thresholds will be a moving target over time with most conductive losses (Small & Stapells, 2017). Defining the laterality and type of loss in the first visit helps direct future management, and provides more certain information for the family.

Typical test time

Use of an efficient protocol can help maximize use of limited test time with an infant that may wake up at any moment.

Test objectives

When evaluating a newborn that did not pass newborn hearing screening, an evaluation of **both ears** must be conducted.

A normal click ABR alone is not sufficient to unequivocally rule out hearing loss. Additionally, given the large amount of information required from infants who may wake up at any moment, modern ABR protocols rarely use click stimuli except in assessing infants suspected of ANSD (see ANSD testing guideline section). If a clear and reproducible Wave V is identified while using toneburst stimuli, measuring a click ABR is not considered necessary according to some protocols (BCEHP, 2012).[4] Therefore, the primary focus is to determine type of loss, and to obtain frequency specific estimates of behavioral hearing thresholds for each ear, ideally in one test session. Using toneburst stimuli:

- Determine the presence or absence of hearing loss in each ear—if hearing loss, determine the degree
- If an elevated hearing level is detected, define type of loss using bone conduction before obtaining additional frequency specific thresholds
- If there is no clear ABR wave V in any toneburst waveform, assess for ANSD using rarefaction and condensation polarity click recordings at a slow rate

ABR listening check

Prior to each evaluation, a listening check of both earphones with at least one stimulus is recommended. A listening check should also be conducted with the bone oscillator prior to each use.

Auditory Brainstem Response (ABR) Stimulus Parameters

Correction factors that account for differences in thresholds between short- and long-duration stimuli (ABR stimuli versus pure tone stimuli respectively) are applied to convert ABR thresholds to estimate the behavioral audiogram. ABR thresholds are responses from the auditory nerve and allow for estimation of behavioral threshold with the use of correction factors. Calibration values to normalized hearing levels (0 dB nHL) and conversion factors to estimated behavioral hearing levels (dB eHL) depend on stimulus and recording parameters used for testing. Audiologists are encouraged to carefully evaluate published data and choose stimulus parameters based on high quality evidence. Ensure that the dial corrections and the conversion values for nHL to eHL are based on the equipment's stimulus parameters. In the interest of individual program integrity and for consistency between clinics, use of evidence-based published parameters is highly recommended. See British Columbia Early Hearing Program, BCEHP; 2012,[4] Ontario Protocol for Auditory Brainstem Response Based Audiological Assessment (Hyde, et al., 2016);[3] Stapells 2011; Small & Stapells, 2017 for examples of evidence-based stimulus parameters (for ABR clicks and brief tone stimuli), and for the corresponding dB nHL values and conversion factors to dB eHL for infants.

ABR Dial Corrections (so that 0dB dial reading for chosen stimulus parameters = 0dB nHL)

Normal hearing level (nHL) refers to the normalized threshold for ABR click or brief tone stimuli. 0 dB nHL for a brief tone does not equal perceptual threshold in 0 dB HL. 0 dB nHL for ABR brief tones will differ based on the specific stimulus parameters used (duration, rate, etc.). Official ANSI standards for ABR stimuli are not currently available and factory installed default calibration values/dial readings do not necessarily match 0 dB nHL values. Therefore, offset adjustments (dial corrections) are required so that signal intensity is at normalized hearing level. There are several publications providing well-researched acoustic levels of normal thresholds in dB nHL for ABR stimuli (Stapells, 2000; 2011). Examples of calibration file offsets and the corresponding recording parameters that do align with 0 dB nHL can be found in the Ontario Infant Hearing Program 2016 Guideline, (Hyde, et al., 2016)[3] and the British Columbia Early Hearing Program 2012 Guideline (British Columbia Early Hearing Program, BCEHP; 2012).[4] Calibration offsets are available for the ER3A insert transducer for clicks and tonebursts, and also for the B71 bone oscillator. ***Please note that the corrections recommended in each source apply only for the ABR recording parameters as defined in that source.***

ABR nHL to eHL conversion factors

Since dB HL and dB nHL are defined with reference to adults, ABR thresholds for infants (expressed in dB nHL) are not directly equivalent to an infant's expected true perceptual thresholds, or estimated behavioral hearing level (dB eHL). Historically, audiologists were advised to generate their own clinic norms and correction factors to account for this. However, there are currently several published, large sample norms that provide nHL to eHL conversion factors using infant longitudinal studies that are generally considered superior to individual clinic norms. ***Provided the ABR test parameters used in the clinic match the parameters used in deriving the chosen published data (regardless of the equipment manufacturer), audiologists can feel confident in using published correction factors to convert from dB nHL to dB eHL.***

Examples of corrections based on published research are:

- British Columbia Early Hearing Program (BCEHP), 2012[4]
- Ontario Infant Hearing Program, (Hyde, et al., 2016)[3]
- Application of a regression formula with corrections based on degree of hearing loss (McCreery, et al., 2015)

Rationale for choosing intensity levels

There is no single test method that is clearly superior for use with all infants. Rationale in choosing the approach should account for the clinical characteristics of the population being assessed (at risk/not at risk, well-baby population/NICU, etc.) so that test method and order of test frequencies align with the expected end result for a given population or baby.

One method for quickly determining whether an ear has some type/degree of hearing loss is to begin testing at minimum stimulus levels (nHL level at each

frequency that corresponds with normal hearing for your stimulus parameters) across the speech frequency range. If a clear response is not present at the minimal level at a given test frequency, then jumping to a moderate test level can quickly help determine whether substantial hearing loss exists and help narrow the range for a threshold search. If elevated threshold levels are determined, then establishing whether it is permanent or not becomes more crucial than obtaining additional frequency thresholds, which can be added once type of loss has been established.

Use of this ascending test method is described in detail in the BCEHP (2012)[4] and Ontario ABR-Based Audiological Assessment (ABRA) protocols (Hyde, et al., 2016).[3] This approach is highly efficient when the majority of newborns seen for diagnostic audiology assessment ultimately have normal hearing. Testing focuses on obtaining an anticipated normal result quickly and assumes that there will be a clearly identifiable response at a low level in the majority of patients seen for diagnostic assessment. The audiologist using this method should be comfortable detecting a clear ABR wave V for low level stimuli. Use of a criterion-based judgment in marking wave V as clearly present is highly encouraged (see waveform interpretation and gold standard thresholds sections).

Knowledge of an abnormal tympanogram in advance of the ABR assessment can be useful in leading a clinician to consider a beginning intensity in the mild/moderate range. If an elevated threshold is detected, moving immediately to bone conduction to confirm (or rule out) the expected finding of conductive loss enables collection of this critical data while the baby is still asleep.

In an at-risk or NICU population, gathering click information first may be worthwhile to rule out ANSD, to assess wave latency and morphology, and to guide the order of next test sequence.

Order of test frequencies

Order of test frequencies is at the discretion of the audiologist and should be prioritized based on importance for each patient, given their known history or other known clinical findings. Basic guidance to consider in determining test order includes:

- The single most valuable frequency in relation to early language development is 2000 Hz
- To ensure not missing a cookie bite hearing loss, choose test frequencies so there is not more than one octave between test frequencies (e.g. 2000 Hz and 500 Hz, or 4000 Hz and 1000 Hz)

ANSD Testing Guideline

If the ABR response to high intensity tonebursts or clicks by air conduction is absent or significantly abnormal, or if wave V is possibly present but does not shift in latency as expected with decreased stimulus intensity, then assessment for ANSD should be initiated.

Absent or severely abnormal ABRs in the presence of an identifiable cochlear microphonic (CM) may indicate ANSD. A long ringing CM can sometimes masquerade as a true neural response. ABR results for a steeply sloping sensorineural hearing loss may look similar to ANSD with a long ringing cochlear microphonic and delayed wave V. Toneburst and OAE data should aid in differential diagnosis with this pattern of test findings.

In order to distinguish a true neural response and inspect the waveform for a CM, the following process should be used.

- Complete separate recordings to high level, slow rate (19-21/sec) condensation click and rarefaction click
- Inspect the waveform for a CM component, which will invert with change in polarity
- If waveform does invert, then care must still be taken to differentiate stimulus artifact from CM by completing an additional “stimulus absent” recording by disconnecting the tubing from the transducer
- If the waveform disappears when stimulus is absent, then stimulus artifact was likely a factor and CM is absent

CM present and artifact ruled out + absent neural

component = ANSD

Abnormal ABR findings (prolonged latencies, odd morphology, etc.) with absent OAEs and absent CM are not generally classified as ANSD. This pattern of test results may also reflect another neural/retro-cochlear issue, which may need further medical evaluation.

Waveform Interpretation: Criteria for Judging Clear Responses

Improve test accuracy by using criteria-based methods of interpreting waveforms. Diagnostic errors are more likely to happen in the presence of a noisy baby. Errors in estimating ABR threshold can be minimized by following recommendations similar to those found in the United Kingdom's Newborn Hearing Screening and Assessment Guidance for ABR testing in babies v2.1 (Sutton, et al., 2013),[5] described in the sections below.

ABR waveforms, especially those near threshold, can be categorized as follows:

CR—Clear Response

Response should meet expected characteristics in terms of latency and morphology. Additionally, amplitude (the size of the response as judged from the peak of wave III or V, whichever is larger, to the following SN10 trough) should be a minimum of 40 nV and at least three times the background noise. The waveform should also be compared with those at other stimulus levels (where available) to confirm they follow the expected change with stimulus level.

- In order to estimate whether the waveform meets the 3:1 signal to noise ratio use the "superimpose" function. Measure the signal from peak to trough, then measure the average difference in noise, which is the gap between the waveforms averaged across the entire window.

RA—Response Absent

The waveform does not meet criterion for a CR (clear response), and should be appropriately flat with no evidence of a response. The average difference (noise) or the average gap between the two superimposed waveforms should be less than or equal to 25 nV. This is to ensure a small peak is not being obscured by noise. When noise is low and yet does not fully meet RA (response absent) criterion, then time may be better spent recording at 5 dB higher or lower.

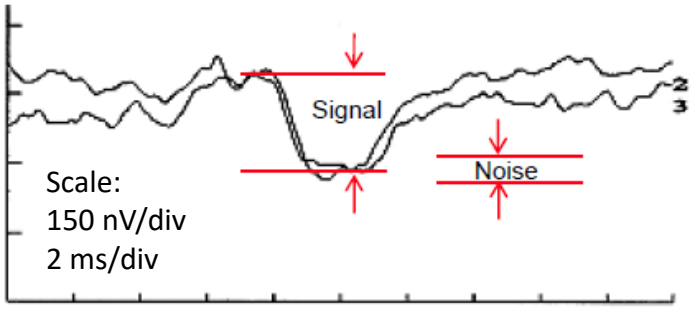


Figure 1. Example of a clear response (CR), satisfying the 3 to 1 signal to noise criterion

INC—Inconclusive

The waveforms have excessive residual noise or very low response amplitude preventing them from meeting criteria for CR or RA. Resolving inconclusive results can be accomplished by:

- Increasing stimulus level by 5 dB
- Completing a stimulus blocked run for comparison when a possible response appears likely, but signal to noise ratio is too low
- Additional averaging (typically not an efficient use of time)

500 Hz Toneburst Interpretation

Infants less than three months of age can commonly have a poor response to 500 Hz tonebursts. Historically, this has been attributed to the infant's neurological immaturity, but research does not support this. Poor low-frequency ABR responses in infants may be related to stimulus parameters following a 2-1-2 cycle format. This results in a stimulus that is no longer very brief for low frequencies, often causing difficulty eliciting a clean repeatable response. Insertion depth and poor probe

fit can also cause greater leakage at low frequencies which may impact effective stimulation level and increase difficulty obtaining low frequency ABR responses. (McCreery, Personal communication, 2017) Care should be used in recording and interpreting elevated 500Hz responses in young infants.

Gold Standard Thresholds

Threshold measurement should continue until there is a high degree of confidence in CR and RA recordings, resolving any inconclusive results. A CR at threshold, a CR at 5-10 dB above threshold, and a RA at 5-10 dB below threshold is a "gold standard" threshold and should be the goal in every evaluation to minimize errors in threshold estimation. Ideally, at least one gold standard AC threshold, and if AC is not normal then one BC threshold for each ear should be achieved before moving on to other frequencies. This standard can be relaxed at other frequencies, but only if needed, given poor sleep state.

Consultation of colleagues with extensive pediatric experience is encouraged when unusual test findings occur.

Expanded BC ABR Detail

Since infants with steeply sloping sensorineural hearing loss can present with delayed absolute latencies (Small & Stapells, 2017), use of latency alone for classifying elevated ABR air conduction click threshold as conductive is discouraged. Bone conducted ABR assessment should be completed as soon as an elevated air conduction threshold is found. Small, Hatton, & Stapells (2007) found that a hand-held bone oscillator was at least as reliable and accurate as an elastic headband procedure ***provided the tester was properly trained in how to couple the oscillator to an infant head.*** When hand-holding the oscillator, proper placement and consistent pressure are important. If the clinician is unable to provide consistent pressure while managing equipment software during testing, then an elastic headband is encouraged. When hand-holding the oscillator, the following tips are important (Hyde, et al., 2016):[3]

- Ensure the oscillator is flat against the temporal bone
- Place the oscillator high on the temporal bone rather than low since the infant ear has very little bone below the ear canal opening compared to an adult (ideal placement zone is between B & C on image below) (Stuart, Yang, & Stenstrom, 1990)

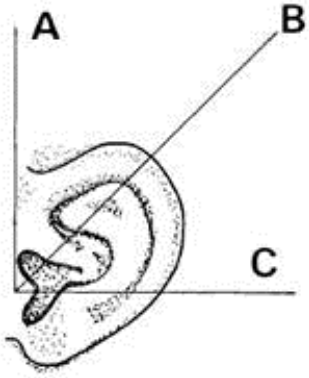


Figure 2. Effect of Temporal Area Bone Vibrator Placement on Auditory Brain Stem Response in Newborn Infants
Used with permission from Wolters Kulwer Health, Inc.

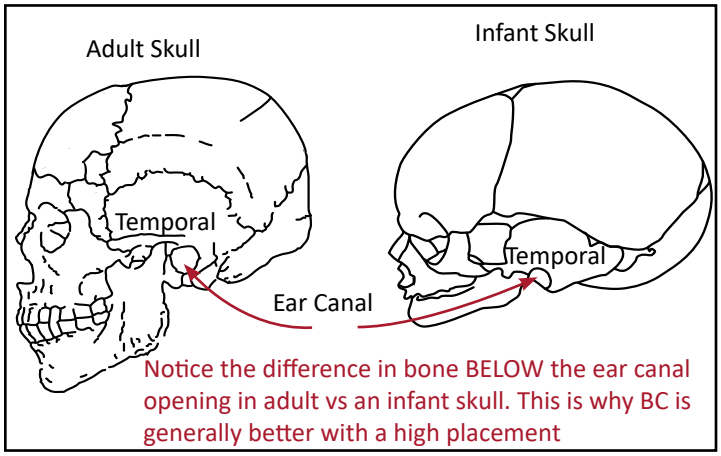


Figure 3. Temporal bone position for infant versus adult.
Used with permission from Marie Pigeon, CHEO.

- Hold the supply lead with the thumb and middle finger at the point of attachment to the oscillator and use the index finger to apply force to the oscillator (do not hold oscillator by its sides as this can dampen stimulus intensity) (BCEHP, 2012)[4]

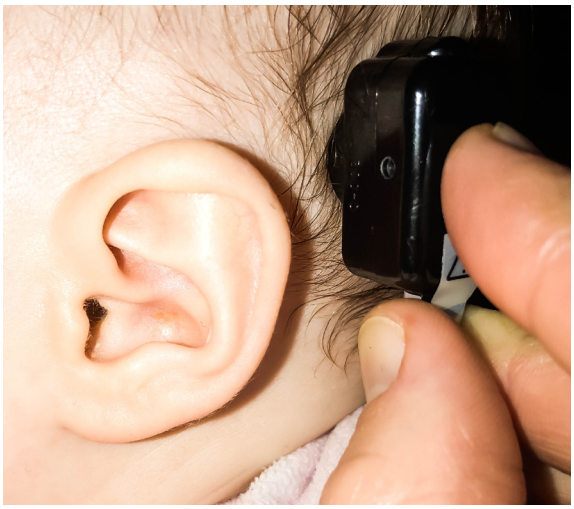


Figure 4. Recommended bone oscillator placement for an infant.

- Force should be firm and steady, but not excessive (approximately 400 to 450 g or 1lb) (BCEHP, 2012;[4] Yang, Stuart, Stenstrom, & Hollett, 1991)

The bone oscillator lead should not be in contact with electrode leads (and distance between the two should be maximized) to avoid interference of stimulus artifact (Hyde, 2008).

In infants, intracranial transmission loss of stimulation level is large (as much as 25 dB) (Small & Stapells, 2008) and each ear must be tested individually. It cannot be assumed that a given mastoid placement stimulates both cochlea equally (Hyde, 2008). Therefore, masking will rarely be required when testing at the low stimulus levels required to demonstrate normal versus impaired cochlear function.

Two recording channels are recommended in order to identify the responding cochlea (wave V is typically earlier and larger in the ipsilateral channel). This avoids practical difficulties and unsolved questions about contralateral masking of BC ABR in infants (Hyde, 2008). At higher stimulus levels, and where inspection of recordings from the two channels doesn't clearly distinguish the responding cochlea, then 50 dBSPL (BCEHP, 2012)[4] of white noise in the contralateral insert phone may be indicated.

As with air conduction stimuli, audiologists should carefully review and evaluate published data, choose bone conduction stimulus parameters based on high quality evidence, and the associated calibration and correction factors that match the chosen parameters (Hatton, Janssen, & Stapells, 2012; Hall, 2006).

ABR Latency/Intensity Data

Use of normed latency/intensity values can provide additional information to support decision-making regarding type of hearing loss and/or appropriate morphology. If utilizing a latency/intensity tool, the ABR test parameters used in the clinic must match (within ranges usually specified by the researcher) the test parameters used in developing the normative data.

Strategies for Improved Electrode Impedance

Proper preparation of skin for placement of electrodes during ABR testing is critical. Electrode impedance should ideally be < 4 KOhms at each site, and within 1 KOhm of other electrodes. The following strategies can help increase success in accomplishing this:

- Do not use expired electrodes or those from an already opened package ("wet gel" may dry out)
- Warm electrodes in pocket while beginning skin prep
- Use an appropriate skin prep material to scrub skin (avoid alcohol; it can dry skin and result in higher impedance levels)
- Avoid placing electrode on hair whenever possible
- If initial impedance is high, place a drop of saline on gel electrode

ABR Test Tips

Many test factors impact successful completion of ABR recordings. Please refer to the many evidence based recommendations throughout the ABR resource documents included in the Selected Links section of this document.

Sedation

When sedation is utilized to complete assessment, the administering facility must have a comprehensive sedation policy that outlines the steps required to ensure patient safety. Sedation should be administered on site at the testing facility as prescribed by the managing physician. Sedation policies typically include provision for written parental informed consent, details of appropriate supervision of the child during and post-sedation, and the process for access to emergency services if necessary. Since not all facilities are equipped to safely provide sedation, referral to another clinic may be necessary.

Infants three months of age or younger will typically sleep adequately without sedation to complete a diagnostic audiologic assessment. With newer evoked potential equipment, unsedated assessment may be possible for older infants.

Other Technologies

Clinicians must critically assess new equipment options to ensure the parameters utilized are supported by sufficient research involving infants with hearing loss and validated relative to frequency specific gold-standard methods (i.e. behavioral or frequency-specific ABR thresholds). In regards to all methods of assessment, Minnesota EHDI will consider further recommendations when methodologies and normative data are more widely available for newer technologies.

Auditory Steady State Response (ASSR)

The auditory steady state response has evolved greatly in the last 10 years. Early equipment utilized a continuous tonal stimulus that was amplitude modulated (in contrast to ABR brief tone stimuli). Response energy was detected at the same frequency as the stimulus modulation rate. Responses to multiple frequency stimuli was recorded simultaneously, then separated with equipment software and independently assessed. This technology increased response amplitude and detectability, and aimed to reduce test time.

Modern equipment utilizes a variety of stimuli including both broadband and frequency specific options. Modern ASSR statistical algorithms also search for a response component at harmonics of the modulation frequency, and may also combine phase coherence for increased accuracy.

However, there is currently insufficient evidence to consider ASSR as a standalone alternative to toneburst ABR to estimate elevated behavioral hearing thresholds in infants with hearing loss (BCEHP 2012[4]; Ontario, 2016[3]). Current limitations include:

- Large gaps in understanding the relationship between ASSR thresholds and pure tone behavioral thresholds in infants with hearing loss. Studies that have determined “normal” levels for infant ASSR have used normal hearing subjects and significantly variable test parameters. Caution is required when interpreting infant ASSR thresholds (Stapells, 2011).
- Significant lack of standardization between different commercially available systems in regards to stimulation and analysis techniques. Current equipment parameters often have very different characteristics than much of the foundational published research. There are few published studies to support the use of newer parameters, particularly in assessment of infants with hearing loss.
- Very limited bone conduction ASSR data in infants with hearing loss.
- Lack of information in the time domain to assess for cochlear microphonic (CM) in an absent response to differentiate ANSD.

Currently, except when air conduction thresholds are normal, ASSR is only appropriate if used in conjunction with tone-evoked ABR (Stapells, 2011, Small & Stapells, 2017).

Chirp-Evoked ABR

Broadband chirp-evoked ABRs were developed to increase synchronous activity of the auditory nerve fibers by compensating for the time delay of the cochlear partition. The stimulus was designed to delay the high frequency content until the lower frequency traveling waves are closer to the apex of the cochlea. As a result, chirp-evoked ABR waveforms are easier to detect near threshold. This can result in decreased test time.

Several variations of the broadband chirp stimulus are currently utilized by equipment manufacturers to elicit ABRs. However, test interpretation should be approached with caution. Age-dependent normative data correlating chirp thresholds with behavioral hearing thresholds in the pediatric population (with normal hearing or with hearing loss) is not currently available (Bargen, 2015). Current studies on use of chirp-evoked ABR mostly focus on adults or children with normal hearing. Stimulus parameters vary significantly between studies. Correction factors that audiologists currently apply when using click or toneburst stimuli will not be appropriate when utilizing a chirp stimulus. Further research is needed in order to maintain evidence-based best practice standards.

Wideband Acoustic Immittance

Newer techniques to assess middle ear function, including energy absorbance and wideband tympanometry, are useful diagnostic tools that can aid diagnosis of conductive hearing loss and may have better sensitivity than single-frequency tympanometry (Hunter & Blankenship, 2017). These procedures may be incorporated into the diagnostic test battery at the audiologist's discretion.

Behavioral Assessment

It is essential to cross-check electrophysiological data using behavioral measures of the child's functional use of hearing as soon as the child is able to provide behavioral responses at levels near true hearing thresholds.

Use of behavioral observation in very young infants can be useful in providing information about auditory awareness or about presence of a startle response, but cannot be used to accurately assess hearing thresholds.

In slightly older infants, visual reinforcement audiometry can be used to gather behavioral threshold information. "Previous studies have shown that valid behavioral measures can accurately delineate hearing loss in infants once they reach a developmental age of about six months" (Widen, et al., 2005). Children with global developmental delay

and/or other medical conditions impacting various aspects of development may be less able to provide reliable behavioral information with VRA. Use of earphones to obtain ear specific data is necessary.

If hearing loss is diagnosed, ongoing behavioral audiological assessment (with age-appropriate test methods) is necessary to obtain more detailed hearing threshold information and to monitor hearing levels and fit amplification. Refer to the MDH Guidelines for Pediatric Amplification - Follow-up section for more details.

FOLLOW-UP AND CASE MANAGEMENT

Report all diagnostic results to the newborn screening program. (See section on reporting below). For permanent hearing losses, hand out the MDH Beginnings Book to parents at the time of diagnosis. Close monitoring of hearing, and benefit from amplification (if chosen) will be necessary as outlined in the MDH Guidelines for Pediatric Amplification. Provide information regarding typical auditory, speech, language and developmental milestones. In addition, consider the following recommendations based on type of hearing loss or hearing status.

Normal with Risk Factors

If the audiological assessment results are normal, check for risk factors for late onset hearing loss. If the infant has a risk factor for progressive or late-onset hearing loss (EHDI Risk Indicators),[6] the audiologist should notify the child's primary care provider of the need for on-going follow-up and discuss implications with the parents.

The JCIH 2007 statement[2] specifically recommends, "The timing and number of hearing re-evaluations for children with risk factors should be individualized depending on the relative likelihood of a subsequent delayed-onset hearing loss. National recommendations indicate infants who pass the neonatal screening but have a risk factor should have at least one diagnostic audiology assessment by 24 to 30 months of age. Early and more frequent assessment may be indicated for children with cytomegalovirus (CMV) infection, syndromes associated with progressive hearing loss, neurodegenerative disorders, trauma, or culture-positive postnatal infections associated with sensorineural hearing loss; for children who have received ECMO or chemotherapy; and when there is caregiver concern or a family history of hearing loss."

New research on risk factors for hearing loss (Dumanch, et al., 2017) concludes that certain risk factors and the number of risk factors put children at greater risk.

Care providers for children birth to three years old should regularly monitor developmental milestones such as language and communication progress. If the parent or medical home provider become concerned about the child's responses to sound or about speech-language development, referral for further hearing evaluation or speech/language evaluation should occur (Minnesota Department of Health, 2014b). Referrals can be made using Minnesota's Help Me Grow Initiative (http://helpmegrowmn.org)

Conductive

If assessment results show conductive involvement is likely, use all possible diagnostic tools to rule out any underlying sensory loss, with the goal of completing

assessment before three months of age.

Do not postpone definitive diagnostic audiological evaluation solely due to middle ear dysfunction. Attempting bone conduction is recommended; however, if bone conduction testing is not possible, please document your rationale for determining conductive loss in your report to the newborn screening program. Please note if you think conductive loss is likely temporary or likely permanent.

If the hearing loss is likely temporary, contact the primary care provider so that a plan of treatment/ referral to an otolaryngologist (with expertise in examination of infants and young children) can be developed for the infant. Help the family schedule the next appointment with audiology and include the appointment date in your report to the newborn screening program.

If medical intervention is recommended, hearing should be re-evaluated after treatment is completed. If results continue to be abnormal, discussion of treatment options to include the use of hearing aids (if elected) should begin (see MDH Guidelines for Pediatric Amplification).

If the conductive hearing loss is deemed longstanding or permanent, discuss treatment options with the family and refer to early intervention and parent-to-parent support (follow Guidelines for Referral to Early Intervention, Medical Specialties and Connection to Parent-to-Parent Support).

Sensorineural

If the audiological assessment results are abnormal, and the hearing loss appears sensorineural, contact the primary care provider and refer to an otolaryngologist. Discuss audiological results and management options with the family and refer directly to early intervention and parent-to-parent support (see Guidelines for Referral to Early Intervention, Medical Specialties and Connection to Parent-to-Parent Support). Listen and respond to questions from families in an unbiased manner. Help families explore opportunities to connect with other parents of DHH children, Deaf mentors, DHH role models, teachers, and providers that can support their child's positive future. Emphasize the importance of early access to language and give parents information about all opportunities including visual language such as ASL and visual communication tools such as Cued Speech, as well as spoken language. Obtain medical clearance for use of amplification, if chosen (see MDH Guidelines for Pediatric Amplification). If assessment is based on ABR data, results should be clearly reported as estimated hearing levels (eHL). JCIH (2007)[2] recommends infants with confirmed hearing loss should have at least one exam by an ophthalmologist experienced in evaluating infants, and MDH guidelines recommend this ophthalmologic evaluation within six months of diagnosis (Minnesota Department of Health, Revised 2017). A genetics consultation should be offered to the families of infants with confirmed hearing loss (JCIH, 2007)[2].

Unilateral

If permanent unilateral hearing loss is identified, case management should be similar to that of bilateral hearing loss. Refer to early intervention and parent-to-parent support (follow Guidelines for Referral to Early Intervention, Medical Specialties and Connection to Parent-to-Parent Support). Discuss unilateral hearing loss and effects on language development, behavior, and safety with parents and consider treatment options. Obtain medical clearance for amplification, if chosen (see MDH Guidelines for Pediatric Amplification).

Auditory Neuropathy Spectrum Disorder (ANSD)

When ANSD is diagnosed, referral to an otolaryngologist is warranted. Discuss results and recommendations with parents and primary care providers, and discuss the need for ongoing assessments as the child grows. Refer to early intervention and parent-to-parent support (see MDH Guidelines for Referral to Early Intervention, Medical Specialties and Connection to Parent-to-Parent Support).

After medical/neurological evaluation has occurred, discuss additional results and implications with the parents. Schedule behavioral assessment of the infant using visual reinforcement audiometry at six months developmental age or when child can maintain head control. If parents express concerns sooner, age appropriate audiological re-evaluation should be conducted.

The impact of ANSD on auditory, language, and speech skills can vary tremendously from one individual to another. Behavioral audiological follow-up is a critical piece in determining the child's needs for intervention. If auditory skills are not developing normally and visual reinforcement audiometry suggests a hearing loss, discuss a trial period with amplification with parents. Loaner hearing instruments[7] could be a useful option during a trial. If adequate progress is not seen with consistent amplification, consider referral for cochlear implant evaluation.

On rare occasions, improvement in ABR thresholds can occur and may be due to neurological maturation. Infants born prematurely or with a history of hyperbilirubinemia should be monitored for change in audiological findings.

Congenital Cytomegalovirus (cCMV)

Hearing loss is one of the most common health issues found in babies born with congenital cytomegalovirus. Approximately 30-50% with symptomatic cCMV will develop hearing loss (Fowler, 2017). Recent advances in the detection of and treatment for cCMV have led to an increase in diagnosis. cCMV is diagnosed by testing the infant's urine or saliva. cCMV testing must be initiated by no later than three weeks of age in order to be certain the CMV was present at birth. For older infants, testing the newborn dried bloodspot may be an option and should be discussed with the infant's primary care or otolaryngology provider.

Infants/Children Diagnosed with cCMV

Infants/children diagnosed with cCMV infection will need more frequent audiologic monitoring to detect emerging hearing loss, progression of existing hearing loss, and to plan appropriate intervention. There is agreement about routine treatment and monitoring of *moderate to severely symptomatic* children. This includes audiologic monitoring at six-month intervals for the first three years of life, and annually thereafter through adolescence (Rawlinson, 2017). Other recommendations that suggest monitoring until age five years should be considered with the possibility of monitoring every three months when hearing levels are changing (Fowler, 2013). In approximately 50% of children with SNHL due to cCMV infection, hearing loss is progressive (Fowler, 2017).

Monitoring of *mildly symptomatic* children, as well as *asymptomatic* children, is not yet systematically routine due to insufficient evidence; but on a case by case basis can follow a similar monitoring process for emerging hearing loss (Rawlinson, 2017). An alternate process of monitoring for infants with no diagnosis of hearing loss (to minimize the burden on the system and on parents) could include follow-up using otoacoustic emissions (Foulon, Vleurinck, Kerkhofs, & Gordts, 2015; Fowler, Ross, & Boppana, 2018). Recommendations for timing of OAE monitoring varies.

Infants/Children with hearing loss and unknown cCMV status

If a child is diagnosed with a permanent hearing loss, consider testing for CMV. Children with asymptomatic cCMV can have hearing loss emerge that is progressive through adolescence (Lanzieri, et al., 2017). Follow above recommendations for regular audiological monitoring if the child is diagnosed with cCMV.

DOCUMENTATION & REPORTING

Provider reporting of hearing rescreen and follow-up assessment results to MDH–EHDI is mandated public health surveillance and does NOT require signed consent from the parent/caregiver.

Communicate audiological rescreen and diagnostic assessment results to the infant's parent/caregiver both verbally and in writing. Include follow-up plans or date of next scheduled visit whenever possible.

Report audiological rescreen and diagnostic assessment results and failed /rescheduled appointments to the infant's primary care physician and MDH–EHDI program. Report to MDH within one week of the scheduled visit date.

Report assessment results for all newly confirmed permanent hearing loss ***through age ten years and eleven months*** to MDH–EHDI.

Continue reporting of follow-up for infants who have confirmed conductive loss due to suspected middle ear fluid (after not passing newborn hearing screen), until final hearing status is determined.

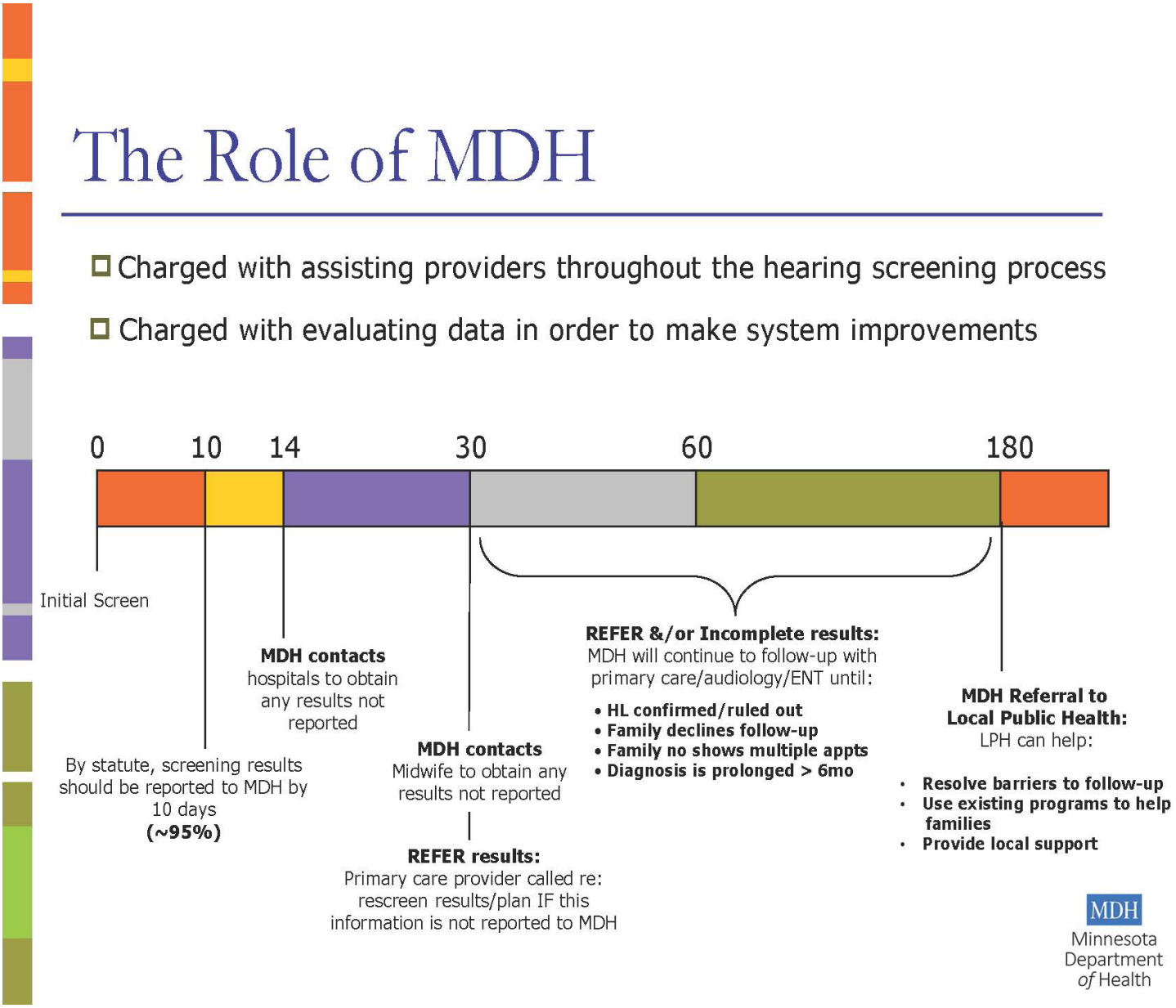
Out of state residents who receive outpatient hearing screening follow-up and new diagnosis of hearing loss in Minnesota, should also be reported to MDH–EHDI.

QUALITY ASSURANCE & QUALITY IMPROVEMENT

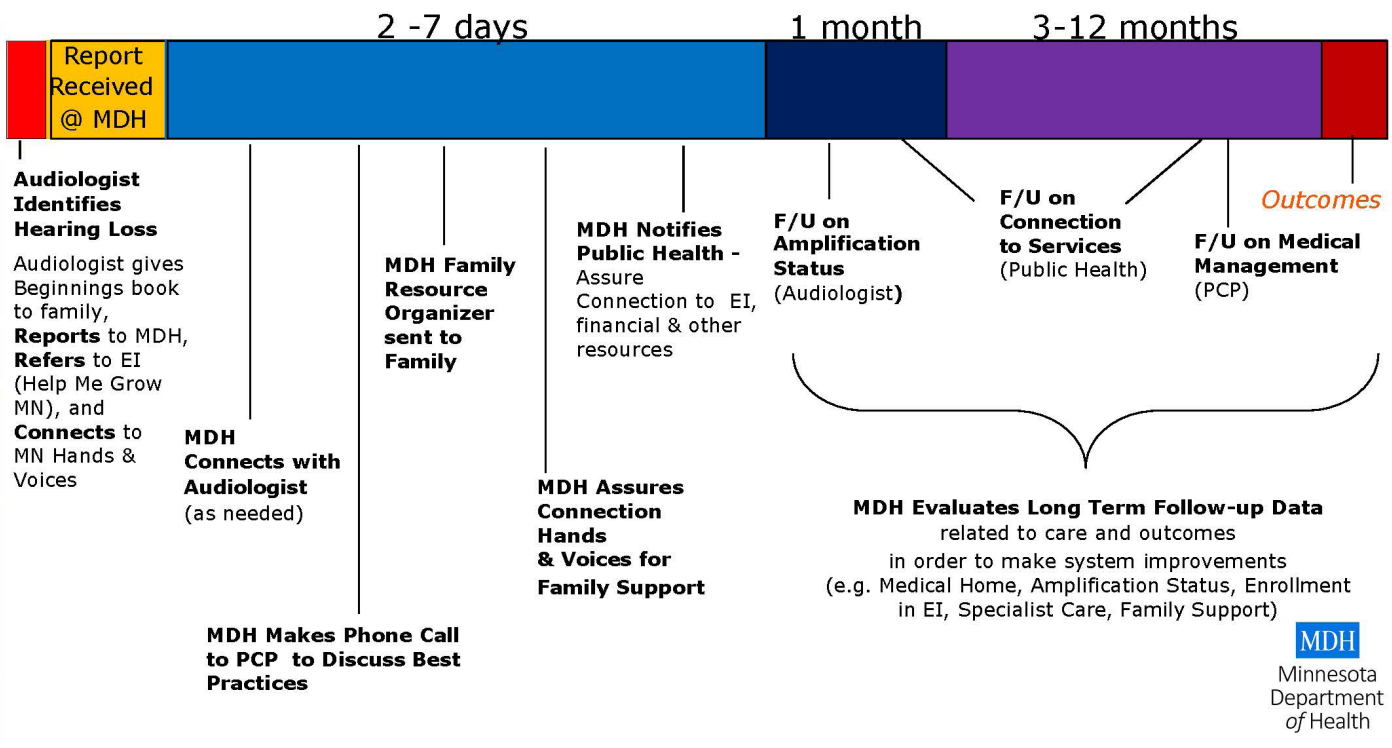
On a statewide level, MDH–EHDI strives for accountability to meet key program goals and for collaboration with providers on innovative quality improvement solutions. MDH–EHDI and audiology providers work together to ensure continuous and measurable improvements, so that every Minnesota infant receives timely and comprehensive follow-up when they do not pass newborn hearing screening.

Each audiology clinic can contribute to quality assurance by critically reviewing its own data and partnering with MDH–EHDI to explore improvement plan options. An online quality improvement action tool, developed nationally, provides guidance and proven improvement strategies. This resource is "Improving Follow-up after Newborn Hearing Screening, An Action Kit for Audiologists," is available at http://improveaudiology.org (NCHAM, 2017).[8] This tool enables clinics to complete a detailed organizational self-assessment to identify possible areas for improvement.

APPENDIX: MDH TIMELINE



What Happens When **Permanent** Hearing Loss is Reported to MDH?



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