Effective and Efficient Pre-School Hearing Screening

James W. Hall III, Ph.D.

Professor
Salus University

Adjunct Professor
Nova Southeastern University

Extraordinary Professor
University of Pretoria South Africa

www.audiologyworld.net  jwhall3phd@gmail.com
Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss
- Rationale for pre-school screening for hearing loss
- Historical perspective on pre-school hearing screening
- Techniques and technology for pre-school hearing screening: What are the options?
- Current clinical guidelines for pre-school hearing screening
- A new strategy for effective and efficient pre-school hearing screening
- Future directions in pre-school hearing screening
Early Hearing Loss Detection and Intervention: 
*The Ideal 1-3-6 Approach to EHDI*

- **< 1 month**
  - An infant is identified with hearing loss through hearing screening
- **< 3 months**
  - Hearing loss is diagnosed following JCIH guidelines
- **< 6 months**
  - Appropriate intervention is implemented based on diagnostic findings.
Most (90 - 98%) newborn infants undergo hearing screening. More than 40% of the children who fail hearing screened do not undergo timely diagnostic evaluation. Intervention can’t begin without diagnosis. Multiple and diverse reasons for infants “lost to follow-up” include:
- Newborn infants discharged from nursery before screening
- Infants transferred to another hospital before screening
- Infants screened in one state and living in another state
- Failure to document screening or diagnostic findings
- Family reasons, e.g.,
  - Transportation problems
  - Misunderstanding about need for follow-up
  - Infant has no primary care physician (medically homeless)
Early Hearing Loss Detection and Intervention (EHDI): The Problem of Infants “Lost to Follow Up (LFU)"

Documented Status of Infants Not Passing Hearing Screening United States, 2007–2010

- LFU / LTD
- No Hearing Loss
- Hearing Loss
- In Process
- Infant Died / Declined
- Non-Resident / Moved

Percent

CDC EHDI (December 2012)
Early Hearing Loss Detection and Intervention (EHDI): Possible Solutions for the Problem of “Loss to Follow Up”

- Well-organized systems for data management and tracking
- Education of
  - Hospital personnel
  - Primary care physicians and pediatricians
- Combination OAE/AABR hearing screening approach for lower failure rate and early diagnosis of hearing loss
- Diagnostic assessment immediately following screening failures in hospitals with audiology clinical services
- More qualified audiologists widely distribution throughout each state to provide diagnostic evaluations
- Tele-audiology strategies for diagnostic evaluations
- Pre-school hearing screenings
<table>
<thead>
<tr>
<th>Effective and Efficient Pre-School Hearing Screening: Essential for Successful EHDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss</td>
</tr>
<tr>
<td>- Rationale for pre-school screening for hearing loss</td>
</tr>
<tr>
<td>- Historical perspective on pre-school hearing screening</td>
</tr>
<tr>
<td>- Techniques and technology for pre-school hearing screening: What are the options?</td>
</tr>
<tr>
<td>- Current clinical guidelines for pre-school hearing screening</td>
</tr>
<tr>
<td>- A new strategy for effective and efficient pre-school hearing screening</td>
</tr>
<tr>
<td>- Future directions in pre-school hearing screening</td>
</tr>
</tbody>
</table>
Early Hearing Loss Detection and Intervention (EHDI):
Pre-School Hearing Screening is a Logical Extension of EHDI

Sites or venues for pre-school hearing screening

- Primary care physician’s office
  - Well baby visits
  - Immunizations
  - Concerns about ear infections or hearing
  - Physician visits for non ear-related reasons

- Head Start Programs
- Pre-school educational programs
- Day care facilities
Rationale for pre-school hearing screening

- Permits identification of hearing loss in children who were not screened as newborns
- Up to 50% of children undergoing newborn hearing screening are “lost to follow-up (LFU)”
- Identifies children with delayed onset or progressive hearing loss
- Approximately 15% of children with hearing loss passed infant hearing screening
- Otitis media and other middle ear disorders are common in the pre-school population
Year 2007 Joint Committee on Infant Hearing (JCIH):
Risk Indicators for Delayed Onset or Progressive Hearing Loss

Year 2007 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs
Joint Committee on Infant Hearing
Pediatrics 2007;120;898
DOI: 10.1542/peds.2007-2333
Delayed onset, late onset, or “acquired” hearing loss: Normal auditory function (hearing) at birth with the onset of auditory dysfunction (hearing loss) in infancy or early childhood

Progressive hearing loss: Normal auditory function (hearing) at birth with the onset of auditory dysfunction (hearing loss) in infancy or early childhood
Increased Prevalence of Hearing Loss in School Age Children versus Newborn Infants

  - Prevalence within 17,160 children increased from 1% at age 3 years to 2% at age 9 to 16 years
  - Up to 50% of children with hearing loss at age 9 passed newborn hearing screening.

  - UNHS programs do not detect 10 to 20% of permanent hearing loss that begins later

- White (October 2010). ASHA Virtual Audiology Conference
  - Prevalence of 3/1000 for permanent hearing loss in infants increases to 9-10/1000 in school age children
Not all newborn infants undergo hearing screening.

A sizeable proportion of infants who are screened as neonates and who fail the screening do not undergo diagnostic hearing assessment before 3 months.

A proportion of children who pass hearing screening as neonates are at risk for delayed onset or progressive hearing loss.

Almost all children will have middle ear disease during the preschool years (before age 5 years).

Hearing is important for communication (and reading) throughout pre-school years.

Preschool hearing screening is recommended by the American Academy of Pediatrics, JCIH, the American Academy of Audiology, and ASHA.
## Effective and Efficient Pre-School Hearing Screening: Essential for Successful EHDI

- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss
- Rationale for pre-school screening for hearing loss
- **Historical perspective on pre-school hearing screening**
- Techniques and technology for pre-school hearing screening: What are the options?
- Current clinical guidelines for pre-school hearing screening
- A new strategy for effective and efficient pre-school hearing screening
- Future directions in pre-school hearing screening
Effective and Efficient Pre-School Hearing Screening: 
*Historical Perspective*

- 1982 US Department of Health and Human Services, PHS
- 1984 American Academy of Pediatrics Policy Statement
- 1985 ASHA Guidelines for identification audiometry
- 1989 US Preventive Services Task Force
- 1989 American Public Health Association
- 1990 ASHA Guidelines for Screening of Hearing Impairment and Middle-Ear Disorders
- 1997 ASHA Guidelines for Audiologic Screening
- Current clinical guidelines will be discussed in a minute
1997 ASHA Guidelines for Audiologic Screening [64 pages]

- Separate guidelines for:
  - Newborns and infants age birth through 6 months
  - Infants and toddlers age 7 months through 2 years
  - Preschool children age 3 to 5 years
  - School-age children age 5 through 18 years

- Personnel
  - “Screening infants and children for hearing disorder and hearing impairment requires considerable professional expertise”
  - Screening process should be designed, implemented, and supervised by an audiologist with CCCs
Effective and Efficient Pre-School Hearing Screening: 
*Historical Perspective*

- **ASHA Guidelines for Audiologic Screening (1997):** Hearing screening of 7-month old through 2-year old children
  - “The panel concluded that for this age group, the development of screening guidelines to be used only by audiologists was appropriate and necessary.”
  - Clinical indications. Screen infants ...
    - “…as needed, requested, or mandated.”
    - “…who have previously received and passed hearing screening”
    - “if they have indicators…” (JCIH, 1994)
Effective and Efficient Pre-School Hearing Screening: 
_Historical Perspective_

- **ASHA Guidelines for Audiologic Screening (1997):** Hearing screening of _7-month old through 2-year old children_
  - For children who can be conditioned for play audiometry
    - Use earphones
    - Screen at 20 dB HL for 1000, 2000, and 4000 Hz
  - For children who can be conditioned for VRA
    - Use earphones
    - Screen at 30 dB HL for 1000, 2000, and 4000 Hz
  - Alternatives
    - Screening in calibrated sound field for those children who do not accept earphones
    - OAEs or ABR may be employed for screening
  - Not permitted: BOA, noncalibrated signals, speech stimuli
Effective and Efficient Pre-School Hearing Screening: 
*Historical Perspective* 

- ASHA Guidelines for Audiologic Screening (1997): Hearing screening of *children 3 to 5 years*

- For children who can be conditioned for play audiometry
  - “Administer a minimum of two conditioning trials at a presumed suprathreshold level to assure that the child understands the task.”
  - Use earphones
  - Screen at 20 dB HL for 1000, 2000, and 4000 Hz
  - “At least two presentations of each test stimulus may be required to assure reliability.”

- REFER: If the child does not respond to at least 2 out of 3 times at the criterion decibel level at any frequency in either ear or if the child cannot be conditioned to the task.”
**Effective and Efficient Pre-School Hearing Screening: Essential for Successful EHDI**

- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss
- Rationale for pre-school screening for hearing loss
- Historical perspective on pre-school hearing screening
- Techniques and technology for pre-school hearing screening: What are the options?
- Current clinical guidelines for pre-school hearing screening
- A new strategy for effective and efficient pre-school hearing screening
- Future directions in pre-school hearing screening
Effective and Efficient Pre-School Hearing Screening:
Pre-School Hearing Screening Options

- General and non evidence-based strategies = Not uncommon but NOT AN OPTION
- Pure tone hearing screening
- Otoacoustic emissions
  - Automated technology
  - Special pass/fail criteria
- Aural admittance measures
  - Tympanometry
  - Tympanometry plus acoustic reflexes
- Combinations of selected techniques depending on:
  - Skills of screening personnel (availability of audiologist)
  - Age of the child
  - Middle ear status
Behavioral Pre-School Hearing Screening: General Strategies (Not Evidence Based ... Worst Practice?)


- Physician’s office “check” for hearing loss includes one or more of the following
  - Parent questionnaire
  - Otoscopy
  - Tympanometry
  - Behavioral observations of response to
    - Hand clapping
    - Bell-ringing
    - Noise makers
Effective and Efficient Pre-School Hearing Screening:  
*Pre-School Hearing Screening Options*

- General strategies
- Pure tone hearing screening
- Otoacoustic emissions
  - Automated technology
  - Special pass/fail criteria
- Aural admittance measures
  - Tympanometry
  - Tympanometry plus acoustic reflexes
- Combinations of selected techniques depending on:
  - Skills of screening personnel (availability of audiologist)
  - Age of the child
  - Middle ear status
Pre-School Pure Tone Hearing Screening

Questions to Ask About Research Studies

- Qualifications of persons performing hearing screening, e.g.,
  - Audiologist
  - Graduate student in audiology or speech pathology
  - Other health professional
  - Trained non-health professional
- Ambient noise levels in the test environment
- Screening protocol including
  - Earphone type (supra-aural versus insert)
  - Test frequencies
  - Response criteria
- How many children could not be tested (CNT)?
- What were the PASS and FAIL (did not pass) rates?

- **Methods**
  - 100 preschool children age 36 to 60 months
  - Testing unsuccessful for additional 3 children
  - Screening performed by first author
  - Settings were daycare centers … “moderate to high socioeconomic status”
  - Hand raising response
  - Protocol and ambient noise consistent with ASHA guidelines (1985, 1990) but NOT with ASHA 1997 requiring conditioned play
Pure Tone Hearing Screening Failure Rate
(Krishnamurti, Hawks & Gerling, 1999)

Initial pure tone screening failure rate = 24%
Pure Tone Hearing Screening Test Time
(Krishnamurti, Hawks & Gerling, 1999)

Note: Not conditioned play audiometry
Behavioral Pre-School Hearing Screening in Physicians’ Office Setting

  - N = 1061 children age 3 to 19 years
  - “Convenience sample” with medical insurance coverage
  - Eight pediatric practices in Alabama
    - 5 nonacademic (private) practices
    - 3 academically affiliated practices
  - Screening in examination room (trained research assistant)
  - 95% conventional screening and 5% play audiometry
  - PT screening at 20 dB HL for 1000, 2000, and 4000 Hz
  - Screening audiometers with supra-aural earphones
Behavioral Pre-School Hearing Screening Screening in Physicians’ Office Setting

Halloran et al (2005)

- Completion of hearing screening
  - Gender
    - Boys: 93%
    - Girls: 94%
  - Race
    - African American: 90%
    - White: 96%
  - Age
    - 3 years: 55% (45% unable to complete screening)
    - 4 years: 93%
    - 5 years: 97%
    - ≥ 6 years: 100%
Behavioral Pre-School Hearing Screening Screening in Physicians’ Office Setting

Halloran et al (2005)

- Pass outcome of hearing screening
  - Gender (90% for boys and girls)
  - Race
    - African American: 88%
    - White: 91%
  - Age
    - 3 years: 95%
    - 4 years: 86%
    - 5 years: 91%
    - ≥ 6 years: 90%
  - Development
    - Delayed: 67% (N=21 or 2% of total population)
    - Normal: 90%
Summary

- 67 children (7%) were unable to complete the screening
- Of the remaining 948 children
  - 90% passed the screening
  - 10% failed the screening
  - A total of 162 children (15%) were CNT or failed screening
- No further evaluation (pediatricians didn’t refer the children)
  - 59% of the children failing the screening
  - 73% of the children with CNT results

- Of the total of 1061 children undergoing hearing screening, a group of 130 children received complete audiological evaluation
- “With audiologic evaluation used as the gold standard”
  - Sensitivity of screening tests not passed was 50%
  - Specificity was 78%
  - None of the 28 children who could not be tested had hearing loss
Behavioral Pre-School Hearing Screening in Physicians’ Office Setting

Halloran et al (2005)

“A national survey of general pediatricians found that guidelines were more likely to be followed if they were:

- Simple
- Feasible
- And demonstrated improved outcomes”


- 34,979 preschool children age 3 to 5 years
- Settings were public pre-school, day care, or head start centers
- Pure tone screening at 20 dB for 1000, 2000, 3000 & 4000 Hz
- Audiology or SLP graduate students from 6 different academic programs in NYC and Long Island area performed screening
- Hand raising response with CPA if CNT
- “Difficult to test” children were screened by supervisor
- Immediate rescreen of failures by supervising audiologist
- Tympanometry after pure tone screening by supervisor
Evidence-Based Problems with Behavioral Pre-School Hearing Screening

Serpanos & Jarmel, 2007

Figure 1. Pass/refer pure-tone and tympanometry screening outcomes. Total number of children screened = 34,979. CNT = could not test.

**REferred**
- 18% (n = 6,337)
  - tympanometry 6% (n = 2,006)
  - pure tone 2% (n = 663)
  - pure tone-CNT 3% (n = 1,185)
  - pure tone & tympanometry 7% (n = 2,483)

**Passed**
- 82% (n = 25,642)

  - N = 1462 3 and 4 year old children in Head Start programs
  - Followed ASHA 1997 Guidelines for pure tone screening, tympanometry, plus stoscopy
  - 54% passed initial screening with all three procedures
  - Pass rate for each procedure
    - 90% for otoscopy
    - 71% for tympanometry
    - 71% for pure tones
  - Rescreen pass rate was 76%
  - Only about 71% received recommended evaluation
  - Hearing status of 18% of the children never determined
According to ASHA and AAA guidelines, audiologists must conduct or supervise hearing screenings. Preschool hearing screenings may be conducted in settings lacking audiologists e.g., Head Start centers, physician offices. Ambient sound levels > 50 dB SPL (1000 Hz) ASHA criterion. Environmental distractions in test setting. Screening time per child may be 4 to 5 minutes or longer. A proportion of children will not or cannot:
- Cooperate in the hearing screening process
- Tolerate earphones
- Participate in conditioned play audiometry

Behavioral hearing screening is not “rapid and simple” for children age 3 years and younger (Northern & Downs, 1991).
Effective and Efficient Pre-School Hearing Screening:
*Pre-School Hearing Screening Options*

- Parent survey (used by physicians)
- Pure tone hearing screening
- **Otoacoustic emissions**
  - Automated technology
  - Special pass/fail criteria for pre-school hearing screening
- Aural admittance measures
  - Tympanometry
  - Tympanometry plus acoustic reflexes
- Combinations of selected techniques depending on:
  - Skills of screening personnel (availability of audiologist)
  - Age of the child
  - Middle ear status
Effective and Efficient Pre-School Hearing Screening: Distortion Product OAEs
Effective and Efficient Pre-School Hearing Loss Identification and Diagnosis: Otoacoustic Emissions


Methods

- 198 preschool children age 3 to 6 years (mean 4.5 years)
- Testing unsuccessful for another 2 children (PTs only)
- Screening procedures
  - DPOAEs
  - PT screening with conditioned play (block in bucket)
- Data collected by audiology and SLP grad students in 8 different preschool facilities
- Protocol consistent with ASHA 1997 guidelines
Hearing Screening Time for DPOAEs versus Pure Tone Technique in Pre-School Children

(Kreisman et al, 2013)

Figure 1. Mean time to complete each screening protocol.
Hearing Screening Pass/Fail Data for DPOAEs versus Pure Tone Technique in Pre-School Children *(Kreisman et al, 2013)*

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pass</th>
<th>Fail</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPOAE (1-5 kHz)</td>
<td>134</td>
<td>64</td>
<td>198</td>
</tr>
<tr>
<td>DPOAE (2-5 kHz)</td>
<td>141</td>
<td>57</td>
<td>198</td>
</tr>
<tr>
<td>Pure-Tone (1,2,4 kHz)</td>
<td>175</td>
<td>21</td>
<td>196</td>
</tr>
</tbody>
</table>

*Note.* DPOAE=Distortion Product Otoacoustic Emissions. Two children would not cooperate to be screened using pure tones.
Effective and Efficient Pre-School Hearing Screening: 
Advantages of OAEs

- Objective and not dependent on child’s
  - Behavioral response
  - Cognition
  - Language level or native language
- Painless
- Reliable
- Efficient and quick to administer (< 4 minutes)
- Simple to administer with low level of technical skill ...Does not require an audiologist
- Measurement doesn’t require acoustically treated environment
- Hand-held and portable equipment
- Test outcome is documented electronically or in printout
OAE Screening in Pre-School and School Age Children: Criterion for PASS versus REFER
(Data for adults and older children from Gorga, Stover & Neely, 1996)

REFER versus PASS

SNHL
Normal

-10 -5 0 5 10

Absolute DP Amplitude (dB SPL)
Effective and Efficient Pre-School Hearing Screening:
Pre-School Hearing Screening Options

- Parent survey (used by physicians)
- Pure tone hearing screening
- Otoacoustic emissions
  - Automated technology
  - Special pass/fail criteria
- Aural admittance measures
  - Tympanometry
  - Tympanometry plus acoustic reflexes
- Combinations of selected techniques depending on:
  - Skills of screening personnel (availability of audiologist)
  - Age of the child
  - Middle ear status
James Jerger
Classic Impedance Studies in Early 1970s at Methodist Hospital
And Baylor College of Medicine in Houston Texas, USA

Clinical Experience With Impedance Audiometry
James Jerger, PhD, Houston

Impedance audiometry was performed as part of the routine clinical examination in a consecutive series of more than 600 patients with various types and degrees of hearing impairment. An electroacoustic bridge (Madsen, type: EI3-70) was used in all cases.

THE development of impedance audiometry during the past decade has added new scope and dimension to clinical audiology. Based on the pioneering efforts of Madsen, subsequent workers have refined instrumentation, techniques, and interpretation to produce an invaluable tool for diagnostic use.

The development of contemporary instrumentation for impedance audiometry has, in the main, followed two essentially parallel paths. In the United States, Zwislocki and Seidman have continued to develop their electroacoustic bridge. In Europe, Thomask, Terkildsen, and others have pioneered the application of the electroacoustic approach, culminating in the present commercially available electroacoustic bridge.

The present paper reports our clinical experience with the latter instrument based on its routine administration to well over 400 consecutive patients over a one-year period. Our aim was to assess the efficacy of the electroacoustic approach as a routine clinic procedure and to evaluate its diagnostic value in a typical audiologic case load.

In general we found that the testing procedure was easily mastered, even by audiologically unexposed personnel, that valid and meaningful results could be obtained for almost every patient, and that, with certain reservations, the data of impedance audiometry constitute extremely valuable diagnostically.

Subsequent sections present statistical information when patients are grouped according to age and type of hearing loss, and individual case reports illustrating the diagnostic value of impedance audiometry.

Method

Apparatus—Impedance audiometry was carried out by means of an electroacoustic importance bridge (Madsen, type: EI3-70) and an electronic programmer (Madsen, type: M1017). Figure 1 shows a schematic diagram of the circuitry of the impedance bridge.

A probe tip containing three tubes is inserted in the external meatus, forming a closed cavity bounded by the inner surface of the probe tip, the tympanic membrane, and a rigid chamber. The probe tip is mounted on a motor-driven micrometer that permits variation of the external diameter of the probe tip and, therefore, of the air pressure in the closed cavity. A potentiometer on the output of the 220-Hz oscillator permits variation of the 220-Hz oscillator which permits variation, in air pressure in the closed cavity over a range of 2-400 mm (water). Air pressure is read on an electrometer.

...
Year 2007 Joint Committee on Infant Hearing (JCIH): Protocol for Evaluation for Hearing Loss In Infants from Birth to 6 months

- Child and family history
- Evaluation of risk factors for congenital hearing loss
- Parental report of infant’s responses to sound
- Clinical observation of infant’s auditory behavior
- Audiological assessment
  - Auditory brainstem response (ABR)
  - Otoacoustic emissions (distortion product or transient OAEs)
  - Tympanometry with 1000 Hz probe tone
  - Supplemental procedures, e.g.,
    - Electrocochleography (ECochG)
    - Auditory steady state response (ASSR)
    - Acoustic reflex measurement (for 1000 Hz probe tone)
Year 2007 Joint Committee on Infant Hearing (JCIH): Protocol for Evaluation for Hearing Loss In Infants from 6 to 36 months

- Child and family history
- Parental report of infant’s responses to sound
- Behavioral audiometry (either VRA or CPA)
- Otoacoustic emissions (distortion product or transient OAEs)
- **Acoustic immittance measures**
  - Tympanometry
  - Acoustic reflex measurement
- **Auditory brainstem response if**
  - Behavioral audiometry responses are not reliable *or*
  - ABR measurement has not been done in the past
Acoustic Stapedial Reflex Pathways According to Erick Borg

Acoustic Reflex Presence as a Function of Age
(From Kankkunen & Liden (1988). Ipsilateral acoustic reflex thresholds in neonates and in normal-hearing and hearing impaired preschool children. Scand Audiol, 13, 139-144)

<table>
<thead>
<tr>
<th>Age of Child</th>
<th>Percentage of Children with Reflexes Present (600 Hz Probe Tone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month</td>
<td>100%</td>
</tr>
<tr>
<td>2 months</td>
<td>92%</td>
</tr>
<tr>
<td>3 months</td>
<td>90%</td>
</tr>
<tr>
<td>4 months</td>
<td>87%</td>
</tr>
<tr>
<td>5-11 months</td>
<td>85%</td>
</tr>
<tr>
<td>1 year</td>
<td>72%</td>
</tr>
<tr>
<td>2 years</td>
<td>67%</td>
</tr>
<tr>
<td>3 years</td>
<td>47%</td>
</tr>
<tr>
<td>4 years</td>
<td>47%</td>
</tr>
</tbody>
</table>
Acoustic Reflexes in Neonates

- 66 full term infants
- Acoustic reflexes recorded with 1000 Hz probe tone
- Tone and BBN stimuli
- All neonates had acoustic reflexes
**Acoustic Reflexes in Neonates**


<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Median ART (dB HL)</th>
<th>90% Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 Hz</td>
<td>80</td>
<td>70 - 95</td>
</tr>
<tr>
<td>2000 Hz</td>
<td>70</td>
<td>60 - 85</td>
</tr>
<tr>
<td>4000 Hz</td>
<td>65</td>
<td>50 - 80</td>
</tr>
<tr>
<td>BBN</td>
<td>55</td>
<td>50 – 75</td>
</tr>
</tbody>
</table>

*N = 68 ears*
Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)
Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss
- Rationale for pre-school screening for hearing loss
- Historical perspective on pre-school hearing screening
- Techniques and technology for pre-school hearing screening: What are the options?
- Current clinical guidelines for pre-school hearing screening
- A new strategy for effective and efficient pre-school hearing screening
- Future directions in pre-school hearing screening
Evidence-Based Efficient and Effective Identification of Pre-School Hearing Loss: Clinical Guidelines

- 1997 ASHA Guidelines for Audiologic Screening
- 2011 AAA Childhood Hearing Screening Clinical Guidelines
2011 American Academy of Audiology Childhood Hearing Screening Clinical Guidelines

- Pure tone (PT) hearing screening
  - *Screening personnel and training not defined in guidelines*
  - Perform biologic equipment calibration
  - Screen populations age 3 (chronologically and developmentally) and older using pure tone screening
  - Perform PT sweep at 1000, 2000, and 4000 Hz at 20 dB HL
  - Present a tone once but not > 4 times if a child fails to response
  - Screen in an acoustically appropriate environment
  - Lack of response at any frequency in either ear is a failure
  - Rescreen immediately
  - Use tympanometry with pure tone screening in preschool
  - Minimum grades to be screening include preschool
Tympanometry screening
- Calibrate equipment daily
- Used as a second stage screening after pure tone or OAE screening failure
- Referral criteria
  - Recommended = 250 daPa tympanometric width
  - If width isn’t possible, use 0.2 mmhos static compliance
  - Final option is negative pressure of > - 200 daPa
- Target young pediatric populations
- Results of OAE and tympanometric screening inform next steps”
Rescreening

- “Rescreen with tympanometry after a defined period”
  - After failing immediate pure tone rescreening
  - In 8 to 10 weeks for children failure pure tone or OAE screening and tympanometry
- “Do not wait to perform a second stage screening on children who fail pure tone screening only

2011 American Academy of Audiology Childhood Hearing Screening Clinical Guidelines
OAEs
- Use only for children for whom PT screening is not developmentally appropriate (< 3 years)
- Calibrate OAE equipment daily
- Maintain primary DPOAE levels at 65/55 dB SPL
- Select DPOAE or TEOAE cut-off values carefully
- Default settings may not be appropriate
- Screening OAE programs must involve experienced audiologist
- Children failing OAE should be screened with tympanometry

Acoustic reflex testing, reflectometry, and hearing screening using speech materials are not recommended
<table>
<thead>
<tr>
<th>Effective and Efficient Pre-School Hearing Screening: Essential for Successful EHDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss</td>
</tr>
<tr>
<td>- Rationale for pre-school screening for hearing loss</td>
</tr>
<tr>
<td>- Historical perspective on pre-school hearing screening</td>
</tr>
<tr>
<td>- Techniques and technology for pre-school hearing screening: What are the options?</td>
</tr>
<tr>
<td>- Current clinical guidelines for pre-school hearing screening and diagnosis of hearing loss</td>
</tr>
<tr>
<td>- A new strategy for effective and efficient pre-school hearing screening</td>
</tr>
<tr>
<td>- Future directions in pre-school hearing screening</td>
</tr>
</tbody>
</table>
Effective and Efficient Screening for Pre-School Hearing Loss: Let’s Consider a New Feasible and Evidence-Based Approach

<table>
<thead>
<tr>
<th>Birth to 4 Years</th>
<th>&gt; 4 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DPOAES</strong></td>
<td></td>
</tr>
<tr>
<td>2000 – 5000 Hz</td>
<td>PASS for previous hearing screening? Follow birth to 4 year objective test protocol.</td>
</tr>
<tr>
<td>PASS = DP ≥ 0 dB SPL</td>
<td></td>
</tr>
<tr>
<td><strong>Immittance measures</strong></td>
<td></td>
</tr>
<tr>
<td>Tympanometry</td>
<td>Previous FAIL outcome or no documented hearing screening?</td>
</tr>
<tr>
<td>ART for BBN</td>
<td>Follow 2011 AAA Guidelines</td>
</tr>
<tr>
<td>PASS = type A; BBN &lt; 80 dB</td>
<td>(Pure tone screening at 20 dB HL)</td>
</tr>
<tr>
<td><strong>Otoscopy as indicated</strong></td>
<td></td>
</tr>
</tbody>
</table>
New Strategy for Pre-School Hearing Screening with OAEs, Tympanometry, and Acoustic Reflexes

- Pass ?
  - Tympanometry + ART for BBN
    - Pass All Tests?
      - No Follow Up
    - Repeat Fail/Abnormal?
      - Medical Referral
  - Otoscopy
    - Fail/Abnormal?
      - Tympanometry
        - Re-Test in < 1 Month
      - Pure Tone Screen (if feasible with age)
    - Tympanometry
      - 2nd Attempt
- DPOAEs
Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

- UNHS doesn’t lead to universal diagnosis and intervention of childhood hearing loss
- Rationale for pre-school screening for hearing loss
- Historical perspective on pre-school hearing screening
- Techniques and technology for pre-school hearing screening: What are the options?
- Current clinical guidelines for pre-school hearing screening and diagnosis of hearing loss
- A new strategy for effective and efficient pre-school hearing screening
- Future directions in pre-school hearing screening
Early Hearing Loss Detection and Intervention (EHDI): 
New Directions in Early Identification of Infant Hearing Loss 
(Devices for OAEs, Tympanometry and Acoustic Reflexes)
Effective and Efficient Pre-School Hearing Screening: Advantages of New Strategy Using OAEs, Tympanometry, and Acoustic Reflexes

- Objective and not dependent on child’s behavioral response, cognition, developmental age, or language level
- Reliable
- Efficient and quick to administer (< 4 minutes)
- Simple to administer with low level of technical skill
- Does not require an audiologist
- Does not require an acoustically treated test environment
- Hand-held and portable equipment
- Test outcome is documented electronically or in printout
- Sensitive measure of
  - Middle ear function
  - Cochlear (outer and inner hair cell) function
  - ANSD
Effective and Efficient Pre-School Hearing Loss Identification and Diagnosis: 
*Wideband Reflectance or Absorbance (Normal vs. Otitis Media)*
Effective and Efficient Pre-School Hearing Loss Identification and Diagnosis: *(OtoStat Device for WBR/A and OAEs)*
Effective and Efficient Pre-School Hearing Screening: Tele-Audiology

De Wet Swanepoel, PhD.1,2 and James W. Hall, Jr., PhD.3

1Department of Communication Pathology, University of Pretoria, South Africa
2Callier Center for Communication Disorders, University of Texas at Dallas, TX, USA
3Department of Speech and Hearing Therapy, University of Witwatersrand, South Africa
4Research and Development Department, GeoAxon, South Africa
5Department of Communicative Disorders, University of Florida, Gainesville, FL, USA
6School of Speech Pathology and Audiology, Kent State University, OH, USA
7Department of Speech Language Pathology and Audiology, School of Dentistry of Bauru, University of São Paulo, Brazil
8School of Speech Pathology and Audiology, University of Pretoria, South Africa
9School of Speech Pathology and Audiology, Dentistry School of Bauru, University of São Paulo, Brazil
10Department of Communication Pathology, University of Pretoria, South Africa
11School of Speech Pathology and Audiology, Kent State University, OH, USA
12Department of Communicative Disorders, University of Florida, Gainesville, FL, USA

Abstract

Permanent hearing loss is a leading global health care burden, with 1 in 10 people affected to a mild or greater degree. A shortage of trained healthcare professionals and associated infrastructure and resource limitations mean that hearing health services are unavailable to the majority of the world population. Utilizing information and communication technology in hearing health care, or tele-audiology, combined with automation offers unique opportunities for improved clinical care, widespread access to services, and more cost-effective and sustainable hearing health care. Tele-audiology demonstrates significant potential in areas such as education and training of hearing health care professionals, paraprofessionals, parents, and adults with hearing disorders; screening for auditory disorders; diagnosis of hearing loss; and intervention services. Global connectivity is rapidly growing with increasingly widespread distribution into underserved communities where audiological services may be facilitated through telehealth models. Although many questions related to aspects such as quality control, licensure, jurisdictional responsibility, certification and reimbursement still need to be addressed; no alternative strategy can currently offer the same potential reach for impacting the global burden of hearing loss in the near and foreseeable future.

Sumario

La pérdida auditiva permanente es una importante carga para los cuidados de la salud a nivel mundial, con 1 de cada 10 personas afectadas en grado ligero o mayor. La escasez de profesionales de salud capacitados e infraestructura asociada y la limitación de recursos determina que los servicios de salud auditiva no estén disponibles para la mayoría de la población mundial. La utilización de la información y la tecnología de la comunicación en los cuidados de la salud auditiva, o teleaudiología, combinada con la automatización, ofrece oportunidades únicas para mejorar los cuidados clínicos, ampliar el acceso a los servicios y tener cuidados de salud auditiva costoefectivos y sustentables. La Teleaudiología ha demostrado un potencial significativo en áreas como la educación y el adiestramiento de profesionales y paraprofesionales de la salud auditiva, padres y adultos con problemas auditivos; tamiz de problemas auditivos; diagnóstico de pérdidas auditivas; y servicios de intervención. La conectividad global está creciendo rápidamente y ha aumentado de manera generalizada su distribución en comunidades con pocos servicios, en donde los servicios audiológicos pueden facilitarse a través de modelos de telesalud. Aunque existen muchas dudas que deben ser resueltas y que están relacionadas con aspectos como el control de calidad, la regulación de la jurisdicción profesional, la certificación y el reembolso de los servicios, no existe una estrategia alternativa que pueda ofrecer el mismo potencial para impactar el peso global de las pérdidas auditivas en el futuro cercano o previsible.
# Effective and Efficient Pre-School Hearing Screening:  
*Audiology Applications of Tele-Health*

- Video-otoscopy
- Pure tone audiometry
- Infant and preschool hearing screening
  - Pure tone
  - OAE
  - Tympanometry and acoustic reflex
- ABR estimation of hearing loss
- Diagnostic auditory assessment
- Vestibular assessment
- Rehabilitation, e.g.,
  - Counseling patients and families
  - Hearing aid fitting and programming
  - Cochlear implant programming
Audiology Applications of Tele-Health:  
*Synchronous Technology for DPOAE Measurement*  
Audiology Applications of Tele-Health: 
Breaking News About Technology

Original Article

Smartphone hearing screening with integrated quality control and data management

De Wet Swanepoel*,†,‡, Hermanus C. Myburgh§, David M. Howe*,§, Faheema Mahomed* & Robert H. Eikelboom*,†,‡

*Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South Africa, †Ear Sciences Centre, School of Surgery, The University of Western Australia, Nedlands, Australia, ‡Ear Science Institute Australia, Subiaco, Australia, §Callier Center for Communication Disorders, University of Texas at Dallas, USA, and ¶Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria, South Africa
# Tele-Audiology:

**Smart Phone hearScreen Application**

![Image](image.jpg)

**Figure 5.** Clinical hearing screening test on school child using smartphone with hearScreen™ application and HD202 headphones. Phone is held upside-down to ensure the microphone faces towards the test subject for environmental noise monitoring.

**Table 3.** Cross tabulation of screening outcomes for ears using conventional and mobile phone based hearing screening (n = 324 ears).

<table>
<thead>
<tr>
<th></th>
<th>Pass</th>
<th>Refer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone screening</td>
<td>96.3% (312)</td>
<td>0.9% (3)</td>
<td>97.2% (315)</td>
</tr>
<tr>
<td>Refer</td>
<td>1.2% (4)</td>
<td>1.5% (5)</td>
<td>2.7% (9)</td>
</tr>
<tr>
<td>Total</td>
<td>97.5% (316)</td>
<td>2.4% (8)</td>
<td></td>
</tr>
</tbody>
</table>
Effective and Efficient Pre-School Hearing Screening: 
*Essential for Successful EHDI*

Austin, Alessandra, Charlie & Ana Sofia Hall  
(2015)

Austin Hall screens Victoria Hall  
(1986)

Austin, Alessandra, Charlie & Ana Sofia Hall  
(2015)