Effective and Efficient Pre-School Hearing Screening: Essential for EHDI

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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

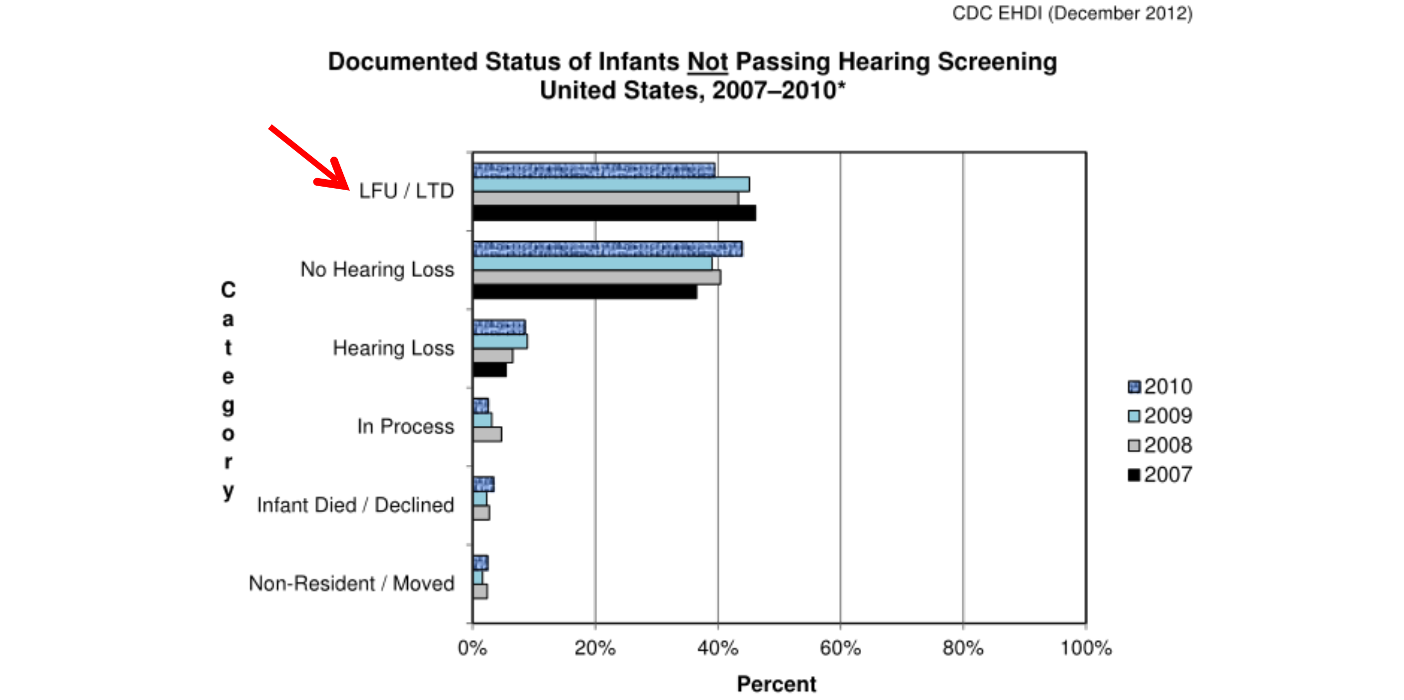
Early Hearing Loss Detection and Intervention:
The Ideal 1-3-6 Approach to EHDI

- < 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.

Effective and Efficient Pre-School Hearing Screening: *The Problem of "Loss to Follow Up"*

- Most (90 - 98%) newborn infants undergo hearing screening
- > 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"
  - 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)"



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 earliy 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

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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

Early Hearing Loss Detection and Intervention (EHDI):
Pre-School Hearing Screening is a Logical Extension of EHDI

- 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 Progresive Hearing Loss

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

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

Year 2007 JCIH Position Statement: Risk Indicators Associated with Permanent Congenital, Delayed-Onset, or Progressive Hearing Loss in Childhood

- **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

- Fortnum, Summerfield, Marshall, Davis & Bamford. (2001). *BMJ, 323*, 536-554
  - 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.
- Grote (2000). Neonatal screening for heairng impairment. *Lancet, 355*, 513-514
  - 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

Effective and Efficient Pre-School Hearing Screening*: Summary of Rationale*

- 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 pre-school 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

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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

Effective and Efficient Pre-School Hearing Screening: *Historical Perspective*

- 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."

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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?)

- Eiserman W, Shisler L, Foust T, Burhmann J, Winston R & White K (2008). *Updating hearing screening practices in early childhood. Volume 21,* Wolters Kluwer Health/Lippincott Williams & Wilkins, pp. 186-193
- 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?

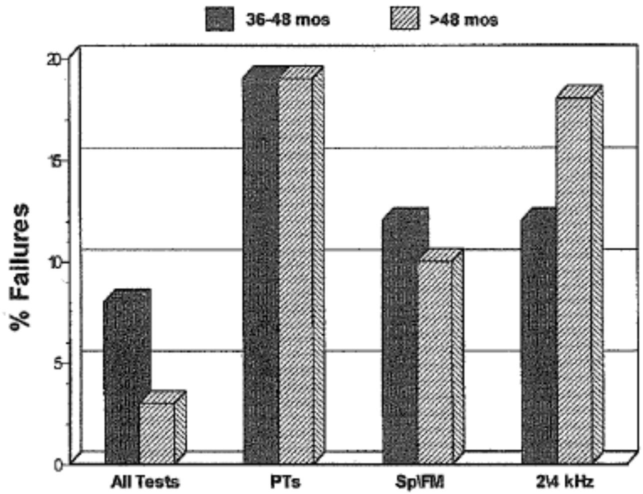
Behavioral Pre-School Hearing Screening
Research Findings

- Krishnamurti, Hawks & Gerling (1999). Performance of preschool children on two hearing screening protocols. *Contemporary Issues in Communication Science and Disorders, 26,* 63-68 [Kent State University]
  - 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

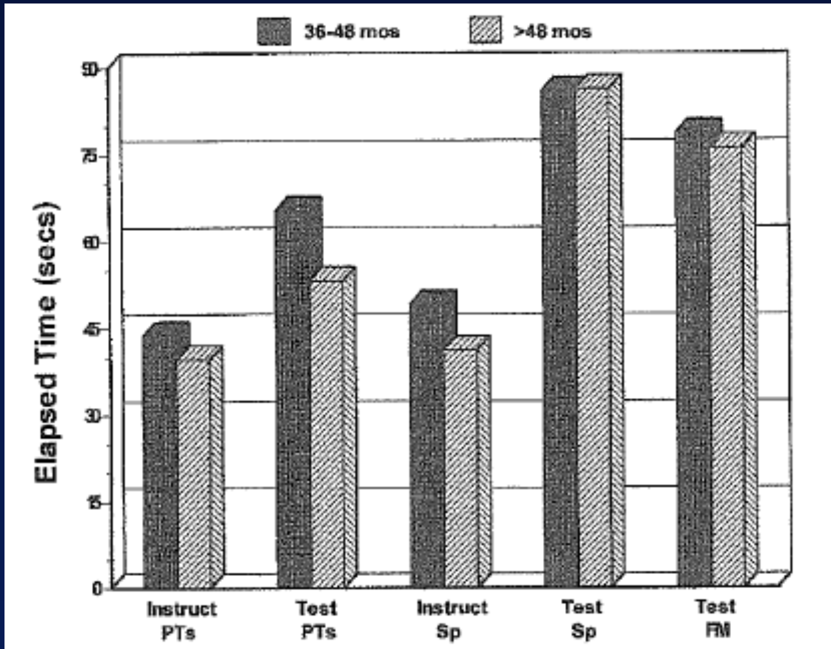
(Krishnamurti, Hawks & Gerling, 1999)

Figure 3. Percentage of screening failures by younger (36 to 48 months) and older (> 48 months) subjects for all tests (pure tone, spondee, and FM tone), pure tone (PTs), spondee and FM tone (Sp\FM), and 2 or 4 kHz pure tones.



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

- Halloran, Wall, Evans, Hardin & Woolley (2005). Hearing screening at well-child visits. *Arch Pediatr Adolesc Med, 159,* 949-955
  - 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%

Behavioral Pre-School Hearing Screening Screening in Physicians' Office Setting

Halloran et al (2005)

- 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

Behavioral Pre-School Hearing Screening Screening in Physicians' Office Setting … Follow Up Study

- Halloran, Hardin & Wall (2009). Validity of pure-tone hearing screening at well-child visits. *Arch Pediatr Adolesc Med, 163,* 158-163
  - 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 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"

Flores G, Leo M, Bauchner H & Kastner B (2000). Pediatrician's attitudes, beliefs, and practices regarding clinical practice guidelines: a national survey. *Pediatrics, 105*, 496-501

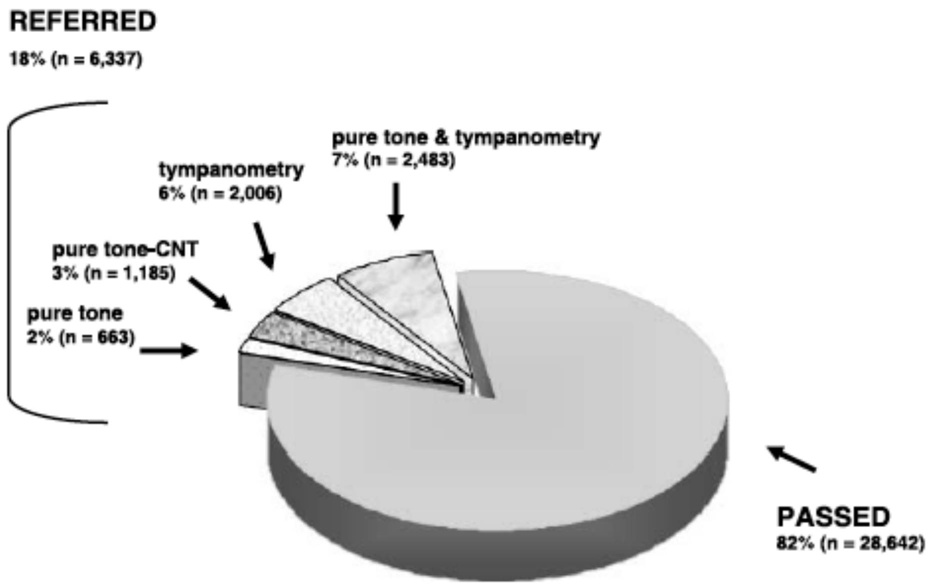
Behavioral Pre-School Hearing Screening in Public Pre-School, Day Care or Head Start Settings

- Serpanos YC & Jarmel F (2007). Quantitative and qualitative follow-up outcomes from a preschool auditory screening program: Perspectives over a decade. *American Journal of Audiology 16,* 4-12
  - 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.



Evidence-Based Problems with Behavioral Pre-School Hearing Screening: Allen et al (2004)

- Allen RL, Stuart A, Everett D & Elangovan S (2004). *American Journal of Audiology, 13*. 29-38
  - 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

Problems with Behavioral Pre-School Hearing Screening

- 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*

- Ho et al (2002). Otoacoustic emissions and tympanometry screening among 0-5 year olds. Laryngoscope, 112, 513-519
- Eisermann et al (2007). Using otoacoustic emissions to screen for hearing loss in early childhood care settings*. Int J Pedi ORL, 72,* 475-482
- Hunter et al (2007). Hearing screening and middle ear measures in American Indian infants and toddlers. *Int J P ORL, 71,* 1429-1438
- Bhatia et al (2013). Early identification of young children with hearing loss in Federally qualified health centers. *J Developmental Behavioral Pediatrics, 34,* 15-21
- Kreisman BM, Bevliacqua E, Day K, Kreisman NV & Hall JW III (2013). Preschool hearing screenings: Comparison of distortion product otoacoustic emission and pure-tone protocols. Journal of Educational Audiology, 19, 48-57

Effective and Efficient Pre-School Hearing Screening: *OAE Research Findings*

- Kreisman BM, Bevilacqua E, Day K, Kreisman NV & Hall JW III (2013). Preschool hearing screenings: Comparison of distortion product otoacoustic emission and pure-tone protocols. *Journal of Educational Audiology, 19*, 48-57
- 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)

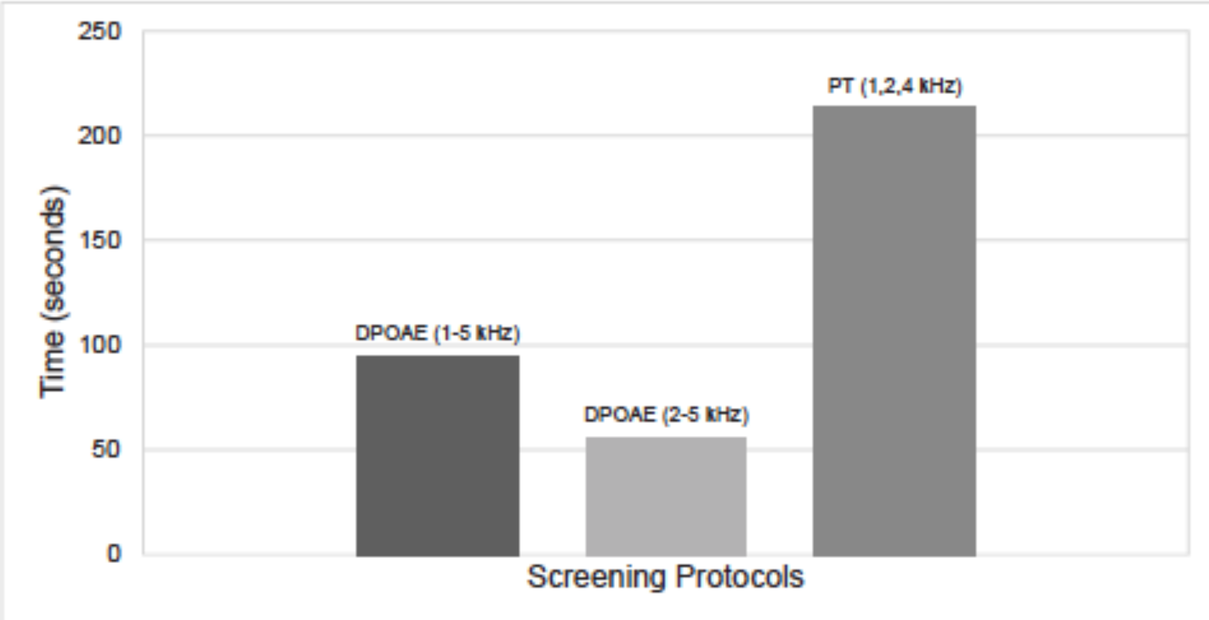


Figure 1. Mean time to complete each screening protocol.

Hearing Screening Pass/Fail Data for DPOAEs versus Pure Tone Technique in Pre-School Children

(Kreisman et al, 2013)

Table 2. Pass/Fail Rates for DPOAE (1-5 kHz), DPOAE (2-5 kHz) and Pure-Tone (1,2,4 kHz) Protocols

Protocol	Pass	Fail	Total
DPOAE (1-5 kHz)	134	64	198
DPOAE (2-5 kHz)	141	57	198
Pure-Tone (1,2,4 kHz)	175	21	196

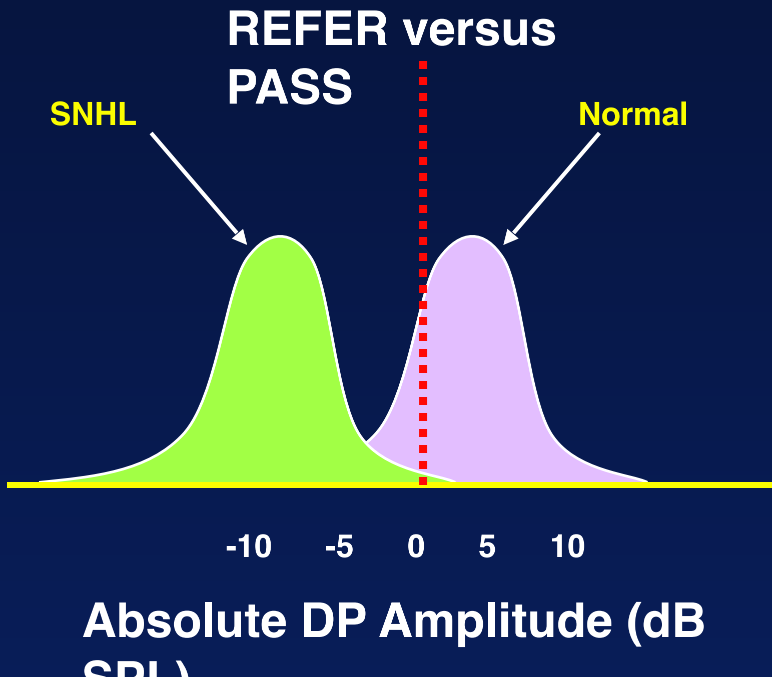
Note. DPOAE=Distortion Product Otoacoustic Emissions. Two children would not cooperate to be screened using pure tones.

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)



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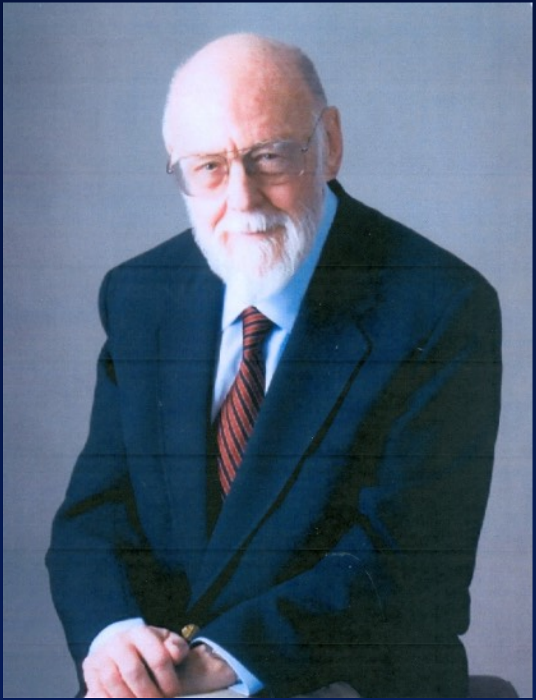
James Jerger

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 400 patients with various types and degrees of hearing impairment. An electroacoustic bridge (Madsen, ZO 70) was used to carry out the measurement of tympanometry, acoustic impedance, and threshold for the acoustic reflex. Results indicate that, while individual components of the total impedance battery lack diagnostic precision, the overall pattern of results yielded by the complete battery can be of great diagnostic value, especially in the evaluation of young children.

THE development of impedance audiometry during the past decade has added new scope and dimension to clinical audiology. Based on the pioneering efforts of Metz,[1] subsequent workers have refined instrumentation, technique, and interpretation to produce an invaluable tool for differential diagnosis.

The development of contemporary instrumentation for impedance audiometry has, in the main, followed two essentially parallel paths. In the United States, Zwislocki and his colleagues[2-6] developed an electromechanical bridge. In Europe, Thomsen, Terkildsen, Møller, and others,[7-10] 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 successive patients over a one-year period. Our aim was to assess the efficacy of the electroacoustic approach as a routine clinical 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 unsophisticated 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 diagnostic information.

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 impedance bridge (Madsen, type ZO-70) and an associated pure-tone audiometer (Beltone, type 10D). Figure 1 shows a schematic diagram of the principal components of the impedance bridge.

A probe tip containing three tubes is sealed in the external meatus, forming a closed cavity bounded by the inner surface of the probe tip, the walls of the external meatus, and the tympanic membrane. One tube is used to deliver, into this closed cavity, a probe tone generated by a 220-hertz oscillator driving a miniature receiver. The second tube is connected to a miniature probe microphone which monitors the sound pressure level of the 220-Hz probe tone in the closed cavity and delivers the transduced voltage through an amplifier to a bridge circuit and balance meter. The balance meter is nulled by an SPL of exactly 95 dB in the closed cavity. A potentiometer on the output of the 220-Hz oscillator permits variation of the SPL over a range corresponding to a compliance variation (equivalent volume) of 0.2 to 5.0 cc. The third tube is connected to an airpump which permits variation in air pressure in the closed cavity over a range of ±400 mm (water). Air pressure is read on an electromanometer.

Accepted for publication June 19, 1970.

From the Department of Otolaryngology, Baylor College of Medicine, and the Audio-Vestibular Laboratory, the Methodist Hospital, Houston.

Reprint requests to 11922 Taylorcrest, Houston 77024.

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

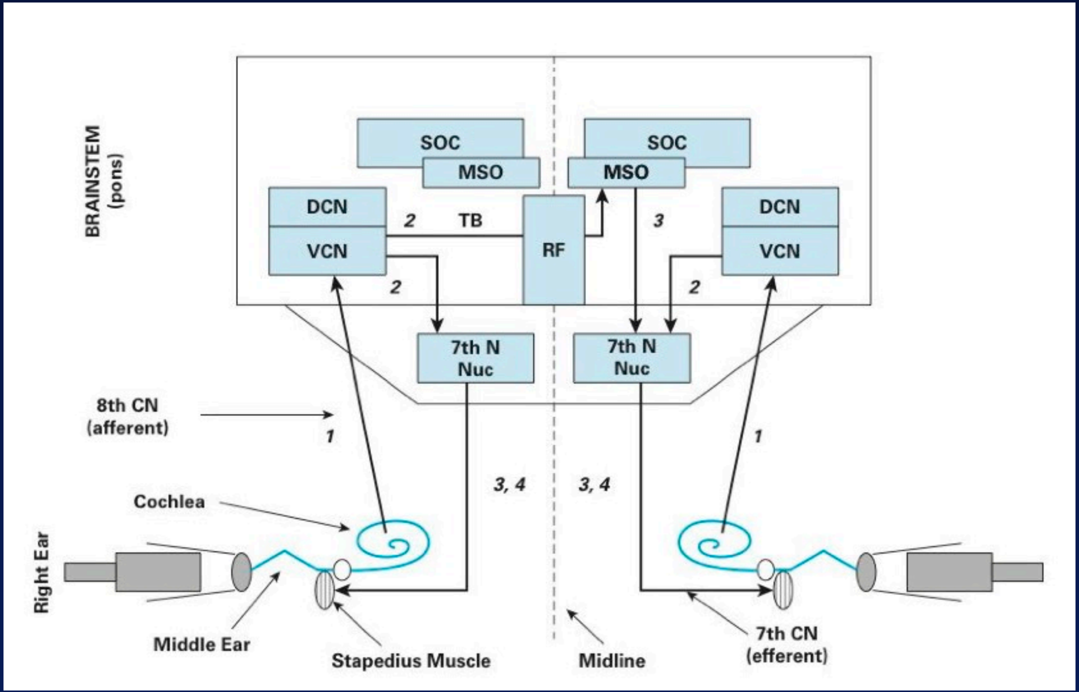
- ❑ Child and family history
- ❑ Evaluation of risk factors for congenital hearing loss
- ❑ Parental report of infant's responses to sound
- ❑ Clinical observation of infant's auditory behavior
- ❑ Audiological assessment
  - Auditory brainstem response (ABR)
  - Otoacoustic emissions (distortion product 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

From Hall JW III (2014). Introduction to Audiology Today. Boston: Pearson



Acoustic Reflexes in Neonates

- Kei J. Acoustic stapedial reflexes in healthy neonates: normative data and test-retest reliability. *JAAA, 23,* 2012
  - 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

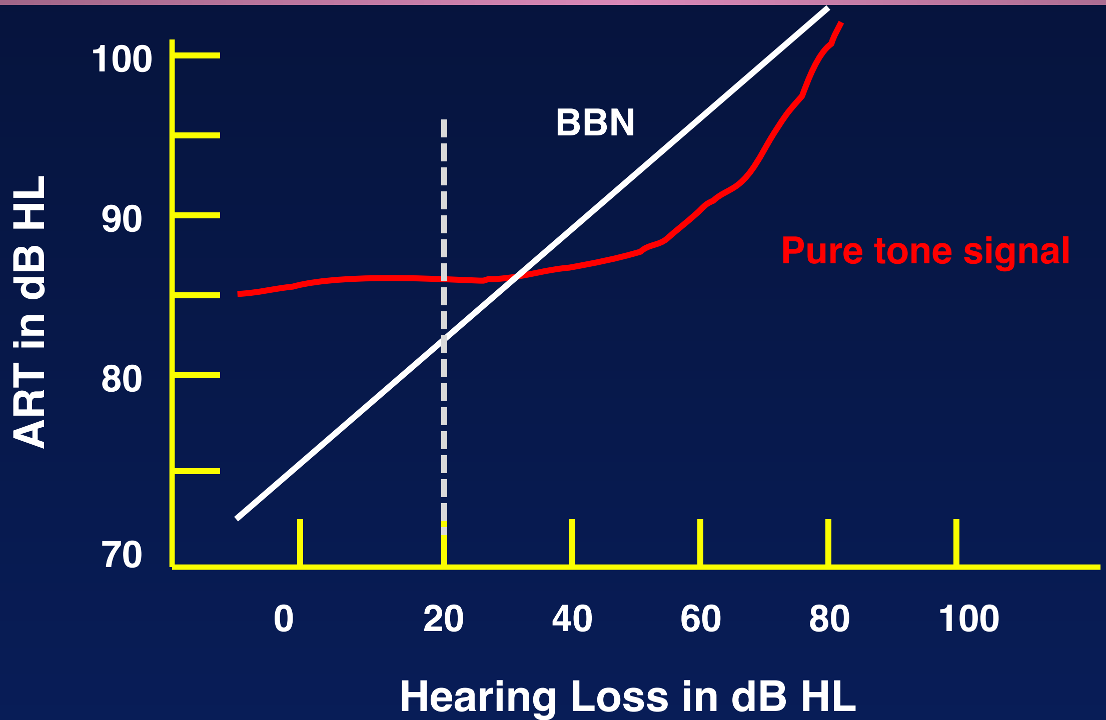
(Kei J. Acoustic stapedial reflexes in healthy neonates: normative data* and test-retest reliability. *JAAA, 23,* 2012)

Stimulus	Median ART (dB HL)	90% Range
500 Hz	80	70 - 95
2000 Hz	70	60 - 85
4000 Hz	65	50 - 80
BBN	55	50 – 75

** N = 68 ears*

Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)

Hall JW III, Berry GA and Olson K. Identification of serious hearing loss with acoustic reflex data: Clinical experience with some new guidelines. Scandinavian Audiology 11: 251-255, 1982



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: *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
- Cunningham M & Cox EO (2003). Committee on Practice and Ambulatory Medicine and the Section on Otolaryngology and Bronchoesophagology. Hearing assessment in infants and children: recommendations beyond neonatal screening. *Pediatrics, 111,* 436-440
- 2007 Joint Committee on Infant Hearing Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs. *Pediatrics, 120*, 2007-2333
- Harlor AD & Bower C. (2009) Hearing assessment in infants and children: Recommendations beyond neonatal screening. *Pediatrics, 124*, 1252-1263
- 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

2011 American Academy of Audiology Childhood Hearing Screening Clinical Guidelines

- 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"

2011 American Academy of Audiology Childhood Hearing Screening Clinical Guidelines

- 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

Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

- UNHS doesn't lead to universal diagnosis and intervention of childhood hearing loss
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Effective and Efficient Screening for Pre-School Hearing Loss: *Let's Consider a New Feasible and Evidence-Based Approach*

Birth to 4 Years

DPOAES
- 2000 – 5000 Hz
- PASS = DP $\geq$ 0 dB SPL

Immittance measures
- Tympanometry
- ART for BBN
- PASS = type A; BBN < 80 dB)

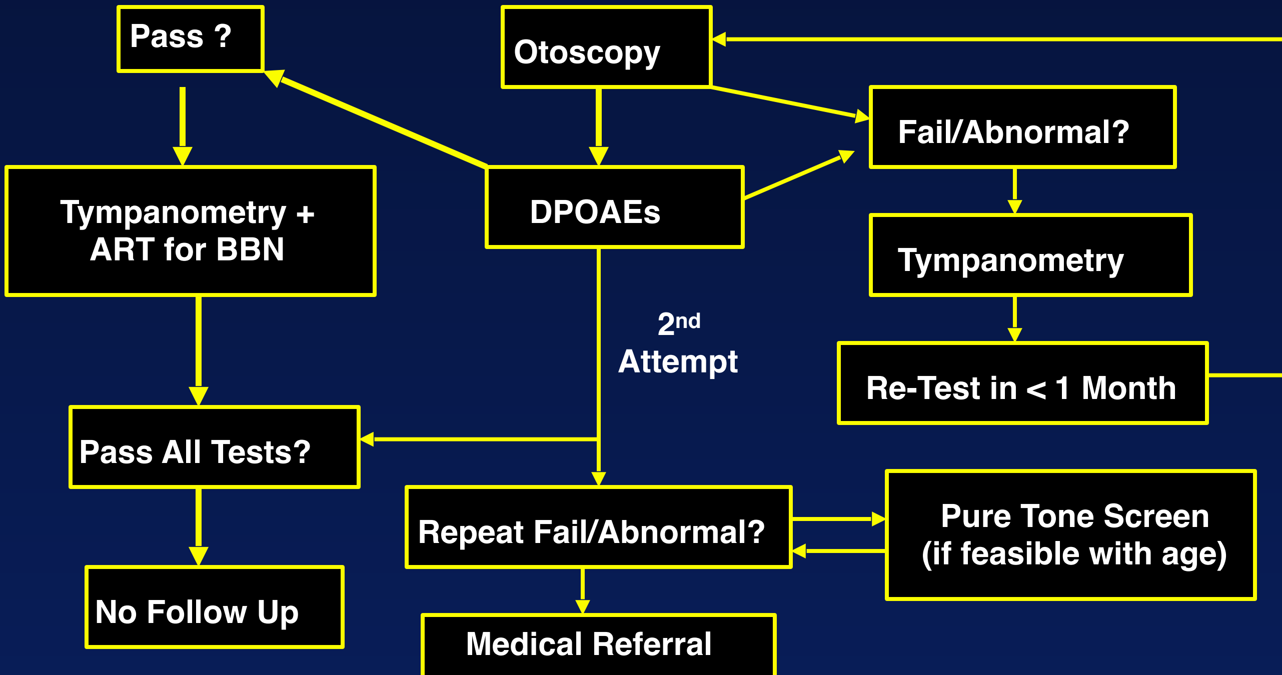
Otoscopy as indicated

$\geq$ 4 Years

PASS for previous hearing screening? Follow birth to 4 year objective test protocol.

Previous FAIL outcome or no documented hearing screening? Follow 2011 AAA Guidelines (Pure tone screening at 20 dB HL)

New Strategy for Pre-School Hearing Screening with OAEs, Tympanometry, and Acoustic Reflexes



Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

- UNHS doesn't lead to universal diagnosis and intervention of childhood hearing loss
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Early Hearing Loss Detection and Intervention (EHDI):

New Directions in Early Identification of Infant Hearing Loss

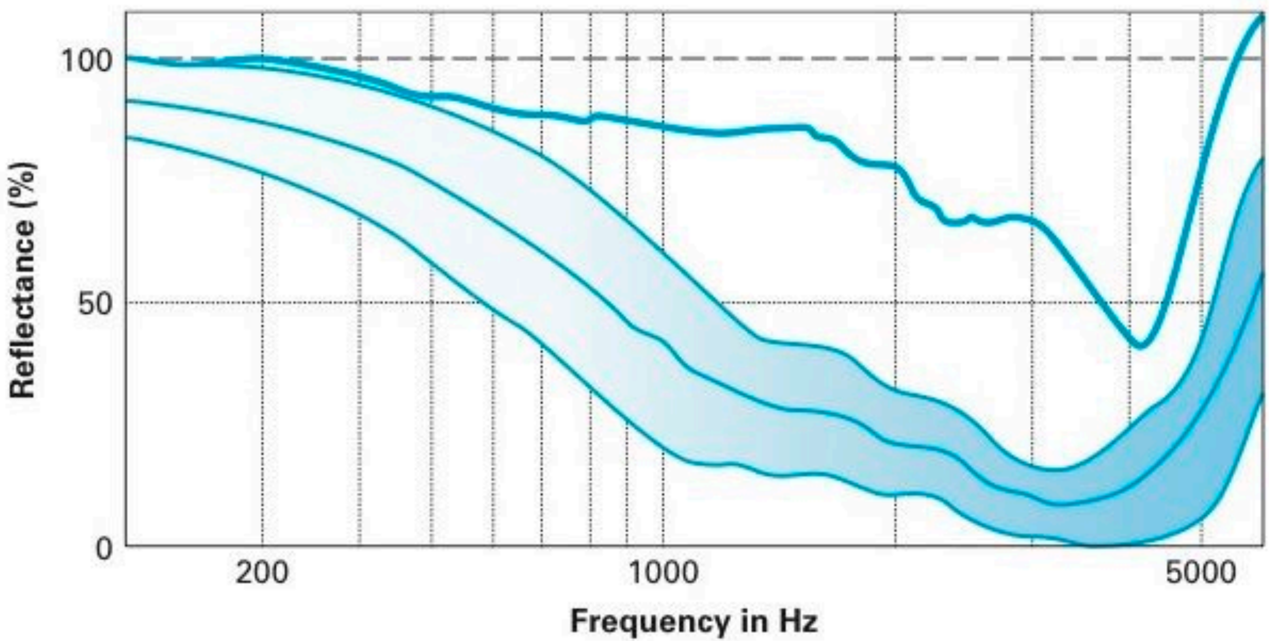
(Devices for OAEs, Tympanometry and Acoustic Reflexes)

Effective and Efficient Pre-School Hearing Screening: *Advantages of New Strategy Using OAEs, Tympanometry, and Acoustic Reflexes*

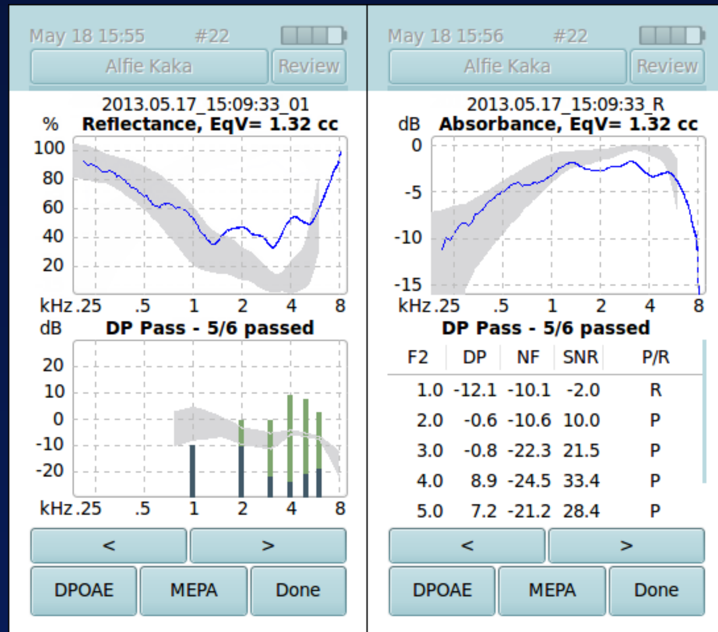
- Objective and not dependent on child's behavioral response, cognition, developmental age, or language level
- Reliable
- Efficient and quick to administer (< 4 minutes)
- Simple to administer with low level of technical skill
- Does not require an audiologist
- Does not require an acoustically treated 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*

(www.audiologyworld.net)

A Systematic Review of Telehealth Applications in Audiology

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Abstract

Hearing loss is a pervasive global healthcare concern with an estimated 10% of the global population affected to a mild or greater degree. In the absence of appropriate diagnosis and intervention it can become a lifelong disability with serious consequences on the quality of life and societal integration and participation of the affected persons. Unfortunately, there is a major dearth of hearing healthcare services globally, which highlights the possible role of telehealth in penetrating the underserved communities. This study systematically reviews peer-reviewed publications on audiology-related telehealth services and patient/clinician perceptions regarding their use. Several databases were sourced (Medline, SCOPUS, and CHINAL) using different search strategies for optimal coverage. Though the number of studies in this field are limited available reports span audiological services such as screening, diagnosis, and intervention. Several screening applications for populations consisting of infants, children, and adults have demonstrated the feasibility and reliability of telehealth using both synchronous and asynchronous models. The diagnostic procedures reported, including audiometry, video-otoscopy, oto-acoustic emissions, and auditory brainstem response, confirm clinically equivalent results for remote telehealth-enabled tests and conventional face-to-face versions. Intervention studies, including hearing aid verification, counseling, and Internet-based treatment for tinnitus, demonstrate reliability and effectiveness of telehealth applications compared to conventional methods. The limited information on patient perceptions reveal mixed findings and require more specific investigations, especially post facto surveys of patient experiences. Tele-audiology holds significant promise in extending services to the underserved communities but require considerable empirical research to inform future implementation.

Introduction

The field of audiology encompasses prevention, assessment, and rehabilitation of hearing, auditory function, balance, and other related systems.[1,2] With an estimated 642 million people in the world affected to a mild or greater degree, and 278 million to a moderate and greater degree, hearing loss is clearly a significant global healthcare concern[3] with pervasive and far-reaching consequences. If not identified and treated early, children with hearing loss may suffer lifelong disability due to developmental delays in language, literacy, academic achievement, and social well-being.[4,5] Hearing loss in adults tends to isolate and stigmatize them, leading to poor social participation and severely restricting vocational opportunities, as evidenced by significantly higher under- and unemployment.[6] Hearing loss is therefore reported as one of the most significant contributors to the global burden of disease.[7]

Audiological diagnosis and intervention for children and adults with hearing loss offer the possibility of excellent outcomes as opposed to the negative consequences of undetected and undiagnosed hearing loss without intervention services.[8,9] The problem in providing the necessary services, however, is the shortage of audiological professionals and services in the majority of regions in the world.[10,11] Even in developed countries like the United States and Australia, rural and remote communities may not be able to access the necessary hearing healthcare services. Telehealth applications in audiology may offer some solutions to the mismatch in the apparent need for services and the limited capacity to deliver services.[12] Using information and communication technology in healthcare, as implied in telehealth,

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informa healthcare

Original Article

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Telehealth in audiology: The need and potential to reach underserved communities

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 offer 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 entrenados en cuidados de la salud y de 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 información y tecnología de la comunicación para 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 las de educación y adiestramiento de profesionales de la salud auditiva, profesionales afines, 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. No obstante, existen muchas dudas que deben resolverse y que estén relacionadas con aspectos como control de calidad, regulación del ejercicio profesional, responsabilidad jurisdiccional, certificación y reembolso de servicios, pero no existe como alternativa ninguna otra estrategia que pueda ofrecer actualmente el mismo potencial, para impactar el peso global de las pérdidas auditivas en el futuro cercano o previsible.

Audiology Applications of Tele-Health: *Breaking News About Technology*

informa healthcare

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International Journal of Audiology

Original Article

Smartphone hearing screening with integrated quality control and data management

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Tele-Audiology:
Smart Phone hearScreen Application

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).

		Conventional screening		
		Pass	*Refer*	*Total*
Mobile phone screening	Pass	96.3% (312)	0.9% (3)	**97.2% (315)**
	Refer	1.2% (4)	1.5% (5)	**2.7% (9)**
	Total	**97.5% (316)**	**2.4% (8)**	

Effective and Efficient Pre-School Hearing Screening: *Essential for Successful EHDI*

Thank You! … Questions?

NCHAM National Center for Hearing Assessment and Management Utah State University

JEHDI
The Journal of Early Hearing Detection and Intervention

2016; 1(1): 2-12

Effective And Efficient Pre-School Hearing Screening: Essential For Successful Early Hearing Detection And Intervention (EHDI)

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Abstract

An unacceptable number of infants failing newborn hearing screening do not receive necessary follow-up services in a timely fashion as a result of loss to follow-up problems. In addition, a high proportion of children who pass newborn hearing screening later acquire hearing loss during the preschool years. Systematic pre-school hearing screening offers a logical strategy for detection of hearing loss among these children.

Pure tone hearing screening of older preschool children has questionable test performance and validity. And, there is consensus that a behavioral technique is not feasible for routine hearing screening of younger preschool children. Otoacoustic emissions (OAEs) offer the most promising option for systematic hearing screening of the preschool population. Multiple advantages of OAEs are cited in support of their role in preschool hearing screening. This paper summarizes a new evidence-based and clinically feasible strategy for effective and efficient preschool hearing screening that relies on objective auditory tests.