The Impact of Minimal and Mild Hearing Loss on Children

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Current Definitions of Minimal Hearing Loss

- **Permanent mild bilateral HL** = PTA at 0.5, 1.0, 2.0 kHz between 20 & 40 dB HL
- **Permanent high frequency HL** = PT thresholds > 25 dB HL at two or more frequencies above 2.0 kHz
- **Permanent unilateral HL** = PTA at 0.5, 1.0, 2.0 kHz > 20 dB or PT thresholds > 25 dB HL at two or more frequencies above 2 kHz in the affected ear
I. Academic, Social, & Behavioral Outcomes
II. Screening for Unilateral & Mild HL
III. Audiological & Medical Management
Academic, Social, & Behavioral Outcomes
Age of Identification: UHL

Bess & Tharpe, 1986
Percent Failing at Least One Grade: UHL

- Bess et al
- Oyler and Matkin

- UHLs
- District Norms
### STUDIES OF UNILATERAL HEARING LOSS

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Failed (1 or more grades)</th>
<th>Resource Help (1 or more years)</th>
<th>Combined (failed and/or resource help)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bess (1986)</td>
<td>35%</td>
<td>13.3</td>
<td>48.3%</td>
</tr>
<tr>
<td>Oyler (1987)</td>
<td>27.3%</td>
<td>40.7</td>
<td>68.0%</td>
</tr>
<tr>
<td>Jensen (1988)</td>
<td>18.0%</td>
<td>36.0%</td>
<td>54.0%</td>
</tr>
<tr>
<td>Martini (1988)</td>
<td>25.0%</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
Speech-Language & Educational Consequences of Unilateral Hearing Loss in Children

- Literature search 1966-June 1, 2003
- 22-35% rate of failing one grade in school
- 12-41% receiving educational assistance

(Lieu, J.E. Arch Otolaryngol Head Neck Surg. 2004;130:524-530)
Failure as a Function of Ear

Bess & Tharpe, 1986
Bilateral Minimal Hearing Loss
Hearing Loss in School-Age Children (3rd, 6th, & 9th grades; N=1218)

(Bess et al., 1998)

<table>
<thead>
<tr>
<th>HL Category</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSNHL</td>
<td>12</td>
<td>1.0</td>
</tr>
<tr>
<td>HFSNHL</td>
<td>17</td>
<td>1.4</td>
</tr>
<tr>
<td>CONDHL</td>
<td>41</td>
<td>3.0</td>
</tr>
<tr>
<td>OTHER</td>
<td>30</td>
<td>2.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>139</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Minimal losses = 8.8 % !!!
Failure Rates of Children with MSHL & with NH (Bess et al., 1998)
EDUCATIONAL STATUS OF CHILDREN WITH MINIMAL HEARING LOSS (N=66)

- 37% failed at least one grade.
- 8% not judged to perform at grade level.
Educational Performance:

- **Comprehensive Test of Basic Skills:**
  - In 3rd grade, children with MSHL exhibited significantly lower scores than the control group for reading, language mechanics, word analysis spelling, & science

- **SIFTER:**
  - Consistently performed more poorly than their normal-hearing peers
Ross et al. (2005)

- NHANES data 1996
- Children 6-16 years of age with minimal or mild or UHL were twice as likely to score 2 SDs below the norm on standardized arithmetic and reading tests
COOP CHARTS

- Screening tool for functional health
- Developed at Dartmouth
- Ten different charts
DOMAINS USED IN COOP CHARTS

- Emotional feelings
- School work
- Social support
- Stress
- Family
- Self esteem
- Behavior
- Energy
- Getting along with others
- Overall Health
**STRESS**

During the past month, how much stress or pressure did you feel from other people? (family, friends, teachers, other grown-ups or other kids)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>A little</td>
</tr>
<tr>
<td>3</td>
<td>Some</td>
</tr>
<tr>
<td>4</td>
<td>Quite a bit</td>
</tr>
<tr>
<td>5</td>
<td>A lot</td>
</tr>
</tbody>
</table>
# SCHOOL WORK

During the last month you were in school, how did you do?

<table>
<thead>
<tr>
<th>I did very well</th>
<th>![Smiley Face] ![Graph: Steady]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did as well as I could</td>
<td>![Neutral Face] ![Graph: Increasing]</td>
</tr>
<tr>
<td>I could have done a little better</td>
<td>![Frowning Face] ![Graph: Decreasing]</td>
</tr>
<tr>
<td>I could have done much better</td>
<td>![Sad Face] ![Graph: Steepest Decrease]</td>
</tr>
<tr>
<td>I did poorly</td>
<td>![Sad Face] ![Graph: Steepest Decrease]</td>
</tr>
</tbody>
</table>
COOP Results:

- **For 6th graders** -
  - scores were higher (more dysfunction) for MSHL group in 9 of 10 domains
  - Significant difference found on energy domain

- **For 9th graders** –
  - Scores were higher for MSHL group in 9 of 10 domains
  - Significant differences found on stress and behavior domains
Listening Effort

Effort = the exertion of physical or mental power
Dual-Task Paradigm (Effort)

- **Subjects**
  - 14 children with mild or HF HL matched with NH children for grade level
  - Ages between 6 – 11 years

(Bourland-Hicks & Tharpe, 2002)
Dual-Task Paradigm

- Primary task: speech recognition in noise (PBK)
- Secondary task: button push to random presentations of probe light
- Reaction times were calculated for button push
Dual Task Paradigm

No difference in baseline RTs between groups
Still Unknown...

Will knowledge about underlying etiology shed some light on why some children with minimal and mild losses perform well while others appear to have significant deficits?

Can we change these outcomes?
We Don’t Know, But We Can…

- Improve identification practices
- Enhance listening in adverse listening situations
Screening for Unilateral & Mild HL

Judy Gravel, Ph.D.
Center for Childhood Communication
The Children’s Hospital of Philadelphia
Challenges:
Screening for Mild & Unilateral HL

- Under identification/confirmation of mild and UHL:
  - CDC 2003 (Version E) DSHPSHWA Data
  - Prevalence calculation based on 1,580,536 screenings:
    - Unilateral SNHL (n=294) = 0.19/1000
    - Bilateral mild SNHL (n =136) = 0.09/1000
Identifying Minimal/ Mild HL in Newborn Period

- Not in target population: U.S. \( \geq 30-40 \text{ dB}^* \text{ HL} \); U.K./Europe \( \geq 40 \text{ dB HL} \) (JCIH 2000; NHSP 2004)

- Current screening technology does not identify some cases of mild hearing loss (Widen et al. 2000; Cone-Wesson et al. 2000)
Identifying Minimal/ Mild HL in through Newborn Period

Cone-Wesson et al. (2000); n = 2995 infants

- VRA confirmed mild PHL (n=22; 30.2% of PHL)
- Outcomes (neonatal ABR and OAE [DPOAE and TEOAE])
  - 10 ears failed both OAE and A-ABR tests,
  - 4 ears passed both OAE and A-ABR tests,
  - 4 passed ABR and failed both OAE measures
  - 2 failed ABR and passed OAE tests.
  - 2 ears that failed ABR passed DPOAE but failed TEOAE.
Incidence of Mild PHL in Infants

Johnson et al. (2005, Pediatrics)

- Designed to address question of how many infants who pass 2-step screening protocol (OAE/A-ABR) have hearing loss
  - Multi-center birth cohort (n = 86,634)
  - Enrolled study cohort: failed OAE/passed A-ABR
  - Study Group: 64% (973 infants) returned for VRA (8-9 months)
Degree of PHL (poorer ear) in Study Group & Comparison Group
(Johnson et al. 2005)

<table>
<thead>
<tr>
<th></th>
<th>Mild (25-40 dB)</th>
<th>Mod (41-70 dB)</th>
<th>Sev/ Prof (≥71 dB)</th>
<th>Total with PHL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study Grp</strong></td>
<td>15 (71.4%)</td>
<td>5 (23.8%)</td>
<td>1 (4.8%)</td>
<td>21 (100%)</td>
</tr>
<tr>
<td><strong>Comp Grp</strong></td>
<td>31 (19.6%)</td>
<td>64 (40.5%)</td>
<td>63 (39.9%)</td>
<td>158 (100%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>46 (25.7%)</td>
<td>69 (38.5%)</td>
<td>64 (35.8%)</td>
<td>179 (100%)</td>
</tr>
</tbody>
</table>
Examples of PHL in Infants who failed OAE/passed A-ABR

(Johnson et al. 2005)

<table>
<thead>
<tr>
<th>ID #</th>
<th>.5 kHz</th>
<th>1 kHz</th>
<th>2 kHz</th>
<th>4 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>091</td>
<td>20</td>
<td>25</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>055</td>
<td>25</td>
<td>25</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>053</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>130</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>002</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>25</td>
</tr>
</tbody>
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Examples of PHL in Infants who fail OAE/pass A-ABR

*(Johnson et al. 2005)*

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<tbody>
<tr>
<td>131</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>005</td>
<td>45</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>122</td>
<td>40</td>
<td>40</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>072</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>003</td>
<td>45</td>
<td>45</td>
<td>60</td>
<td>55</td>
</tr>
</tbody>
</table>
Conclusions:

- Infants with PHL (bilateral or unilateral) who pass 2-step NHS in this birth cohort;
  - 11.7% of PHL missed
  - Adjusted estimate: 22.8% of PHL missed

- Based on Johnson et al. birth cohort:
  - Conservative estimate of mild bilateral/unilateral PHL in infancy = 0.55/1000 (Gravel et al. 2005)
Prevalence of UHL
Lieu 2004

- Majority of cases of moderate to profound congenital/early onset permanent UHL detected by NHS (e.g., Dalzell et al. 2000)
- 0.4% to 3.4% in infants identified by UNHS (Widen et al. 2000; Barsky-Firkser & Sun 1997; Mehl & Thompson 1998);
- 0.1% to 5% in school-aged children
- Prevalence variation: differences in inclusion criteria; include late onset/acquired; HR pop
Niskar et al. (1998)

- NHANES data
- P-T thresholds at 0.5 to 8 kHz in 6166 children
- Ages 6-19 years
- High frequency and low frequency HL
- Prevalence-- ~15%
Challenges:
Screening for Mild & Unilateral HL

- Need for agreed-upon definition of “mild hearing loss/minimal hearing loss/unilateral hearing loss”:

- Impacts:
  - Estimates of prevalence
  - Screening protocol development
  - Consideration of additional screening methods (i.e., genetic) in the newborn period
Challenges:
Screening for Mild & Unilateral HL

- Lack of uniform standards for the calibration of OAE or ABR instrumentation.
- Insufficient manufacturer supporting evidence allowing determination of the validity of the specific pass-fail criteria and/or automated algorithms incorporated in screening instruments.
Challenges:
Screening for Mild & Unilateral HL

- Potential variability of screening results within and between technologies, across manufacturers’ devices and by earphone type (ABR technologies)
- Current test protocols and pass-refer criterion will likely not identify the majority of infants with mild forms of hearing loss
Challenges:
Screening for Mild & Unilateral HL

- Lower sensitivity and specificity of audiologic diagnostic methods (particularly < 6 months) for delineating normal hearing from mild hearing loss may preclude early confirmation of some infants.

- Lack of organized programs beyond the newborn hearing screen to identify children with mild and unilateral forms of hearing loss in early life.
Why MHL Missed at School-Age

- Lack of organized screening efforts beyond neonatal period
- Behavioral audiometry screening of infants, toddlers & pre-school children requires trained & experienced personnel
- Little data on efficiency and effectiveness of OAE screening + tympanometry for detection of MHL
- OME prevalence high; refer rate high; follow-up problematic (School age: Bess et al. 1998: 3.5% conductive loss)
Why MHL Missed at Pre-School & School-Age

- Background noise levels during screening not optimal:
  - Change pass-fail criterion
  - Bess et al. 1998: identification of MHL in acoustically-treated test space

- Lack of use of functional measures in screening protocols (caregiver/teacher report; SIFTER; Pre-School SIFTER; ELM; etc.)
Audiological & Medical Management

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Nashville, Tennessee
Literature on aid use – Unilateral Loss

- CROS HAs are not recommended for consideration until child is able to control his/her communication environment (AAA, 2003; Kenworthy et al., 1990)
- BAHA can be considered at age 5 years and above; however, data with the pediatric population are lacking (AAA, 2003)
- There is a lack of data to support a strong recommendation for HA use in children with UHL but should be presented as option to families for children with “aidable” ear at time of diagnosis (McKay, 2002)
- Retrospective survey showed benefit from amplification provision (McKay, 2002)
- But … low compliance in aid use among children with unilateral hearing loss (Kiese-Himmel & Kruse, 2000; Reeve, 2002; McKay, 2002)
Contributors to poor compliance?

- Dalzell et al. (2000) found a 5 month delay in fitting aids
- Harrison & Roush (1996) found a 7 month delay
- The older the child, the less likely to wear HAs (Reeve et al., 2005)
- Uncertainty among professionals on whether to aid mild loss
  - Level below which you would not consider providing aids:
    - 25 dBHL (range from 15 - 35dBHL)
  - Level above which you would definitely provide aids:
    - 40 dBHL (range from 25 to 50dBHL)
Distance and background noise

Teacher's voice

Background noise

Distance (meters)
A wireless FM system consists of two basic components:

- **Transmitter**
- **Receiver**
Follow up Concerns: Unilateral to Bilateral HL

- Of 159 unilateral refers who were found to have HL, 64% had UHL and 36% had bilateral HL

- Two groups who move from UHL to BHL:
  - Those who had BHL at time of screening
  - Those who had UHL at time of screening but develop BHL later

(Neault, 2005)
Follow up Concerns:
Unilateral to Bilateral HL

- Some unilateral losses prove to be progressive
  - Cytomegalovirus (CMV)
  - Enlarged vestibular aqueduct (EVA)
  - Hereditary progressive loss
  - Unknown causes

(Neault, 2005)
CT Scan Findings in UHL:

- Of 18 children with unilateral sensorineural hearing loss (mild to profound) who underwent CT scans of the temporal bone, 8 (45%) had abnormal findings, including:
  - Enlarged vestibular aqueduct
  - Mondini deformity
  - Cochlear hypoplasia
  - Dysplastic vestibule and semicircular canals

The CT scan findings were abnormal BILATERALLY in 5 of the 8 children

(Licameli, Robson & Kenna, Children’s Hospital Boston)
Centers for Disease Control & Prevention Workshop Proceedings (2005)

Summarizes
- presentations &
- breakout group discussions
- future research needs

Online Literature Review
- Includes summary tables (by topic)
- Over 100 articles
- All available on the CDC EHDI website:

www.cdc.gov/ncbddd/ehdi/