Outcomes of Children with Hearing Loss

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Supported by NIDCD R01 DC009560
Most outcome studies focus on children who are deaf

Reduced body of literature concerning children with mild to severe HL

- Sample sizes are small or mix D/HH children
- Lack of control of amplification histories/audibility
- Few studies attempted a population sample
- Varied measurement strategies; earlier generation technologies

Need to understand sources of individual difference in outcomes
Aims of study

• To describe the characteristics of:
  – children and families
  – intervention services
  – factors associated with service variations

• To characterize:
  – developmental, behavioral and familial outcomes
  – compared to normally-hearing age mates with similar backgrounds

• To explore:
  – how variations in child and family factors and in intervention characteristics relate to functional outcomes
Target Population

- 400 children with hearing loss
- 150 children with normal hearing
- Ages 6 months to 6 years 11 months
- Speaks English in the home
- No major secondary disabilities
- Permanent Bilateral Mild to Severe Hearing Loss — PTA of 25-75 dB HL (500, 1k, 2k, 4 kHz)
Recruitment

- Sampling Frame
  - All children in Iowa, Nebraska, Eastern Kansas/Northern Missouri, Northern Illinois and North Carolina with mild to severe permanent bilateral hearing loss

- Sampling Method
  - Recruit children who have been identified via
    - Refer from Newborn Hearing Screening
    - Children identified in EHDI via follow up clinics
    - Children identified via audiology or medical service providers
    - Children identified through school screening

- Contact Method
  - Return of post card in flyer or telephone contact
  - Flyers come to Iowa for processing
  - Telephone contact is made by the appropriate the regional research group
Study design

- Each child followed for 3 years+.
- Retrospective data prior to enrollment obtained by medical record history.

Accelerated Longitudinal Design
Domains of study

Child and Family Outcomes

- Vocal stages, Phonology, Articulation, Speech intelligibility
- Age-appropriate speech perception batteries, Audibility
- Rec-expressive language, vocabulary, concepts, reasoning, narratives
- Phonological awareness, reading, math
- Nonverbal reasoning, CBC, friendships, memory,
- HA fit, Frequency and Intensity of Interventions, Provider background
- SES, parental ed, Community, household, day care, Audiological status
Data collection and management

- Telephone Survey of Parents
  - One person conducts a phone interview (between test sessions) concerning home and parental information
- Audiology Service Provider Survey (online)
- Services & Provider Survey (online)
  - Birth to Three
  - Pre-School
  - School Age
- Teacher Survey
  - Pre-School
  - School Age
- Medical Records
  - ENT & Pediatrician
Year one results
Demographics
Geographic Distribution of Participants

<table>
<thead>
<tr>
<th>Centers</th>
<th>HH</th>
<th>NH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys Town</td>
<td>73</td>
<td>29</td>
</tr>
<tr>
<td>Iowa</td>
<td>72</td>
<td>26</td>
</tr>
<tr>
<td>North Carolina</td>
<td>87</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>232</strong></td>
<td><strong>70</strong></td>
</tr>
</tbody>
</table>
Age Distribution of Children at Enrollment

Mean 42.8 51.0
SD 21.8 21.0
Distribution of HH Children Tested at Each Age Level

Total = 330

Protocol Administered (Age Level)

<table>
<thead>
<tr>
<th>Age Level</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
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<tr>
<td>3</td>
<td>50</td>
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<tr>
<td>4</td>
<td>50</td>
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<tr>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>30</td>
</tr>
</tbody>
</table>

Total = 330
Distribution of Better Ear PTA

Mean = 49.29
SD = 19.5
Household Income

The bar chart shows the distribution of household income levels. Categories include:

- <20
- 20-40
- 40-60
- 60-80
- 80-100
- 100-125
- >125

The chart compares 'HH' (Household) and 'NH' (Non-Household) income levels. The y-axis represents the number of households in each income category, ranging from 0 to 45.
Age at First HA Fit

The bar chart shows the number of individuals fitting in each age group for hearing aids. The x-axis represents the age at which the hearing aids were first fitted (in years), and the y-axis represents the number of individuals. The bar chart indicates that the largest number of individuals (100) were fitted with hearing aids before the age of 6, followed by 32 individuals between 6 and 12 years old, and so on. The scatter plot in the inset suggests a trend where the age at which hearing aids were fitted is negatively correlated with the better ear unaided pure tone average (PTA).
Hearing aid use consistency

- **Weekdays**
  - Estimated Daily Use Time (hours)
  - Individual Subjects

- **Weekends**
  - Estimated Daily Use Time (hours)
  - Individual Subjects

Legend:
- Green diamonds: infant
- Blue squares: preschool
- Red triangles: >48 months
Speech and Language
Speech and Language Outcomes

- **Standardized tests**
  - Vocabulary
    - MBCDI, WPPSI, PPVT, WASI
  - Receptive/Expressive Language
    - Mullen Scales, CASL
  - Articulation
    - GFTA

- **Non-standardized tests**
  - Infant Vocal Interview, Open and Closed Set Test, Morphology Elicitation Task
Conflicting reports related to vocabulary development

- Not delayed at school age (Plapinger & Sikora, 1995; Wolgemuth, et al, 1998)
- Bimodal distribution of performance (Gilbertson & Kamhi, 1995)


Prolonged lexical access (Jerger et al, 2006)
Vocabulary at 12 months-2 years: MBCDI

12-18 months:
Words and Gestures

19-30 months:
Words and Sentences
Vocabulary at 4 years: WPPSI

X = 7.96
<7 Sc S = 30.3%
Vocab at 5 & 7 years: PPVT

X = 95.53 (5 yr), 102 (7 yr)
<85 SS = 28.1% (5 yr), 20% (7 yr)
Vocab at 6 & 7 years: WASI

$X = 46.28$ (6 yr), $51.09$ (7 yr)

$<40$ $T = 28\%$ (6 yr), $18\%$ (7 yr)
Key points: Vocabulary

- MBCDI: Early vocabulary development may be delayed.
- Mean scores in average range, but wide variance in vocabulary scores.
- About 30% of children below average range.
- Possible improvement by 7 years
Previous studies report wide variability in the outcomes for children with hearing loss.

- Children with HL performed similarly to age matched peers on receptive grammar (Briscoe, Bishop & Norbury, 2001)
- Children with HL performed similarly to younger children with normal hearing on test of grammar understanding (Gilbertson & Khami, 1995).
1 & 2 years: Mullen Scales--Expressive
CASL at 3 & 4 years

**CASL: Age Three**

- **Syntax**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference

- **Pragmatics**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference

- **Concepts**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference

**CASL: Age Four**

- **Syntax**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference

- **Pragmatics**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference

- **Concepts**
  - NH: [Standard Score]
  - HI: [Standard Score]
  - * indicates significant difference
Key points: Language

- Like vocabulary, wide variance in scores
- Many falling below the average range
- Syntax remains delayed while other domains may be catching up (pragmatic judgment and basic concepts)
The current evidence is mixed with regard to component literacy skills in children with mild to severe hearing loss.

- **Phonological Processing**

- **Word Reading**
  - Bess, Dodd-Murphy and Parker (1998) and Most et al. (2006) found poorer word reading in mild HI children.
  - Bristoe et al. (2001) and Gibbs (2004) did not find poorer word reading in HI children.

- **Reading Comprehension**
  - Davis, et al. (1986) and Blair et al. (1985) found HI children to be below hearing norms
  - Bristoe et al. (2001) found normal reading levels.
Phonological Awareness
4 years old

Elision
Say playground
Now say playground without ground
Say heat
Now say heat without the /t/

Blending
What word do these make? Star Fish Starfish
What word do these sounds make? /ka p/ Cap
Reading Achievement at 6 yrs

Word Attack- ability to apply phonic and structural analytic skills
  - Nonsense words
  - Words with very low frequency usage

Word-ID –ability to read real words

Passage Comprehension – ability to complete a passage based on information in passage.
Summary of Literacy

• Pre-Reading PA
  ○ Phonological awareness appears to be depressed in the children with HL. Why?
    ▪ Task does require listening to phonetic details (heat without the /t/), thus some demand is placed on audition.
      ○ Aided SII & PA r=0.38, p=0.09
    ▪ PA is thought to place demands on robust phonological representations.

• Early Reading
  ○ Initial reading appears to be slightly above average for the group.
  ○ We have one extremely high outlier (SS 178 on Word ID)
  ○ Reading at this stage in development reflects word decoding. Later reading becomes more language driven.
  ○ The early weak PA does not seem to be realized in the good word attack.
Speech Production

- Delays in babble onset increase with increasing hearing loss (Carney, 1996)
- Some children at risk for slow transitions from babble to word productions (Moeller, et al., 2007)
- Generally intelligible speech as they mature (Wallace, et al, 2000)
  - Number & type of phoneme errors increase with increased severity of loss (Elfenbein, et al, 1994)
  - Substitution of fricatives & affricates most common
Articulation at 3, 5, & 7 years: GFTA

\[ M = 84.41 \text{ (3 yr)}, \ 89.75 \text{ (5 yr)}, \ 105.2 \text{ (7yr)} \leq 85 \ SS = 48.3\% \text{ (3yr)}, \ 34.4\% \text{ (5yr)}, \ 0\% \text{ (7yr)} \]
Non-standardized measures

- Infant Vocal Interview (Moeller & Bass-Ringdahl)
  - Parent interview
  - Early vocalizations and word production
- Ertmer’s Open and Closed set test
  - Single word imitation and closed set picture identification
- Morphological Elicitation Procedure
  - Questions are asked after viewing short clips of children performing everyday activities. The clips are designed to prompt the child to use grammatical word endings (e.g., key/keys; mom/mom’s, walk/walked).
Vocal Development Landmarks

Interview

PROVISION OF VOCAL EXAMPLES AND PAIRED COMPARISONS

To avoid use of technical terms
To ensure that parent and clinician “on same page”
To calibrate examiners

USES STANDARD INTERVIEW FORMAT AND PP SLIDES WITH AUDIO FILES

3 sections: precanonical, canonical, word
Item 2-6 (canonical)

Jargon or jabber
Vocal Interview

\(M \text{ age younger} = 11.0 \text{ mos (SD = 2.32);} \quad M \text{ age older} = 18.7 \text{ months (SD = 1.29)}\)
Key points: Speech production

- **GFTA:** Older children have increased accuracy, but still large variance. Seven year olds within average range, although small number tested.
- **Vocal Interview:** Advances in canonical babbling and word formation from 12 to 18 months.
- Children with HL significantly delayed on phonology and word production
- Phonology may be vulnerable until older ages
Hearing aid fitting & audibility
Child’s thresholds

Average speech (Unaided)

Normal Hearing Levels
Connect coupler and instrument to coupler microphone. Select one of REAR 1 through REAR 4.
Results of HA verification

Both low and high frequency components of speech inaudible
Hearing loss and audibility

For each band –
Audibility x FIW =
weighted audibility

SII = Sum of weighted audibility of all frequency bands
Hearing aid fit

- Optimal: 60%
- Suboptimal: 40%
Word Recognition: Aided and Unaided

Age > 4

**PBK**

- $r = .552^*$
- $p < .000$

**SII**

**Better ear PTA**

- $r = -.288^*$
- $p = .032$
Audibility and Speech Production

$r = 0.34 \ (N=86) \ p = .0014$
Audibility and Vocabulary

$r = .44$ (n=51) $p = .0013$
Hearing aid use consistency

Put an X in the boxes below to indicate how consistently your child uses HAs in the situations listed:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Never (0)</th>
<th>Rare (1)</th>
<th>Sometimes (2)</th>
<th>Often (3)</th>
<th>Always (4)</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-School/School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Care</td>
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<tr>
<td>Meal Time</td>
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<tr>
<td>Playing Alone</td>
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<tr>
<td>Book Sharing</td>
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<tr>
<td>Playground</td>
<td></td>
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<tr>
<td>Public (store, zoo)</td>
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<td></td>
</tr>
</tbody>
</table>
Hearing aid use consistency

Infants (n=28)

- never/rarely
- sometimes
- often
- always

Percent of Group

Situation

Preschool (n=26)

>48 months (n=26)
Audiology & EI Service provider info
Service Provision: Birth to Three

Intervention Providers

- SLP Involved = 50.1%
- Audiological Care = 100%
- Multiple Providers = 35.7%
Average Monthly Service Provision (0-3)

Visits/Month

<table>
<thead>
<tr>
<th>State</th>
<th>Number Per Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>3.5</td>
</tr>
<tr>
<td>Nebraska/KS</td>
<td>3.0</td>
</tr>
<tr>
<td>NC</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Range = 0 to 11

Time/Month

<table>
<thead>
<tr>
<th>State</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>200.0</td>
</tr>
<tr>
<td>Nebraska/KS</td>
<td>150.0</td>
</tr>
<tr>
<td>NC</td>
<td>250.0</td>
</tr>
</tbody>
</table>

Range = 0 to 660 minutes
Hearing aid fitting method

![Bar chart showing fitting methods and age groups]

- **Percentage of Respondents**
- **Fitting method**
  - DSL
  - NAL
  - Other
  - No answer

- **Birth-3 years**
- **4-6 years**
- **7 or older**

The chart illustrates the distribution of hearing aid fitting methods by age group.
Hearing aid verification

- Probe Mic Measures
- 2 cc Coupler w Measured RECD
- 2 cc Coupler w Ave RECD
- Aided Freq-spec thresh
- Mfgr suggested
- No answer

Percent of Respondents

- Birth-3 years
- 4-6 Years
- 7 or Older
Comfort level of Audiologists

![Bar chart showing comfort levels of Audiologists for various procedures.]

- **Procedure**
  - VRA
  - CPA
  - OAE
  - Imittance
  - Equip troubleshooting
  - Dx ABR
  - FM dispensing

- **Percentage of respondents**
  - Very Comfortable
  - Somewhat comfortable
  - Do not perform

**Comfort levels:**
- Very Comfortable: High percentages for VRA, CPA, OAE, and Imittance.
- Somewhat comfortable: Lower percentages for Dx ABR and FM dispensing.
- Do not perform: Very low percentages for all procedures.
Key points: Audiology

- Beyond PTA, better speech production and vocabulary with increased audibility.
- Children have longer wear time and better use consistency once they are preschool age, although once in school some do not wear as often.
- Most audiologists report they are comfortable with pediatric evaluation and fitting techniques except ABR and FM.
• Most audiologists indicate they use DSL prescriptive fitting method

• Regarding Verification:
  • For children under 3, 2/3s of audiologists reported they verify HAs with 2cc coupler w/ either measured or average RECD.
  • Some still report using aided detection thresholds or manufacturer suggested settings.
Take home messages

- Many early-identified children score within the average range or better on speech and language tests, but approximately 1/3 of the children are lagging behind their NH peers.
- While many children are delayed at younger ages, they may catch up as they get older.
- Better audibility is associated with better speech and language scores.
- Need to be vigilant over children’s speech/language evaluations and hearing aid use as they age.
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Thanks

Any questions?