Effectiveness of Early Intervention in Improving Child Outcomes: a Longitudinal Population Study

Robert Cowan
Teresa YC Ching and the LOCHI Team

The HEARing Cooperative Research Centre, Australia

www.hearingcrc.org
Hearing Disorder vs Hearing Disability

**HEARING DISORDER:**
What’s wrong with the auditory pathway

**HEARING DISABILITY:**
What a person cannot do as a consequence…

Soundwaves

Understanding

Acoustic transformation
Mechanical transduction
Electro-neural sensing
Neural pathways
Sound processing
Communications processing
Hearing Disability: A global problem

- 5.3% of the world’s population have a disabling hearing loss
- 80% of adults over 80 years of age have a hearing disorder that degrades their communication and increases isolation, known factors contributing to cognitive decline

“hearing loss is a significant issue affecting all Australians across their lifetime”*

CHILDREN delaying language development and impacting educational achievement;

ADULTS reducing productivity, employment, leisure and social participation;

ELDERLY accelerating cognitive decline.

* Australian Senate enquiry “Hear Us”, 2010
Economic Impact of Hearing Loss

Impact on Australia

$11.75bn p.a. financial cost
$11.30bn p.a. disability & lost well-being cost

$23.05bn p.a.

Contributors to financial impact

- 57% Productivity & direct employment
- 27% Cost of informal carers
- 8% Deadweight tax losses
- 6% Direct healthcare costs
- 2% Education and support services

Source: “Listen Hear Australia”, Access Economics 2006
Longitudinal Outcomes of Children with Hearing Impairment

Prospective study to directly compare outcomes of early- and late-identified children on a population basis.
Participants (n = 451)

- Gender: 55% M
- Add disabilities: ~24%
- Aud Neuropathy: ~10%
- Parents with no hearing impairment: ~78%
- English used at home: ~79%
- Maternal education (university): ~33%
- Enrolled in educational intervention: ~89%
- Oral communication mode: ~75%
Participants

New South Wales (NSW), Queensland (QLD) and Victoria (VIC).

First fit < 6 months: 53 %
# Hearing Devices at Age 5 Years

<table>
<thead>
<tr>
<th></th>
<th>No CI</th>
<th>One CI</th>
<th>Two CIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No HA</td>
<td>12</td>
<td>14</td>
<td>93</td>
</tr>
<tr>
<td>One HA</td>
<td>20</td>
<td>56</td>
<td>-</td>
</tr>
<tr>
<td>Two HAs</td>
<td>272</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>304</td>
<td>70</td>
<td>93</td>
</tr>
</tbody>
</table>
Language and Communication Mode

As used in home

Communication Mode

Oral 75%
Mixed 24%
Manual 1%

English 81%

Arabic 7%
Italian 4%
Vietnamese 1%
Cantonese 1%
Spanish 1%
Greek 1%
Polish 1%
Persian 1%

Creating sound value™
Child
- Age at fitting
- Age at implantation
- Birthweight
- Gender
- Hearing thresholds
- HA – Prescription
- Additional disabilities
- Auditory neuropathy
- Aetiology
- Cognitive ability

Family
- Communication mode
- Involvement in intervention
- Language used at home
- Maternal education
- Socio-economic status

Intervention
- Age at enrolment
- Communication mode
- Hours of intervention
- Parental involvement
And measure children’s outcomes ...

- Expressive Communication
- Auditory comprehension
- Receptive vocab.
- Expressive vocab.

- Articulation
  - Phonological dev
    - Speech perception
    - Spatial release from masking

- Phonological awareness
  - Reading
  - Spelling
  - Math reasoning

- Aural-oral function in real life
  - Pragmatics
  - Mental health
  - Quality of life

- Educational attainment
- Employment

- Working memory
  - Orthographic learning
  - Paired associate learning
  - Lexical access

- Articulation
  - Phonological dev
    - Speech perception
    - Spatial release from masking

- Literacy & numeracy

- Speech perception
- Spatial release from masking

- Expressive Communication
- Auditory comprehension
- Receptive vocab.
- Expressive vocab.

- Language

- Speech

- Literacy & numeracy

- Psycho-social dev.

- Education & employment

- Cognition

- Creating sound value™
Age 5 Test scores: 25th, 50th, 75th percentiles...
Performance vs Age at First Fit (n= 325)

Fitting age: $p = 0.009$
Forming a global score

• Combine 20 test scores into a global language score using factor analysis,

• Fit regression models for:
  – Children using hearing aids
  – Children using cochlear implants

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Factor loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLS language expression</td>
<td>0.92</td>
</tr>
<tr>
<td>CDI language comprehension</td>
<td>0.90</td>
</tr>
<tr>
<td>CDI expressive language</td>
<td>0.87</td>
</tr>
<tr>
<td>Peabody picture vocabulary</td>
<td>0.86</td>
</tr>
<tr>
<td>PLS auditory comprehension</td>
<td>0.85</td>
</tr>
<tr>
<td>DEAP vowel production</td>
<td>0.78</td>
</tr>
<tr>
<td>DEAP consonant production</td>
<td>0.73</td>
</tr>
<tr>
<td>PEACH</td>
<td>0.63</td>
</tr>
<tr>
<td>CDI social score</td>
<td>0.63</td>
</tr>
<tr>
<td>TEACH</td>
<td>0.53</td>
</tr>
</tbody>
</table>
Distribution of Global Language Scores (5 yr)

![Histogram showing the distribution of global language scores for normal-hearing children, with the mean at 84 and 90.]
Predictor Variables Assessed

- Age at first fitting
- Age at CI activation
- 4FA hearing loss
- Gender
- Birthweight
- Presence of additional disabilities
- Presence of auditory neuropathy
- Hearing aid prescription
- Non-verbal cognitive ability
- Maternal education
- Socio-economic status
- Communication mode in early intervention
## Significant Predictors for 114 children with CI

<table>
<thead>
<tr>
<th>Predictor</th>
<th><strong>$R^2 = 0.70$</strong></th>
<th>Significance (p – value)</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age first switch on (log)</td>
<td></td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>4FA hearing loss</td>
<td></td>
<td>0.60</td>
<td>-0.06 (-0.30, 0.17)</td>
</tr>
<tr>
<td>Cognitive ability/WNV</td>
<td></td>
<td>&lt;0.001</td>
<td>0.53 (0.37, 0.69)</td>
</tr>
<tr>
<td>Gender (Female re male)</td>
<td></td>
<td>0.15</td>
<td>4.84 (-1.73, 11.42)</td>
</tr>
<tr>
<td>Birthweight</td>
<td></td>
<td>0.79</td>
<td>0.51 (-3.27, 4.3)</td>
</tr>
<tr>
<td>Other disability</td>
<td></td>
<td>&lt;0.001</td>
<td>-19.1 (-28.39, -9.83)</td>
</tr>
<tr>
<td>Maternal education (Dip re school)</td>
<td></td>
<td>0.20</td>
<td>4.64 (-4.33, 13.61)</td>
</tr>
<tr>
<td>(university re school)</td>
<td></td>
<td></td>
<td>8.28 (0.76, 17.32)</td>
</tr>
<tr>
<td>Socio-economic status (dec)</td>
<td></td>
<td>0.40</td>
<td>2.3 (-3.05, 7.65)</td>
</tr>
<tr>
<td>Communication mode in Edn.</td>
<td></td>
<td>0.04</td>
<td>-12.38 (-24.5, -0.31)</td>
</tr>
<tr>
<td>(other re oral)</td>
<td></td>
<td></td>
<td>2.56 (-7.42, 12.55)</td>
</tr>
<tr>
<td>(changed or nil re oral)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**$R^2 = 0.58$**

Impact of category change. For continuous variables, variation as per specification.
Yr 5 Global Language Development …

- Earlier age of implantation
- Higher cognitive ability
- Oral communication mode
- Additional disabilities
Age at Switch-On

CI group, model 2

Global language score vs. Age at switch-on (months)

- 0.7 SD
- 0.37 SD
- 0.25 SD
## Australian Prevalence and Penetration

Estimated percentage treated for people with severe to profound bilateral SNHL in Australia by age group, prevalence, and CI surgeries in 2013

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Total population</th>
<th>Prevalence 65+ dB HL</th>
<th>CI Surgeries (2013)</th>
<th>% Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 years</td>
<td>809,919</td>
<td>151</td>
<td>147</td>
<td>97.6%</td>
</tr>
<tr>
<td>3-17 years</td>
<td>4,071,901</td>
<td>1,122</td>
<td>197</td>
<td>17.6%</td>
</tr>
<tr>
<td>18-29 years</td>
<td>3,708,434</td>
<td>1,855</td>
<td>86</td>
<td>4.6%</td>
</tr>
<tr>
<td>30-49 years</td>
<td>6,278,387</td>
<td>7,516</td>
<td>268</td>
<td>3.6%</td>
</tr>
<tr>
<td>50-64 years</td>
<td>4,097,171</td>
<td>17,183</td>
<td>151</td>
<td>0.9%</td>
</tr>
<tr>
<td>65-74 years</td>
<td>1,806,843</td>
<td>25,547</td>
<td>337</td>
<td>1.3%</td>
</tr>
<tr>
<td>75+ years</td>
<td>1,465,264</td>
<td>71,298</td>
<td>209</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total</td>
<td>22,237,919</td>
<td>124,672</td>
<td>1,345</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

Remote Wireless Mapping

Remote fitting: Sydney to Samoa

- project based on procedures using commercially-available hardware & software
- assessment of cost effectiveness of remote service delivery

• enable mapping of cochlear implants for people located remotely from urban centre-based services using electronic communications including internet protocols and video-conferencing

• develop strategies and procedures for training and monitoring audiologists and other clinicians using electronic communications
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From left to right: Linda Cupples, Louise Martin, Paola Incerti, Megan Gilliver, Kirsty Gardner-Berry, Vicky Zhang, Sanna Hou, Vivienne Marnane, Teresa Ching, Miriam Gunnourie, Jessica Sjahalam-King, Lauren Burns, Harvey Dillon, Julia Day, Laura Street,