Cost Effectiveness of Cochlear Implantation in the US and Europe

Debara L. Tucci MD
CI 2015 Symposium
October 16, 2015

No Conflicts to Disclose
Why measure cost effectiveness?

• Population based analysis
• Helps governments and payers prioritize health care interventions – assuming fixed resources for health care
• Develops argument of value of an intervention – for example if cochlear implantation of severely hearing impaired adult prevents dementia and consequences to health care system (more expensive health care); educational savings
• Allows direct comparison of two interventions in terms of cost and benefit (value)
# Forms of Economic Evaluation

Drummond MF et al., 2006

<table>
<thead>
<tr>
<th>Form of Economic Evaluation</th>
<th>Measure of costs</th>
<th>Measure of Consequences</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-effectiveness analysis</td>
<td>Money</td>
<td>Natural units (e.g. life-years gained)</td>
<td>Life-saving treatment</td>
</tr>
<tr>
<td>Cost-utility analysis</td>
<td>Money</td>
<td>Health status (e.g. quality-adjusted life years, or QALY)</td>
<td>CI Compares value for money of interventions in different fields of healthcare</td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>Money</td>
<td>Money</td>
<td>All costs and consequences expressed in money units (irrespective of worth to society)</td>
</tr>
</tbody>
</table>
How to measure cost effectiveness? – The DALY

- Disability-Adjusted Life Year (DALY) -Introduced in 1993 by the World Bank and World Health Organization (WHO) as part of an effort to quantify the global burden of disease (GBD) in developing countries
- Main advantage – provides means to compare the health impact of a wide range of medical conditions through the use of standardized disability weights
- Weights determined through iterative process by health professionals; weights have a major impact on what is considered cost effective; GBD 2013 figures recently published
- DALY = years of life lost (YLL) due to premature mortality plus years lived in disability/disease (YLD); 0 = perfect health; 1 = death
- For example, if last 5 years spent in disability state with weight of 0.33, but no premature death, then DALY = 0.33 x 5 = 1.65

Adult onset Hearing Loss – DALYs in 2002 (WHO)
How to measure cost effectiveness? – The QALY

- First described in 1968
- Considers both quantity and quality of life generated by healthcare interventions
- Concept of utility – QALYs are maximized by increasing utility; cost utility analysis (CUA)
- Utility is a measure of value or preference that is attached to a health outcome and linked to quality of life measures
- Include medical costs to obtain cost/QALY
- Parameter can be used to compare the cost effectiveness of any treatments
- Incremental cost effectiveness ratio – compares cost/QALY
- Willingness to pay – guideline set by payer

Utility values range from 1 (perfect health) to 0 (death)

Negative utility value less desirable than death (e.g. vegetative state)

1  -----------------------  Best possible health state

0  -----------------------  Death

-  +  

0  -----------------------  Worst possible health state

Utility values range from 1 (perfect health) to 0 (death)

Negative utility value less desirable than death (e.g. vegetative state)
Example: Comparison of treatments using QALY

- Treatment B improves Quality of Life over Treatment A
- Does not extend life
- Information on cost needed to determine which is more cost effective option
Types of Economic Valuations

Example: Recommendations in healthcare decision making based on cost/QALY and level of evidence (Stevens et al., 1995)

<table>
<thead>
<tr>
<th>Evidence quality</th>
<th>Cost per QOLY gained</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. At least one randomized controlled trial</td>
<td>&lt;3k: Strongly recommended; 3-20k: Strongly recommended; &gt;20k: Limited support; Negative</td>
</tr>
<tr>
<td>II. Well designed controlled trial</td>
<td>&lt;3k: Strongly recommended; 3-20k: Supported; &gt;20k: Limited support; Negative</td>
</tr>
<tr>
<td>III. Expert consensus or opinion</td>
<td>&lt;3k: Supported; 3-20k: Limited support; &gt;20k: Limited support; Negative</td>
</tr>
<tr>
<td>IV. Conflicting or inadequate evidence</td>
<td>&lt;3k: Not proven; 3-20k: Not proven; &gt;20k: Not proven; Negative</td>
</tr>
</tbody>
</table>

Comparative Economic Valuations

- Threshold/willingness to pay may include clinical evidence
- Comparative analysis extra cost/QALY gained
- Incremental Cost Effectiveness Ratio (ICER) - \( \text{ICER} = \frac{C1-C0}{E1-E0} \); compare to no treatment, or best available treatment
- Sensitivity analysis – varies input costs over a range to examine main determinants of cost of intervention
Measures of Health-Related Quality of Life

- **Formal methods** – used to establish public preferences
  - Time trade-off (TTO) – requires respondents to estimate the number of years in perfect health that would be equivalent to living their expected remaining years of life in current state of health
  - Standard gamble – certain health state vs gamble for better health
  - Visual analogue scale – VAS – place each health state on continuum to value difference
- **Informal methods** – establish patient’s level of function
  - Disease specific questionnaires – validated vs. ad hoc
  - Generic disease questionnaires
  - Commonly used questionnaires: Health Utilities Index Mark 3 (HUI3), EuroQol descriptive system (EQ5D)
  - HUI3 responsive to impaired hearing (hearing/no hearing)
    - Questionnaires may not be adequately sensitive due to inability to reflect change in disease states or ceiling effects
Advantages and Disadvantages of QALY

**Advantages**

- Allows us to value health gains associated with interventions
- Can be used to guide priority setting
- Allow comparisons of the effectiveness of one intervention with effectiveness of another intervention for the same problem
- Allow comparisons across disease areas to help show which programs provide the greatest allocative efficiency

**Disadvantages**

- Values assigned to the quality of life component of the QALY may not reflect the values of patients receiving the intervention (public vs. patient based utilities)
- May lack sensitivity within a disease area (especially a problem for establishing utility of bilateral CI)
- Can oversimplify complex healthcare issues (and societal consequences) and suggest ‘quick and easy’ resource allocation decisions that may not be appropriate
## Cost Utility Analysis of CI – What to Measure?

<table>
<thead>
<tr>
<th>Costs: Fixed costs attributed to CI program + Variable patient-based cost</th>
<th>(Potential) Measures of Improved Health Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff, training, space, equipment</td>
<td>Improved access to auditory stimuli</td>
</tr>
<tr>
<td>Device, maintenance, upgrades</td>
<td>Enhanced academic achievement</td>
</tr>
<tr>
<td>Surgery, surgical complications</td>
<td>Decreased costs of education</td>
</tr>
<tr>
<td>Rehabilitation, other follow up</td>
<td>Improved vocational outcomes (decreased costs to society?)</td>
</tr>
<tr>
<td></td>
<td>Improved overall quality of life</td>
</tr>
<tr>
<td>Bilateral implants: sequential or simultaneous; second side implant discounted or not</td>
<td>Health care cost savings?: (hearing loss associated with dementia and increased hospitalizations)</td>
</tr>
</tbody>
</table>
Analysis of Cost Effectiveness of CI for severe to profound deafness in children and adults

*Bond et al., Health Technology Assessment 2009; systematic review; UK*

Questions: 1) for severe to profoundly deaf people, is it effective and cost effective to provide a unilateral CI? 2) to provide a second (bilateral) CI?

<table>
<thead>
<tr>
<th></th>
<th>QALY</th>
<th>£/episode</th>
<th>ICER £/QALY; ($) (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHILDREN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CI</td>
<td>4.48</td>
<td>60,070</td>
<td>13,413 ($25,000)</td>
</tr>
<tr>
<td>2 CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous</td>
<td>+0.67</td>
<td>+27,105</td>
<td>40,410 ($75,000)</td>
</tr>
<tr>
<td>Sequential</td>
<td>+0.60</td>
<td>+32,657</td>
<td>54,098 ($100,000)</td>
</tr>
<tr>
<td><strong>ADULTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CI</td>
<td>2.40</td>
<td>33,959</td>
<td>14,163 ($26,000)</td>
</tr>
<tr>
<td>2 CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous</td>
<td>+0.38</td>
<td>+19,048</td>
<td>49,559 ($92,000)</td>
</tr>
<tr>
<td>Sequential</td>
<td>+0.33</td>
<td>+19,678</td>
<td>60,301 ($110,000)</td>
</tr>
</tbody>
</table>
Conclusions

• Profoundly hearing impaired children and adults: when measured on lifetime horizon, and compared with either non-technical support or hearing aids, unilateral cochlear implants are likely to be cost-effective at willingness to pay thresholds of £30,000/QALY ($46,000)
• Bilateral implants – high degree of uncertainty regarding utility gain (tinnitus alleviation not considered)
• Sensitivity analysis showed cost-utility results particularly sensitive to:
  • discount rates for costs and benefits (3.5%)
  • time horizon used in the analysis – lifetime
  • failure rate of implant external components outside of warranty
  • incremental utility for 1 vs. 2 CI
  • discount offered on second implant
Outcomes and Cost-Utility with Cochlear Implants

Semenov et al., 2012

- Cost-utility ratios for CI are highly favorable (WTP < $25K), esp in US

<table>
<thead>
<tr>
<th>Study</th>
<th>Instrument</th>
<th>Country</th>
<th>Population</th>
<th>Cost-Utility Ratio ($)/QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unilateral vs No CI</td>
</tr>
<tr>
<td>Summerfield et al, 2010</td>
<td>TTO</td>
<td>UK</td>
<td>Children</td>
<td>34 824</td>
</tr>
<tr>
<td></td>
<td>VAS</td>
<td></td>
<td></td>
<td>23 026</td>
</tr>
<tr>
<td>Bond et al, 2009</td>
<td>HUI</td>
<td>UK</td>
<td>Children</td>
<td>25 519</td>
</tr>
<tr>
<td></td>
<td>HUI</td>
<td></td>
<td>Adults</td>
<td>33 132</td>
</tr>
<tr>
<td>Bichey et al, 2008</td>
<td>HUI</td>
<td>US</td>
<td>Children</td>
<td>10 221</td>
</tr>
<tr>
<td></td>
<td>HUI</td>
<td></td>
<td>Adults</td>
<td>11 092</td>
</tr>
<tr>
<td>Summerfield et al, 2002</td>
<td>HUI</td>
<td>UK</td>
<td>Adults</td>
<td>45 215</td>
</tr>
<tr>
<td>Cheng et al, 2000</td>
<td>TTO</td>
<td>US</td>
<td>Children</td>
<td>9029</td>
</tr>
<tr>
<td></td>
<td>VAS</td>
<td></td>
<td></td>
<td>7500</td>
</tr>
<tr>
<td></td>
<td>HUI</td>
<td></td>
<td></td>
<td>5197</td>
</tr>
<tr>
<td>Palmer et al, 1999</td>
<td>HUI</td>
<td>US</td>
<td>Adults</td>
<td>14 670</td>
</tr>
<tr>
<td>Wyatt et al, 1996</td>
<td>HUI</td>
<td>US</td>
<td>Adults</td>
<td>15 928</td>
</tr>
</tbody>
</table>
Outcomes and Cost-Utility with Cochlear Implants: Pediatric Implants

Semenov & Niparko, 2015; Semenov et al., 2012

- Special challenges in measurement of health utility (derived from parent questionnaire or hypothetical)
- Overall cost utility should include benefits obtained in achieving educational independence and improved educational (and potentially vocational) outcomes relative to no CI
- Initial educational costs for CI children remain static or increase for 3 years post implant, ultimately educational independence achieved for most children within first 5 years (75%; Francis et al., 1999)
- Net savings ranges from $30,000 - $100,000 (including CI costs)
- Younger age at CI associated with not only more favorable outcomes but also lower direct and indirect costs
Outcomes and Cost-Utility with Cochlear Implants: General Conclusions
(Semenov & Niparko, 2015)

• Unilateral CI is highly cost effective for adults and children at WTP threshold of £20-30,000 ($31-46,000) per QALY
• Cost utility of bilateral CI is less clear, but reaches favorable cost utility ratios when compared with non-implant controls at a WTP < $50,000, when appropriate QoL measures are used
• QoL instrument used matters: Particularly for bilateral CI, HUI3 is insensitive to differences in subtle improvements in hearing (vs. hearing/no hearing comparison). Generic instruments often do not reflect hearing specific changes
• Propose newly developed disease specific YHRQL
• Cost utility slightly better in children (longer time horizon) with estimated lifetime cost savings due to educational benefits
Outcomes and Cost-Utility with Cochlear Implants: Research needs

• Better validated disease-specific instrument to measure quality of life, sensitive to subtle changes in hearing provided by bilateral CI

• Cost utility of CI for less than profound SNHL, including contemporary expanded indications including hybrid CI, unilateral SNHL, and consideration of tinnitus alleviation

• Better assessment non-clinical benefits of CI and measurement of impact on QoL and cost utility, including:
  • Physical and emotional function
  • Interpersonal communication
  • Independence in daily living
  • Overall satisfaction with life
  • Mental health