Cost Effectiveness Analysis and Cochlear Implantation

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No Conflicts to Disclose
Why measure cost effectiveness?

- 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 for pediatric population
- Allows direct comparison of two interventions in terms of cost and benefit (value)
- Allows for analysis of incremental benefit of one intervention over another (for example bilateral vs. unilateral CI)
- Helps governments and payers prioritize health care interventions – assuming fixed resources for health care (single payer systems)
# Forms of Economic Evaluation

Drummond MF et al., 2006

<table>
<thead>
<tr>
<th></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</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>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 QALY

- **Quality Adjusted Life Year**
- Measure of disease burden – quality and quantity of life
- Concept of **utility** –
  - Utility is a measure of value or preference that is attached to a health outcome and linked to quality of life measures
  - QALYs are maximized by increasing utility
- Include costs of intervention to obtain cost/QALY
- Can be used to compare the cost effectiveness of any treatments
- Incremental cost effectiveness ratio – compares cost/QALY for 2 txs
- 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)
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>&lt;3k</th>
<th>3-20k</th>
<th>&gt;20k</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. At least one randomized controlled trial</td>
<td><strong>Strongly recommended</strong></td>
<td><strong>Strongly recommended</strong></td>
<td>Limited support</td>
<td>Not supported</td>
</tr>
<tr>
<td>II. Well designed controlled trial</td>
<td><strong>Strongly recommended</strong></td>
<td>Supported</td>
<td>Limited support</td>
<td>Not supported</td>
</tr>
<tr>
<td>III. Expert consensus or opinion</td>
<td>Supported</td>
<td>Limited support</td>
<td>Limited support</td>
<td>Not supported</td>
</tr>
<tr>
<td>IV. Conflicting or inadequate evidence</td>
<td>Not proven</td>
<td>Not proven</td>
<td>Not proven</td>
<td>Not supported</td>
</tr>
</tbody>
</table>
Comparative Economic Valuations

- Incremental Cost Effectiveness Ratio (ICER)- type of CEA
- Statistic shows difference in cost between two interventions, divided by difference in their effectiveness
  \[ \text{ICER} = \frac{C_1 - C_0}{E_1 - E_0} \]
- Comparator = no treatment, or best available treatment (eg unilateral CI vs. no implant, or unilateral vs bilateral CI,)
- Is new intervention acceptable to payers?
  - Depends on effectiveness and cost (willingness to pay)
- In US, threshold is generally $50,000 per QALY; if in excess of this threshold, the intervention may not be deemed cost effective.
- Higher cost requires higher level of evidence of benefit
Measures of Health-Related Quality of Life

• ‘Formal’ methods – 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
  • Heterogeneity of tools precludes aggregation of health utility data
  • 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, replacement (device failure), upgrades</td>
<td>Enhanced academic achievement</td>
</tr>
<tr>
<td>Surgery, surgical complications</td>
<td>Decreased costs of education (Semenov et al., 2013)</td>
</tr>
<tr>
<td>Rehabilitation, other follow up</td>
<td>Improved vocational outcomes – lower unemployment, higher salary (Emmett and Francis, 2014)</td>
</tr>
<tr>
<td>Bilateral implants: sequential or simultaneous; second side implant discounted or not</td>
<td>Improved overall quality of life</td>
</tr>
<tr>
<td></td>
<td>Health care cost savings? (hearing loss associated with dementia and increased hospitalizations and use of health care resources)</td>
</tr>
</tbody>
</table>
Sensitivity Analysis

• Useful to describe the variety of costs and other assumptions that drive the determination of cost-utility
• Costs and cost-utility differ between countries
• WHO defines cost effectiveness as CER/GDP <3; very cost effective defined as CER/GDP <1
• Factors that can be examined in SA include (among others):
  • Implant cost
  • Discount rates (for costs as well as benefits over time)
  • Time horizon of the intervention
  • Device failure rate, maintenance costs
  • Expenditures for CI eval, post implant care
Sensitivity Analysis CI cost: CE in SS Africa
S. Emmett et al, 2015 *GDP matters: Cost effectiveness of CI and Deaf Education in SSA*

<table>
<thead>
<tr>
<th>Country</th>
<th>Device Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malawi</td>
<td>753</td>
</tr>
<tr>
<td>Uganda</td>
<td>1,358</td>
</tr>
<tr>
<td>Rwanda</td>
<td>1,426</td>
</tr>
<tr>
<td>Kenya</td>
<td>2,675</td>
</tr>
<tr>
<td>Nigeria</td>
<td>5,386</td>
</tr>
<tr>
<td>South Africa</td>
<td>12,258</td>
</tr>
</tbody>
</table>

![Graph showing the relationship between device cost and CER/GDP](image)

- **CER/GDP**
- **Device Cost (USD)**
- **GDP**
  - Malawi: 753
  - Uganda: 1,358
  - Rwanda: 1,426
  - Kenya: 2,675
  - Nigeria: 5,386
  - South Africa: 12,258

- **WHO threshold for cost effectiveness**
Quality of Life and Cost-Effectiveness of Cochlear Implants

Crowson, Semenov, Tucci, Niparko; Audiology Neurotology 2017

Weighted average of QoL changes (gains) after cochlear implantation
Comparing unilateral/bilateral CI with no intervention; and unilateral vs bilateral CI

<table>
<thead>
<tr>
<th></th>
<th>Unilateral vs No Intervention</th>
<th>Bilateral vs. No Intervention</th>
<th>Bilateral vs. Unilateral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHILDREN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>generic</td>
<td>0.27</td>
<td>0.26</td>
<td>0.04</td>
</tr>
<tr>
<td>disease-specific</td>
<td>0.09</td>
<td>---</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>ADULTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>generic</td>
<td>0.21</td>
<td>0.24</td>
<td>0.08</td>
</tr>
<tr>
<td>disease-specific</td>
<td>0.28</td>
<td>0.62</td>
<td>0.10</td>
</tr>
</tbody>
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### Quality of Life and Cost-Effectiveness of Cochlear Implants

_Crowson, Semenov, Tucci, Niparko; Audiology Neurotology 2017_

Summary of Cost-Utility Ratios by age groupings – mean values
HUI QoL measure (generic but includes hearing specific question)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Unilateral vs No Intervention</th>
<th>Bilateral vs. No Intervention</th>
<th>Bilateral vs. Unilateral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHILDREN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$17,689</td>
<td>$29,519</td>
<td>$70,470*</td>
</tr>
<tr>
<td><strong>ADULTS</strong></td>
<td>$23,058</td>
<td>$21,448</td>
<td>$60,032*</td>
</tr>
<tr>
<td><strong>OLDER ADULTS</strong></td>
<td>$9,530 (one study)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Outcomes and Cost-Utility with Cochlear Implants: Challenges

• Determination of health utility
  • Population based – compare with other health conditions but may not be sensitive to hearing interventions
  • Disease specific – not as widely applicable
  • Pediatric population – derived from parent questionnaire (proxy)
  • QoL tool used matters and should be considered in analysis

• Modeling should include long term benefits, such as educational and economic independence and success
  • Analyses are usually better at including all costs than all benefits (costs more well defined)
Cost Effectiveness of Cochlear Implants: *Key Findings*

- Cochlear implants are cost effective
  - Costs well below the $50,000 willingness to pay threshold in US
- Although CI has been determined to be cost effective in UK, costs in UK are higher (reasons unknown)
- Cost effectiveness more favorable in pediatric population than adult patients, due to longer time horizon
- We do not have measures that reflect benefits of bilateral CI
- ICER for bilateral implants is driven largely by cost: impacted by
  - simultaneous vs sequential implantation
  - whether second CI cost is discounted
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, unilateral SNHL, and 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