Cost Effectiveness/Utility of CI’s. Commentary and Summary. (Text mainly from summaries below)

Context.

The studies on the cost effectiveness of Cochlear Implants (CI’s) have consistently shown that unilateral implants for adults and unilateral and bilateral implants for children are cost effective on most accepted willingness to pay calculations in high income countries such as the UK (Bond 2009; Summerfield 2010) and USA (McKinnon 2014) and in other developed economies (Turchetti 2011a&b; Saunders 2016) and developing ones (Montes 2017). Earlier studies on cost effectiveness of adult bilateral implantation where sceptical about how cost effective sequential or simultaneous bilateral CI was in adults (Bond 2009; Turchetti 2011b; McKinnon 2014), mainly due to a smaller gain from fitting the second implant (Lammers 2011; Chen 2014). While nevertheless supporting that bilateral implants are clinically effective (Crathorne 2012) and demonstrated clear benefits over unilateral CI in speech recognition (van Schoonhoven 2013).

More recent studies have advanced understanding on a number of grounds which reflect improved levels of hearing benefit from CI’s (Arnoldner 2013), technological and surgical advances delivering better outcomes and reduced cost (Büchner 2017), appropriateness of methodologies used to test hearing benefit, and comparisons against other interventions. It has also been argued that wider societal outcomes and cost savings of not needing access to other health services and social care provision needs to be taken account of in assessing the value and cost effectiveness of CI.

Cost Effectiveness of Bilateral CI.

Kuthubutheen (2015) found that the choice of utility instrument in cost-utility analysis of bilateral CI heavily influences whether the second implant is deemed cost-effective. The HUI3 is the utility of choice in CI studies and is the most conservative. Using different instruments would produce a much more positive cost effective assessment. Washington State (2013) approved bilateral fitting under certain conditions as suitable for reimbursement. Chen (2014) found that Sequential bilateral CI was cost-effective when compared to no intervention, although gains were made mostly by the first implant. Cost-effectiveness compared to unilateral implantation was borderline but improved through base case variations to reflect long-term gains or cost-saving measures. A multi-centre RCT (Smulders 2016) describes a cost-utility analysis to compare unilateral with simultaneous bilateral CI in postlingually deafened adults and found that compared with accepted societal willingness-to-pay thresholds, simultaneous bilateral CI is a cost-effective treatment for patients with a life expectancy of 5-10 years or longer. Further Foteff (2016) showed that when placed in the context of the generally treated population Unilateral, sequential, and simultaneous bilateral CI were cost-effective when compared with bilateral hearing aids. Also that technologies which reduce the total number of visits for a patient could introduce additional cost efficiencies into clinical practice. While Trinidade (2017) found allowing SeqCI would save health provider money in that if 29 of their patients had progressed directly to SeqCI, there would have been a total potential saving of $149,179.67 (4.3%). Concluding that in institutions where only SeqCI is allowed in adults, overall patient management may cost marginally more than if SimCI were practiced. This would in turn impact on assessment of cost utility measures.
Wider Economic Case for CI’s.

There has also been substantial work showing that the wider economic and social benefits, not usually taken into account in cost utility studies. As McKinnon (2014) concluded cost-effectiveness economic evaluations are only part of broader assessment of social and economic benefit when determining resource allocation. Kochin 2007 showed that serious hearing loss (decile 10) could be expected to earn $12,000 less per year than an individual with a mild (decile 1) hearing loss. While in the Canadian context Monteiro (2012) found that Cochlear implantation was associated with a significant increase in median yearly income compared to preimplantation ($42,672 vs $30,432. Clinkard (2014) found that with a 6.6-year mean duration from cochlear implantation, 31% of respondents had increased income enough to move income brackets, with a mean category rise of $10,021. They concluded that increased accesses to cochlear implantation may provide opportunities for competitive employment and associated economic benefits for the individual, their families, and society. Peñaranda (2011) comparing those with a cochlear implant to a control group using hearing aids to teat profound sensorineural hearing loss and found a economic cost differential to the advantage of the cochlear implant-of close to US$ 204,000 between the implant and the use of hearing aids over the expected life span of the patients analyzed. On a cost benefit analysis this meant that for each dollar invested to treat the cochlear-implant patient, there is a return on the investment of US$ 2.07.

Further as Bubbico (2007) noted the direct medical costs, such as audiological diagnosis, hearing aids, etc., only account for 3.8% of the societal cost, whereas education, rehabilitation and welfare costs reach 96.2% of the total. Archbold (2015) that showed that overall the costs associated with hearing loss were £30.13 billion in the UK on a conservative estimate. O’Neil (2016) also looked at the potential savings from the introduction of hearing technologies, including CI’s, from 1992–2009 and concluded that £1.5 billion has been saved over this period, on a conservative estimate, in lower use of health and social care services. Concluding that discussions of expanding the criteria for cochlear implantation should consider the potential savings to the health and social care budgets as a whole, rather than focus solely on the increased costs of providing the technology. This was supported further by (Lamb 2016). Monteiro (2012) also concluded that cochlear implantation not only improves quality of life but also translates into significant economic benefits for patients and the Canadian economy. Further that these benefits appear to exceed the overall costs of cochlear implantation. Evidence suggests that this currently the gap between those who could benefit and those with a CI is large even under current restrictive criteria in the UK where less than 5% of those eligible are fitted (Raine 2016) and in Germany where the figure is 10% (Jacob 2013).

Recognition of the importance of hearing loss has led some countries to enshrine rights to hearing as (Jacob 2013) notes for Germany in social law (SGB V and IX) doctors are requested to advise and recommend all measures which contribute to normal hearing (both sides). This indicates that doctors may be prosecuted for not offering help when medically possible. Further patients in the UK highly value their CI’s and put a high financial value on their provision (Ng 2016).

<table>
<thead>
<tr>
<th>Study</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archbold, S. Lamb, B. O’Neill, C. Atkins, J. The Real Cost of Hearing Loss: reducing its impact by increasing access to the latest hearing technologies. (2015) Ear Foundation.</td>
<td>overall the costs associated with hearing loss were £30.13 billion in the UK including £4 Billion on lost earnings and £76 million on additional GP visits.</td>
</tr>
<tr>
<td>Arnoldner, C.. Lin, V. Expanded selection criteria in adult cochlear Implantation. Cochlear implants international , November 2013.</td>
<td>The past decade of CI has shown a remarkable improvement of performance of the average cochlear implant recipient.</td>
</tr>
<tr>
<td>Büchner A, Gärtner L. Technical advancements in cochlear implants : State of the art. HNO. 2017 Apr;65(4):276-289.</td>
<td>successive advances in CI technology and the consequent substantial hearing improvements over time have since then resulted in continuous relaxation of indication criteria toward residual hearing.</td>
</tr>
<tr>
<td>Bond M, Mealing S, Anderson R, Elston J, Weiner G, Taylor RS, Hoyle M, Liu Z, Price A, Stein K. The effectiveness and cost-effectiveness of cochlear implants for severe to profound deafness in children and adults: a systematic review and economic model. Health Technol Assess. 2009 Sep;13(44):1-330.</td>
<td>The clinical effectiveness review included 33 papers, of which only two were RCTs. They used 62 different outcome measures and overall were of moderate to poor quality. All studies in children comparing one cochlear implant with non-technological support or an acoustic hearing aid reported gains on all outcome measures, some demonstrating greater gain from earlier implantation. The strongest evidence for an advantage from bilateral over unilateral implantation was for understanding speech in noisy conditions (mean improvement 13.2%, p &lt; 0.0001); those receiving their second implant earlier made greater gains. Comparison of bilateral with unilateral cochlear implants plus an acoustic hearing aid was compromised by small sample sizes and poor reporting, but benefits were seen with bilateral implants. Cochlear implants improved children’s quality of life, and those who were implanted before attending school were more likely to do well academically and attend mainstream education than those implanted later. In adults, there was a greater benefit from cochlear implants than from non-technological support in terms of speech perception. Increased age at implantation may reduce effectiveness and there is a negative correlation between duration of deafness and effectiveness. Speech perception measures all showed benefits for cochlear implants over acoustic hearing aids [e.g. mean increase in score of 37 points in noisy conditions (p &lt; 0.001) with BKB sentences]; however, prelingually deafened adults benefited less than those postlingually deafened (mean change scores 20% versus 62%). For unilateral versus bilateral implantation, benefits in speech perception were significant in noisy conditions on all measures [e.g. 76% for HINT sentences (p &lt; 0.0001)]. Quality of life measured with generic and disease-specific instruments or by interview mostly showed significant gains or positive trends from using cochlear implants. The Markov model base-case analysis estimated that, for</td>
</tr>
</tbody>
</table>
prelingually profoundly deaf children, the incremental cost-effectiveness ratio (ICER) for unilateral implantation compared with no implantation was 13,413 pounds per quality-adjusted life-year (QALY). Assuming the utility gain for bilateral implantation is the same for adults and children, the ICERs for simultaneous and sequential bilateral implantation versus unilateral implantation were 40,410 pounds and 54,098 pounds per QALY respectively. For postlingually sensorineurally profoundly deaf adults, the corresponding ICERs were 14,163 pounds, 49,559 pounds and 60,301 pounds per QALY respectively. Probabilistic threshold analyses suggest that unilateral implants are highly likely to be cost-effective for adults and children at willingness to pay thresholds of 20,000 pounds or 30,000 pounds per QALY. There are likely to be overall additional benefits from bilateral implantation, enabling children and adults to hold conversations more easily in social situations.

CONCLUSIONS:
Unilateral cochlear implantation is safe and effective for adults and children and likely to be cost-effective in profoundly deaf adults and profoundly and prelingually deaf children. However, decisions on the cost-effectiveness of bilateral cochlear implants should take into account the high degree of uncertainty within the model regarding the probable utility gain.


Abstract
Congenital hearing loss still remain an important medical and social problem for the delayed language development. Object of this study is to provide an updated and close estimate of the economic burden involved in pre-lingual hearing loss. Data were provided by the Ministry of Health data bank, the Ministry of Education national data bank, the National Institute of Social Insurance national data bank and the Italian Central Statistics Institute. The information was collected by means of a specially provided Societal Cost Questionnaire (SCQ). Direct medical costs, direct non-medical costs and indirect welfare costs involved in deafness were included in the cost estimate. Was enrolled in the study a sample of subjects with pre-lingual deafness, with a mean bilateral neuro-sensorial hearing impairment equal to 60 dB or more for 500, 1,000 and 2,000 Hz frequency tones in the better ear detected in neonatal age, had prevented speech from developing. The statistical assessment was performed according to an actuarial approach, considering the estimated life expectancy at birth, based on updated population data from census 2001. Based on life expectancy, the lifetime mean cost assessed for a subject affected by profound pre-lingual deafness turned out to be equal to Euro 737,994.76 for a male and Euro 755,404.02 for a female. Unlike other disabling affections, deafness weighs significantly more on the social system than on the health system. As a matter of fact, the direct medical costs, such as audiological diagnosis, hearing aids, etc., only account for 3.8% of the societal cost, whereas education, rehabilitation and welfare costs reach 96.2% of the total. Finally, our results suggest that societal costs can only be reduced by zeroing in on promotion and broadening of effective prevention.
strategies. The appropriate public health measures (such as the universal newborn hearing screening) set up and implemented in several European and non-European countries proved effective and reduced the handicap degree resulting from deafness. The investment in prevention will be widely paid.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinkard D, Barbic S, Amoodi H, Shipp D, Lin V.</td>
<td>Abstract</td>
</tr>
</tbody>
</table>

**Abstract**

**Objectives/Hypothesis**

To determine the cost-effectiveness of bilateral cochlear implantation (CI) in deaf adults.

**Study Design**

Cost–utility analysis.

**Methods**

Ninety patients and 52 health professionals served as proxies to estimate the benefit of bilateral cochlear implantation, utilizing the Health Utility Index. Three scenarios were created to reflect 1) deafness without intervention, 2) unilateral CI, and 3) bilateral CI. Cost evaluation reflected the burden on a publicly funded healthcare system. The base case included 25 years of service provision, processor upgrades every 5 years, 50% price reduction for second side, and 15% failure rate. Discounting and sensitivity analyses were applied.

**Results**

Costs were $63,632 (unilateral CI), $111,764 (bilateral CI), and $48,132 (incremental cost of second CI). The health preference gained from no intervention to unilateral CI, and to bilateral CI were 0.270 and 0.305. Incremental utility gained by the second implant was 11.5% of total. The incremental cost-utility ratio (ICUR) was $14,658/quality-adjusted life year (QALY) for bilateral CI compared to no intervention. It was stable regardless of discounting or sensitivity analyses. ICUR was $55,020/QALY from unilateral to bilateral CI with higher uncertainties. It improved with differential discounting, further second-side price reduction, and reduced frequency of processor upgrades. ICUR worsened with reduced length of use and higher failure rates.

**Conclusions**

Sequential bilateral CI was cost-effective when compared to no intervention, although gains were made mostly by the first implant. Cost-effectiveness compared to unilateral implantation was borderline but improved through base case variations to reflect long-term gains or cost-saving measures.

**The economic and societal benefits of adult cochlear implant implantation: A pilot exploratory study.**

**BACKGROUND:**
Cochlear implantation has been shown to result in significant improvements in communication and quality of life, but little is known about the effect of cochlear implantation and changes in a person’s employment status and earning potential. The purpose of this study is to measure the extent to which personal income changes in people who receive a cochlear implant.

**METHODS:**
We mailed a survey to a random selection of 150 cochlear implantees who receive health services in a large urban setting. Of the 93 respondents, 65 were eligible for inclusion. Demographics, current income and income prior to implantation were recorded into income categories.

**RESULTS:**
With a 6.6-year mean duration from cochlear implantation, it was found that 31% of respondents had increased income enough to move income brackets, **with a mean category rise of $10 021**. Forty participants reported working pre-implant, while 49 reported working post-implant.

**IMPLICATIONS:**
Our results suggest preliminary evidence for an association between cochlear implantation and income. Increased access to cochlear implantation may provide opportunities for competitive employment and associated economic benefits for the individual, their families, and society.

**Crathorne L, Bond M, Cooper C, Elston J, Weiner G, Taylor R, Stein K.**

**Abstract**

**BACKGROUND:**
In the UK, approximately 10 000 people have cochlear implants, more than 99% with a unilateral implant. Evidence shows that adults implanted bilaterally may benefit from binaural advantages; however, systematic review evidence is limited.

**OBJECTIVES OF THE REVIEW:**
To conduct a systematic review to discover the evidence for effectiveness and cost-effectiveness of using bilateral cochlear implants in adults with severe-to-profound hearing loss by comparing their effectiveness with unilateral cochlear implantation or unilateral cochlear implantation and acoustic hearing aid in the contralateral ear.

**TYPE OF REVIEW:**
Systematic review.

**SEARCH STRATEGY:**
This examined 16 electronic databases, plus bibliographies and references for published and unpublished studies.

**EVALUATION METHOD:**
Abstracts were independently assessed against inclusion criteria by two researchers, and disagreements were resolved. Selected papers were then retrieved and further independently assessed in a similar way. Included studies had their data extracted by one reviewer and checked by another.

RESULTS:
Searches yielded 2892 abstracts producing 19 includable studies. Heterogeneity between studies precluded meta-analysis. However, all studies reported that bilateral cochlear implants improved hearing and speech perception: one randomised controlled trial found a significant binaural benefit over the first ear alone for speech and noise from the front (12.6 ± 5.4%, P < 0.001) and when noise was ipsilateral to the first ear (21 ± 6%, P < 0.001); and another found a significant benefit for spatial hearing at 3 and 9 months post-implantation compared with pre-implantation [mean difference (sd) scores: 3 months = 1.46 (0.83-2.09), P < 0.01]. Quality of life results varied, showing bilateral implantation may improve quality of life in the absence of worsening tinnitus. Limited cost-effectiveness evidence showed that bilateral implantation is probably only cost-effective at a willingness-to-pay threshold above £62 000 per quality adjusted life year.

CONCLUSIONS:
Despite inconsistency in the quality of available evidence, the robustness of systematic review methods gives weight to the positive findings of included studies demonstrating that bilateral implantation is clinically effective in adults but unlikely to be cost-effective.


Abstract
OBJECTIVES:
Sequential and simultaneous bilateral cochlear implants are emerging as appropriate treatment options for Australian adults with sensory deficits in both cochleae. Current funding of Australian public hospitals does not provide for simultaneous bilateral cochlear implantation (CI) as a separate surgical procedure. Previous cost-effectiveness studies of sequential and simultaneous bilateral CI assumed 100% of unilaterally treated patients’ transition to a sequential bilateral CI. This assumption does not place cochlear implantation in the context of the generally treated population. When mutually exclusive treatment options exist, such as unilateral CI, sequential bilateral CI, and simultaneous bilateral CI, the mean costs of the treated populations are weighted in the calculation of incremental cost-utility ratios. The objective was to evaluate the cost-utility of bilateral hearing aids (HAs) compared with unilateral, sequential, and simultaneous bilateral CI in Australian adults with bilateral severe to profound sensorineural hearing loss.

RESEARCH DESIGN:
Cost-utility analysis of secondary sources input to a Markov model.

SETTING:
Australian health care perspective, lifetime horizon with costs and outcomes discounted 5% annually.
**INTERVENTION:**
Bilateral HAs as treatment for bilateral severe to profound sensorineural hearing loss compared with unilateral, sequential, and simultaneous bilateral CI.

**MAIN OUTCOME MEASURES:**
Incremental costs per quality adjusted life year (AUD/QALY).

**RESULTS:**
When compared with bilateral hearing aids the incremental cost-utility ratio for the CI treatment population was AUD11,160/QALY. The incremental cost-utility ratio was weighted according to the number of patients treated unilaterally, sequentially, and simultaneously, as these were mutually exclusive treatment options.

**CONCLUSION:**
No peer-reviewed articles have reported the incremental analysis of cochlear implantation in a continuum of care for surgically treated populations with bilateral severe to profound sensorineural hearing loss. **Unilateral, sequential, and simultaneous bilateral CI were cost-effective when compared with bilateral hearing aids. Technologies that reduce the total number of visits for a patient could introduce additional cost efficiencies into clinical practice.**

<table>
<thead>
<tr>
<th>Jacob R, Stelzig Y</th>
<th>[Cochlear implant treatment in Germany]. [Article in German]</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION:</td>
<td>Restoration of impaired auditory function through cochlear implant is possible, with high reliably and great success. Nevertheless, there are regular disputes between patients and insurance companies due to high costs. In Germany, approx. 1.9 Mio. people are severely hearing impaired. It can be estimated that for adequate hearing rehabilitation about 30,000 cochlear implants/year are necessary. Currently, less than 10% of those affected are offered cochlear implant.</td>
</tr>
<tr>
<td>DISCUSSION:</td>
<td>A handicap is defined if there is deviation from normal hearing for more than 6 months. This sets a time frame for the supply with cochlear implant after sudden deafness. The professional code requires to advice all medical options to a person seeking help for hearing loss. This includes benefit-risk consideration. At this point, the economic aspect plays no role. The indication for medical treatment is only subject to the treating physician and should not be modified by non-physicians or organizations. It should be noted that a supply of hearing aids is qualitatively different to the help from a cochlear implant, which provides a restoration of lost function. In social law (SGB V and IX) doctors are requested to advise and recommend all measures which contribute to normal hearing (both sides). This indicates that doctors may be prosecuted for not offering help when medically possible, just because health insurance employees did not approve the cost balance.</td>
</tr>
<tr>
<td>CONCLUSION:</td>
<td></td>
</tr>
</tbody>
</table>
The current situation, with insufficient medical care for the hearing impaired, needs clarifying. To do this, patients, health insurance companies, the political institutions, legislation and professional societies need to accept their responsibilities.

### Kuthubutheen J, Mittmann N, Amoodi H, Qian W, Chen JM.
The effect of different utility measures on the cost-effectiveness of bilateral cochlear implantation.

**Abstract**

**OBJECTIVES/HYPOTHESIS:**
To determine if the choice of health utility measure affects the incremental cost-utility ratio (ICUR) when assessing the cost-effectiveness of bilateral cochlear implantation (CI).

**STUDY DESIGN:**
A scenario-based estimate with three scenarios: 1) a patient with severe to profound sensorineural hearing loss with no intervention, 2) the same patient with a unilateral CI with average or better performance, and 3) the same patient with bilateral CIs with average or better performance.

**METHODS:**
One hundred and forty-two subjects comprising preimplantees (n = 30), unilateral cochlear implantees (n = 30), bilateral implantees (n = 30), and healthcare professionals (n = 52). The four health utility instruments applied were the Health Utility Index Mark 3 (HUI3), European Quality of Life Questionnaire in 5 Domains (EQ5D), visual analog scale (VAS), and time trade-off (TTO). Cost for each implant was based on a 25-year time horizon, 50% discount for the second implant, and a 15% failure rate.

**RESULTS:**
Using the HUI3, the utility gain from unilateral to bilateral implantation was 0.035 or 11.5% of the total utility gain. This ratio was higher using the other instruments: EQ5D (22.2%), VAS (35.0%), and TTO (41.4%). For the scenario of bilateral CI compared to no intervention, HUI3 ICUR estimates were the lowest, and for bilateral CI compared to unilateral CI, HUI3 ICUR estimates were the highest.

**CONCLUSIONS:**
The choice of utility instrument in cost-utility analysis of bilateral CI heavily influences whether the second implant is deemed cost-effective. The HUI3 is the utility of choice in CI studies and is the most conservative.

**LEVEL OF EVIDENCE:**
4


In other words individuals with the most serious hearing loss (decile 10) could be expected to earn $12,000 less per year than an individual with a mild (decile 1) hearing loss.

The estimated cost in lost earnings due to untreated hearing loss is $122 billion while the cost to society in terms of unrealized Federal Taxes is $18 billion.

### Kochkin, S. (2010). The efficacy of hearing aids

There is a $14,100 income differential between subjects with mild and severe hearing loss. People

With untreated hearing loss loss as much as $30,000 annually, depending on their degree of hearing loss.

❖ Hearing aids were shown to mitigate the impact of income loss by 90%-100% for those with milder hearing losses and from 65%-77% for those with severe to moderate hearing loss.

❖ The loss in income for people with untreated hearing loss due to underemployment is estimated at $176 billion, and the cost to society is estimated to be as high as $26 billion in unrealized federal taxes.

❖ Unemployment rates for aided subjects were not significantly related to degree of hearing loss.

❖ There was a strong relationship between degree of hearing loss and unemployment for unaided subjects. Those with severe hearing loss had unemployment rates (15.6%), double that of the normal-hearing population (7.8%) and nearly double that of their aided peers (8.3%). Thus, one would expect that the cost to society of unemployment benefit payments is double that for normal hearing households, depending on degree of hearing loss.


Moreover by not extending the criteria it is clear that the health, social care and welfare systems are all storing up future costs which far exceed the costs which would be incurred by enabling greater access to cochlear implantation now. The UK is poor at taking account of the additional costs of not taking action in candidacy criteria as the additional savings of early intervention tend to get discounted or ignored often because the cost of doing nothing is taken by other areas of public expenditure.


Abstract

OBJECTIVES/HYPOTHESIS:
The (cost-)effectiveness and the subsequent reimbursement of bilateral cochlear implantation has been vigorously debated. Throughout the world healthcare commissioners are still struggling with the decision to reimburse bilateral implantation. Given this debate, this study's objective was to review the literature on the cost-utility of bilateral cochlear implantation in both children and adults, and study the impact of the used cost and quality-of-life estimates.

STUDY DESIGN:
Systematic review.

METHODS:
Electronic databases were systematically searched for relevant studies published up to December 2010. All studies reporting on cost-utility and bilateral cochlear implantation were included.

RESULTS:
Five studies fulfilled the inclusion criteria. The methodological quality of the studies, assessed with Drummond's checklist of cost-effectiveness studies, varied from poor to good. The assumptions regarding gain in quality-adjusted life years (QALYs) and direct costs varied among studies, resulting in a varying gain in QALY (0.38-1.93). The incremental cost-effectiveness ratios for bilateral cochlear implantation differed widely.
CONCLUSIONS:
The incremental cost-effectiveness ratios for bilateral cochlear implantation vary widely and appear to depend on the gain in QALY due to the second implant. The results of this review confirm that more empirical data are required to estimate the cost-effectiveness of bilateral implantation.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montes F, Peñaranda A, Correa S, Peñaranda D, García JM, Aparicio ML, Varela AR, Castillo</td>
<td>In Colombia there are three main treatment approaches for bilateral profound sensorineural hearing loss, also known as profound deafness (PD): cochlear implants (CI), hearing aids (HA), and no treatment (NT). The objective of this study is to determine the optimal treatment approach for PD in terms of productivity and cost-effectiveness. The results for the CI, the HA, and NT in terms of productivity ratio were 1.53, 0.94, and 1.47, respectively. Patients using CI had a gain of 5.7 QALYs, whereas patients using HA had a gain of 4.6 QALYs. The results for the CI and the HA in terms of cost-effectiveness were $15,169 and $15,430 per QALY, respectively. The CI was found to be the optimal treatment for PD, as it was the most efficient and cost-effective in terms of improving patients’ productivity and quality of life. We observed that children who had received CI developed hearing and speech abilities that contributed to their productivity and quality of life to a greater extent than those with HA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Authors</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKinnon BJ</td>
<td>Health professionals would be well served to have as good an understanding of cost effectiveness as clinical effectiveness, as both are critical to their patients having access to better health care and achieving better health outcomes.</td>
</tr>
</tbody>
</table>
health outcomes. Cost-effectiveness evaluations allow decision makers a means of comparing different interventions when deciding resource allocation. It is a powerful tool, but like any analysis, not understanding the processes and assumptions involved leads to misinterpretation.

**RECENT FINDINGS:**
Cost effectiveness is an economic evaluation of cost and benefit. The threshold at which an intervention is considered cost effective is reflected by the payer's "willingness to pay", which can vary considerably from country to country. These evaluations are complex and can involve the use of incomplete financial data, and subjective impressions of benefit, while excluding broader social and economic benefits.

**SUMMARY:**
Pediatric unilateral and simultaneous bilateral cochlear implantation, and adult unilateral cochlear implantation are felt to be cost effective in the United States. Pediatric sequential cochlear implantation, adult bilateral cochlear implantation, implantation in the aged and the long deaf are not. However, cost-effectiveness economic evaluations are only part of broader assessment of social and economic benefit when determining resource allocation.

---

**Monteiro E, Shipp D, Chen J, Nedzelski J, Lin V.J**  
Cochlear implantation: a personal and societal economic perspective examining the effects of cochlear implantation on personal income.  

**Abstract**

**OBJECTIVE:**
Although cochlear implantation has been shown to improve quality of life, the socioeconomic benefit to the individual and society has not been thoroughly investigated. Our objective was to determine the economic impact of profound deafness and subsequent effects of unilateral cochlear implantation.

**DESIGN:**
Retrospective analysis of a prospectively collected cochlear implantation database.

**SETTING:**
An academic, tertiary care hospital.

**METHODS:**
A prospectively collected cochlear implantation database of 702 patients was reviewed. Known Canadian economic surrogates were used to estimate the personal economic impact of both deafness and unilateral cochlear implantation.

**MAIN OUTCOME MEASURES:**
The main outcome measures included employment rates and personal income prior to and following cochlear implantation.

**RESULTS:**
A total of 637 patients had sufficient occupational data for inclusion in the study; 36.7% suffered a negative economic impact as a result of their deafness. **Cochlear implantation was associated with a significant**
### Increase in median yearly income compared to preimplantation ($42,672 vs $30,432; p = .007).

**CONCLUSIONS:**

Cochlear implantation not only improves quality of life but also translates into significant economic benefits for patients and the Canadian economy. These benefits appear to exceed the overall costs of cochlear implantation.

---

**Ng, Z., Lamb, B., Harrigan, S., Archbold, S., Athalye, S., & Allen, S.**

*Cochlear Implants International* Vol. 17, Iss. sup1, 2016

---

**CIs are highly valued economically, but even more so personally. Discussions on funding in public health need to include non-health care costs and measures of real-life outcomes in order to increase accessibility and funding, and reflect the value CIs can have for adults.**

---


---

**INTRODUCTION:**

Undue attention in the allocation of healthcare resources can be given to expenditures as opposed to expenditures avoided. This can be particularly apparent when expenditures avoided fall across different budget holders and budgetary pressures are strained.

**METHODS:**

The paper presents estimates of the potential savings attributable to the adoption of new hearing assistive technologies in Britain between 1992 and 2014 based on multivariate analyses of survey data.

**RESULTS:**

The reduction in service use among the hearing impaired between 1992 and 2014 is estimated to amount to between £53 and £92 million per annum.

**CONCLUSION:**

Issues in estimating the impact of widening candidature for cochlear implants on costs exist related to potential savings. This research begins to lay a firmer evidence base for such work as well as identifying some of the challenges.

Discussions of expanding the criteria for cochlear implantation should therefore consider the potential savings to the health and social care budgets as a whole, rather than focus solely on the increased costs of providing the technology more widely.

---

**Peñaranda A1, Mendieta JC, Perdomo JA, Aparicio ML, Marín LM, García JM, Barón C**


---

**Abstract**

**OBJECTIVE:**

Evaluate the cost-benefit, cost-utility, and cost-effectiveness of cochlear implantation, comparing it to the use of hearing aids in children with profound bilateral sensorineural hearing loss.

**METHODS:**

The nonparametric propensity score matching method was used to carry out an economic and impact
assessment of the cochlear implant and then perform cost-benefit, cost-utility, and cost-effectiveness analyses. Primary information was used, taken randomly from 100 patients: 62 who received cochlear implants (treatment group) and 38 belonging to the control group who used hearing aids to treat profound sensorineural hearing loss.

RESULTS: An economic cost differential was found to the advantage of the cochlear implant of close to US$ 204,000 between the implant and the use of hearing aids over the expected life span of the patients analyzed. This amount refers to the greater expenses that hearing-aid patients will have. With this adjusted figure, the cost-benefit indicator shows that for each dollar invested to treat the cochlear-implant patient, there is a return on the investment of US$ 2.07.

CONCLUSIONS: The cochlear implant produces economic benefits for the patient. It also produces health utilities since positive cost-utility (gain in decibels) and cost-effectiveness (gain in language discrimination) ratios were found.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raine, C., Atkinson, H., Strachan, D. R., &amp; Martin, J. M.</td>
<td>Access to cochlear implants: Time to reflect, Cochlear Implants International, 17: 51, 42-46.</td>
<td>Within the UK the anticipated adult utilization (of CI’s) is below 5%... The UK performs half the number per million of population as compared with Germany or Austria.</td>
</tr>
<tr>
<td>Saunders JE, Francis HW, Skarzynski PH.</td>
<td>Measuring Success: Cost-Effectiveness and Expanding Access to Cochlear Implantation, Otol Neurotol. 2016 Feb;37(2):e135-40.</td>
<td>The cost effectiveness of both pediatric and adult cochlear implantation has been well established in developed economies.....All of these studies have been performed using Cost Utility techniques with a QALY measure of effectiveness using a variety of methods.</td>
</tr>
</tbody>
</table>
OBJECTIVE: To study the cost-utility of simultaneous bilateral cochlear implantation (CI) versus unilateral CI. STUDY DESIGN: Randomized controlled trial (RCT). SETTING: Five tertiary referral centers. PATIENTS: |
Thirty-eight postlingually deafened adults eligible for cochlear implantation.

**INTERVENTIONS:**
A cost-utility analysis was performed from a health insurance perspective.

**MAIN OUTCOME MEASURES:**
Utility was assessed using the HUI3, TTO, VAS on hearing, VAS on general health and EQ-5D. We modeled the incremental cost per quality-adjusted life year (QALY) of unilateral versus bilateral CI over periods of 2, 5, 10, 25 years, and actual life-expectancy.

**RESULTS:**
Direct costs for unilateral and bilateral CI were €43,883 ± €11,513 (SD) and €87,765 ± €23,027 (SD) respectively. Annual costs from the second year onward were €3,435 ± €1,085 (SD) and €6,871 ± €2,169 (SD), respectively. A cost-utility analysis revealed that a second implant became cost-effective after a 5- to 10-year period, based on the HUI3, TTO, and VAS on hearing.

**CONCLUSION:**
This is the first study that describes a cost-utility analysis to compare unilateral with simultaneous bilateral CI in postlingually deafened adults, using a multicenter RCT. Compared with accepted societal willingness-to-pay thresholds, simultaneous bilateral CI is a cost-effective treatment for patients with a life expectancy of 5-10 years or longer.

**Summerfield AQ, Lovett RE, Bellenger H, Batten**

*Estimates of the cost-effectiveness of pediatric bilateral cochlear implantation.*

**G.Ear Hear. 2010 Oct;31(5):611-24.**

**Abstract**

**OBJECTIVES:**
Objectives were, first, to estimate the additional number of quality-adjusted life years (QALYs) gained by deaf children from bilateral compared with unilateral implantation (DeltaQ); second, to estimate the additional cost to the healthcare system in the United Kingdom for providing bilateral compared with unilateral implantation (DeltaC); and, third, to compare the values of incremental net benefit (INB), rDeltaQ - DeltaC, with criteria used by policy makers in deciding whether to adopt health technologies. In England and Wales, the healthcare policy-making body must be satisfied that the INB is positive for a maximum value of r of pound30,000 (the "net-benefit" criterion). Policy makers may also require the likelihood that the technology is cost-effective to exceed 0.8 (the "likelihood" criterion).

**DESIGN:**
An opportunity sample of 180 informants, composed of clinicians/researchers, students, and parents, valued the quality of life of a hypothetical child born profoundly deaf. The child was described in written vignettes as achieving typical outcomes with no implant, a unilateral implant, a unilateral implant with benefit from a contralateral acoustic hearing aid, or bilateral implants. Valuations were made using the time trade-off (TTO) and a visual analog scale (VAS). A decision model was constructed to describe events related to implantation
that could occur over a child's lifetime after the decision to implant. A cost and a probability were associated with each event. Monte Carlo simulations modeled the management of cohorts of 3000 children and estimated a value of DeltaC for each child. An increment in quality of life was sampled with replacement from the appropriate distribution of informants' valuations to estimate a value of DeltaQ for each child. The minimum value of r for which the average INB was positive was calculated to test the net-benefit criterion.

The proportion of simulations for which the INB was positive when r was £30,000 was calculated to test the likelihood criterion.

RESULTS:
Estimates of the cost-effectiveness of unilateral implantation aligned closely with published estimates, giving credibility to analyses of bilateral implantation. Based on TTO data (VAS data in parentheses), bilateral implantation was associated with an increment in quality of life of +0.063 (+0.076), yielding 1.57 (1.87) additional QALYs at a cost of £34,000. Net benefit was positive, provided that £21,768 (pound 18,173) could be spent to gain a QALY. If £30,000 could be spent, the probability that bilateral implantation is cost-effective was 0.480 (0.539). Thus, the net-benefit criterion, but not the likelihood criterion, was met in both analyses. The net-benefit criterion was also met in analyses based on data from the three groups of informants individually.

CONCLUSIONS:
Groups of adults varying widely in age and life experience perceived sufficient additional quality of life from giving children two implants rather than one to mean that bilateral cochlear implantation is possibly a cost-effective use of healthcare resources in the UK. Wide variation in valuations within the groups of informants means that considerable uncertainty surrounds that conclusion. Further data on the costs and benefits of bilateral implantation are needed to resolve the uncertainty.


Abstract
OBJECTIVES/HYPOTHESIS:
From a purely surgical efficiency point of view, simultaneous cochlear implantation (SimCI) is more cost-effective than sequential cochlear implantation (SeqCI) when total direct costs are considered (implant and hospital costs). However, in a setting where only SeqCI is practiced and a proportion of initially unilaterally implanted patients do not progress to a second implant, this may not be the case, especially when audiological costs are factored in. We present a cost analysis of such a scenario as would occur in our institution.

STUDY DESIGN:
Retrospective review and cost analysis.

METHODS:
Between 2005 and 2015, 370 patients fulfilled the audiological criteria for bilateral implantation. Of those, 267 (72.1%) underwent unilateral cochlear implantation only, 101 (27.3%) progressed to SeqCI, and two underwent SimCI. The total hospital, surgical, and implant costs, and initial implant stimulation series audiological costs between August 2015 and August 2016 (29 adult patients) were used in this analysis.

**RESULTS:**
The total hospital, surgical, and implant costs for this period was $2,731,360.42. Based on previous local trends, if a projected eight (27.3%) of these patients decide to progress to SeqCI, this will cost an additional $750,811.04, resulting in an overall total of $3,482,171.46 for these 29 patients. Had all 29 undergone SimCI, the total projected cost would have been $3,332,991.75, representing a total potential saving of $149,179.67 (4.3%).

**CONCLUSIONS:**
In institutions where only SeqCI is allowed in adults, overall patient management may cost marginally more than if SimCI were practiced. This will be of interest to CI programs and health insurance companies.

**LEVEL OF EVIDENCE:**

**Turchetti G, Bellelli S, Palla I, Forli F. Systematic review of the scientific literature on the economic evaluation of cochlear implants in paediatric patients.**


**Abstract**
The aim of the study consists in a systematic review concerning the economic evaluation of cochlear implant (CI) in children by searching the main international clinical and economic electronic databases. All primary studies published in English from January 2000 to May 2010 were included. The types of studies selected concerned partial economic evaluation, including direct and indirect costs of cochlear implantation; complete economic evaluation, including minimization of costs, cost-effectiveness analysis (CEA), cost-utility analysis (CUA) and cost-benefit analysis (CBA) performed through observational and experimental studies. A total of 68 articles were obtained from the database research. Of these, 54 did not meet the inclusion criteria and were eliminated. After reading the abstracts of the 14 articles selected, 11 were considered eligible. The articles were then read in full text. Furthermore, 5 articles identified by bibliography research were added manually. After reading 16 of the selected articles, 9 were included in the review. With regard to the studies included, countries examined, objectives, study design, methodology, prospect of analysis adopted, temporal horizon, the cost categories analyzed strongly differ from one study to another. Cost analysis, cost-effectiveness analysis and an analysis of educational costs associated with cochlear implants were performed. Regarding the cost analysis, only two articles reported both direct cost and indirect costs. The direct cost ranged between € 39,507 and € 68,235 (2011 values). The studies related to cost-effectiveness analysis were not easily comparable: one study reported a cost per QALY ranging between $ 5197 and $ 9209; another referred a cost of $ 2154 for QALY if benefits were not discounted, and $ 16,546 if discounted. Educational
costs are significant, and increase with the level of hearing loss and type of school attended. This systematic review shows that the healthcare costs are high, but savings in terms of indirect and quality of life costs are also significant. Cochlear implantation in a paediatric age is cost-effective. The exiguity and heterogeneity of studies did not allow detailed comparative analysis of the studies included in the review.

Turchetti G1, Bellelli S, Palla I, Berrettini S.
Systematic review of the scientific literature on the economic evaluation of cochlear implants in adult patients.

Abstract
A systematic review of the economic literature of cochlear implants (CI) was conducted with the aim of summarizing the results of studies on the cost effectiveness of monolateral and bilateral (sequential/simultaneous) CI in adult patients affected by severe to profound prelingual and postlingual hearing impairment. The literature search was performed using "PubMed MEDLINE" and the Centre for Reviews and Dissemination search engines. Inclusion criteria related to economic evaluation included primary studies published in English language from January 2000 to May 2010 and aimed to quantify costs of CI and compare monolateral CI vs. acoustic prosthesis and bilateral (sequential/simultaneous) CI vs. monolateral CI in terms of cost per unit of effectiveness. Four articles were identified. The mean direct medical cost of the monolateral CI varied from € 30,026 to € 45,770 in postlingually deafened patients, and the cost of device represented the main cost component. Additional median costs of simultaneous and sequential bilateral CI were, respectively, € 21,831 and € 25,459. The mean direct medical cost of monolateral CI was € 31,942 in prelingually deafened patients. Monolateral CI in postlingually deafened patients represented a cost effective intervention as compared with no implant (€ /QALY varied from € 7,930, € 24,983 to € 33,094). Monolateral CI were not a cost effective intervention for traditional patients with more than 40 years of hearing impairment (€ 64,604/QALY ) or for patients with marginal benefits from using acoustic prosthesis with more than 30 years of hearing impairment (€ 106,267/QALY ). The cost effectiveness of monolateral CI worsened with increasing age (€ /QALY from € 23,439 for patients < 30 years old to € 55,369 for patients > 70 years). Bilateral CI in postlingually deafened patients were less cost effective than monolateral CI (from € 91,943/QALY to € 102,640/QALY ). Monolateral CI were cost effective in prelingually deafened patients (€ /QALY : € 8,096). Given the few economic evaluation studies in literature, future researches are needed to support the cost effectiveness results of CI in adults and to evaluate the cost effectiveness of bilateral CI, as well as to estimate the non-medical direct and indirect cost components.

van Schoonhoven J, Sparreboom M, van Zanten BG, Scholten RJ, Mylanus EA, Dreschler WA, Grolman W, Maat B.
The effectiveness of bilateral cochlear implants for severe-to-profound deafness in adults: a

Abstract
OBJECTIVE:
Assessment of the clinical effectiveness of bilateral cochlear implantation compared with unilateral cochlear implantation or bimodal stimulation, in adults with severe-to-profound hearing loss. In 2007, the National Institute for Health and Clinical Excellence (NICE) in the U.K. conducted a systematic review on cochlear implantation. This study forms an update of the adult part of the NICE review.
| **systematic review.** | **DATA SOURCES:**  
The electronic databases MEDLINE and Embase were searched for English language studies published between October 2006 and March 2011.  
**STUDY SELECTION:**  
Studies were included that compared bilateral cochlear implantation with unilateral cochlear implantation and/or with bimodal stimulation, in adults with severe-to-profound sensorineural hearing loss. Speech perception in quiet and in noise, sound localization and lateralization, speech production, health-related quality of life, and functional outcomes were analyzed.  
**DATA EXTRACTION:**  
Data extraction forms were used to describe study characteristics and the level of evidence.  
**DATA SYNTHESIS:**  
The effect size was calculated to compare different outcome measures.  
**CONCLUSION:**  
Pooling of data was not possible because of the heterogeneity of the studies. As in the NICE review, the level of evidence of the included studies was low, although some of the additional studies showed less risk of bias. All studies showed a significant bilateral benefit in localization over unilateral cochlear implantation. Bilateral cochlear implants were beneficial for speech perception in noise under certain conditions and several self-reported measures. Most speech perception in quiet outcomes did not show a bilateral benefit. The current review provides additional evidence in favor of bilateral cochlear implantation, even in complex listening situations. |
Age 12 months or older;  
- Bilateral severe to profound sensorineural hearing loss;  
- Limited or no benefit from hearing aids;  
- Cognitive ability and willingness to participate in an extensive auditory rehabilitation program;  
- Freedom from middle ear infection, an accessible cochlear lumen that is structurally suited to implantation, and freedom from lesions in the auditory nerve and acoustic areas of the central nervous system;  
- No other contraindications for surgery; and  
- Device used in accordance with the FDA approved labeling. |

Complied by Brian Lamb for the Action Group. For additions or comments please contact brian.actiongroupci@gmail.com also for the latest information see our website at https://actiongrouponadultcochlearimplants.wordpress.com/