Impact of cochlear implants on the functional health status of older adults
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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The use of cochlear implants in elderly patients.

Type of intervention
Rehabilitation.

Economic study type
Cost-utility analysis.

Study population
The study population comprised patients aged 50 years and older who received cochlear implants at the Johns Hopkins Hospital. No further exclusion or inclusion criteria were reported.

Setting
The setting was secondary care (Johns Hopkins Hospital). The economic study was carried out in the USA.

Dates to which data relate
The study retrospectively analysed patients who received cochlear implants between June 1989 and February 2000. Audiological assessment was performed before cochlear implantation, and at 6 and 12 months after surgery. The dates pertaining to the health utility assessment were not reported, nor were the dates during which the resource use data were collected. The price year was not reported.

Source of effectiveness data
The effectiveness data were derived from a single study.

Link between effectiveness and cost data
The costing was carried out retrospectively on the same sample of patients as that used in the effectiveness study.

Study sample
It was not apparent from the study that the sample size was determined in the planning phase. The authors did not perform any power calculations. Eighty-four consecutive patients who received cochlear implants at the Johns Hopkins Hospital between June 1989 and February 2000 were identified. The mean age was 66.3 years (mean age at implant, 63.4 years) and the mean duration of deafness was 18.7 years. The mean cochlear implant use was 2.6 years.

The authors mentioned that one patient had relocated without a forwarding address and one had died. This left 82 eligible patients to whom questionnaires were sent. Forty-seven completed questionnaires were returned, giving a
response rate of 57.3%. Of these, 6 patients had prelingual deafness and 41 had postlingual deafness. The authors reported that they obtained informed consent from all patients who agreed to participate.

**Study design**
The analysis was based on a retrospective cohort study that was carried out in a single centre. The duration of follow-up was unclear.

**Analysis of effectiveness**
It appears that the analysis of the clinical study was conducted on the basis of treatment completers only. The primary health outcomes used were speech perception performance before and after the surgery, and quality of life. Responses to additional questions about life with a cochlear implant were also analysed.

Speech perception performance was tested just before cochlear implantation, and at 6 and 12 months after surgery, using CID sentence and monosyllabic word tests in the patient’s best aided and cochlear implant conditions. The data were available in the patients’ charts and in an audiological database. Quality of life was assessed using the Ontario Health Utilities Index Mark 3 (HUI-3) system and was administered as a quantitative measure of general health status. The patients were first asked to recall their health status at 4 weeks before cochlear implant surgery and were then asked to report their current health condition. The responses from the HUI-3 survey were computed into a health utility index score that ranged from 0.00 (dead) to 1.00 (perfect health). Single-attribute utility scores were reported on a scale from 0.00 (lack of function) to 1.00 (full function).

The relationship between changes in speech perception scores and HUI-3 scores was analysed using regression model statistics in the StatView for Windows program (version 5.0.1, SAS Institute Inc.). Pre-implantation and post-implantation speech perception and HUI-3 scores were statistically compared using the paired t-test. The authors reported that, for the audiological evaluation, there was no significant difference between study participants and non-participants in their postoperative speech perception gains at 6 or 12 months.

The group with prelingual deafness was, on average, 6 to 7 years younger at implantation than the group with postlingual deafness. However, both groups had similar implant experience (2 years for the prelingual group and 2.7 years for the postlingual group).

**Effectiveness results**
Quality of life was increased significantly after cochlear implantation in individuals aged 50 to 83 years (mean 63.4 years, standard deviation, SD=8.6). The HUI-3 scores increased from a preoperative mean of 0.37 (SD=0.26) to a postoperative mean of 0.61 (SD=0.25). This resulted in a statistically significant mean difference of 0.24 (paired t-test, t=-5.07; p<0.0001). The assessment of individual attributes in the HUI-3 test revealed the largest and most significant increases in utility indices for hearing (difference 0.15; p<0.05) and emotion (difference 0.11; p<0.05). Postlingually deafened patients had a significant increase in their HUI-3 scores after surgery (0.25, SD=0.34; t=-4.69; p<0.0001). The increase experienced by the prelingually deafened group did not achieve statistical significance (0.21, SD=0.28; t=-1.87; p=0.1).

Postlingually deafened patients had a large and statistically significant increase in speech perception scores at 6 months after surgery for both CID sentence (t=-6.9; p<0.0001) and monosyllabic words (t=-5.8; p<0.0001), with minimal additional gains noted between 6 months and 1 year. Post-implantation speech perception was generally higher in patients with some residual hearing. The positive correlation between pre- and post-implantation scores was most evident for both monosyllabic words (r=0.56; p<0.05) and CID sentence (r=0.47; p<0.05) tests at 1 year after surgery.

The analysis showed that the larger the hearing benefit with cochlear implant, the larger the increase in quality of life reported on the HUI-3 by postlingually deafened patients. A strong correlation between the magnitude of change in HUI-3 scores and gains in speech perception scores at 6 months after implantation was demonstrated (CID sentences, r=0.55; p<0.005; monosyllabic words, r=0.55; p<0.005). A correlation between speech perception gains at 6 months and changes in the emotional sub-test score (monosyllabic words, r=0.47; p<0.05; CID sentence, r=0.48; p<0.05) was also demonstrated, but there was no correlation with the hearing sub-test.
Twenty-seven (65.9%) postlingually and 3 (50%) prelingually hearing-impaired patients reported that their quality of life was much better since the cochlear implant. Nine (22%) postlingually and 2 (33%) prelingually hearing-impaired patients reported that it was somewhat better. None of the 47 respondents reported their quality of life to be worse. These results were consistent with changes in HUI-3 scores (analysis of variance, p<0.0001).

Twenty-four (58.5%) postlingually and 3 (50%) prelingually hearing-impaired patients reported an increase in social activities since using the cochlear implant. These patients also had significantly larger increases in HUI-3 scores compared with patients who did not report improvements in their social lives, (p<0.01).

Thirty-three (80.5%) postlingually and 5 (83.3%) prelingually hearing-impaired patients reported an increase in confidence. This was associated with larger increases in HUI-3 scores compared with patients who did not experience this benefit (t=2.5; p<0.05). Although there was a trend toward larger increases in speech perception scores in relation to increased confidence, the authors reported that it did not achieve statistical significance.

Twenty-six (63.4%) postlingually and 2 (33.3%) prelingually hearing-impaired patients reported that they could converse over the telephone. They also reported larger improvements in quality of life, as reflected by changes in the HUI-3 score, 0.34 (SD=0.3) versus 0.09 (SD=0.37), (t=2.36; p<0.05). Overall, among the postlingual group there was a trend toward higher scores and postoperative gains for the monosyllabic word test at 1 year in individuals who could converse on the telephone, compared with those who could not. The scores were 44.5 (SD=23.6) versus 26.1 (SD=15.7), (t=1.9; p=0.07), and the postoperative gains were 38.7 (SD=20.2) versus 23 (SD=15.8), (t=1.7; p=0.1).

The mean duration of cochlear implant use was 13.6 hours/day (SD=4.2). The correlation between the daily hours of implant use and speech perception gains was low at 6 months for postlingually hearing-impaired patients (monosyllabic words, r=0.37; p=0.05; CID sentence, r=0.25; p=0.2). However, this relationship became stronger and was statistically significant at 1 year (monosyllabic words, r=0.54; p<0.05; CID sentence, r=0.53; p<0.05). The authors proposed that the strengthening of this relationship over time indicated that there was a benefit gained from practice with the device or, alternatively, that better performers tended to use their implant more.

Based on their experience, 37 (90.3%) postlingually and 5 (83.3%) prelingually hearing-impaired patients reported that they would again choose to undergo cochlear implantation for rehabilitation of their hearing loss. The increase in HUI-3 scores was significant for the affirmative group (0.30, SD=0.30; analysis of variance, p<0.005) and greater than for the 3 patients who would choose not to repeat the process (-0.03, SD=0.26), or the 2 patients who were unsure (-0.45, SD=0.02).

**Clinical conclusions**

The authors concluded that the group of older deaf patients experienced a significant improvement in health-related quality of life and a significant improvement in audiological performance after cochlear implantation.

**Measure of benefits used in the economic analysis**

The measure of benefits used was the quality-adjusted life-years (QALYs) gained. These discounted at an annual rate of 3%. The authors derived the HUI-3 scores as described in the ‘Analysis of Effectiveness’ section. The QALYs were obtained by multiplying the life-years by the health utility scores.

Life-years, estimated at 21 years for all 47 participants, was the mean anticipated number of years of implant experience based on a life expectancy of approximately 85 years.

**Direct costs**

The costs were discounted at an annual rate of 3%. They were incurred during more than 2 years, making discounting a relevant factor. The quantities, unit costs and their source were not reported, making it difficult to understand whether they were based on actual data or a guess. The dates to which the costs and quantities related were not reported, nor was the price year. The authors reported only that the costs associated with cochlear implantation included pre-surgical evaluation, the cost of the device, surgeons and anaesthesiologists’ fees, hospital costs, and postoperative services. The
latter covered programming, insurance, extended warranty and miscellaneous hardware costs. The authors did not explicitly state the perspective adopted in the study.

**Statistical analysis of costs**
The costs were treated deterministically.

**Indirect Costs**
No indirect costs were included.

**Currency**
US dollars ($).

**Sensitivity analysis**
A sensitivity analysis was not carried out.

**Estimated benefits used in the economic analysis**
The authors reported that the gain in HUI-3 scores was 0.24 for all patients, 0.25 for the postlingual group, and 0.21 for the prelingual group.

The QALYs gained, discounted at an annual rate of 3%, were 3.78 for all patients, 3.80 for the postlingual group, and 3.96 for the prelingual group.

**Cost results**
The total discounted cost was $36,025 for all patients and for the postlingual group.

The total discounted cost was $38,324 for the prelingual group.

**Synthesis of costs and benefits**
The cost-utility was $9,530 per QALY for all patients, $9,480 per QALY for postlingually hearing-impaired patients, and $9,678 per QALY for prelingually hearing-impaired patients.

**Authors' conclusions**
"Cochlear implantation in older adults is a highly cost-effective intervention for both groups of patients, as the cost-utility results are well below the threshold of $20,000 to $25,000 per QALY for procedures that are considered to be acceptable value for money".

**CRD COMMENTARY - Selection of comparators**
The rationale for the choice of the comparator (no cochlear implantation) was clear. You should decide whether it represents a currently used approach in your own setting.

**Validity of estimate of measure of effectiveness**
The analysis was based on a retrospective cohort study. This was not the most appropriate study design as it minimises the internal validity of the study and potential recall bias might have affected the results. A randomised controlled trial would have been a more appropriate design given the study question. Power calculations were not carried out. Hence, the sample size might have been insufficient to obtain robust results. The study sample was representative of the study
population since it comprised patients aged 50 years and older who had received cochlear implants. The authors do not seem to have conducted statistical analyses to take potential biases and confounding factors into consideration.

Validity of estimate of measure of benefit
The estimation of benefits was obtained through a survey using the HUI-3 system, which is a generic, multi-attribute, preference-based questionnaire system. However, since the health utility assessment was collected retrospectively, it is possible that recall biases might have affected the results. The relationship between changes in speech perception scores and HUI-3 scores was analysed using regression model statistics, while the pre- and post-implantation speech perception and HUI-3 scores were compared using appropriate statistical tests.

Validity of estimate of costs
The authors did not explicitly report the perspective adopted in the study, making it difficult to know whether all the relevant categories of costs were considered. However, the perspective could not have been societal since the indirect costs were not included in the analysis. Few details on the unit costs and quantities of resources used were reported, which limits the generalisability of the economic analysis to other settings. The price year was not reported and this limits reflation exercises. Discounting was relevant and was performed. No statistical analyses of the quantities and prices were carried out. The authors did not conduct any sensitivity analyses to estimate the impact of changes in cost values. Consequently, caution should be exercised when extrapolating the cost results to different contexts.

Other issues
The authors compared their results with published studies addressing younger adult cohorts, finding them to be consistent. The only difference observed was in the percentage of patients able to converse by telephone. The authors suggested that the different rates may reflect differences in the study populations. For example, the use of more advanced implant design and speech processing strategies in their study, or alternatively a higher prevalence of residual hearing.

The authors did not discuss the generalisability of the results to other settings. The absence of detailed reporting of the resources and costs, and the omission of any sensitivity analysis, means that the reader would be unable to generalise the cost-effectiveness to other settings. The authors do not appear to have presented their results selectively. The authors pointed out some limitations of the study. These included the aspects they did not consider. For example, a comparison of the speech perception outcome between pre- and postlingual hearing-impaired patients, owing to the lack of data for the prelingually deafened group. They also mentioned the possibility of recall bias in their study (as is the case in any retrospective study). However, the authors reported that the extent of recall bias in cochlear implant patients may be minimal, given that the patients are not cured of their deafness and re-experience their impairment whenever they remove their speech processor. The authors also stated that selection bias based on functional outcome is unlikely because study participants and non-participants had similar perception scores.

Implications of the study
The authors did not make any specific recommendations for policy or practice. They pointed out that the decision to pursue cochlear implantation in older patients should take into consideration the increased risk of anaesthesia-related morbidity. In addition, a careful medical assessment of the risks and benefits on a case-by-case basis should be made. The authors identified some issues to be addressed in further research. For example, a more detailed study of a larger sample of patients, to understand better the role of cochlear implantation in the management of hearing impairment in prelingually deafened adults. Further, a larger sample size is needed to elucidate the contribution of age, duration and etiology of deafness to speech perception results and quality of life outcomes of cochlear implantation.

Source of funding
None stated.
Bibliographic details

PubMedID
12172266

DOI
10.1097/00005537-200208000-00028

Indexing Status
Subject indexing assigned by NLM

MeSH
Age Factors; Aged; Aged, 80 and over; Cochlear Implants /economics; Cost-Benefit Analysis; Health Status; Humans; Middle Aged; Quality of Life; Retrospective Studies; Speech Perception; Surveys and Questionnaires

AccessionNumber
22002001405

Date bibliographic record published
31/01/2005

Date abstract record published
31/01/2005