COST-BENEFIT, COST-UTILITY, AND COST-EFFECTIVENESS ANALYSIS OF THE COCHLEAR IMPLANT IN PRELINGUAL CHILDREN WITH PROFOUND HEARING LOSS

Augusto Peñaranda, MD[1], Juan Carlos Mendieta[2], Jorge Andrés Perdomo[2], María Leonor Aparicio[3], Lina Marcela Marín[4], **Juan Manuel García, MD**[1], Clemencia Barón[3]

1. Otology- Neurotology Fundación Santafé de Bogotá, 2. Magíster in Economics Universidad de los Andes, 3. Audiologist. Fundación Santafé de Bogotá. Cochlear Implant program, 4 Economist. Universidad de los Andes

Introduction

Sensorineural hearing loss in prelingual children is a condition with the following implications: delays in language development, poor academic achievement, more years in aural (re)habilitation and less work productivity at adulthood. Congenital deafness is one of the most common congenital diseases: 200 per 100,000 infants [1]. In Colombia profound hearing loss affects 1 per 1,000 births[2].

The economic consequences of the profound deafness condition include costs in special education and societal costs due to reduced work productivity. Cochlear implants may diminish these costs significantly; nevertheless, in Colombia the access to this technology is limited basically because it is an expensive treatment.

The following study provides information about the effectiveness, utility, and benefits of the cochlear implant taking into account lifetime costs of this technology in comparison with hearing aids.

Objective

To estimate the cost-benefit, cost-utility, and cost-effectiveness of cochlear implants in children with prelingual profound deafness vs. children with hearing aids, under the same hearing condition, and without other clearly defined disabilities in both cases.

Methods

► **Population:** 100 children with prelingual profound deafness using cochlear implant or hearing aid for at least 36 months

► **2 groups:** Treated group: **62** patients with cochlear implant
Non-treated group: **38** patients with hearing aids

► **Survey to parents.**

► **Data collection from CI group history and hearing aid fitting center**
- demographic characteristics - treatment costs - educational costs
- other health expenses
- audiological information (initial auditory levels in dB)
- auditory development (measured as percentage).

Costs included within this study, for both groups were as follows:

► Cost of surgery and cochlear implant device. Or hearing aid cost

► Audiologic treatment.

► (re)habilitation fees (language and occupational therapy.

► Cost related with patient's health (medications, medical visits, etc.).

► Cost of education (regular education or special education).

► Cost of accessories (for cochlear implant or hearing aids) such as batteries, cables, hearing aid mold and hearing aid replacement every 5 years

► Average wage earned during working age and retirement age (according to Colombian law, 65years old for men and 60 for women); for treated group, equivalent to wage of normal hearing people; for non treated group, the cost of reduced productivity was taken into account.

Statistical analysis

Econometric method = Propensity Score Matching (PSM) to calculate the probability of being treated (with a CI) as well as estimates of the average values of total cost, auditory level, and auditory development between patients with cochlear implant and patients with hearing aids.

The economic benefit is measured as the difference in lifetime costs between a child with hearing aids and a child with CI; this difference is defined as a net savings for society and for the child's home.

The utility of the intervention is defined in terms of how well children with CI perform in hearing thresholds (dB) compared with children with hearing aids.

Cost-effectiveness analysis is measured as the gain on auditory development (percentage) after 36 months of cochlear implant or hearing aids use.

Results

Table No 1 . *Means Test Comparison of Total Cost, PSM (N-neighbors y Kernel)*

	Treated	Non-treated	Difference	P***
Average Impact ATT with N-Neighbors	US $ 89,347	US $ 267,290	US $ 177,942	0,01
Average Impact ATT with Kernel	US $ 90,994	US $ 285,734	US $ 194,740	0,01
Average Impact ATT between N-Neighbors and Kernel	**US $ 90,171**	**US $ 276,512**	**US $ 186,341**	**0,01**

Source: Author's calculations. ATT= Average effect of Treatment on the Treated.
Statistical significance at the (*) 0,10, (**)0,05 (***) 0,01.

The total cost in patient's life expectancy was US$90,171 for children with cochlear implant, compared with US$276,512 for patients with hearing aids (a cost difference of US$186,341). ***Table No 1.***

Table No 2. *Means Test Comparison of Decibels (dB), PSM (N-neighbors and Kernel)*

	Treated	Non-treated	Difference	P***
Average Impact ATT with N-Neighbors	30 dB	49 dB	19 dB	0,01
Average Impact ATT with Kernel	29 dB	58 dB	29 dB	0,01
Average Impact ATT between N-Neighbors and Kernel	**29 dB**	**54 dB**	**24 dB**	**0,01**

Source: Author's calculations. ATT= Average effect of Treatment on the Treated.
Statistical significance at the (*) 0,10, (**)0,05 (***) 0,01.

The change of hearing level after 36 months, was from 130 dB to 29dB using CI or hearing aids to 53 dB . The difference between treated and non-treated groups was 24dB. The tests of significance proved that cochlear implant outcomes on auditory levels are better than hearing aids. ***Table No 2.***

Table No 3. *Means Test Comparison of Gain in Language Development (%), PSM (N-neighbors and Kernel)*

	Treated	Non-treated	Difference	P***
Average Impact ATT with N-Neighbors	63%	33%	30%	0,01
Average Impact ATT with Kernel	59%	17%	43%	0,01
Average Impact ATT between N-Neighbors and Kernel	**61%**	**25%**	**36%**	**0,01**

Source: Author's calculations. ATT= Average effect of Treatment on the Treated.
Statistical significance at the (*) 0,10, (**)0,05 (***) 0,01.

The average value of gain in auditory and language development was 61% for children with cochlear implant, and 25% for the control group. As well as the previous tables, the tests of significance demonstrate that auditory and language development is greater with CI than with hearing aids. ***Table No.3.***

Table No 4. *Cost Utility and Cost Effectiveness Index*

	Treated	Non-treated
Cost / Utility Index. 1 dB	1	4,03
Cost / effectiveness. 1% sd	1	7,71

sd = speech discrimination

To gain 1dB, the cost is 4,03 times in non-treated, (hearing aids), and to gain 1 % of speech discrimination the cost is 7,71 times in non-treated, (hearing aids). ***Table No. 4.***

The following table ***(Table No. 5)*** show an ex post evaluation about cost-benefit index (CBI), which considers the number of children implanted between 1995 and 2008 at Fundación Santafe de Bogotá (FSFB), the average cost of having cochlear implant, and the net savings compared with hearing aids, with an estimation of the potential patients during these years. The net present value (NPV) of the total cost (TC) and total benefit (TB) were calculated from these variables, and the cost-benefit index was calculated from these two values. The result was US$2.07, which means that for every dollar invested on cochlear implant treatment, US$2.07 was returned. Three different discount rates were considered in this evaluations; nevertheless, the results indicate the same: cochlear implant offers economic benefits on patients.

Table No 5. **Cost-Benefit Index, Ex post Evaluation (1995-2008)**

	Discount Rate: 5 %	*Discount Rate: 8%*	*Discount Rate: 10 %*
CBI	US $ 2.07	US $ 2.07	US $ 2.07
NPV (TB)	US $ 37,349,991	US $ 30,560,491	US $ 26,996,408
NPV (TC)	US $ 18,073,803	US $ 14,788,340	US $ 13,063,665

Source: Author's calculations

Conclusions

✓ This study provides evidence, which supports that cochlear implantation is a cost-effective healthcare intervention in profoundly hearing-impaired young children. Moreover, its benefits and utilities are larger than its cost and hearing aids outcomes.

✓ The government should develop an intervention strategy for children with hearing loss to ensure that, regardless of geographic location, all families receive information on the intervention options available, (re)habilitation, amplification, and technology. Moreover, the Government should provide an easier access of this technology, considering that the initial investment reduces the future high costs generated by delays in language development and academic achievement, as well as by reduced work productivity.

✓ These findings coincide with international studies that demonstrate the effectiveness of the implant in terms of Cost - benefit, utility and cost - effectiveness [3] [4] [5] [6]

References

1. Castaño R. Tamizaje auditivo neonatal una utopía para países en desarrollo. Acta de Otorrinolaringología, cirugía de cabeza y cuello.2002; 30 (1):19-25.
2. Estudio del sistema nacional de información sobre discapacidad. Vicepresidencia de la república. Consejería Presidencial de política social. Ministerio de educación nacional. Universidad Javeriana: Bogotá, 1995.
3. Alfaro G., Hernan J., Obando Y., Valverde E.M. Evaluación financiera y económica del implante coclear en adultos poslinguales con sordera bilateral profunda. Tesis especialización en evaluación social de proyectos. Facultad de Economía, Universidad de Los Andes 1997.
4. Schroeder L., Petrou S., Kennedy C., McCann D., Law C., Watkin P.M., Worsfold S., Yuen H.M. The Economic Costs of Congenital Bilateral Permanent Childhood Hearing Impairment. Pediatrics 2006; 117: 1101-1112.
5. Wyatt J.R., Niparko J.K., Rothman M. et al. Cost Utility of the Multichannel Cochlear Implants In 258 Profoundly Deaf Individuals. Laryngoscope 1996; 106: 816-821.
6. Fugain C., Ouayoun M., Meyer B. et al. QALY Index and Assessment of Cost Efficiency of the Cochlear Implant In Acquired Profound Deafness. Ann otolaryngol Chir Cervicofac. 2000; 117: 3-11.