Cost-Benefit Analysis of Pediatric Bilateral Cochlear Implantation in Taiwan

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Introduction:

Taiwan National Health Insurance Administration has covered the expenses of surgery and one CI for children with bilateral severe-to-profound sensorineural hearing loss (SNHL) since 2017. This policy was expanded in 2024 to cover bilateral CI devices. Although these measures alleviate some financial burden, families still face high out-of-pocket expenses for frequent private speech training and related productivity losses. This study aims to evaluate the economic burden of pediatric CIs on society before individuals enter the workforce or pursue higher education.

Methods:

A retrospective analysis was conducted on children with bilateral SNHL who received bilateral CIs(CICI), categorized into early sequential, early simultaneous, and late CICI implantation groups. The total cost analysis included direct medical expenses, educational costs, social welfare allowances, and family out-of-pocket expenses.

Three bilateral CICI groups were compared: early-CICI-sim (simultaneous CIs before age 2), early-CICI-seq (first CI before age 2 and second before age 5), and late-CICI (first CI between ages 2–5 and second before age 12). Primary caregivers of eligible children completed a questionnaire that collected information on sociodemographic characteristics, hearing loss etiology and severity, hearing aid and CI experience, CI implantation dates, education-related expenses, out-of-pocket costs for surgery and device maintenance, frequency and cost of private speech training, as well as travel and productivity losses. All costs were reported in U.S. dollars, using the 2022 exchange rate (US$1 = NT$29.81). Health utility values for children with severe-to-profound SNHL using hearing devices were obtained from Chen et al., with a utility value of 0.90 for children with CICI.

Benefits were quantified as the product of quality-adjusted life years (QALYs) and willingness-to-pay (WTP), with WTP equated to Taiwan's GDP per capita. Net present value (NPV) was calculated as the difference between total benefits and costs over an 18-year period, adjusted for discounting.

Table 1. Cost parameters

Parameters			(USD)	Data Sources
Government				
Healthcare	Pre-surgery assessment	CICI simultaneous	$863	Lin et.al.
		CICI sequential 2nd ear	$228	Lin et.al.
	Surgery and hospitalization	CICI simultaneous	$3,262	Lin et.al.
	Post-surgery visit/ mapping	CICI simultaneous		
		1st /2nd /3rd /4th year and after	$2,240/ $1,414/ $859/ $322	Lin et.al.
		CICI sequential 2nd ear		
		1st /2nd /3rd /4th year and after	$1,574/ $1,020/ $538/ $159	Lin et.al.
	CI device (external and internal)		$19,123	TNHIA
Social welfare subsidy	Early intervention (age 1-6) per year		$1,610	MOHW
	Living per year		$2,189	MOHW
	HA (age 0-12, every 2 year; age 12~18, every 4 year)		$1,342	MOHW
	CI external device upgrade (every 10 year)		$3,355	MOHW
Education	Special school/ centralized special class		$21,176	Fang et.al.
	Mainstream	Resource class	$12,481	Fang et.al.
		Itinerant program	$10,381	Fang et.al.
		Regular class	$5,323	Fang et.a l.
Family out-of-pocket				
Healthcare	Pre-surgery assessment	CICI simultaneous	$23	Lin et.al.
		CICI sequential 2nd ear	$30	Lin et.al.
	Surgery and hospitalization	CICI simultaneous	$744	Lin et.al.
	Post-surgery visit/ mapping	CICI simultaneous		
		1st /2nd /3rd /4th year and after	$47/ $34/ $20/ $10	Lin et.al.
		CICI sequential 2nd ear		
		1st /2nd /3rd /4th year and after	$34/ $35/ $10/ $5	Lin et.al.
Device	HA: cost/maintenance per year (USD)		$2,013/ $134	Lin et.al.
	CI external device: cost/maintenance per year (USD)		$8,466/ $772	Lin et.al.

Table 2. Main parameters

Parameters	Base-Case Value	Data Sources
Mean time of device replacement (year)		
HA	5	Lin et.al.
CI external device	5	Survey
Health Utility		
HAHA/ CIHA/ CICI	0.69/ 0.81/ 0.90	Chen et.al.
Willingness-to-Pay Threshold (USD)	$32,827	National Statistics
Annual discount rate	3%	

Table 3. Demographic data

Group	Hearing (PTA, dB)	Implantation age	Case number	Mean age now	Age of 1st implant		Age of 2nd implant	
					Mean ± SD	(Range)	Mean ± SD	(Range)
Early CICI sim	bilateral ≥ 90	<2	5	6.5	1.3 ± 0.4	(1.0~2.0)	1.3 ± 0.4	(1.0~2.0)
Early CICI seq	bilateral ≥ 90	1st ear <2, 2nd ear<5	17	7.2	1.4 ± 0.3	(1.0~1.9)	3.2 ± 0.9	(1.7~5.0)
Late CICI	bilateral ≥ 90	1st ear ≥2 and <5, 2nd ear<12	11	9.2	3.1 ± 1.0	(2.1~5.0)	4.5 ± 1.4	(2.8~7.0)

Table 4. Cumulative costs of each domain up to age 18 (USD)

	Family	Medical	Education	Social welfare
Early CICI sim	$77,031	$48,749	$173,188	$46,987
Early CICI seq	$76,653	$49,681	$159,987	$46,987
Late CICI	$72,272	$46,229	$154,197	$47,947

Table 5. Cost-benefit analysis based on fixed parameters

	Total Cost (USD)	QALYs	Benefits (USD)	Net Present Value (USD)	Benefit/Cost Ratio
Early CICI sim	$345,955	12.35	$404,726	$58,772	1.17
Early CICI seq	$333,309	12.18	$399,155	$65,846	1.20
Late CICI	$320,645	11.88	$389,324	$68,678	1.21

Discussion and Conclusion:

Children who received their first implants before age of 2 represented the early implantation group, in alignment with current clinical recommendations. Notably, many of the children received their implants after age of 2. Therefore, we included late implantation groups to ensure a comprehensive evaluation.

Cost-benefit analysis demonstrated a positive NPV for all CICI groups, using a WTP threshold equal to one times the GDP per capita. Educational costs accounted for the largest share of total expenses. The early-CICI-sim group had the lowest, yet still positive, NPV. In this group, parents opted for a shorter duration of private speech training for their children, but many children attended costly special classes during preschool. This shifted the costs from families to the educational domain, increasing total societal costs. From both medical and economic perspectives, bilateral implantation is recommended for children with bilateral severe to profound SNHL to maximize benefits and reduce long-term societal burdens.

References

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