Economic Burden of Pediatric Unilateral Cochlear Implantation: A Comparative Analysis by Age and Characteristics

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Introduction:

Cochlear implantation (CI) is the standard of care for children with severe-to-profound sensorineural hearing loss (SNHL). Previous studies have consistently shown that bimodal hearing—using a cochlear implant in one ear and a hearing aid in the other (CIHA)—is more cost-effective than bilateral hearing aids (HAHA). However, from a societal perspective, the long-term economic burden—driven largely by special education needs and lost productivity in adulthood—far exceeds the direct medical costs. This study evaluates the societal economic burden associated with pediatric CIHA and explores how factors such as age at implantation and the presence of comorbidities affect cost-effectiveness outcomes.

Methods:

A retrospective analysis was conducted on children with congenital SNHL who underwent unilateral CI in 2021 to 2024. Participants were stratified based on age at implantation, severity of hearing loss, and comorbidities. The cost encompassed government expenditures on healthcare, social welfare subsidies, and compulsory education, alongside family out-of-pocket expenses and productivity losses. All costs were calculated and projected until participants reached 18 years of age. The primary caregivers of children who met the inclusion criteria completed a questionnaire, covered sociodemographic characteristics, HL etiology and severity, comorbidities, HA and CI experience, CI implantation date, educational, out-of-pocket expenses for surgery, device maintenance, frequency and cost of speech training in private institutions, and associated travel costs and productivity losses. All monetary values were presented in US$ at the 2022 exchange rate (US$1 = NT$29.81).

Table 1. Cost parameters

Parameters			(USD)	Data Sources
Government				
Healthcare	Pre-surgery assessment		$863	Lin et.al.
	Surgery and hospitalization		$2,525	Lin et.al.
	Post-surgery visit/ mapping	1st /2nd /3rd /4th year	$2,240/ $1,414/ $859/ $322	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.al.
Family out-of-pocket				
Healthcare	Pre-surgery assessment		$23	Lin et.al.
	Surgery and hospitalization		$741	Lin et.al.
	Post-surgery visit/ mapping	1st /2nd /3rd /4th year	$47/ $34/ $20/ $10	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.
Mean time of device replacement (year)				
	HA		5	Lin et.al.
	CI		5	Survey

Results:

Table 2. Demographic data

Group	Hearing (PTA, dB)	Implantation age	Case number	Mean age now	Age of 1st implant	
					Mean ± SD	(Range)
Early CIHA	bilateral ≥ 90	<2	11	10.1	1.5 ± 0.4	(0.8~2.0)
Late CIHA	bilateral ≥ 90	≥2, <5	30	9.8	3.3 ± 1.0	(2.0~5.0)
Asym CIHA	1 ear ≥70, 1 ear ≥90	≥5, <7	3	10.5	5.5 ± 0.7	(5.0~6.3)
Comorb CIHA	bilateral ≥ 90	<2	3	4.4	1.7 ± 0.1	(1.6~1.8)

Table 3. Family out-of-pocket cost for speech training: The class fees were significantly low in the asymmetric CIHA and significantly high in the comorbidity CIHA.

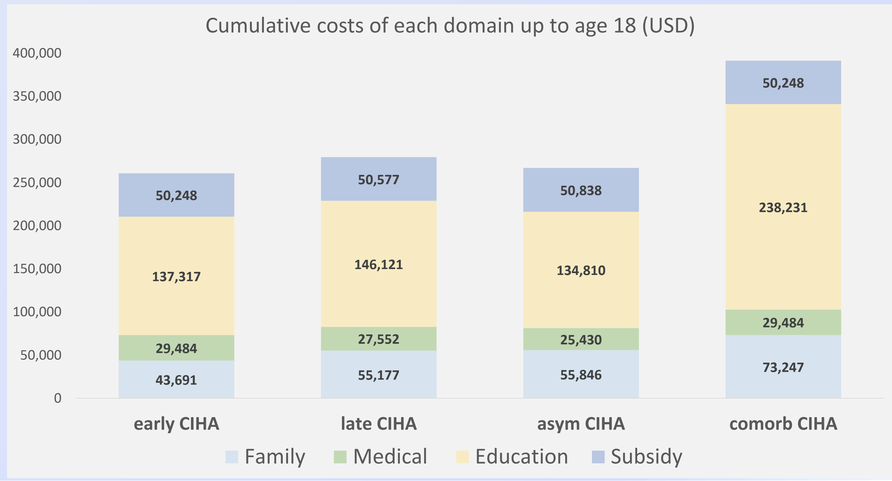
	Cost per session (USD)		
	Speech training class fee	Travel fee per session	Productivity loss per session
	Mean (Range)	Mean (Range)	Mean (Range)
Early CIHA	18 (0-27)	7 (2-13)	50 (34-67)
Late CIHA	20 (0-50)	8 (2-34)	52 (34-67)
Asym CIHA	3 (0-7)*	8 (3-12)	51 (34-67)
Comorb CIHA	42 (23-60)*	10 (3-17)	38 (21-67)

Table 4. Total family out-of-pocket cost: Costs were high during the first 2 years after implantation, primarily because of increased expenditures related to speech training and hospital visits.

	Total family cost (USD)				
	Pre-surgery	1st year post-surgery	2nd year post-surgery	3rd year post-surgery	4th year and after
	Mean (Range)	Mean (Range)	Mean (Range)	Mean (RangeD)	Mean (Range)
Early CIHA	573 (0-2467)	1,323(707-1973)	890 (0-1450)	954 (0-1450)	$0
Late CIHA	6,346 (0-20140)	4,731 (1761-15706)	3,978 (0-11075)	2,672 (0-9062)	2,537 (0-16236)
Asym CIHA	14,166 (3263-20605)	8,083 (3746-12420)	4,978 (3746-6210)	1,553 (0-3105)	$0
Comorb CIHA	4,255 (0-11544)	5,327 (0-14430)	$0	$0	$0

Figure 1. Cumulative costs of each domain up to age 18 (USD)

Direct medical costs, family out-of-pocket expenses, educational costs, and social welfare allowances were combined, with a 3% annual discount rate applied to estimate the total cumulative costs up to the age of 18.



Discussion and Conclusion:

Educational expenses accounted for the largest share of total cumulative costs per child, significantly influencing overall expenditures. Additional financial burdens were noted in family out-of-pocket expenses. The societal cost of unilateral pediatric CI was approximately USD 260,000–280,000 per child, increasing to around USD 390,000 for those with comorbidities. Children with asymmetric SNHL who received late implantation incurred costs similar to those of early-implanted children.

References

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