The Laryngoscope

Costs of Severe to Profound Hearing Loss & Cost Savings of Cochlear Implants

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Objective: To estimate costs of severe to profound hearing loss, including costs and cost-savings associated with cochlear implantation.

Methods: Data was obtained from the National Health Interview Survey, the National Health and Nutrition Examination Survey and national Medicare rates.

We used continuous time state transition models with individual patient simulations to estimate the costs of severe to profound hearing loss (SPHL) across the lifespan. The model included four states, normal hearing, severe to profound hearing loss, cochlear implantation, and death.

Results: The estimated lifetime cost of an individual born with SPHL is $489,274 [377,518; 616,519]. Costs are lower for those who received a cochlear implant before 18 months of age $390,931 [311,976; 471,475], compared to those who are not implanted $608,167 [442,544; 791,719]. For individuals with a later onset of hearing loss (60 years old) lifetime costs were $154,536 [7,093; 302,936]. The annual societal costs for the US population were estimated to be $37 [8; 187] billion.

Conclusions: SPHL is a costly condition, with the primary driver being lost productivity. Medical costs were higher for cochlear implantation, however, the higher income earnings offset the higher medical costs. Overall, early implantation substantially reduced lifetime costs. Access to hearing health care and technology is critical given the documented benefits for language, education, and quality of life. Government and insurance policies should be modified to allow for equal access and coverage for hearing technology, which will ultimately reduce lifetime and societal costs.

Levels of Evidence: N/A The current study used existing nationally representative datasets. Thus, these levels of evidence do not apply.

Key Words: cochlear implants, economic evaluation, lifetime costs, lost productivity, severe to profound hearing loss.

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INTRODUCTION

Hearing loss is the most common form of sensory deprivation, affecting 430 million people worldwide, including 34 million children.[1] Currently, 5% of the world's population has disabling hearing loss, which increases drastically to 25% for those older than 60 years. By 2050, the World Health Organization predicts that 2.5 billion people will have some degree of hearing loss, with 700 million individuals requiring hearing rehabilitation. Hearing loss can range from mild to profound, with those who have more severe hearing loss requiring more intervention. Current estimates indicate that 30.7 million people have severe hearing loss worldwide, with an additional 17.2 million having a profound hearing loss.[1,2] It is estimated that 1.77 million people in the United States have severe bilateral hearing loss and 0.35 million have bilateral profound hearing loss.[3]

Hearing loss has substantial implications for an individual's communication, educational attainment, employment, social relationships, emotional functioning, and quality of life. Global costs for unaddressed hearing loss are $980 billion annually, including costs of education and lost productivity.[1] Cost estimates for severe to profound hearing loss (SPHL) have been hampered by limited information about the incidence of SPHL, the loss of earning potential, and incomplete accounting of medical

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costs.[4,5] As the landscape of hearing health care continues to change with expanded criteria for cochlear implantation, more research is needed on the societal costs and the cost–benefits of hearing technologies, such as cochlear implants (CI). Cochlear implantation is the standard of care for bilateral SPHL in the US, with long-term benefits on language, academic achievement, and quality of life.[6] However, access and coverage for cochlear implantation varies substantially by location and health insurance. The major aim of the current study was to estimate the lifetime costs and societal burden of SPHL using current, national data sources. The secondary aim was to model the cost savings of CIs on overall societal costs.

MATERIALS AND METHOD

This study conducted a comprehensive evaluation of the costs associated with SPHL. These costs arise from three main sources: reduced work productivity due to potentially delayed entry into the labor market, underemployment, and unemployment; special education resources; and medical costs. Our updated estimation of costs included multiple data sources and simulation of patient life histories. The study was approved by the University of Miami Institutional Review Board (#20201102).

Data Sources

The current study utilized several data sources to estimate the incidence of SPHL, medical and educational costs, as well as income earnings for individuals with SPHL (see Table I). Data sources were diverse and included national and government databases, as well as published data. Incidence was estimated using the 2017 to March 2020 National Health and Nutrition Examination Survey (NHANES) as it included degree of hearing loss measured by an audiological evaluation and reported on the onset of hearing loss. To estimate income, both the National Health Interview Survey (NHIS) and 2017–2018 NHANES were used. Educational cost estimates were obtained by using the Individuals with Disabilities Education Act recommendations of twice the cost-per-pupil for public education in 2019. To estimate medical and audiology costs, the national Medicare 2021 rates were used. These data sources were selected because they provide the most comprehensive and nationally representative estimates for prevalence, incidence, and costs. In addition, death rates were obtained from the 2019 National Center for Health Statistics Mortality data and data on the incidence of SPHL identified through newborn screening was obtained from the 2019 CDC Vital Statistics.[7,8]

TABLE I.
Data Sources Used to Estimate Lifetime & Societal Costs.

Costs	Data Source
Income	2018 National Health Interview Survey (NHIS)
	2017–2018 National Health and Nutrition Examination Survey (NHANES)
Education	2x cost-per-pupil for public education in 2019 (based on IDEA recommendations)
	Education Policy and Practice. (2021). IDEA Funding Gap by State FY 2020 [Non-profit]. National Education Association.
Medical	Medicare 2021 Rates
Surgical (including cost of CI)	Medicare.gov Procedure Price Lookup for Outpatient Services for "Cochlear device implantation, with or without mastoidectomy; Code: 69930
Audiology	Medicare 2021 Rates
Hearing Aids	Average of different level technology from UM Hearing Aid practice

Analytic Approach

We used continuous time state transition models with individual patient simulations[9] to estimate the costs of SPHL across the lifespan. The model included four states: normal hearing (NH), SPHL, CI, and death with time-varying transition probabilities being estimated for the transition among states. Uncertainty in the transition and cost models was estimated using 1,000 random draws from the sampling distributions of the survival and regression models detailed below. Simulations were run for 100,000 participants over 100 years using the R package hesim v0.5.1 (See Supplementary Material 1). Time heterogeneous yearly costs for SPHL and CI states were mapped onto each simulated life history according to age for special education (≤ 18 years) and income (18–30; 30–45; 45–65; 65+), and age and years since the transition into SPHL and CI states for medical costs. SPHL and CI costs were calculated relative to NH. We used the 5th and 95th percentiles of the random draws to construct 95% confidence intervals around the estimates. All estimates included discounting at a rate of 3.9%. All amounts are expressed in 2018 dollars (the year of the NHIS data used in analyses); an expected inflation rate of 2.3% is considered for both future costs and compensation. Results of sensitivity analyses along with tornado plots are presented in supplemental materials (see Supplementary Material 2).

RESULTS

Model Parameter Estimates

Transition models

TRANSITION TO SPHL. Transition between NH and SPHL was modeled using data from the 2017 to March 2020 NHANES. A total of 4,579 participants completed a full or partial audiological exam. We excluded participants who had a difference of more than 10 decibels in the 1-kiloherz retest of the same ear. Participants who did not hear the stimulus at the highest level tested (120 dB) were assigned a threshold of 125 decibels. We averaged across the (0.5, 1, 2 and 4 kHz) to calculate a 4-frequency pure-tone-average threshold for each ear. Hearing status was determined by classifying the pure-tone-average for the best ear using World Health Organization criteria (> 25 dB through 40 dB), moderate (> 40 dB through 60 dB), severe (> 60 dB through 80 dB),

or profound (> 80 dB). A total of 68 participants had severe or profound hearing in their best ear. We used a parametric survival model with the hazard function estimated using a proportional hazard Weibull distribution. The model used survey weights and Taylor series linearization to account for the complex survey design. This model underestimated the rate for those diagnosed at birth and was thus supplemented using data from the 2018 Annual Data Early Hearing Detection and Intervention Program. These data provide the rates of SPHL diagnoses identified through newborn screening. The rate of $.003 \pm .0003$ was calculated using the proportion of children with identified hearing loss that met the criteria for bilateral severe or profound hearing loss. The parametric survival model also had a large degree of uncertainty which has a strong influence on societal cost estimates but not the individual lifetime cost estimates.

TRANSITION TO CI. We set the transition to CI to be one year following the onset of SPHL. The transition rate was set at $.55 \pm .05$ for youth and $.07 \pm .007$ for adults with SPHL. These rates were taken from a review of CI penetration.[10]

DEATH RATE. Transition to death was estimated using the CDC National Vital Statistical Report for 2019.[11] The survival tables from the report were expanded to 100,000 participants and used to fit a parametric survival model with proportional hazards Weibull distribution. The rate of transition to death was assumed to be the same for those in the NH, SPHL, and CI states.

Lost productivity. Our key data source was the NHIS. These data are nationally-representative household surveys that included information about demographic, socioeconomic, and health-related characteristics (including hearing status). Participants were asked about their hearing without a hearing aid, and we coded those who indicated "A lot of trouble" and "Deaf" ($N = 928$ or 1.38%) as SPHL (Supplementary Material3). As in Mohr and colleagues,[5] we value lost productivity at mean job market earnings. Previous estimates of productivity loss were limited by bias due to samples being selected based on having hearing loss. Previous societal cost studies relied on demographics matching to estimate SPHL status (as opposed to observing SPHL status directly) in the context of earnings estimation. In the current study, we were able to account for these limitations by the following: (1) using data that was not sampled based on hearing status, and (2) having access to individual-level data on hearing status and income.

Our analysis showed that individuals with SPHL in the US consistently earn less across all age groups. The largest gaps were observed for individuals 18 to 30 years of age (those with SPHL earn 61% of what individuals without SPHL earn) and for individuals 30 to 45 years of age (57%). Similarly, individuals with SPHL were less likely to be employed compared to individuals without hearing loss. The gap is particularly large for individuals 45 to 65 years old; employment rate was estimated to be 76.1% for individuals without SPHL and 62.2% for individuals with SPHL (see Table II).

We performed a similar procedure with the NHANES data, and the results are qualitatively similar (see Supplementary Table 1, which illustrates sensitivity results for cost estimates). We favor the NHIS data analysis for a number of reasons: (1) A more precise definition of earnings (NHIS focuses on job earnings while NHANES includes income from all sources, including Social Security, welfare, unemployment benefits, which are transfer payments); (2) A more precise measure of earnings (NHIS uses individual-level specific income figures, whereas NHANES uses household income intervals); and (3) A larger survey sample. Notably, NHIS uses multiple imputation and survey weights; our analysis used NHIS-recommended strategies to obtain appropriate standard errors.

EDUCATIONAL ATTAINMENT. We explored one of the key mechanisms through which labor market outcomes can be worse for individuals with SPHL, lower educational attainment. For the analyzed age groups, educational attainment was lower for individuals with SPHL (see Tables III, S2 and S3, which illustrates the proportion of adults who completed higher education, some higher education, and high school). The proportion of adult individuals who completed college was estimated at 45.6% for individuals without SPHL, but only 33.4% for individuals with SPHL. The gap is particularly large for individuals 30 to 45 years old, 53.8% and 14.4%, respectively.

Special education costs. There is minimal published information about the cost of educational support for deaf and hard-of-hearing individuals. Therefore, we utilized a conservative approach by estimating the educational costs similar to the Individuals with Disabilities Act as twice the cost-per-pupil of public education. According to the 2019 Public Elementary-Secondary Education Finance Data, the average national per-pupil cost was $13,187 per year with a standard deviation across states of $3,934, for a total per-pupil yearly educational

TABLE II.
Proportions of Employed Individuals and Annual Earnings per Person in the US by SPHL Status.

Age range	% Employed—Individuals with SPHL	% Employed—Individuals with no SPHL	Earnings—Individuals with SPHL	Earnings—Individuals with no SPHL	Earnings difference and 95% confidence interval
18 to 30	67.5% (0.1780)	78.5% (0.0088)	$ 16,439 (4790)	$ 26,793 (661)	-$10,354 [−20,145; −564]
30 to 45	66.2% (0.1051)	84.7% (0.0061)	$ 30,127 (7062)	$ 53,319 (820)	-$23,192 [−37,219; −9,165]
45 to 65	62.2% (0.0450)	76.1% (0.0059)	$ 50,120 (5473)	$ 57,897 (826)	-$7,778 [−18,501; 2,946]
65+	8.7% (0.0130)	23.1% (0.0063)	$ 37,136 (5538)	$ 43,851 (1417)	-$6,715 [−17,906; 4,476]

National Health Interview Survey, 2018. Standard errors in parentheses.

TABLE III.
Education Level: Proportion of Adult Individuals Who Completed Higher Education.

Age range	SPHL	No SPHL
18 to 30	25.5% (0.1408)	34.2% (0.0094)
30 to 45	14.4% (0.0824)	53.8% (0.0095)
45 to 65	39.3% (0.0498)	49.0% (0.0071)
65+	33.2% (0.0264)	41.5% (0.0079)
Overall	33.42% (0.0222)	45.62% (0.0054)

Source: NHIS 2018. Standard errors in parentheses.

cost for SPHL of $26,374 (StDev: $7,868),[12] which is within the range reported by Mohr.[5] We used the national per-pupil cost in modeling as it represents the additional costs of SPHL relative to NH states.

Medical costs. Medical costs were estimated for diagnosis, fitting with initial hearing device, speech therapy (pediatric only), CI surgery, and post-surgical follow-up. Rates were estimated using billing codes, Medicare rates, and frequency of visits (Tables IV and V). Medicare rates were used because they provide a national average of costs, as opposed to Medicaid which varies by location (e.g., state, county). The billing codes and frequency were selected through expert consensus and review of practice guidelines.[13,14] As shown in Tables IV and V, costs vary by age, time following onset of SPHL, and time following CI, with more costs occurring in the first year and tapering to yearly visits. We assumed that for the CI cohort, implantation occurred a year after the transition into an SPHL state so that costs would include the initial diagnosis as well as the fitting of hearing aids prior to implantation. Cost of surgery was estimated using the Medicare.gov Procedure Price Lookup for Outpatient Services for "Cochlear device implantation, with or without mastoidectomy; Code: 69930" which provided estimates for doctors and facility fees for hospitals. We estimated the 30-year failure rate of CIs to be 5% ± 0.5% at which point surgical costs were again added.[15]

Costs of hearing aids were estimated using price lists for hearing devices at a large otolaryngology/audiology practice; an average of four price options was used in our estimation. Cost of the CI device was included in the facility costs of the surgery. We also used catalogs from manufacturers to price replacement of external equipment which averaged $9,994. To estimate maintenance costs, we took the estimated cost of the replacement device divided by the number of years of a typical warranty (3 years for hearing aid, 5 years for CI). Variability in medical costs was set to be 10% of the yearly costs.

Economic Assessment

Estimated incidence rates for SPHL and CI are presented by age in Table VI. The estimates are higher than those published by Mohr[5] and have a large range due to the uncertainty in the incidence estimates. Average costs per person are presented in Table VII. Individual lifetime costs were calculated for cohorts of participants with the following characteristics: (1) identified SPHL at birth and not implanted, (2) identified SPHL at birth and received a CI, and (3) transitioned into SPHL at age 60 years and not implanted. Examining the cost breakdown, there were higher lifetime medical costs for children identified and implanted early compared to children who were not implanted at $106,265 [95% confidence interval: 90,253; 122,178]. This extra cost would be offset by having a reduction of 61% in educational costs or a 15% reduction in earning losses or a combination of both. We assumed that the educational costs were 0.64% ± 6.4% of the costs of the SPHL state and economic earnings-related costs were 0.30% ± 3% of the costs of SPHL state.[6,16–18] There is no data on higher educational attainment, adult employment or income disparities for those implanted compared to those not implanted. There is evidence that academic performance during adolescence showing those implanted early in life perform like typically hearing peers.[6] Given these assumptions, there was a lifetime cost savings for children who were identified and implanted early compared to children who were not implanted $215,393[112,257; 332,174]. This difference was primarily driven by higher earnings of $264,379 [164,561; 370,877] and savings in education $58,616 [27,520; 98,721]. The overall societal costs of SPHL are reported in Table VII. These estimates were obtained by averaging costs by age group (birth to 85 in 5-year increments), weighting these estimates by the age distribution of the 2019 US population, and then scaling to the 2019 population.[19] Societal cost estimates are strongly influenced by the estimated incidence of SPHL which had a high degree of uncertainty that carried into the confidence intervals for overall societal costs.

DISCUSSION

This study presents the most comprehensive estimate to date of the lifetime and societal costs of SPHL in the United States. The most recent analysis was conducted over 20 years ago, prior to the wide-spread adoption of CIs as standard of care for bilateral SPHL.[5] Our study utilized several data sources to estimate the societal costs of SPHL including nationally representative surveys of the US population and detailed accounting of medical costs. Results suggested that the lifetime cost for individuals with early onset of SPHL is $489,274 [377,518; 616,519] with 48% being attributed to lost productivity, 29% to educational costs, and 24% to medical costs. Notably, individual costs were greatly reduced when individuals received CIs, resulting in reduced educational costs and smaller income gaps, despite higher medical costs. Reduced costs are consistent with robust empirical evidence showing that CIs are associated with improved language, education, and quality of life outcomes.[6,20–24] These findings are also consist with international studies that have reported that the majority of children with hearing loss are in mainstreamed educational settings.[25,26] Further, prior research has provided evidence that children implanted early require less teacher support thus, leading to educational savings.[27] To

TABLE IV.
Proportions of Employed Individuals and Annual Earnings per Person in the US by SPHL Status

	CPT Code (s)	Description	# Of Appts	Medicare Rate*	# Of Appts	Medicare Rate*	# Of Appts	Medicare Rate
Diagnosis & Hearing Aid Costs			Year 1		Year 2–5		Year 5+	
			Under 4					
	92652; 92567; 92588	ABR Natural Sleep plus OAE	2	$341.94	0			
	V5010	Hearing Aid Evaluation	1	NA	0			
	92550; 92579	6 Months—3 years Audio	2	$140.96	4	$281.92		
	V5140; V5160; V5264 (x2)	Hearing Aid Device and Fitting	1	NA	0			
			Over 4					
	92652; 92567; 92588	ABR Natural Sleep plus OAE	2	$341.94	0		0	
	V5010	Hearing Aid Evaluation	1	NA	0		0	
	92567; 92556; 92582	4+ Child Audio	4	$531.80	2	$265.90	1	$132.95
	92557; 92567	Older Child Audio	2	$111.66	1	$55.83	1	$55.83
	V5140; V5160; V5264 (x2)	Hearing Aid Device and Fitting	1	NA	0		0	
CI Evaluation to Post-CI Audiology Costs			Year 1		Year 2–5		Year 5+	
			Under 7					
	92567; 92626; 92627	CI Evaluation	2	$259.60	0		0	
	92601	Initial Stimulation under 7 Years Old	1	$170.28	0		0	
	92602; 92567	CI Programming under 7 Years Old	6	$749.52	4	$499.68	1	$124.92
	92626; 92627	Post Testing	3	$339.15	4	$452.20	1	$113.05
			Over 7					
	92567; 92626; 92627	CI Evaluation	2	$259.60	0		0	
	92603; 92567	Initial Stimulation 7 Years +	1	$175.17	0		0	
	92604; 92567	CI Programming 7 Years +	6	$676.26	3	$338.13	1	$112.71
	92626; 92627	Post Testing	3	$339.15	4	$452.20	1	$113.05
ENT Costs			Year 1		Year 2		Year 3+	
	99204	New Patient Visit	1	$168.04†	0		0	
	99213	F/U Low Level Decision Making	1	$86.66†	2	$173.32	1	$86.66†
	99214	F/U Complex Case	1	$124.82†	0		0	
	69930	CI Surgery (including device)	1	$34,342	0		0	
Speech/Rehab Costs			Year 1		Year 2+			
	92523; 92626; 92627	Speech Evaluation	2	$696.46	2	$696.46		
	92630; 92507	Aural Rehab	52	$4064.32	0			

*2021 Medicare rates were utilized. This column represents the total cost for all the visits in one year.
†Medicare hospital and Medicare office rates averaged.

date, this is the most robust and comprehensive estimate of lifetime costs for SPHL. Of note, cost estimates for cochlear implantation are limited by not being able to identify individuals with CIs in large nationally representative health surveys. No study to date directly compares educational utilization, employment rates, or income in individuals with SPHL with and without CIs. Future studies including individuals with hearing loss should not only report on the severity of hearing loss but also specify which individuals use CIs or other forms of hearing technology.

The annual societal costs of SPHL was estimated as 37.09 [7.63; 186.65] billion dollars. Thus, while hearing loss is often referred to as a low-incidence condition, these estimates highlight the large economic impact that hearing loss has on society. Total societal costs for SPHL were

TABLE V.
CPT Codes and Costs for Adult Audiology and CI Services.

	CPT Code(s)	Description	# Of Appts	Medicare Rate*	# Of Appts	Medicare Rate*
			Year 1		Year 2+	
Diagnosis & Hearing Aid Costs	92557; 92550	Audio Diagnostic	1	$61.76	1	$61.76
	NA	Hearing Aid Eval and Hearing Aid Device		Self-Pay		Self-Pay
CI Evaluation to Post-CI Audiology Costs	92567; 92626; 92627	CI Evaluation – 90 min	1	$151.43	0	
	92692; 92567	Initial Stimulation	1	$124.92	0	
	92604; 92567; 92626; 92627	CI Programming/Testing	5	$1236.95	2	$494.78
ENT Costs	99204	New Patient Visit	1	$168.04†	0	
	99213	F/U Low Level Decision Making	1	$86.66†	1	$86.66†
	99215	F/U Complex Case	1	$124.82†	0	
	69930	CI Surgery (including device)	1	$34,342	0	

*2021 Medicare rates were utilized.
†Medicare hospital and Medicare office rates averaged.

TABLE VI.
Estimated Incidence of SPHL and CI by Age.

Age range	SPHL	CI
0–2	25 [22; 29]	14 [12; 16]
3–18	13 [−2; 27]	6 [−1; 13]
19–30	37 [13; 60]	3 [1; 5]
30–45	99 [59; 138]	7 [4; 10]
46–65	239 [152; 326]	16 [10; 22]
66+	369 [189; 550]	15 [8; 23]

Notes: Rates are per 10,000 Patients. Estimates and 95% Confidence Intervals.

larger than previous estimates.[5,24] These findings are consistent with prior literature documenting the lower employment rate, as well as differential earnings for individuals with hearing loss.[28,29] Annual earning differences ranged from $6,714 to $23,191, with the largest difference observed for individuals 30–45 years of age. A key determinant of income is educational attainment; we found lower educational attainment for those with SPHL, which is consistent with previous literature.[30,31] Notably, while no data exists that explicitly compares educational attainment or income earnings for individuals with hearing loss by severity and/or use of CIs, studies do exist that report on the benefits of CIs on education, employment, and income. Research has consistently reported that individuals using CIs can achieve education and employment levels similar to their hearing peers.[26] In fact, one study reported a higher percentage of individuals with CIs not only completed high school but also obtained a 4-year college degree compared to the general population.[32] Further, another study in Canada documented the increased earnings from pre to post-implantation. This study reported that individuals who underwent cochlear implantation earned approximately $12,000 more at post- versus pre- implantation.[33]

Using current treatment recommendations and Medicare costs we were able to provide a detailed evaluation of medical costs including costs associated with cochlear implantation. Societal cost estimates are highly dependent on incidence estimates for SPHL. Small changes in the incidence rates result in significant increases in the societal cost estimates. We generated our estimates using audiological evaluations using nationally-representative NHANES data while accounting for the complex sampling required by the dataset. We were only able to identify 68 participants with SPHL using this dataset resulting in a large amount of uncertainty.

Policy & Clinical Implications

Our data highlights the power of potential earnings across the lifespan between those who receive CIs versus non-CI users in overcoming the higher medical costs of an implant, which has major clinical and societal implications. Despite the initially high medical costs of CIs, the overall lifetime and societal costs are lower due to lower special education costs, and improvement in educational attainment and subsequent increased earnings. Although there is a large body of literature documenting the benefits of CIs, there continues to be poor utilization of CIs in both children and adults. Current estimates showed that only 12.7% of individuals who meet criteria for CIs undergo implantation.[34] Better education related to the impact of hearing loss on overall outcomes, as well as education and work productivity is warranted. Barriers to early implantation include delayed identification, reduced availability for CI evaluations or specialists, lack of insurance reimbursement, earning losses for families who must miss work to attend appointments, and a lack of understanding about the urgency and time sensitivity for cochlear implantation to achieve the best outcomes. Future studies should evaluate the effects of delayed intervention and comorbidities in the population of individuals with severe to profound hearing loss. However, prior to this initiative more data is needed

TABLE VII.
Cost per Individual and Societal Costs.

	Lifetime Costs per Individual (Thousands USD)				Total Societal Costs (Billions USD)
	Early onset SPHL (95% CI)	Early Implantation (95% CI)	No Implantation (95% CI)	Late onset SPHL (95% CI)	2019 US population
Medical	116 [106; 127]	164 [149; 179]	58 [52; 64]	21 [18; 24]	6.09 [1.85; 24.73]
Education	139 [68; 205]	112 [54; 169]	173 [84; 252]	0 [0; 0]	2.09 [1.02; 5.78]
Earning losses (NHIS)	233 [146; 330]	114 [68; 165]	382 [240; 532]	133 [−14; 279]	28.67 [3.94; 156.02]
Total	489 [378; 617]	391 [312; 471]	608 [443; 792]	155 [7; 303]	37.09 [7.63; 186.65]

Notes: Estimates and 95% confidence intervals. The total societal cost depends on the incidence estimates that have a large degree of uncertainty.

on educational utilization, employment rates, and income for individuals with hearing loss with and without CIs.

Improvement in insurance coverage, as well as state and government funding related to educational and rehabilitation programs for deaf or hard-of-hearing individuals is critically needed. Increased funding and access to early and intensive interventions for this population may lead to a reduction in the overall societal costs. At this time, it is common practice to proceed with implantation as early as 6 months of age if the child is a candidate; however, many families must wait until 9 months or later to proceed with a CI due to the link between FDA criteria and Medicaid insurance coverage. To reduce long-term societal costs, efforts related to improving awareness of hearing loss and CIs in primary care and pediatric settings are essential. As CI criteria continues to expand, otology/audiology practices need to collaborate within their communities to provide education on the new criteria, establish referral pathways for patients with hearing loss and grow capacity of special education and listening and spoken language professionals to support the development of spoken communication skills in a growing number of children with CIs.

CONCLUSION

In conclusion, SPHL is a costly condition that has large societal implications for educational attainment and the workforce. Results from this study add to the existing evidence on the benefits of CIs, informing policy-makers and hearing health providers of the possible cost savings of timely identification of hearing loss and early implantation. As a specialty, otolaryngology and audiology practices need to bolster their outreach and increase their CI access to improve both CI penetration and outcomes. Programs should work with their community, early intervention programs, and legislators to enable early intervention and improve children's language and quality of life, which will ultimately lead to considerable societal savings.

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