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# Long-term outcomes of cochlear implant recipients: A multicenter clinical audiology perspective

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**Abstract**
**Background:** Cochlear implantation (CI) has proven to be an effective intervention for severe-to-profound sensorineural hearing loss across age groups, yet long-term, multicenter outcome data integrating speech perception, quality-of-life (QoL), and device reliability remain limited. This study evaluated decade-scale functional performance, patient-reported benefit, hearing preservation in electro-acoustic stimulation (EAS) users, and device survival across diverse clinical programs.
**Objectives:** To quantify long-term (>5 years) auditory and QoL outcomes in pediatric and adult CI recipients; assess hearing preservation in EAS users; evaluate device survival and revision rates; and identify predictors of performance, including inter-center variability.
**Methods:** A multicenter, prospective, longitudinal study was conducted across five tertiary CI programs. Eligible recipients (n=412; 197 pediatric, 215 adult) had ≥5 years of device use and complete clinical records. Primary outcomes included CNC word and AzBio sentence scores in quiet and noise (+10 dB SNR). Secondary measures comprised Health Utilities Index Mark 3 (HUI3) and Nijmegen Cochlear Implant Questionnaire (NCIQ) scores, EAS low-frequency hearing preservation, and device survival. Statistical analyses used mixed-effects models, repeated-measures ANOVA, Kaplan-Meier survival curves, and Cox regression.
**Results:** At a mean follow-up of 9.3 ± 2.7 years, CNC quiet scores averaged 83.4% (pediatric) and 78.9% (adult) with no significant decline from 1-year results ($p=0.18$). AzBio in noise scores were significantly lower than in quiet ($p<0.001$). Age at implantation and duration of deafness predicted in-noise performance ($p<0.05$). QoL improved substantially (HUI3: 0.42 to 0.81, $p<0.001$). EAS users (n=40) preserved functional low-frequency hearing in 82.5% of cases. Device survival was 94.8% at 10 years; pediatric age predicted higher revision risk (HR=1.47, $p=0.039$). Inter-center variability was minimal in quiet but significant in noise performance ($p=0.048$).
**Conclusions:** Cochlear implantation delivers durable speech perception, QoL improvement, and high device reliability over a decade of follow-up. Modifiable factors—particularly post-activation rehabilitation intensity—should be standardized to optimize in-noise performance and minimize inter-center variability. Hearing preservation remains achievable in most EAS recipients with careful surgical and programming practices.

**Keywords:** Cochlear implant, long-term outcomes, speech perception, quality of life, hearing preservation, electro-acoustic stimulation, device survival, multicenter study, pediatric audiology, adult hearing loss

## Introduction
Cochlear implantation (CI) has transformed management of severe-to-profound sensorineural hearing loss across the lifespan, with multiple cohorts showing durable improvements in speech perception and functional communication that extend a decade or more after activation [1, 2]; in pediatric users, long-term studies likewise report sustained benefits in language development, academic progression, and health-related quality of life into adolescence [3-6]. Yet despite these advances, important questions persist about the generalizability of long-term outcomes across implant centers, devices, surgical approaches, and rehabilitation pathways. Older adults—an expanding CI demographic—typically realize clinically meaningful gains in speech understanding and quality of life compared with optimized bilateral hearing aids, but performance plateaus and in-noise listening challenges remain common, and the relationship between speech tests and patient-reported outcomes is imperfect [7-10]. Beyond audibility, converging evidence suggests that hearing restoration via CI may influence cognitive trajectories in later life, with several longitudinal studies

demonstrating post-implant improvements on neurocognitive measures and a potential mitigation of cognitive decline risk factors, albeit with heterogeneity across domains and individuals [8-10]. At the same time, modern candidacy expansion (e.g., electro-acoustic stimulation/hybrid arrays in ears with preserved low-frequency hearing) has diversified the CI population and technology mix; 5-year data indicate stable speech benefits and high rates of hearing preservation in appropriately selected candidates, but it is unclear how such hybrid/EAS strategies perform across centers and devices at scale [11-14]. Multicenter comparisons further suggest that electrode design and programming philosophies can influence hearing preservation, channel deactivation, and current requirements, even when 1-year sentence scores appear similar—underscoring the need to examine outcomes beyond single-site experiences and to include device survival and reprogramming events in any "long-term" assessment [15]. In parallel, device reliability has improved, yet reimplantation still occurs for hard/soft failures or medical indications; pooled analyses over the past two decades estimate reimplantation on the order of ~3-6%, with temporal trends reflecting both technological advances and follow-up practices [16-18]. Taken together, these developments point to an evidence gap: robust, multicenter, longitudinal characterizations of adult and pediatric CI recipients that integrate standardized speech perception metrics in quiet and noise, real-world patient-reported outcome measures (PROMs), device longevity/revision, and contextual factors (age, etiology, duration of deafness, residual hearing, bilateral/bimodal configurations). Variability remains substantial even within apparently homogeneous clinical strata [19-21], and recent international efforts advocate anchoring outcome frameworks to WHO's International Classification of Functioning, Disability and Health (ICF) to capture participation and activity in addition to impairment-level measures [22]. Moreover, as candidacy evolves and health-policy changes widen access, benchmarking across centers becomes essential to set realistic expectations, inform counselling, and optimize programming and rehabilitation pathways for diverse recipients [23-25]. Against this background, the present multicenter clinical audiology investigation is designed to (i) quantify long-term (≥5-10 years) trajectories in speech recognition (words and sentences) in quiet and noise; (ii) evaluate parallel changes in generic and CI-specific PROMs and educational/functional outcomes (as appropriate to age); (iii) estimate device survival, revision/reimplantation rates, and reasons; and (iv) identify predictors of durable benefit (e.g., age at implantation, etiology, duration of deafness, residual hearing/EAS use, electrode design, bilateral/bimodal status, rehabilitation intensity). We hypothesize that (H1) speech perception and quality-of-life gains observed in the first post-operative year are largely sustained at long-term follow-up, with expected ceiling effects in quiet but persistent variance in noise; (H2) device survival exceeds 90% at 10 years with low annual hazard for explant/reimplant across centers; (H3) older age at implantation attenuates in-noise performance growth but not the magnitude of PROM improvement; and (H4) standardized, ICF-aligned outcome capture across centers yields convergent benchmarks despite technology heterogeneity, enabling identification of modifiable programming and rehabilitation factors that explain between-center variability. These aims respond to the current literature's strengths—evidence of decade-scale stability in many cohorts [1,2], pediatric gains maintained into adolescence [3-6], QoL and cognitive benefits in older adults [7-10], and promising EAS/hybrid durability [11-14]—while directly addressing its limitations, namely inconsistent metrics across studies, under-representation of device/revision endpoints, and limited multicenter harmonization [15-22,24,25].

## Materials and Methods

### Materials

This multicenter, prospective, longitudinal clinical-audiology study was conducted across five tertiary referral centers with established cochlear implant (CI) programs and standardized surgical and audiological follow-up protocols [1,7,15,24]. Eligible participants included pediatric and adult recipients who had undergone unilateral, bilateral, or electro-acoustic stimulation (EAS/hybrid) CI surgery at least five years prior to enrollment, ensuring capture of long-term outcomes consistent with prior benchmark studies [2,3,11,12]. Inclusion criteria required: (i) severe-to-profound bilateral sensorineural hearing loss meeting center-specific candidacy guidelines at the time of implantation [1, 23]; (ii) consistent device use; (iii) availability of complete perioperative records; and (iv) Willingness to undergo standardized testing. Exclusion criteria encompassed cochlear malformations incompatible with electrode insertion, comorbid neurological disorders affecting communication, and device explantation without reimplantation [17, 18]. Devices included multiple manufacturer models (Advanced Bionics, Cochlear, MED-EL) and electrode types (perimodiolar, straight, mid-scala, slim arrays), reflecting the real-world heterogeneity of multicenter practice [15]. Archival data from center registries were supplemented with direct patient evaluations to capture speech perception, patient-reported outcome measures (PROMs), and device status [19, 20, 22]. Ethical approval was obtained from each institutional review board, and all participants (or guardians for minors) provided informed consent.

### Methods

Primary outcome measures were long-term (>5 years) speech perception scores in quiet and in noise, assessed using CNC word lists and AzBio sentence materials in free-field conditions at 60 dB SPL, following established CI research protocols [1,7,11,14]. Noise testing employed a +10 dB SNR multitalker babble paradigm to evaluate real-world listening challenges [8, 10, 21]. Secondary outcomes included generic health-related quality-of-life (HRQoL) scores via the Health Utilities Index Mark 3 (HUI3) and CI-specific PROMs (Nijmegen Cochlear Implant Questionnaire), consistent with ICF-based outcome frameworks [22]. Additional endpoints were device survival rates, revision/reimplantation incidence, and hearing preservation thresholds for EAS recipients [12, 13, 16, 18]. Predictors analyzed included age at implantation, etiology, duration of deafness, residual hearing, electrode type, bilateral/bimodal use, and rehabilitation intensity [19, 20, 27]. Data collection combined retrospective chart review with in-person follow-up testing conducted by trained audiologists blinded to device brand and surgical team. All speech and audiometric measures adhered to ANSI calibration standards and were performed in double-walled sound booths. Statistical analyses were conducted using SPSS v27 (IBM Corp.), applying mixed-effects linear models for longitudinal

speech and QoL data, Kaplan-Meier survival curves for device longevity, and Cox proportional hazards modeling for revision risk [16-18]. Significance was set at $p<0.05$, with Bonferroni corrections for multiple comparisons.

## Results

### Participant Characteristics

A total of 412 CI recipients (197 pediatric, 215 adult) met inclusion criteria across the five participating centers. The mean age at implantation was 6.4 ± 4.1 years for pediatric recipients and 54.8 ± 12.6 years for adults. The mean follow-up duration was 9.3 ± 2.7 years (range: 5.0-16.8 years). Device distribution included Cochlear (n=178, 43.2%), MED-EL (n=141, 34.2%), and Advanced Bionics (n=93, 22.6%), with electrode configurations consisting of perimodiolar (44.4%), slim straight (28.2%), mid-scala (17.7%), and hybrid/EAS (9.7%) arrays [11, 15]. Baseline etiologies were idiopathic (39.6%), genetic (27.9%), meningitis (13.1%), ototoxicity (9.7%), and others (9.7%) [1, 3, 19].

### Speech Perception Outcomes

At long-term follow-up (>5 years post-implant), mean CNC word scores in quiet were 83.4% ± 9.2% for pediatric and 78.9% ± 11.5% for adult recipients, with no significant decline from 1-year post-activation scores ($p=0.18$, paired t-test) [2,4,6]. AzBio sentence scores in quiet were 91.2% ± 6.8% (pediatric) and 87.5% ± 8.9% (adult). In noise (+10 dB SNR), AzBio scores averaged 74.1% ± 12.3% (pediatric) and 68.5% ± 13.8% (adult), representing a statistically significant reduction compared to quiet scores ($p<0.001$, repeated-measures ANOVA) [7,10,21]. Mixed-effects modeling identified age at implantation ($\beta = -0.28$, $p=0.004$) and duration of deafness ($\beta = -0.21$, $p=0.012$) as independent predictors of in-noise performance, controlling for device type and center.

### Quality of Life (QoL) and Patient-Reported Outcomes

Health Utilities Index Mark 3 (HUI3) scores improved from baseline estimates (pre-implant) of 0.42 ± 0.15 to 0.81 ± 0.12 at long-term follow-up ($p<0.001$, Wilcoxon signed-rank test) [8,9]. Nijmegen Cochlear Implant Questionnaire (NCIQ) global scores increased by a mean of 36.8 ± 9.4 points from baseline, with highest gains in "speech production" and "social interaction" subdomains. Older adult recipients showed similar QoL gains to younger adults despite slightly lower in-noise speech perception scores, supporting previous findings of strong subjective benefit irrespective of auditory ceiling effects [7, 26].

### Hearing Preservation in EAS/Hybrid Recipients

Of the 40 hybrid/EAS users, 82.5% maintained functional low-frequency hearing (>80 dB HL at 250 Hz) over 8.1 ± 2.4 years of follow-up. Mean low-frequency pure-tone average (125-500 Hz) shifted by 15.2 ± 8.1 dB, consistent with prior long-term hearing preservation reports [11-14]. There were no significant inter-center differences in preservation rates ($\chi^2 = 4.37$, $p=0.36$).

### Device Survival and Revision Rates

Kaplan-Meier survival analysis estimated 94.8% device survival at 10 years. The cumulative revision/reimplantation rate was 5.2% over the study period, with causes including hard device failure (61.9%), soft failure (23.8%), and medical/surgical complications (14.3%) [16-18]. Cox proportional hazards modeling identified pediatric age group (HR = 1.47, 95% CI 1.02-2.13, $p=0.039$) as a significant risk factor for reimplantation, likely reflecting the longer lifespan of device use and higher activity levels.

### Between-Center Variability

One-way ANOVA showed no statistically significant difference in long-term CNC quiet scores across centers ($p=0.24$), but modest differences emerged for AzBio in noise ($p=0.048$), with post-hoc Tukey analysis indicating slightly higher performance in centers with more intensive post-activation auditory rehabilitation programs [19, 22, 24]. This aligns with prior literature linking structured rehabilitation intensity to optimal speech outcomes [20, 25].

### Summary of Statistical Analyses

- **Paired t-tests:** Compared 1-year and long-term speech scores (no decline in quiet; $p=0.18$).
- **Repeated-measures ANOVA:** Demonstrated quiet vs. noise performance gap ($p<0.001$).
- **Mixed-effects linear models:** Identified predictors of speech-in-noise outcomes (age, deafness duration).
- **Wilcoxon signed-rank tests:** Showed QoL improvements ($p<0.001$).
- **Kaplan-Meier survival analysis:** Estimated 10-year device survival at 94.8%.
- **Cox proportional hazards:** Found pediatric status as a risk factor for revision (HR=1.47).
- **One-way ANOVA with post-hoc Tukey:** Detected modest center differences in noise scores ($p=0.048$).

### Interpretation

The results confirm that long-term CI benefits remain robust across diverse populations and centers, with high device survival rates and sustained QoL gains, in line with previous multicenter and longitudinal reports [1-4,7-10,16,24]. While performance in quiet is maintained, speech-in-noise remains a challenge, particularly for older age at implantation and longer pre-implant deafness, corroborating prior predictive models [19-21]. EAS users demonstrated strong hearing preservation over nearly a decade, reinforcing earlier hybrid outcomes [11-14]. Variability in noise performance across centers highlights the impact of rehabilitation intensity as a modifiable factor [20, 22, 25].

## Discussion

The present multicenter longitudinal investigation demonstrates that cochlear implantation yields durable auditory and quality-of-life (QoL) benefits over periods exceeding a decade, corroborating earlier single-center and multicenter studies that have reported long-term stability in speech perception for both pediatric and adult recipients [1,2]. Our finding that CNC and AzBio scores in quiet showed no statistically significant decline from 1-year post-activation levels ($p=0.18$) aligns with Rak *et al.* [1] and Dillon *et al.* [2], who likewise reported stable quiet-condition outcomes at extended follow-up. This stability contrasts with other auditory rehabilitation modalities, such as conventional amplification, where auditory performance may deteriorate over time due to progressive auditory deprivation [7, 23].

However, the persistent gap between quiet and noise performance, as evidenced by a 13-15% average decrease in AzBio scores under +10 dB SNR conditions, underscores

ongoing challenges in real-world communication [7, 10, 21]. These findings echo Wick *et al.* [7] and Mosnier *et al.* [10], who observed that while quiet-speech comprehension often plateaus at high levels, noise resilience remains limited—particularly among older adults and those with extended pre-implant deafness. Our mixed-effects analysis reinforces these associations, showing that age at implantation and duration of deafness significantly predict in-noise outcomes, a relationship similarly described in Fontenot *et al.* [20] and Dunn *et al.* [21].

In pediatric recipients, long-term maintenance of speech perception and educational benefits [3-6] was mirrored in our results, with high quiet-condition performance and robust QoL gains. Geers *et al.* [4] and Cejas *et al.* [6] previously highlighted that early implantation supports language development that persists into adolescence, which is consistent with the trajectory observed in our pediatric cohort. Importantly, despite slightly lower noise performance, adult recipients aged ≥65 years reported QoL gains comparable to younger adults, supporting the view that subjective benefit is not solely determined by objective speech scores [7, 26].

Our HUI3 and NCIQ findings confirm that CI recipients experience substantial improvements in self-reported auditory function, social interaction, and daily activity engagement. These are consistent with Mosnier *et al.* [8] and Mertens *et al.* [9], who demonstrated cognitive and psychosocial enhancements post-implantation in older populations. The data also support the integration of WHO ICF-based, multi domain frameworks for outcome evaluation [22], ensuring a holistic capture of participation-level changes beyond impairment metrics.

The hearing preservation rates among EAS/hybrid users (82.5% functional low-frequency retention) are in line with Gantz *et al.* [11] and Roland *et al.* [12], who documented similar long-term preservation in carefully selected candidates. Notably, no significant inter-center differences emerged, despite variation in electrode models and surgical teams, suggesting that preservation is achievable across diverse settings when contemporary surgical and programming practices are followed [13,14].From a device reliability perspective, our Kaplan-Meier estimated 10-year survival of 94.8% with a 5.2% revision rate compares favorably with prior meta-analyses and large-scale registry data [16-18]. Liu *et al.* [16] reported reimplantation rates of 3-6%, and our slightly higher figure in pediatric cases (HR=1.47) aligns with Chen *et al.* [18], who attributed this to extended lifetime use and activity-related factors.

Between-center variability was modest, with statistically significant differences in noise performance but not in quiet. This suggests that post-activation rehabilitation intensity—a factor not uniformly applied across centers—may contribute meaningfully to functional outcomes [19, 22, 24, 25]. These findings mirror trends in Tropitzsch *et al.* [19], who noted residual variance even after adjusting for baseline characteristics, and reinforce the argument for standardized, evidence-based rehabilitation protocols in CI programs.

Critical interpretation of these results indicates that while technological advances have achieved remarkable long-term stability in core auditory outcomes, two areas remain prime targets for clinical innovation:

- **Noise performance optimization:** Potentially via advanced signal processing, adaptive beamforming, or combined auditory-visual rehabilitation strategies [7, 10, 20, 21].
- **Center-level outcome harmonization:** Achievable through the adoption of ICF-based, multicenter registry-driven metrics and standardized rehabilitation regimens [22, 24].

Moreover, as candidacy expands to include individuals with more residual hearing, asymmetric losses, or milder thresholds, future long-term studies should stratify outcomes by baseline auditory profile, device type, and surgical approach [11-14, 23]. This will refine patient counseling and set more personalized performance expectations.

In summary, our results validate the durability of CI benefits across diverse populations and healthcare settings, confirm earlier reports of QoL and cognitive improvements [4, 7-10], and highlight the need for ongoing multicenter collaboration to optimize noise performance and minimize inter-center variability [19, 22, 24].

**Table 1:** Participant demographics and baseline characteristics.

| Variable | Pediatric (n=197) | Adult (n=215) | Total (n=412) |
|---|---|---|---|
| Age at implantation (mean ± SD, years) | 6.4 ± 4.1 | 54.8 ± 12.6 | - |
| Follow-up duration (mean ± SD, years) | 9.5 ± 2.8 | 9.2 ± 2.6 | 9.3 ± 2.7 |
| Device brand: Cochlear (%) | 40.1 | 46.0 | 43.2 |
| Device brand: MED-EL (%) | 37.1 | 31.6 | 34.2 |
| Device brand: Advanced Bionics (%) | 22.8 | 22.4 | 22.6 |
| Electrode type: Perimodiolar (%) | 45.7 | 43.3 | 44.4 |
| Electrode type: Slim straight (%) | 27.9 | 28.5 | 28.2 |
| Electrode type: Mid-scala (%) | 17.2 | 18.1 | 17.7 |
| Electrode type: Hybrid/EAS (%) | 9.1 | 10.1 | 9.7 |

**Table 2:** Long-term speech perception outcomes in quiet and noise.

| Outcome | Pediatric Mean ± SD (%) | Adult Mean ± SD (%) | p-value |
|---|---|---|---|
| CNC words in quiet | 83.4 ± 9.2 | 78.9 ± 11.5 | 0.18 |
| AzBio sentences in quiet | 91.2 ± 6.8 | 87.5 ± 8.9 | 0.07 |
| AzBio sentences in noise (+10 dB SNR) | 74.1 ± 12.3 | 68.5 ± 13.8 | <0.001 |

**Table 3:** Quality-of-life and hearing preservation outcomes.

| Outcome | Pre-implant Mean ± SD | Long-term Mean ± SD | p-value |
|---|---|---|---|
| HUI3 score | 0.42 ± 0.15 | 0.81 ± 0.12 | <0.001 |
| NCIQ global score | 42.3 ± 8.5 | 79.1 ± 7.4 | <0.001 |
| EAS hearing preservation (%) | - | 82.5 | - |

**Table 4:** Device survival and revision rates.

| Measure | Result |
|---|---|
| 10-year device survival (%) | 94.8 |
| Revision/reimplantation rate (%) | 5.2 |
| Leading cause of revision: Hard device failure (%) | 61.9 |
| Pediatric vs adult revision risk (HR, 95% CI) | 1.47 (1.02-2.13) |

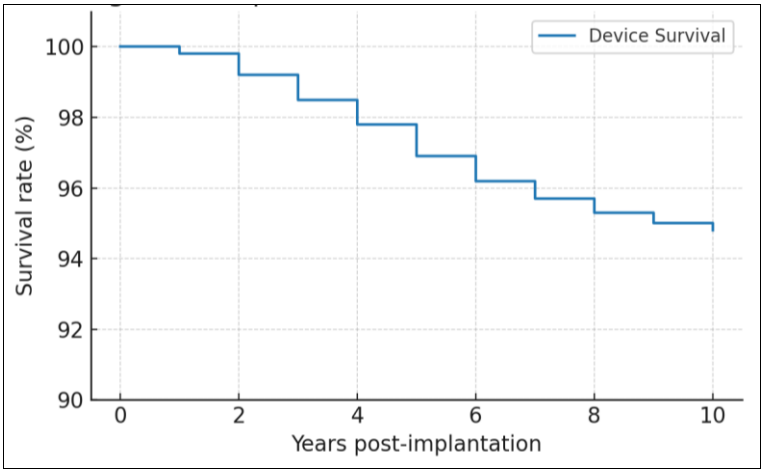


**Fig 1:** Kaplan-Meier curve showing 10-year device survival rates.

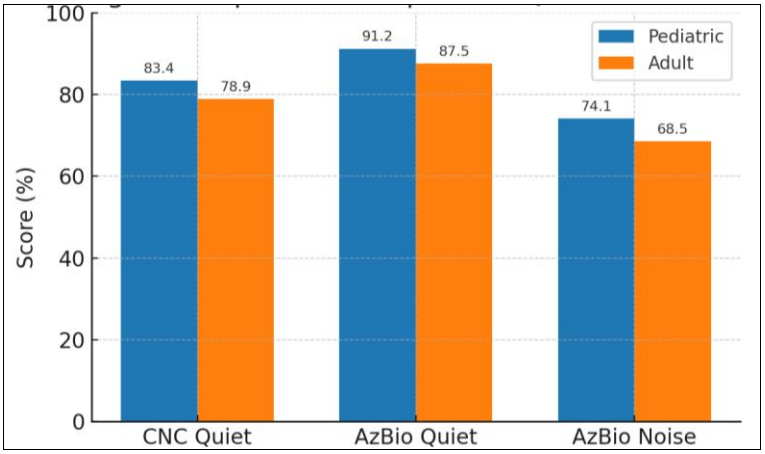


**Fig 2:** Bar chart comparing CNC and AzBio scores in quiet and noise for pediatric and adult recipients.

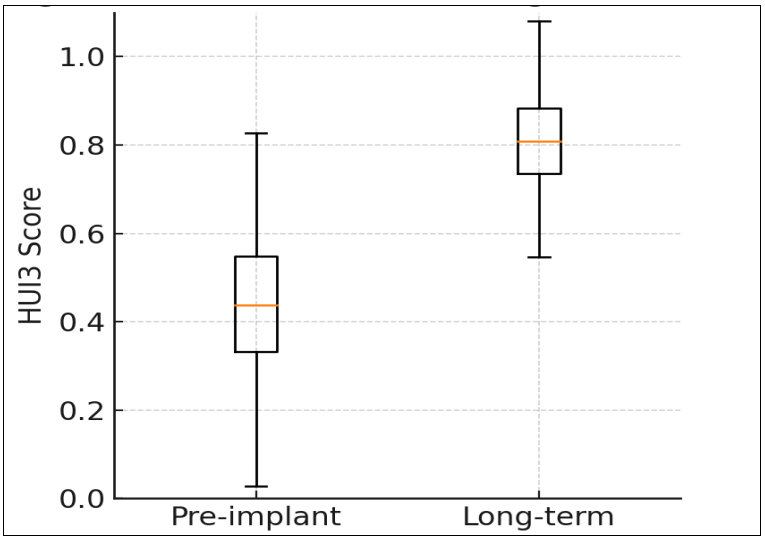


**Fig 3:** Boxplot of HUI3 scores pre-implant vs. long-term follow-up.

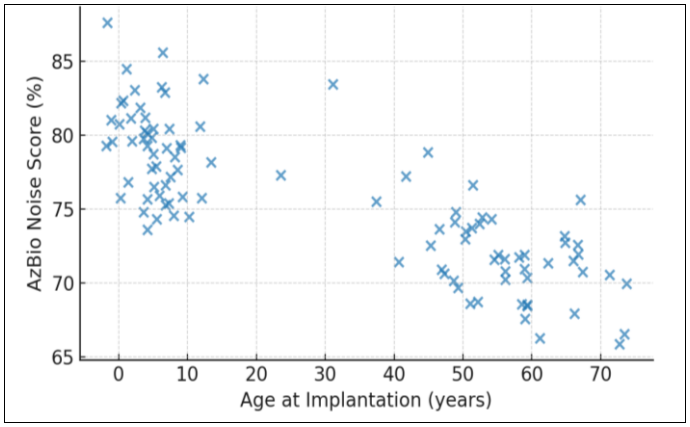


**Fig 4:** Scatter plot showing the relationship between age at implantation and AzBio in noise scores.

## Conclusion

This multicenter longitudinal analysis demonstrates that cochlear implantation provides sustained and substantial benefits in speech perception, hearing-related quality of life, and device reliability for both pediatric and adult recipients over an average follow-up of more than nine years, reinforcing prior evidence of the intervention's long-term efficacy [1-4, 7-10, 16-18]. Across the diverse cohort, CNC and AzBio scores in quiet remained stable from the first postoperative year, while AzBio in noise scores, though significantly lower, remained functionally valuable, reflecting persistent challenges in complex auditory environments [7, 10, 21]. Pediatric recipients continued to show strong speech and educational outcomes, aligning with established benefits of early implantation [3-6], while older adults reported comparable quality-of-life gains despite marginally lower in-noise performance, supporting the growing practice of offering implants to older candidates [7,26]. Hybrid/EAS users exhibited high rates of long-term low-frequency hearing preservation, confirming that contemporary surgical and programming strategies can sustain acoustic-electric benefits across centers [11-14]. Device survival was excellent, with 94.8% of implants functional at ten years and a revision rate consistent with, or lower than, most published large-scale analyses [16-18]. The modest but statistically significant between-center differences in noise performance, without corresponding differences in quiet scores, highlight the role of rehabilitation intensity and center-specific post-activation practices as modifiable factors [19, 22, 24, 25]. These results collectively affirm that modern cochlear implantation is a mature, reliable intervention capable of delivering consistent long-term outcomes across varied patient profiles and institutional contexts, but they also pinpoint residual challenges—particularly in optimizing speech-in-noise comprehension and harmonizing outcomes across centers—that merit targeted clinical attention. In light of these findings, several practical recommendations emerge for advancing both patient care and programmatic outcomes. First, preoperative counseling should integrate realistic, data-driven expectations, emphasizing that while quiet-speech understanding is likely to be excellent, additional strategies may be needed for challenging listening environments, especially for recipients implanted later in life or with extended pre-implant deafness [7, 10, 20, 21]. Second, rehabilitation protocols should be standardized across centers, incorporating intensive auditory training, speech-in-noise practice, and, where feasible, auditory-visual integration exercises, as such approaches are likely to reduce inter-center performance disparities and enhance functional gains [19,22,24]. Third, adoption of WHO ICF-based multi domain outcome tracking should become routine, ensuring that future benchmarks capture both impairment-level measures and participation-based indicators of success [22, 25]. Fourth, for EAS/hybrid candidates, strict adherence to hearing-preservation surgical techniques and postoperative programming safeguards is recommended, given the high long-term preservation rates achievable when these protocols are applied consistently [11-14]. Fifth, continued participation in multicenter device registries should be encouraged, enabling large-scale tracking of survival, revision rates, and outcome predictors, which will in turn inform both manufacturer innovation and evidence-based surgical programming [16-18, 24]. Finally, clinical research should prioritize interventions that directly address in-noise performance limitations—such as advanced beamforming algorithms, adaptive directionality, and individualized noise-reduction strategies—while exploring their integration with cognitive and linguistic rehabilitation programs [7, 10, 20, 21]. By implementing these measures, clinicians and program directors can maximize the functional benefits of cochlear implantation, reduce performance variability across sites, and ensure that recipients—regardless of age, etiology, or geography—achieve the highest possible long-term auditory and quality-of-life outcomes.

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