Long-term Outcomes of Cochlear Implantation in Prelingually Deaf Children
A Review of Speech and Language Development

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ABSTRACT

The research study has based on the analysis of long-term language and speech outcomes among prelingually deaf children who have cochlear implants. The study further explored the way by which early implantation affected speech production, auditory perceptions, and development of language. An SLR design was used to synthesize research findings from multiple studies based on the chosen topic. The findings of the current study highlighted that the implantation of cochlear implants before 2 years of age led to major enhancements in language skills and speech recognition. Moreover, early implantation resulted in understanding how much improvement in expressive grammar and receptive vocabulary were seen among implant users and normal hearers. On the other hand, it was also observed that although the enhancements were seen even after 4 years of using the implants, the efficacy reduced after 6 years of using the device. Differences in results were primarily associated with factors that include developmental disabilities and cognitive decline. The research has further recommended focusing on the use of cochlear implantations as an early intervention to enhance its benefits. The research findings are insightful for families and clinicians appointed to promote the life quality of children who have been using cochlear implants for a long period of time.

Keywords: *Cochlear Implantation, Prelingually Deaf Children, Speech Development, Language Outcomes, Early Intervention, Long-term Effects, Influencing Factors.*

INTRODUCTION

Cochlear implants have transformed the treatment of extreme to significant hearing loss, providing life-changing advantages to individuals with substantial auditory impairment (Athanasopoulos et al., 2024). By skipping damaged inner ear structures and stimulating the auditory nerve, CIs allow sound perception in individuals who are deaf or have difficulty hearing (Athanasopoulos et al., 2024). Prelingually deaf children, who lose hearing prior to developing language skills, specifically benefit from cochlear implantation. This system facilitates speech and language purchase, empowering these children to interact effectively and merge seamlessly into common society.

Prelingual deafness critically obstructs speech and language development due to insufficient auditory revelation during the important language purchase phase, typically covering the initial years of life (Bruwer, 2021). Cochlear implants provide a hopeful solution, enabling auditory perception and thereby supporting natural speech and language development (Alhassan, 2022). However, the long-term efficiency of cochlear implantation, particularly regarding speech and language development, has become a topic of considerable interest and persistent research. Outcomes can differ significantly due to different factors, including age of implantation, duration of implant application, and quality of post-implantation clinical interventions.

Research on cochlear implantation has experienced exceptional growth, with investigations focusing on the technology's effectiveness on increasing auditory perception and consequent speech and language effect (Carlyon and Goehring, 2021). Numerous studies have recorded substantial improvement in speech perception and production among children who experience implantation at a young age (Jiam and Limb, 2020; Carlyon and Goehring, 2021). Moreover, despite these advancements, cases persist where speech and language development drop short of expected levels, suggesting that extra factors may impact the success of the implantation method.

Considering the increasing acceptance of cochlear implants as a treatment for prelingual deafness, understanding the prolonged consequences of these actions is vital (Dazert et al., 2020). While the prior advantages of cochlear implants in amplifying auditory perception and speech development are well-renowned, the endurance of these benefits over time, particularly regarding language development, stays less understood.

Recognizing the long-term outcomes of cochlear implantation enables improvement of pre- and post-implantation methods, personalised restoration programs, and familiar clinical guidance for families, realistic in observational evidence (EL Hayek, 2024). This systematic review pursuit to synthesise ongoing research on long-term speech and language consequences following cochlear implantation in prelingually deaf children, while also explaining factors influencing outcome diversity.

Despite substantial progress in cochlear implantation and its extensive recognition as a resolution for prelingual deafness, significant variability continues in long-term speech and language consequences among children experiencing this procedure

(DeFreese et al., 2024). The long-term outcomes of cochlear implantation in prelingually deaf children differ significantly, with some gaining nearly typical speech and language capability while others show only minimal gains. This inequality necessitates a complex examination of the factors encouraging these outcomes and strategies for enhancement.

A systematic review of the ongoing literature is immediately needed to thoroughly examine the consequences and determine the elements contributing to the noticed variability in speech and language development among cochlear implant beneficiaries. This inclusive analysis will widen the gap between the found benefits of cochlear implants and the irregular long-term results, providing invaluable guidance for medical professionals, therapists, and families.

METHOD

This study employs a systematic literature review methodology to evaluate the long-term efficacy of cochlear implantation in prelingually deaf children (Pattisapu et al., 2020). By combining existing research findings, this method provides a comprehensive examination of the subject, integrating evidence on speech and language development in cochlear implant beneficiaries, identifying knowledge gaps, and notifying well-substantiated outcomes.

This research uses a systematic literature review procedure to evaluate the long-term efficiency of cochlear implantation in prelingually deaf children (Debruyne et al., 2020). The systematic review infrastructure enables the integration of existing research, offering a comprehensive understanding into the topic. This methodology is ideally suited for combining evidence on speech and language development in children with cochlear implants, recognizing research gaps, and artwork informed, evidence-based outcomes.

A systematic literature review provides numerous benefits, including a complete understanding of a research topic, recognition of knowledge gaps, and combination of current evidence. It allows researchers to examine the effectiveness of actions, compare consequences, and inform research-based practice (Lim et al., 2022). Systematic reviews encourage transparency, consistency, and reduction of bias, increasing the responsibility of findings. They also enable decision-making among clinicians, policymakers, and stakeholders by providing a comprehensive overview of the present state of knowledge (Garavito et al., 2024). Eventually, systematic literature reviews improve research, practice, and enhance outcomes in various fields, including education, healthcare, and social sciences.

The research objectives and theory will inform the development of a customized search strategy. An inclusive and thorough search of equal-reviewed literature will be performed across admired academic databases, especially PubMed and the Cochrane Library, picked for their extensive coverage of medical and healthcare literature relevant to this review (Zhang et al., 2022). To assure the incorporation of modern findings, the search will value English-language studies issued within the past two decades.

PubMed is an essential database for biomedical research, offering access to over 33 million residents from 7,000+ journals (Sayers et al., 2023). The importance of PubMed includes complete coverage of life

sciences, healthcare, and medicine. Free availability to idealize and often full-text articles, reliable search purpose, connections to related research and citations, daily updates, services, evidence-based research and medicine (Sayers et al., 2022). The Cochrane Library is a crucial database for proof-based medicine, offering high-quality, similar-reviewed systematic reviews and research Meta synthesis (Luchini et al., 2021). The importance of Cochrane Library includes complete coverage of healthcare programs, precise methodology and excellence standards, neutral independent reviews, and enables informed decision-making for policymakers, clinicians, and patients. Improve healthcare quality and outcomes, assist research and protocol development for better analysis with benefits of prelingually deaf children. To conduct this Systematic review the search words that have been used with the word Cochlear implant are prelingually deaf children, speech development, language development, long-term outcomes, speech outcomes, factors affecting, age at implantation, duration of device use, post-implantation therapy. Boolean operators are systematic operators used to exclude or combine keywords in search requests, especially in computer search engines, programming languages, and databases. They help improve search outcomes by describing relationships between search topics. Basic Boolean operators are “AND”, “OR”, and “NOT”.

The following search words and Boolean operators have been occupied to maximise the access of relevant studies:

- "Cochlear implant*" AND "prelingually deaf children" AND "speech development"
- "Cochlear implant*" AND "language development" AND "long-term outcomes"
- "Cochlear implant*" AND "speech outcomes" AND "factors affecting"
- "Cochlear implant*" AND "age at implantation" OR "duration of device used"
- "Cochlear implant*" AND "post-implantation therapy"

An expertly designed screen strategy is important in research to ensure that suitable studies are identified and unrelated ones are excluded, consequently increasing the efficiency and consistency of the findings. It allows researchers to methodically search, filter, and choose studies that meet predefined criteria, reducing errors and bias (Purssell and McCrae, 2020). A transparent screen strategy also enables transparency, reliability, and efficiency, enabling others to duplicate the search process. By utilising specific exclusion and inclusion criteria, researchers can target high-quality studies that deal with the research question, moreover, strengthening the proof base and informing award decisions.

The screening process will follow a two-step approach:

Title and Abstract Screening: Identified studies will meet title and abstract screening to examine alignment with the research target. Studies examining language and speech development in prelingually deaf children following cochlear implantation have been proceeding to full-text review for additional evaluation.

Full-Text Screening: Full texts of articles briefing initial screening will endure in-depth review to confirm

their relevance and suitability for inclusion in the systematic review. This step ensures that only studies providing substantial data on long-term outcomes of cochlear implantation are included.

Inclusion Criteria:

- Studies aiming on prelingually deaf children who received cochlear implants.
- Studies published in peer-reviewed journals.
- Studies that report on factors encouraging speech and language consequences, such as age at implantation and post-implantation therapy.
- The studies published in the English language only have been included.
- Research articles that were published within 2014-2024 were taken into consideration.

Exclusion Criteria:

- Studies including adults or post lingually deaf children.
- Studies with less than five years of post-implantation follow-up.
- Studies not published in English.
- Articles that do not specifically target speech or language outcomes.
- Research articles that were published before 2014 have been excluded in this research context.

Data collection will stick to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which gives a structured approach to leading systematic reviews (Page et al., 2021). The PRISMA guidelines ensure transparency, consistency, and inclusiveness in the review process. By providing a uniform structure, PRISMA minimises partiality, ensures broad reporting, and facilitates reliability. Its utilisation enhances review loyalty, simplifies genuine review, and informs proof-based decision-making. PRISMA's classified checklist guarantees addition of crucial information, allowing readers to assess review quality and relevance (Sabia, 2020).

This systematic review's data extraction will methodically collect essential information paralleled with research objectives, using a standardised form to assure consistency. Isolated details will cover study characteristics (authors, study design, publication year), participant data (deafness duration, age at implantation, implant use length), and speech and language development consequences (perception, creation, language skills enhancement). Furthermore, encouraging factors such as post-implantation therapy, age at implantation, and device utilization duration will be examined to understand irregularity in long-term outcomes, offering valuable knowledge for evidence-based practice.

Thematic analysis, a descriptive methodology, has been employed to analyse the retrieved data, identifying regular themes and patterns over studies (Peel, 2020). This method has synthesised different outcomes, providing a detailed understanding of long-term speech and language development in prelingually deaf children with cochlear implants. The analysis have included three phases, firstly, speech development to be evaluated, categorising studies by recorded improvements in speech production and perception, ranging from minimal to maximal advancements. Secondly, language development has been measured by evaluating progress in expressive and receptive language skills, focusing on

common patterns in language purchase (Calder et al., 2021). Lastly, factors encouraging outcomes, including implant use duration, age at implantation, and post-implantation therapy are examined to explain variability in results.

RESULTS

3.1. Introduction

The current chapter has presented the results of the research study. The chapter has begun with the representation of the data screening process in the form of a PRISMA flowchart. Then, the chapter has stated the data extraction table (See Table 1.). The findings obtained from the collected pieces of evidence were further subjected to thematic analysis. Themes that addressed the research objectives were discussed later in the current chapter. Finally, the chapter was closed with a concluding segment.

Theme 1: Long term speech development outcomes in prelingually deaf children with cochlear implants

The long term development of speech outcomes among prelingually deaf children using CIs varied significantly. In addition, it was observed that the same was based on age at implantation. As per the findings of Dettman et al. (2016), implants before 12 months of age had better open set perception scores than individuals who were implanted after 2 years. In addition, Rauch et al., (2021) highlighted that children who were implanted before 3 years of age had better improvements in discrimination of speech than children who were implanted post 4 years of age. Moreover, Montag et al., (2014) has also highlighted that CI users showed similar speech intelligibility as normal hearing users. However, long term use of CIs were not effective in enhancing speech developments among on a long-term basis. Instead, the reverse effect was observed. Furthermore, another research study from Macias et al., (2014) showed that children with implants before 2 years of age have shown better outcomes in terms of speech recognition and discriminations in noisy environments than children who had implants after 2 years. Thus, it can be concluded that the age at implant plays a major role in the long-term speech development outcomes among prelingually deaf children with cochlear implants. A period of 2 years can be regarded as the threshold to achieve the best long term speech development outcomes among deaf children.

Theme 2: Progress in long term language development post cochlear implantation

As per the findings of the current research study, long term language development progress after cochlear implantation is primarily altered by consistent and early interventions for language exposure. Wie et al., (2020) opined that the gap in receptive and expressive language abilities between normal hearers and children with CIs were primarily associated with the first four years after the implantation was done. In other words, it can be said that language skills among children with CIs was comparable to normal hearing children during that period. Both receptive grammar approaches and expressive vocabulary were observed to be partially similar between the two groups. However, it was observed that the gap widened when the duration increased from 4 to 6 years. Children with CIs have shown significantly lesser expressive grammar skills and receptive vocabulary skills than normal hearers after 6 years was over from

the implantation year. This overtime declination of CI performances was also identified by another group of researchers (Montag et al., 2020). Lack of continuous exposure to language can lead to overtime declination of language outcomes after long term usage of cochlear implantation by children with hearing impairments. However, it was also observed that children using CI benefited more from rich spoken language environments and ongoing language therapy in terms of enhancing the longevity of language outcomes gained by using cochlear implants for a long time.

Theme 3: Factors influencing long term speech variability and development of language outcomes

Various factors were observed to contribute towards the variability in language outcomes and long term speech outcomes among prelingually deaf children using cochlear implants. The first factor has been observed to be age at implantation. This factor has been identified by Dettman et al. (2016), which identified that 2 years was the maximum age at which implantations provide the maximum scopes of development better speech and language skills among children with hearing impairments. Moreover, the second factor has been observed to be the combination of maternal education and age at activation. As per the findings of Wie et al., (2020), maternal education and activation age (socio-economic factors) were essential to determine the language outcomes among children with hearing disabilities. On the other hand, developmental as well as cognitive factors were also equally significant according to the findings of Wakil et al. (2014). There was a 38% discontinuation from using the second side CIs after the first side CIs failed to show much long-term improvements in speech and language outcomes among children. Montag et al., (2014) has highlighted that family income played a major role in influencing speech intelligibility. Macias et al. (2014) also reported that short intervals of inter-implant were more beneficial in enhancing recognition outcomes. This finding was similar to the results of Myhrum et al. (2017) that showed that longer inter-implant intervals were associated with worse speech perceptions after the second side implant.

Overall, it can be said that the outcomes variability is not primarily dependent on the cochlear implant itself. It is also dependent on the developmental status, environmental factors, time at implant, early interventions, and cognitive abilities associated with the child.

DISCUSSION

The findings of this research have revealed a complex effect of factors that influence long term language as well as speech development in prelingually deaf children using cochlear implants. Children, who were implanted before 1 or 2 years of age, demonstrated better speech and language outcomes. Thus, it can be said that early intervention is more effective in promoting the long term language outcomes among children who use CIs. In addition, early CI also closes the existing gap between normal hearers and children who use implants. These gaps primarily existed in terms of receptive vocabulary and expressive grammar. However, CI users experienced these benefits only till 4 years after the implantation. After 4 years, the gaps re-emerge and the problems with receptive vocabulary and expressive grammar begins to show again among the children using CIs.

Lastly, various factors were observed to affect the usefulness of CIs in enhancing speech and language outcomes among children. These factors included age at implantation, socio-economic factors, developmental disabilities, and family income. Furthermore, it was observed that longer times of inter-implant intervals for bilateral cochlear implants were associated with reduced speech outcomes among children.

The observed results are highly significant since they specifically underscore the significance of early implantation of CIs for the optimization of language and speech development among prelingually deaf children. Moreover, the results are also significant for children who were below 2 years old and are suffering from hearing disabilities. The findings also provide strong evidences to promote early diagnosis of hearing disabilities and use early interventions to promote cognitive and language outcomes. In addition, the results have also talked about the significance of post-implantation therapies. Ongoing language support is essential to maintain the language and speech outcome benefits experienced by children after 5 years of using the cochlear implant. Moreover, the observations are also significant since it shows that various factors affect the long term language and speech development and outcomes among CI users. This is because of the fact that children with limited exposure to language and developmental delays were observed to benefit less from the cochlear implants. Thus, it can be summarised that educational resources and comprehensive family support is essential in ensuring long term language development outcomes for children using cochlear implants.

The main implications of the findings are for clinical practice, policy developments on cochlear implantation, and early intervention programs on cochlear implantations for prelingually deaf children. The results also emphasize the importance of early screening and diagnosis of hearing issues to ensure cochlear implantation before 12 months of age. Health professionals and family members must prioritize early referrals as well as streamline the surgical processes and diagnostic process to enhance the language and speech outcomes for prelingually deaf children. Moreover, implications are also associated with the continuation of language exposure and post-implementation support to maintain the progress of language and speech developments among children with hearing aids. Policy implications include promoting equitable access to cochlear implants and ensuring that long-term language and cognitive therapies are integrated into health and education systems, thus supporting children's comprehensive development post-implantation.

The findings of the current research study were observed to be comparable to the existing evidence base of the study topic. The importance of CIs in improving language development in children and speech intelligibility was observed to be one of the similarities between the existing knowledge body and the current research findings. As per the findings of Tamati et al. (2022), CI usage had profound effects on spoken language access as well as recognition of words among children with hearing issues. This finding was observed to be in alignment with the research results of Dettman et al. (2016), which showed that children experienced better language outcomes when they were implanted during the first year of their life.

Moreover, the negative correlation between age and effectiveness of CIs in enhancing speech intelligibility were reported by two other research studies (Hassanzadeh et al., 2021 and Ajalloueyan et al., 2021). The results of these two research studies have opined on the fact that implantation at a very young age was correlated to the best language and speech development outcomes for longer terms. Furthermore, both the findings of the current research and previous research findings have shown the need for monitoring the progress after implantation and significance of continued intervention. According to the research results of Wie et al. (2020), receptive vocabulary and expressive grammar skills were enhanced during the initial years post-implementation. However, it was observed that the same decreased without continuous exposure to language after 5 years of the implantation. This finding was in alignment with Tamati et al., (2022)'s results. Furthermore, variability of outcomes was also associated with various factors such as cognitive development, device limitations, and socio-economic factors. These findings were like the results of Tamati et al. (2022).

However, there are differences between the findings of the current research and the existing knowledge body. For example, the findings of the current research have highlighted the fact that language skills greatly improved when cochlear implantation was done at a very young age. Despite of this, the findings of Ajalloueyan et al. (2021) and Hassanzadeh et al. (2021) found that there was no specific difference in language scores between late and early implant groups. Although speech intelligibility was better in the early intervention groups, language scores (development) was not comparable between early and later intervention groups. Furthermore, it was observed that this specific discrepancy pointed to various differences on how language skills were measured across various studies. This is because of the fact that Hassanzadeh et al., (2021) carried out the analysis using the Persian version of the Intelligibility Context Scale, which was not similar to the scales used in other studies. Therefore, there was a chance of divergent outcomes between the findings of the current research and the previous research papers. One of the striking differences was associated with the role of pragmatic skills. As per the research results of Ajalloueyen et al. (2021), no specific relationship between pragmatic skills and cochlear implantation age existed. This observation was contradictory to the findings of the current research study. In other words, it can be said that CIs effects in enhancing language and speech recognition and developments in children with hearing issues might not be affected by age. Moreover, another difference existed regarding the developmental factors that affected the progress of language and speech development among the CI users. Tamati et al. (2022) did not talk about any such factors as the focussed on the technological and clinical factors that affected the outcomes of cochlear implants. On a summarising note, it can be said that both the results of the current research and the available evidence base agrees on the significance of early cochlear implantation for better speech and language outcomes and intelligibility. However, they differ on various language development aspects, mainly in the long-term influence of the implantation and pragmatic skills. Moreover, the variations can be attributed to the study design or the assessment tools used for the collection of data.

The main strength of the systematic review was associated with its ability to gather, analyse and interpret data in a comprehensive manner. In addition, it has been observed that the study has provided a holistic understanding of the effect of auditory training programs on speech recognition in noise among children with hearing impairments. The use of thematic analysis further enhanced the quality of the outcomes as the objectives were specifically addressed in the research study. However, there were some limitations also. The main limitation was regarding the choice of 7 papers for the purpose of a systematic review. This selection of small number of papers have reduced the external validity of the findings. In other words, data obtained from the current review cannot be generalised. Moreover, variability in the study design, interventions used, and participant populations might have resulted in heterogeneity. In other words, these weaknesses have the research made it challenging to synthesize the results in a coherent manner. Overall, publication bias might have skewed the results as studies with favourable outcomes were included in the research.

CONCLUSION

On a concluding note, it can be said that the thesis encapsulates the culmination of the research journey. The purpose of the current study was to review the speech and language development by exploring long-term outcomes of cochlear implantation in prelingually deaf children. A total of 7 primary research studies were reviewed to analyse the effect of auditory training accompanied by cochlear implantation on speech and language recognition among children affected by hearing issues. The systematic review has met the objectives of the study by providing a comprehensive analysis of the long-term language and speech development outcomes among prelingually deaf children associated with CI. After the systemic evaluation was performed, the first objective of reviewing and evaluating long term speech development among hearing impaired children was completed. Considering the outcomes of the current research study, it is evident that CIs can improve speech and language perception and intelligibility among prelingually deaf children. Moreover, a specific threshold of age for the optimization of the language and speech development benefits for children was also found. The results have also revealed that long term benefits of CIs solidified the positive effect of CIs on speech development.

The second research objective was to assess the progress of children in language development on an over-time basis after cochlear implantation. Both the results of the current research and existing research papers on the same topic have shown that early cochlear implantation promotes language skills that include grammar, vocabulary, and speech intelligibility. However, challenges in maintaining skills such as expressive grammar and vocabulary performance were observed on a long-term basis. Furthermore, the research has revealed that CIs help in enhancing the process of language development among children with hearing issues even after 3-4 years of the implantation. However, continuous training and language exposure after 6 years of implantation are needed to maintain the benefits obtained from CIs.

The third research objective was to analyse factors that influenced long term speech and

variability in language outcomes that included the implementation age, duration of using CI, and the post implementation therapies. Out of all these factors, age at implementation was found to the most significant factor that influenced long term speech and language development in children with hearing disabilities. Moreover, continuous language support was needed to maintain language and speech developments made by the use of CIs. Factors including maternal education as well as socio-economic status were also needed to be addressed to enhance the beneficial effects of CIs on speech and language development.

As a final point, it can be stated that the research has successfully met all the objectives by reviewing the existing evidence pieces on language outcomes and long term speech outcomes among prelingually deaf children. The observations have shown the need for early intervention and continuous support to enhance the benefits obtained from the use of CI by children with hearing disabilities.

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APPENDIX

Table 1. Data extraction table

Slot number	Aim	Participants	Intervention	Design	Outcomes	Findings	Conclusion
1	To analyze the influence of cochlear implantation age on speech perception, language and speech production outcomes among children with cochlear implants.	403 children with congenital bilateral severe to profound hearing impairments.	Cochlear implants	Cohort study	Speech perception, sentence understanding, open-set words	Age at implant had a significant effect on the influence of cochlear implantation on speech outcomes. Language standard scores, open set speech perception and understandings were higher for children who had implantations when they were 12 months or younger.	The results support the fact that cochlear implants can be implanted among children when they are 12 months or younger to optimize speech and language perceptions.
2	To analyze the effect of combination of early and simultaneous bilateral cochlear implants (CIs) on the trajectories of language development and outcomes among children with hearing impairments.	21 Norwegian children	CIs	Longitudinal case control research study design	Language skills, vocabulary, Grammar	During the first 4 years after implantation, children language performance in the CI group were similar to the healthy group. However, skills like receptive vocabulary and expressive grammar were enhanced in the healthy group than the CI group after 5 years of the implantation. Therefore, a need of long-term language intervention was highlighted by the research to increase chances of continued language development among children.	Language outcomes after cochlear implantation after 6 years were associated with speech recognition skills, maternal education, and age at implantation.

3	To analyse the long term speech intelligibility outcomes among prelingually deaf children with cochlear implants.	63 children with cochlear implants before age 7.	CIs	Case control research study design	Speech intelligibility	CI users who utilised CIs for a longer period of time have shown poorer scores of speech intelligibility. Moreover, the reason was regarding the wearing out of the implant with time. Amount of spoken language experience was also associated with the language outcomes of children with cochlear implants.	Many factors are associated with differences in language outcomes between individuals with hearing issues and normal hearing individuals.
4	To assess the hearing threshold as well as language based outcomes of cochlear implanted children.	57 children between 10 months to 5 years of age	CIs	Observational, descriptive, transversal study	Recognition of disyllabic and sentences with and without noise	Children who have been implanted with CIs while they were below 2 years of age had better outcomes in disyllabic and sentences with and without noise. Moreover, disyllabic test with noise has also shown better outcomes for children who were implanted with CIs before 2 years of age. However, children implanted with CIs after 2 years of age did not reach the same levels of performance in terms of speech recognition like the other group.	Children affected by pre-lingual deafness with CIs implanted before 2 years of age had more benefits in terms of linguistic competence and language development. In other words, the audiology results are better for children with implantations under 2 years of age.
5	To analyze the long term benefits of cochlear implantation among children with hearing disabilities.	21 children with complex disabilities	CIs	Retrospective cohort research	Open set speech recognition abilities	The long term speech outcomes were dependent on the developmental status of children. In other words, children with developmental delay showed no open set speech recognition abilities. However, children with no developmental delay have shown high open set scores. Furthermore, 38% of children were found to discontinue their usage of CIs after being diagnosed with developmental delay and other disabilities.	Long term speech recognition outcomes were lined to complex developmental issues of children. Thus, developmental status of children and its knowledge among families is essential before deciding on whether to get an implant for their children or not.

6	To analyse the long term results of cochlear implantation among children affected by single sided eafness.	11 children with congenital single sided deafness (SSD).	CIs	Retrospective study design	Speech discrimination, Speech, Spatial, and Qualities scale (SSQ), and Categories of Auditory Performance (CAP) score.	Children who were below 2 years during the CI surgery experienced the highest benefits in terms of speech discrimination. Moreover, children above 4 years during the surgery improved partially considering the subjective audiological measurements. However, children who were above 5 years during the surgery, did not show any much improvement in long term speech recognition.	Age was a critical factor for the maximum effectiveness of CI surgery in enhancing long term speech discrimination among children with hearing impairments.
7	To assess long term speech perception outcomes of second side cochlear implants and first side cochlear implants among children.	160 participants who received cochlear implants during their childhood.	CIs	Retrospective cohort study design	Speech perception, and speech recognition in noise.	First side implants have shown 28% higher speech perception than second side implants among children with little or no oral language skills before implantation. However, longer interimplant interval were observed to be ineffective in enhancing speech perception among children. Thus, there was a high risk of not using second side cochlear implant among children for cases where long term implant failed to promote better speech perceptions.	Increased interimplant intervals were not associated with better speech perception results.