EFFECT OF LONG-TERM COCHLEAR IMPLANT USE ON EDUCATION AND OCCUPATION: A SYSTEMATIC REVIEW

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CERTIFICATE

This is to certify that this dissertation entitled "**Effect of Long-Term Cochlear Implant Use on Education and Occupation: A Systematic Review**" is a bonafide work submitted as a part of the fulfillment for the degree of Master of Science (Audiology) of the student with Registration Number: 20AUD020. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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This is to certify that this dissertation entitled "**Effect of Long-Term Cochlear Implant Use on Education and Occupation: A Systematic Review**" has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "**Effect of long-term cochlear implant use on education and occupation: A systematic review**" is the result of my own study under the guidance of Dr. Geetha. C, Associate Professor in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No: 20AUD020**

August, 2022

Dedicated to

My Very Supportive Parents

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ABSTRACT

Aim and objective: *The purpose of the current study was to summarize existing literature on the effect of long-term cochlear implant use on education and occupational outcomes.* ***Method:*** *The search for the articles began with finalizing appropriate keywords, putting those through various search engines to retrieve articles from 2011 to 2021. The retrieved articles were assessed in two stages: title and abstract screening, followed by a full-length article review. Ten studies were finalized at the end of the search process.* ***Results:*** *The review showed mixed results from the selected studies. Some research found that cochlear implant/s users did worse than their normal hearing peers. In contrast, a few other studies found that cochlear implant recipients performed equal to or better than their normal hearing peers or the general population. When compared to the general population, cochlear implant recipients have considerably lower occupational levels. Many factors could influence educational and occupational outcomes in long-term cochlear implant users. The factors may be the child's current hearing status, multiple disabilities, peer relationships, learning pressure, social skills, language development, self-efficiency, preferred communication mode, parents' hearing situation, parents' education, and family expectations, teachers' attitudes toward children, and the educational environment.* ***Conclusion:*** *Even though there are varied results regarding educational outcomes in long-term CI users, some studies showed good educational performance in CI recipients. However, there is a need for more studies for a better understanding of the factors influencing the educational and occupational abilities of children with a long-term cochlear implant.*

Chapter 1

INTRODUCTION

Hearing loss is the most frequent sensory deficit (Monteiro et al., 2012). In April 2021, the World Health Organization (WHO) reported that over 430 million people worldwide (approximately 5% of the population) need hearing loss rehabilitation (432 million adults and 34 million children).

Individuals with hearing loss have hearing aids, cochlear implants, and other assistive listening devices as intervention options. Hearing aids are frequently used to compensate for hearing loss in patients with hearing loss (Wu & Liu, 2019). The cochlear implant is much more useful in patients with severe to profound hearing loss than hearing aids. The cochlear implant electrically stimulates the auditory nerve to restore the damaged cochlea, allowing individuals with severe to profound hearing loss to hear properly (Venail et al., 2010). Cochlear implants are reported to improve their hearing (Sarant et al., 2015), speech perception abilities (Geers et al., 2003; Pyman et al., 2000; Sarant et al., 2001), speech production, language, listening, and social developmental outcomes (Marschark et al., 2007).

Another indicator of CI success has been the attainment of mainstream education (Francis et al., 1999). Education in a field aids individuals in thinking, feeling, and acting in a manner that advances their achievement and improves their satisfaction. Education has various benefits such as good employment, good status in society, and self-confidence. There may be more and better opportunities for better jobs. Through education, an individual can perceive problems as an opportunity to try new things without fear (Shuaibi, 2014). Academic success, positive family connections,

and work satisfaction, among other factors, all influence life satisfaction (Diener et al., 1985).

In many countries, children with hearing loss are rarely educated (Jung & Bhattacharyya, 2012). Nevertheless, early-implanted children should be expected to attain the same educational level as their hearing peers due to the advancement in the field of cochlear implants and early identification, habilitation, and educational interventions (Huber et al., 2015). Most children with CI are reported to attend mainstream schools (Ruffin et al., 2013). According to studies conducted in Austria, 81% of cochlear implant students who attended mainstream schools had achieved similar educational levels that of their normal-hearing peers (Huber et al., 2008). Early implantation and early acquisition of oral language in children with CI have improved school achievement (Geers et al., 2011; Motasaddi-Zarandy et al., 2009).

Good employment is another indicator of the success of any rehabilitation. Hearing-impaired individuals have a substantially greater unemployment rate than their hearing peers (Olusanya & Newton, 2007). Among those employed, many indivudlas with hearing impairment are working at lower employment levels (*Deafness and Hearing Loss*, 2021)**.** Higher academic achievement is expected to improve employment opportunities for those with hearing loss. Academic success for the hearing impaired has been enhanced in recent years, but employment rates for the hearing impaired have fallen in contrast to the general workforce (Punch et al., 2004). Individuals with hearing impairment earned less money than their hearing colleagues with the same amount of schooling (Goh et al., 2016) though Fazel and Gray (2007) found that cochlear implants help to improve job satisfaction. Whereas, Illg et al. (2017)

reported that good CI performers will have the same occupational opportunities as their normal-hearing peers.

Several factors are reported in the research, including etiology, age at implantation, duration of hearing loss before CI, pre-operative residual hearing, duration of CI use, bilateral implanted CI, auditory rehabilitation, and family involvement may have a role in the performance of CI (Venail et al., 2010) including education and employment. However, the above list is said to be incomplete (Huber & Kipman, 2012). All these variables are insufficient to explain why some implantees get more benefits than others in terms of academic skills and occupational level (Connor et al., 2006; Connor & Zwolan, 2004).

1.1 Need for the study

Cochlear implant technology has significantly improved over the last few decades. Extensive research is being conducted to report the CI device's effectiveness and the benefits received by CI recipients. According to Goh et al. (2018), the CI aims to increase listening capacity in severe to profound hearing-impaired children, which will, in turn, help their access to spoken language. Their study reported that over 60% of CI recipients who had at least three years of CI use were using oral language to communicate. The potential for oral/spoken language acquisition increases with an earlier implantation age. Speech perception and language abilities do not fully represent CI effectiveness; other aspects, such as education and employment, life satisfaction, etc., are also essential in documenting CI outcome (Goh et al., 2016). Hence, it is important to integrate children with CI into mainstream classrooms to acquire the same academic skills as their peers with normal hearing.

There is little research on educational and occupational benefits of CI in the literature. Some studies show greater educational (Geers et al., 2011; Motasaddi-Zarandy et al., 2009) and occupational outcomes and some studies show lesser benefits when compared with normal hearing peers (Damen et al., 2006; Marschark et al., 2007; Mukari et al., 2007). A few research studies showed that children with CI in mainstream schools achieved satisfactory academic results (Wu et al., 2013; Motasaddi-Zarandy et al., 2009), while other studies found that their academic performance lagged behind that of their normal-hearing peers (Damen et al., 2006; Mukari et al., 2007). Only a few researchers have reported long-term CI outcomes in educational and occupational domains to review the literature. Studies on long-term CI usage will provide guidance to professionals and family members regarding the therapy process and expectations as well as a detailed understanding of the factors in the development of communicative, educational, and occupational abilities of children with CI (Tanamati et al., 2011).

A systematic review on the topic will provide insight into a better understanding of the long-term effects of CI. As the results reported contradict one another, systematic review will hep understand the factors that influence education and occupational skills in children with long-term CI use. It can provide evidence to counsel parents on CI outcomes in terms of education and occupation, improving quality of life. Hence, there is a need for a systematic review to provide evidence for audiologists about the long-term benefits of cochlear implantation on education and occupation and evidence to counsel parents regarding the outcome of cochlear implantation.

1.2 Aim of the study

The present study aimed to conduct a systematic review of available scientific evidence on the effect of long-term cochlear implant use on education and occupation.

1.3 Research questions

- What is the effect of long-term cochlear implant use on education and occupation in children?
- What factors contribute to successful education and employment in cochlear implantees implanted in childhood?

1.4 Objectives of the study

- To systematically review and summarize the studies available on the effect of long-term cochlear implant use on education and occupation using systematic review.
- To report the factors contributing to successful education and employment in cochlear implantees implanted in childhood.

Chapter2

METHOD

The Preferred Reporting Items for Systematic Reviews and Meta-analyses statement (PRISMA statement) was followed in this systematic review (Page et al., 2021). The steps followed for the systematic review of literature are provided in the following section.

2.1 Information sources

Articles were extensively searched from different database searches such as Google Scholar, PubMed/Medline, Com-Disdome, and Science Direct. Lists of references and citations were searched manually for further relevant studies.

2.2 Search strategy

The keywords used were “Long term outcome,” “cochlear implant,” “education,” “occupation,” “Academic performance,” “Classroom performance,” and “employment.”

The search was carried out with multiple combinations of keywords to find articles related to this topic and MeSH words relevant to the study combined with Boolean operators such as ‘AND,’ ‘OR,’ ‘NOT’. “Long term outcome” AND “Cochlear implant” AND “education” OR “classroom performance” OR “academic performance” OR “school achievement” AND “occupation” OR “employment.”

2.3 Inclusion Criteria for Literature

For the systematic review, studies were selected based on the quality of the

method, data, intervention, and outcome. The following criteria were followed for the selection of studies:

- Articles that have been published in peer-reviewed journals over the past ten years (2011-2021) were included.
- Each study should have had a minimum of ten participants.
- Original articles with human participants, appropriate samples, and relevant data were taken.
- The review only evaluated articles that had been published in English.
- The selection was also based on the PICO (participant, intervention, control, and outcome) criteria.
    - → **Population**: adolescents or young adults with pre-lingual hearing-impaired participants were taken.
    - → **Intervention**: Studies that have been performed using the CI device for more than five years were included.
    - → **Control group**: Studies with no control group or with normal hearing individuals/Hearing impaired with no CI/Hearing Aid users as a control group were taken.
    - → **Outcomes:** Studies that evaluated long-term effect of CI on education and occupation were included.

2.3 Exclusion Criteria for Literature

The following criteria were followed for excluding the studies:

- Articles with poor methodological quality or published in a language other than English were rejected.
- Case reports, letters to editors, and editorials were excluded.
- Articles that included participants with additional disorders were excluded.
- Studies that involved a group of individuals who were post-lingually deafened were also ruled unsuitable.

2.4 Study selection

The studies for systematic review were selected in two stages. Two researchers screened all the articles. The search results were combined using the Rayyan QCRI (Qatar Computing Research Institute) version 2.0 and Zotero desktop reference manager system version 6.0.9, and the duplicate studies were eliminated. In the first stage, the studies that met the inclusion criteria were identified by screening the titles and abstracts retrieved from the search strategies. After that, in the second stage, the full text of the potential studies was retrieved and evaluated to see if they were eligible by two researchers.

2.5 Data extraction

The extracted data included article title, author details with their affiliation, year of publication, research design, study population, sample size, age group, the mean age of implantation, comparison group, details of the questionnaire or tests used, and method of outcome measures. Later it was represented through the PRISMA flow diagram (Peters et al., 2015), given in the result section.

2.6 Quality analysis

Quality assessment of eligible studies was carried out to minimize the risk of bias. The studies included in the systematic review were subjected to a methodological quality assessment. The critical Appraisal Skills Programme (CASP) checklist given by Ruth Brice in 2018 was used to analyse the selected studies. The cohort study version of the CASP checklist was employed because the systematic review primarily included cohort studies. CASP has 12 questions divided into three sections. The questions were rated using three categories: yes, cannot tell, and no. The questions covered the study's purpose, cohort recruitment, measurement bias, and identification and analysis of confounding factors. The checklist was also used to score the consistency of follow-up, the generalizability of the results, and their implications.

Chapter 3

RESULTS

The present study aimed to conduct a systematic review of the studies focusing on the effect of long-term cochlear implant use on education and occupation status. Several steps lead to narrowing the search of the articles for review. Results of the systematic search process

A total of 11,037 articles were identified using database searches and through back references of articles, and 178 duplicates were eliminated. Title screening of 10,859 articles was done, and only 43 articles were included in the abstract screening. Sixteen articles were selected for the full-length article screening. Based on the study's inclusion criteria, ten articles were finally selected for the systematic review. The remaining six articles were excluded because of the inclusion of pre-lingual deafness, lesser age group, or irrelevant study design (case series). Figure 3.1 shows a thorough Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart of selection of the studies.

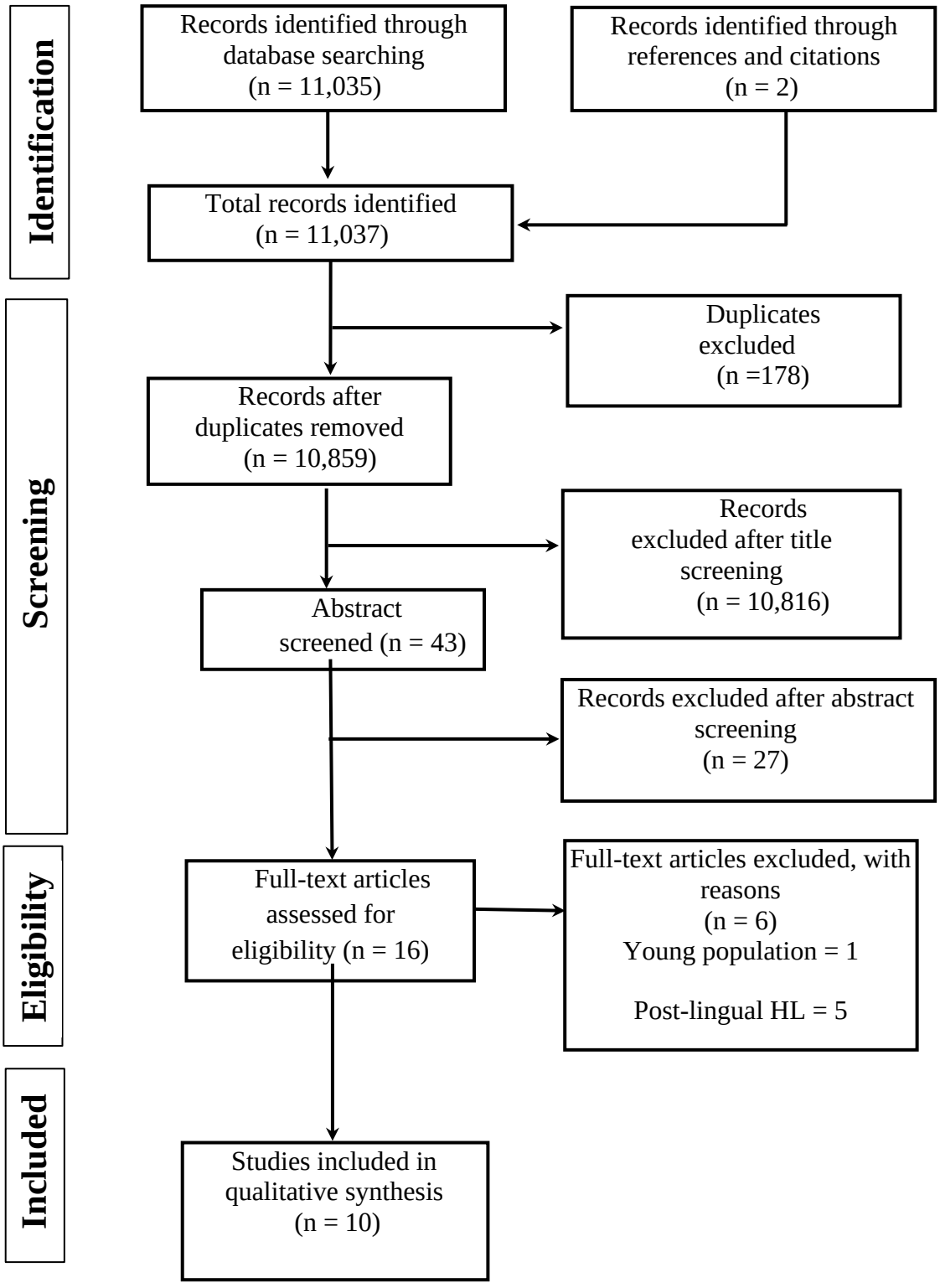

Figure 3.1:

PRISMA flowchart to represent the selection process of articles included in the review.

3.1 Results of qualitative analysis

The final short-listed articles underwent qualitative analysis using the cohort study version Critical Appraisal Skills Programme (CASP) questionnaire, given by Ruth Brice in 2018. It is important to separate relatively high and low-quality research to organize the contribution of studies based on their quality. Typically, researchers quantify evaluation outcomes to generate an overall study quality score. A determining criterion was applied to establish comparable study quality. The inclusion criterion for the current study was a score of 5 or more for close-ended questions. The results of the quality assessment for all of the selected studies are provided in Table 3.1.

Table 3.1

Results of qualitative assessment of the included studies

Q. no	CASP	Illg et al. (2017)	Wu & Liu (2019)	Sarant et al. (2015)	Choi et al. (2020)	Huber and Kipman (2012)
Q1.	Did the study address a clearly focused issue?	Yes	Yes	Yes	Yes	Yes
Q2.	Was the cohort recruited in an acceptable way?	Yes	Yes	Yes	Yes	Yes
Q3.	Was the exposure accurately measured to minimize bias?	Yes	Yes	Yes	Yes	Yes
Q4.	Was the outcome accurately measured to minimize bias?	Cannot tell	Cannot tell	Yes	Cannot tell	Yes
Q5.	(a) Have the authors identified all-important confounding factors?	Yes	Yes	Yes	Yes	Yes

	(b) Have they taken account of all the confounding factors in the design and/or analysis?	Yes	Yes	Yes	Cannot Tell	Yes
Q6.	(a) Was the follow up of subjects complete enough?	Yes	Yes	Yes	Yes	Yes
	(b) Was the follow-up of subjects long enough?	Yes	Yes	Yes	Yes	Yes
Q7.	What are the results of this study?	CI recipients' educational and occupational levels are poorer than the general German population.	Poor academic performance in China and Czech CI recipients.	CI recipients achieved similar academic outcomes as their normal hearing peers.	Children with CI in mainstream schools scored below average in academic performance.	The CI recipients performed worse in Arithmetic and reading skills.
Q8.	How precise are the results?	Very precise	Very precise	Very precise	Very precise	Very precise
Q9.	Do you believe the results?	Yes	Yes	Yes	Yes	Yes

Q10.	Can the results be applied to the local population?	Yes	Yes	Yes	Yes	Yes
Q11.	Do the results of this study fit with other available evidence?	Yes	Yes	Yes	Yes	Yes
Q12.	What are the implications of this study for practice?	Early implanted participants achieve better educational and occupational outcomes	Child's and family-related factors influence educational outcomes.	Bilateral and early CI implantation is must to get better academic outcomes.	Listening modifications are necessary for mainstream education of children with CI.	Cognitive development is dependent on educational background of the implantees.
Scores		**8**	**8**	**9**	**9**	**9**

Table 3.1 (cont.)

Q. no	CASP	Spencer et al. (2012)	Goh et al. (2018)	Nelson et al. (2017)	Diaz et al. (2019)	Langereis and Vermeulen (2015)
Q1.	Did the study address a clearly focused issue?	Yes	Yes	Yes	Yes	Yes
Q2	Was the cohort recruited in an acceptable way?	Yes	Yes	Yes	Yes	Yes
Q3.	Was the exposure accurately measured to minimize bias?	Cannot tell	Yes	Yes	Cannot tell	Yes
Q4.	Was the outcome accurately measured to minimize bias?	Yes	Yes	Yes	Yes	Yes
Q5.	(a) Have the authors identified all-important confounding factors?	Yes	Yes	Cannot tell	Yes	Yes
	(b) Have they taken account of all the confounding factors in the design and/or analysis?	Yes	Yes	Cannot tell	Yes	Yes
Q6.	(a) Was the follow-up of subjects complete enough?	Yes	Yes	Yes	Yes	Yes

	(b) Was the follow-up of subjects long enough?	Cannot tell	Yes	Yes	Yes	Yes
Q7.	What are the results of this study?	Education attainment was higher than the general public.	Early implanted children had better educational outcomes.	Children performed the same as or better than peers across academic recipients.	The number of grade failure increased significantly between CI+5 and CI+10 years after CI use.	Children with CI in mainstream education performed better in academics compared to deaf education and hard of hearing education.
Q8.	How precise are the results?	Precise	Very precise	Very precise	Very precise	Very precise
Q9.	Do you believe the results?	Yes	Yes	Yes	Yes	Yes
Q10.	Can the results be applied to the local population?	Yes	Yes	Yes	Yes	Yes
Q11.	Do the results of this study fit with other available evidence?	Yes	Yes	Yes	Yes	Yes
Q12.	What are the implications of this study for practice?	A mother's education influences the CI	Early age of implantation is a crucial factor to be considered for	The audiologist's role is important in CI	Early implantation and high parental	Early intervention will improve the educational

	child's educational level.	better educational outcomes.	management & counselling family members, which helps CI students get better educational outcomes.	education will positively affect CI recipients' education.	level of CI recipients.
Scores	**7**	**9**	**7**	**8**	**9**

All the articles met the criteria of the quality assessment. It can also be seen in Table 3.1 that all the above ten articles prove to be of high-quality, and hence were included in the review.

3.3 Study characteristics

The study characteristics of all the studies were categorized in the PICO (participant, intervention, control, and outcome) format. It is given below.

Population: The participants in the included studies were cochlear implant children aged between 3 and 44.6 years. Though some studies had included younger groups with children of 3 years, the results of the older groups were only included for the review. All the studies had children with hearing impairment using cochlear implants as participants without any associated problems like intellectual disability, attention deficit hyperactive disorder, autism spectrum disorder, etc.

Intervention: In this study, the intervention of interest was long-term (at least 5 years) CI use. All the studies had participants using the cochlear implant for at least five years. Out of ten studies selected, seven studies done by Choi et al. (2020), Diaz et al. (2019), Goh et al. (2018), Illg et al. (2017), Nelson et al. (2017), Spencer et al. (2012), and Wu and Liu (2019) used a questionnaire for assessing educational status in children with CI, and three studies done by Huber and Kipman (2012), Langereis and Vermeulen (2015), and Sarant et al. (2015) administered tests for evaluating educational status.

Control group: Normal-hearing individuals were taken as a control group in four studies (Huber & Kipman, 2012; Illg et al., 2017; Langereis & Vermeulen, 2015; Spencer et al., 2012). Three studies done by Choi et al. (2020), Goh et al. (2018) and Nelson et al. (2017) had no control group, and another three studies by Diaz et al.

(2019), Sarant et al. (2015), and Wu and Liu (2019) compared outcome between two different groups with CI or between two-time measurements.

Outcomes: Long-term effect of CI on education was the interest in all the selected articles and only one article by Illg et al. (2017) has evaluated occupation.

3.4 Results of Data Extraction

The data was extracted from the reviewed articles and summarized as mentioned in the Table 3.2. Table 3.2 shows the aim, details of the participants, the testing method/questionnaire used in the selected studies, and the results of each study.

Table 3.2

The details of participants, questionnaire/tests used, and results of educational and occupational outcomes in children with CI in studies included for systematic review.

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
1.	Illg et al. (2017)	To study long-term educational level, type of vocational training, and occupational outcomes.	● 174 CI recipients ● Age range: between 14.2 and 44.6 years. ● Participants had their first CI implantation between 1986 and 2000. ● Compared with the general population in German.	● 5 years of CI usage. ● > 11 hours per day.	● Self-administered questionnaire regarding the educational and occupational outcome. ● To measure and compare education-Levels of the International Standard Classification of	● Educational, and occupational level of CI recipients was significantly poorer compared with the general German and global population. ● Education: 64% of CI recipients attended schools for hearing-impaired individuals, and 36% attended

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
					Education (ISCED-97) were assigned to qualifications. ● International Standard Classification of Occupation-88 (ISCO) skill levels were created for occupations.	integrated or mainstream schools. ● Occupation: 74% of CI recipients obtained the occupation they wanted, 8% had not, and 19% of recipients reported they had, in some way, managed to land the job they wanted.
2.	Wu and Liu (2019)	To examine and compare educational placement and school adjustment	● ***China:*** 28 CI recipients ● ***Czech Republic:*** 15 CI recipients ● 43 caregivers of CI recipients	>5 years (implanted at the age of 1-3 years)	● Questionnaire survey among 48 children with CI, their parents, caregivers, and class teachers.	● Both groups: Poor academic performance compared to normal hearing peers. - Czech children: 66.67% were placed in regular

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		in cochlear implantees.	(parents and main school teachers) ● Age range: 3-18 years		● Conducted interviews and field observation.	schools, 13.33% were in deaf schools, 6.67% were in institutions, and 2 stayed at home. - Chinese children: 46% were placed in regular schools, 17.86%- in resource classroom, 3.57% in special schools, 14.29% in deaf schools, and 10.71% in institutions.
3.	Sarant et al. (2015)	(i) To study academic outcomes in	● 44 children (34 bilateral CI and 10 unilateral CI)	● 5-6 years of CI usage (CI done before 2	● WIAT-II (Wechsler Individual Achievement Test-Second Edition) was	● Children with CI achieved similar academic outcomes as

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		early children with CI. (ii) To determine whether bilateral and unilateral CI have different academic outcomes.	with normal cognitive abilities. ● Age range: 8-9 years.	years of age).	used to assess academic skills. ● A Reading Habit Questionnaire was mailed to parents. ● Audiological and CI information was collected from the hospital files.	their normal hearing peers. ● Many profound HL children can achieve age-appropriate academic skills with bilateral Cis. ● When the second CI was implanted at a younger age, the benefit was greatest.
4.	Choi et al. (2020)	To evaluate the academic performance, communication skills, and	● 67 CI recipients ● Pre-lingual hearing impairment.	● Atleast 5 years of CI experience.	● Structured questionnaire on academic performance (in-	● The academic performance of children with CI in mainstream schools scored below

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		psychosocial development in children with CI who are attending mainstream schools.	● All participants were attending mainstream schools. ● Age range: 6-17 years.		person or telephone interview). ● Medical records were reviewed for auditory and speech performances, retrospectively.	average in some recipients. ● Mostly satisfactory outcome was present. >50% of children with CI scored above average in general academic achievement. ● Grade retention was reported in 12 children.
5.	Huber and Kipman (2012)	To assess cognitive abilities and basic academic achievement of children with CI	● 40 children with CI, with age range of 7-11 years. ● 40 children with normal hearing	● >5 years of experience with the first CI.	● The Number Sequences and the Arithmetic Operations subtest of the Heidelberger Rechen test 1-4	● The children with CI performed equally well in cognitive and visual skills as normal hearing peers and performed significantly worse in

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		compared with normal hearing peers.	who were matched for age and sex were included as a comparison group.		(HRT) was used to evaluate maths, and Salzburger Lese–Screening (SLS) was used to check for basic reading skills. ● Five cognitive tests and two visual tests were also done along with the review of the medical report.	Arithmetic and reading skills. ● Early cochlear implantation had positive effects, such as mainstream schooling and high parental educational attainment.
6.	Spencer et al. (2012)	To study the educational, vocational, affiliation, and quality of life	● 85 CI users ● Implant age: 24 months to 15 years.	● >12 years of CI use (Implanted between 1987-1999)	● The Living Status Questionnaire was administered to assess educational, vocational, family	● 41 out of 85 responded to the questionnaire. ● Many (39 of 85) graduated from the mainstream high school

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		outcomes in CI users.	● Education attainment was compared between CI and hearing adults of the general public (U.S. Census- age range of 20-24 years)		status, quality of life, life satisfaction and affiliation patterns.	program. Their education attainment was higher than the general public. ● 32% of CI users, who finished their 4 years university program, had the highest level of educational attainment than that of general population.
7.	Goh et al. (2018)	To study the long-term outcome of UKM (Universiti Kebangsaan Malaysia) CI	● 126 children with CI's parents/ caregivers	● >3 years of CI usage. 42% = Atleast 10 years of CI	● Two sets of questionnaires (i) The first set of questionnaires contained questions	● 58.5% of children with CI were attending mainstream education, 11% in integration school, 6.8% in cued

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		program: in terms of mode of communication, educational placement & their functional auditory/ oral performance.	● Implanted between 1995-2012, before the age of 7 years. ● At least 3 years of habilitation of the implant.	use, 23.8% = 7-9 years of CI use, 34.1% = 3-6 years of CI use.	to assess the children's usage of CI, their types of education placement, and their modes of communication. (ii) The second set included the Parent's Evaluation of Aural/Oral Performance of Children (PEACH) to evaluate the children's auditory functionality.	speech school, and 23.7% in special schools. ● Better outcome was observed in early implanted children in this study.

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
8.	Nelson et al. (2017)	To study parent perceptions of communication and academic experiences in CI recipients.	● 81 parents of CI recipients were surveyed ● Age of the CI recipients: <18 years. ● Participants were divided into 2 groups: (i) K-12 = Kindergarten through grade 12 (ii) 0-5 = Birth to 5 years, still in pre-school.	● K-12 (Kindergarten to 12th grade) = 82% with atleast 5 years of CI experience ● 0-5 (birth to preschool) =75% children with 3 years of CI experience.	● ***Questionnaire Surveys*** 16–23 multiple choices and/or Likert ratings, four open-ended questions to evaluate reasons for acquiring a CI, the degree of satisfaction with the CI, and suggestions for professionals were included.	● The majority (75% of parents reported) of K-12 children performed the same as or better than peers across academic recipients. 85% of children with CI were attending mainstream classrooms. ● 0-5 years group had variability in academic development and hence the study did not include them in the analysis. 95% of K-12 children and 100% of preschool

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
						children used spoken language as their primary mode of communication.
9.	Diaz et al. (2019)	To study school achievement in terms of grade failures in children with CI	● 50 children with CI, implanted between 2- 7 years of age.	● > 10 years of CI use	● Measured at 2 points: 5 and 10 years after implantation (CI+5 and CI+10, respectively). ● Parent questionnaire- regarding child's school grade. ● School delay was calculated using the number of repeated years.	● The number of grade failures increased significantly between CI+5 and CI+10. ● At CI+5, 74% of children with CI were in the appropriate grade for their age. ● In CI+10, only 18% were in the appropriate grade for their age.

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
					● Language comprehension, production, and speech intelligibility were also measured.	● Early CI, high parental education level (high socio-economic status) positively impacted school achievement in children with CI with fewer grade failures in this study.
10.	Langereis and Vermeulen (2015)	To assess the long-term impact of CI on the educational, social-emotional, auditory, and language development of	● 58 children with unilateral CI with normal cognition ability.	60 months (atleast 5 years) of CI usage	● Three different educational settings (mainstream, hard of hearing- sign supported spoken language, and deaf education settings)	● 84% of children with CI of mainstream education performed at an average level or higher than the norm average. ● 90% of children with CI in deaf education

Sl. no	Author/s and Year	Aim of the study	Population type	CI duration	Testing method/questionnaire	Results
		hearing-impaired children in various educational and communicative situations.			• Assessed auditory speech perception, receptive language, educational attainment, and wellbeing by collecting data from the school.	obtained education levels below the average norm. • Achievement in children in deaf education was poorer than the children in hard of hearing education.

3.5 Results of educational outcome

All the ten selected articles aimed to study educational outcomes in cochlear implant (CI) recipients with at least five years of hearing experience through CI. Illg et al. (2017) compared the educational status of children with CI and the general German population. The self-assessment questionnaire regarding education outcome was administered, and qualifications were converted into the International Standard Classification of Education levels to quantify and compare school education. The results showed that the educational level of implantees is significantly poorer than the German population. Similar results were found in Wu and Liu (2019). Wu and Liu (2019) compared the educational placement and school adjustment of children with CI in China and the Czech Republic. A questionnaire survey was done on CI recipients, parents, and main school teachers and found poor academic performance in both the groups. Similarly, Huber and Kipman (2012) assessed the basic academic achievement of CI recipients compared with normal-hearing peers. They assessed maths and basic reading skills in both groups. CI recipients performed significantly worse in arithmetic and reading skills compared to the normal-hearing group.

Choi et al. (2020) also studied the academic performance of children with CI attending mainstream schools. They used a questionnaire on academic performance; the results showed that more than half of the CI recipients in their study scored below average in general academic achievement. Diaz et al. (2019) collected information on school achievement regarding grade failures in children with CI. The results showed an increase in the number of grade failures among CI recipients between 5 and 10 years after CI use.

In contrast, the study by Sarant et al. (2015) showed that children with CI can achieve academic outcomes similar to their normal hearing peers. The study evaluated academic skills (oral language, mathematics, written language, and reading) in CI recipients. Spencer et al. (2012) and Nelson et al. (2017) also reported that most children with CI performed the same or better than their normal-hearing peers. Similar results were also found in the study by Goh et al. (2018), wherein results showed that their educational placement was good for those who had been implanted early.

Langereis and Vermeulen (2015) evaluated the long-term effects of CI on education in three different educational settings (mainstream, hard of hearing-sign-supported spoken language & deaf education settings). Educational attainment information was collected from the school. The performance of CI recipients of mainstream education showed an average level or higher than the normal average. Children in deaf education achievement are poorer than those in hard-of-hearing education. Therefore, in this study, the authors showed different educational performances in different educational settings.

To summarize, four of the reviewed studies revealed a good performance of CI recipients in educational setup. CI recipients who are attending mainstream education with their normal hearing peers, who were early implanted, and early spoken language acquired had a good educational status.

3.6 Results of occupational outcome

One out of ten reviewed articles studied occupational outcomes in pre-lingual CI recipients. Illg et al. (2017) studied long-term occupational outcomes in CI users compared with General Germany using a questionnaire that assessed occupational level, job satisfaction, and workplace-related questions. Occupations were converted into the

International Standard Classification of Occupation-88 skill levels (ISCO). The authors concluded that the occupational levels achieved by CI users were significantly poorer than the average German and worldwide population.

3.7 Factors contributing to successful education and occupation in CI

As it is seen earlier, though majority of the studies show positive educational outcomes in children with CI, some studies present contradicting results. Hence, it is important to look into other factors affecting the educational and occupation performance of children with CI. The major factors which have been reported to influence the educational and occupational outcomes of CI recipients in the reviewed articles are as follows: early age of implantation (Diaz et al., 2019; Goh et al., 2018; Huber & Kipman, 2012; Illg et al., 2017; Spencer et al., 2012), high parental education (Diaz et al., 2019; Huber & Kipman, 2012; Illg et al., 2017; Spencer et al., 2012; Wu & Liu, 2019), mainstream educational placement (education environment) (Choi et al., 2020; Langereis & Vermeulen, 2015; Nelson et al., 2017; Wu & Liu, 2019), and early acquisition of spoken language (communication mode) (Langereis & Vermeulen, 2015). The above factors lead to better educational and occupational outcomes.

Chapter 4

DISCUSSION

The systematic review aimed to summarize the effect of long-term cochlear implant use on education and occupational outcomes and the factors contributing to successful education and employment in cochlear implantees from existing research findings. Out of 11,037 articles, 10 articles were selected for this systematic review. The results of the systematic review are discussed in the following sections:

4.1 Educational outcomes in long-term Cochlear Implant (CI) users

4.2 Occupational outcomes in long-term Cochlear Implant (CI) users

4.3 Factors contributing to successful education and occupation in long-term Cochlear Implant (CI) users

4.4 Limitations of the reviewed studies

4.1 Educational outcomes in long-term Cochlear Implant (CI) users

The first objective of the present study was to explore the effect of long-term cochlear implant use on educational outcomes. Mixed results were found from the selected studies. Studies done by Choi et al. (2020), Huber and Kipman (2012), Illg et al. (2017), Diaz et al. (2019), and Wu and Liu (2019) reported that CI users performed poorer than normal hearing peers, while only one study by Sarant et al. (2015) reported average performance when compared with their normal hearing peers. On the contrary, some studies by Langereis and Vermeulen (2015), Nelson et al. (2017) and Spencer et al. (2012) reported that CI recipients performed equal to or higher than their normal-hearing peers or the general population.

The contradicting results maybe because of many factors which might have influenced the educational and occupation outcomes of CI users. Some of the influencing factors of educational and occupational outcomes include the child's current hearing situation, multiple disabilities, peer relationships, learning pressure, social skills, self-efficiency, language development, preferred communication mode, parents' hearing situation, parents' education, and family expectation, teachers' attitudes toward accepting children, teachers' preferred communication mode, and the educational environment (Wu & Liu, 2019).

Due to the variation in the age of implantation, age of identification of hearing loss, parent's education, education environment, and many other factors might have resulted in mixed results in educational outcomes in CI recipients. Illg et al. (2017) found that CI recipients performed poorer than the general population. All the CI recipients in their study were implanted between 1986 and 2000. Maybe due to the old CI technology, poorer results might have been obtained. They mentioned maternal education is a major factor influencing the CI recipient's education level.

Similarly, Wu and Liu (2019) reported poorer performance among CI users in China and the Czech Republic groups. The study reported that poorer academic performance was due to delay in deciding on a regular or special school, poor oral communication, and poor peer relationship. Choi et al. (2020) found CI recipients performed poorer in second language (English) and social science studies because CI users have difficulty understanding abstract concepts in science and social sciences and difficulty with listening comprehension. Hence, CI recipients may need supplementary materials, and pre-reading school educational materials are necessary for better academic achievements. In addition, their study had a heterogenous CI group in terms

of age, age of implantation, and educational support received by the parents, so this might be the reason for the poorer academic performance.

Even Huber and Kipman (2012) reported that children with CI performed worse in academic (arithmetic/maths) skills. However, the study included a small sample and not controlled the type of hearing loss and etiology (syndromic or non-syndromic hearing impairment) which might have affected the results. The study highlighted the role of the second teacher in school. The second teacher may help children with CI increase verbal communication and compensate for the loss of information in classrooms.

In Sarant et al. (2015) study, average performance was seen in CI users. In oral language and maths, CI users performed relatively poorer than the normative mean due to language delay and poor cognitive ability in CI users. CI users achieved average to their normative data in both written language and reading skills. Early implantation, parental involvement in children's education, and increasing the regular reading habit (additional 15min/day reading time) had a direct influence on child's academic performance and have a significant role in achieving an age-appropriate education level in CI users.

Spencer et al. (2012) reported that CI users' educational attainment is higher/exceeds that of the general population because the duration of the CI use was longer (more than 12 years) and the age of the participants were higher (20-24 years). A study by Goh et al. (2018) showed that more than 60% of the CI participants had oral language as their primary mode of communication, more than 50% was attending mainstream education, all participants were implanted early, and attended rehabilitation atleast for 3 years which might be the reason of success of the CI. On the other hand,

Nelson et al. (2017) surveyed CI users' parents. Parents reported that children with CI performed better than their peers across academic subjects. Authors have not accounted for parents' overestimation of the child's performance and have not done any tests or not verified the child's school performance scores; these could be the reason for the better academic outcomes.

In summary, the variation in the educational outcomes could be due to the test material or the methodological difference, and participants considered in the study. Some studies used only questionnaires (Choi et al., 2020; Goh et al., 2018; Illg et al., 2017), while some used standard test material (Huber & Kipman, 2012; Nelson et al., 2017). General academic performance was reported in some studies, and in some studies (Diaz et al., 2019), each subject in academics was assessed separately (Choi et al., 2020), and the results vary depending on the task. Many studies have administered questionnaires on CI users themselves, while some accounted for parents' responses.

4.2 Occupational outcomes in long-term Cochlear Implant (CI) users

In the reviewed articles, only one study by Illg et al. (2017) assessed occupational outcomes in pre-lingual long-term CI users. The occupational level was significantly poorer than the general German population. Age of implantation, auditory performance, and educational placement (school type) played an important role in determining occupational level in this study.

A good educational level increases occupational opportunities. From this review, we can observe that there are mixed results in pre-lingual CI individual's education. Education has an influence on occupation. Occupations provide identity, and it reflect society's values for a person. A better occupational level improves quality of life and life satisfaction. Hardly there are few researches studied occupational level

in pre-lingual in CI individuals. Occupational level of these CI individuals depicts CI benefit and their active involvement in the society. Thus, there is a need for future studies on occupational outcomes in these individuals.

4.3 Factors contributing to successful education and occupation in long-term Cochlear Implant (CI) users

Inspite of the methodological differences among different studies, some factors can be considered crucial for good educational and occupational achievements. The first one among them is the *age of implantation*. The results suggests that early implantation will improve CI performance. Auditory deprivation is a highly influential factor that affects CI outcomes (Archbold et al., 2008). The Delayed implantation reduces the number of children going to mainstream schools (Goh et al., 2018). The review also shows that implantation at a younger age improves educational level (Diaz et al., 2019; Goh et al., 2018; Huber & Kipman, 2012; Illg et al., 2017; Spencer et al., 2012). The age of intervention is also important in achieving good auditory speech perception, age-appropriate language, and verbal communication, which in turn increases educational (Langereis & Vermeulen, 2015), and occupational attainment (Illg et al., 2017).

Further, higher the *parental education*, the level of CI child's education also tend to increase (Diaz et al., 2019; Huber & Kipman, 2012; Illg et al., 2017; Spencer et al., 2012; Wu & Liu, 2019). Therefore, the children with CI's parental education plays an important role in CI users' schooling delay (Diaz et al., 2019).

The *educational placement and school adjustment* of children with CI can affect by the large class size, low teacher-student ratio, acoustic noise environment, etc. The *educational environment* is important for good academic performance (Choi et al., 2020; Langereis & Vermeulen, 2015; Nelson et al., 2017; Wu & Liu, 2019). The

educational level of the CI users in mainstream educational settings performed similarly to their normal hearing peers (Langereis & Vermeulen, 2015), whereas those in special schools performed poorly.

Bilateral CI is another major factor. Unilateral CI recipients develop mature brainstem and thalamocortical responses to sound after long-term CI use. Loss of normal cortical response to sound will occur if the bilateral CI is not done (Gordon et al., 2013). Undergoing bilateral CIs at a younger age predicted good CI outcomes (Sarant et al., 2015).

Other factors such as *Language level* influences educational attainment (Langereis & Vermeulen, 2015). Early *acquisition of oral language* in CI recipients will influence their school achievements (Geers et al., 2011). *Parents' involvement* in school and parents who communicate with class teachers and other professionals are related to CI students' education level.

To summarize, early implantation influences the influence educational and occupational outcomes in CI users. Long-term CI usage, early rehabilitation with CI device, placing in mainstream education, use of oral communication, and parental support also tend to effect the educational outcomes in CI users. Hence, the role of an audiologist in providing proper referrals, early identification of hearing loss, early implantation, early rehabilitation, and counselling parents for better academic outcomes in children with CI is crucial. Nevertheless, more studies are required, especially in the occupation domain, as the above factors have not been systematically and extensively evaluated.

4.4 Limitations of the reviewed studies

The studies on the effect of educational and occupational outcomes on long-term cochlear implant users have included only a small number of individuals, mostly from single or two CI centres/hospitals. This could be due to the lack of CI participants who match the inclusion criteria of the studies (Choi et al., 2020; Diaz et al., 2019; Huber & Kipman, 2012; Illg et al., 2017; Langereis & Vermeulen, 2015; Nelson et al., 2017; Sarant et al., 2015; Spencer et al., 2012; Wu & Liu, 2019). Further, Wu and Liu (2019) compared two groups (China and Czech Republic); the participants' language and cultural differences might have affected the study results. Whereas Nelson et al. (2017) surveyed parental opinion on a CI child's education level and did not verify the results with objective measures.

In the Diaz et al. (2019) study, grade failure in CI students might be due to the quality of teaching; it was not considered in the study. All the reviewed articles, except a study by Huber and Kipman (2012), had a heterogeneous group such as the age of implantation, chronological age, CI characteristics, etc., of CI participants, which may have also affected the results. All these limitations should be considered while constructing a study that aims to evaluate the outcome measures in cochlear implant users.

Chapter 5

SUMMARY AND CONCLUSION

The systematic review summarizes the effect of long-term cochlear implant use on education and occupational outcomes and the factors contributing to successful education and employment in cochlear implantees from existing research findings. The search for the articles began with finalizing appropriate keywords and putting those through various search engines. The articles found were screened at various stages. At the end of the screening, ten studies that were relevant to our research questions were selected. The entire procedure of searching and identifying articles was done using PRISMA. Ten studies were short-listed at the end of this process. The full-length articles of the ten studies were read through, and the results of the articles were analysed.

The review showed mixed results in terms of educational outcomes. Some research found that cochlear implant (CI) users did worse than their normal hearing peers. In contrast, few other studies found that CI recipients performed as well as or better than their normal hearing peers or the general population. Only one out of ten articles assessed occupational outcomes; that showed lower occupational levels in CI recipients compared to the general population.

Some factors that effects the educational outcomes are in CI users: age of implantation, parental education, age of intervention, chronological age, duration of implant use, educational environment, and language level. Yet, more studies in the educational and occupational domain are warranted to better understand all the factors.

To conclude, this systematic review shows varied results regarding educational and occupational outcomes in CI users though some studies showed better academic

performance in CI users. Though some factors that could influence these outcomes could be retrieved from the published articles, there is a need to systematically study these factors affecting educational and occupation outcomes in CI users. There is very little research done, especially on occupational outcomes in CI users. Since CI technological advancements occur very often, there is a need to track changes in the cochlear implantation outcomes to see its performances. Therefore, further research is necessary to better understand CI outcome measurement in terms of educational and occupational levels.

5.1 Clinical Implication of the Study

This review provides evidence for the audiologist to understand the long-term effects of CI on educational and occupational outcomes. The review also provides evidence for the audiologist to understand the factors influencing education and occupational skills in children with long-term CI use. It emphasizes the importance of early implantation; hence, caregivers should be advised to get early rehabilitation and parents/family involvement in the child's development. Further, the rehabilitation does not end with formal therapy sessions, even children with CI need assistance at the school level.

5.2 Future Direction

- More studies are needed to comprehensively understand educational and occupation outcomes in CI users, especially in pre-lingual long-term CI users.
- Further research should be conducted with bigger sample size.
- Evaluating new CI recipients implanted early and with more advanced CI technologies is necessary.

- There are only limited studies on employment outcomes in pre-lingual CI users. More studies are warranted on employment outcomes.

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