A Systematic Review on the Effectiveness of Early Cochlear implantation on Quality of life

(Basic Hearing Sciences)

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19AUD019

This Dissertation is submitted as a part of fulfilment

for the Degree of Master of Science in Audiology

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September 2021

CERTIFICATE

This is to certify that this Dissertation entitled **"A systematic review on the effectiveness of early cochlear implantation on quality of life"** is bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) student with Registration Number 19AUD019. 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.

Mysuru

September, 2021

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DECLARATION

This is to certify that this Dissertation entitled **"A systematic review on the effectiveness of early cochlear implantation on quality of life"** is a result of my study under the guidance of Dr. Chandni Jain, Reader 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. 19AUD019**

September, 2021

Dedicated to

My

Family

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Abstract

This systematic review aims to look into the impact of early cochlear implantation on quality of life. This review compares the effect of cochlear implantation on quality of life (QoL) for children based on their age of implantation. The study used a literature search of electronic databases (e.g., Pub Med, Google Scholar, J stage, Research Gate, Science direct) and the AIISH repository from 2015 to October 2020. The retrieved articles were assessed in two stages: title and abstract screening, followed by a full-length article review. Eight articles were selected after the full length article review out of 340 shortlisted articles. Among the selected studies, four used the cohort design, two used the cross-sectional design, and two used the case-control design. Parents and self-reported questionnaires were used to evaluate the quality of life. Early detection and rehabilitation improved auditory ability and quality of life in younger children. If the child's auditory stimulation and surroundings provided adequate auditory information, implant at a later age also (> 24-36 months) produced similar outcomes. To completely understand the context and various levels of effect of CI on QoL, investigations on QoL in children should involve longer follow-up periods. The impact of parent and child status on quality of life is an issue that merits additional investigation. It is likely to differ significantly depending on the quality of life instruments used, respondents, and methods of follow-up provided.

Keywords; cochlear implantation, less than one year, pediatric, children, quality of life, Health-related quality of life.

Chapter 1

Introduction

The WHO definition of "deafness" refers to the complete loss of hearing ability in one or two ears. Approximately 63 million people (6.3 percent) have substantial hearing loss (Varshney, 2016). Individuals with hard of hearing loss can be classified as mild to moderate to moderately severe hearing loss (Lieu et al., 2020). Nearly four of every 1000 children in India suffer from severe to profound hearing loss (Varshney, 2016). Profound hearing loss is a type of hearing loss that can prevent people from hearing typical conversations (Lieu et al., 2020).

Hearing loss caused due to the lesion found in the outer or middle ear leads to conductive hearing loss. A lesion in the inner ear or the central auditory pathway causes sensorineural hearing loss, and mixed hearing is the combination of both (Korver et al., 2017). Children with bilateral hearing loss require hearing amplification in both ears for better speech and language development (Lieu et al., 2020).

Hearing aids and cochlear implants (CI) are among the devices available to manage hearing loss. Bilateral hearing aids or bilateral CI, or a CI in one ear and a hearing aid in the other, can be used to assist a child with bilateral sensorineural hearing loss (bimodal devices) (Lieu et al., 2020). Almost all hearing aids come with digital and programmable features that allow users to customize their hearing needs. The universal availability of hearing screening for infants has greatly increased the usage of hearing aids in children. For patients with mild-to-severe sensorineural hearing loss, conventional hearing aids can provide the best hearing rehabilitation. They are also available in various sizes and configurations.

Cochlear implantation has become the standard of care for children with profound hearing loss due to the availability of early detection and treatment (Korver et al., 2017). CI activates auditory nerve fibers by converting acoustic signals into electrical stimuli, restoring the function of inner hair cells. Advances in CI technology and excellent outcomes have prompted hearing aid users to consider surgery for enhancing their auditory skills (Dowell et al., 2004). Previous studies of pediatric CI have shown that when children with hearing loss are identified and rehabilitated early with CI, it is associated with higher levels of language and speech intelligibility and better emotional stability (Waltzman & Roland, 2005).

Early auditory stimulation is essential for the development of spoken language. Hence CI before the age of 12 months has been acknowledged as a rehabilitation opti on for children with substantial hearing impairment (West et al., 2018). It has been reported that children implanted before the age of 12 months have higher rates of receptive and expressive language progression than those implanted between the ages of 12 and 24 months (Leigh et al., 2013).

CI has an impact on communication and psychosocial outcomes in children (Byčkova et al., 2018). When evaluating the benefit of CI, research has been done to measure the clinical parameters (hearing thresholds, speech perception, and language skills) (Svirsky et al., 2004). The social aspect is also a critical part of a child's overall development. It helps incorporate the real meaning of quality of life (QoL) and other problems related to functionality, physical, and mental well-being (Morettin et al., 2013). Beyond improved hearing, language skills, speech output, and perception, CI surgery has a wide range of benefits for children with severe or profound hearing loss.

However, the amount of benefits varies among children and depends on several factors (Govaerts et al., 2002).

Studies in the literature report, early cochlear implantation affects audiological performance, communication outcomes, and QoL (Ali & O'Connell, 2007). Studies have shown that QoL improves in children with early cochlear implantation, making cochlear implantation an affordable intervention (Francis & Niparko, 2003). However, assessing QoL in the pediatric population is difficult because it is critical to assess the multidimensional impact of hearing loss and CI use in children's lives, in addition to clinical measures (Morettin et al., 2013). This review updates the effect of cochlear implantation to compare the quality of life in children based on their age of implantation. For this purpose, a systematic search for studies on the effect of CI on QoL published between 2015 and October 2020 was conducted.

1.1 Need for the Study

Studies have shown that even though CI is a good predictor of speech development and language, there is no detailed evidence to explain the other benefits of early CI (Bruijnzeel et al., 2016). As mentioned earlier, studies have been done to assess the outcome of CI on hearing thresholds, speech perception, and language skills (Svirsky et al., 2004). However, the impact of CI on QoL, which is the true benefit of CI in a broader context: in a child's everyday life in the family, at school, and as a result of changes in the social environment, has received less attention. It is well known that CI impacts both communication and socio-psychological well-being (Bykova et al., 2018). The goal of evaluating a child's CI-related QoL is to achieve the best possible CI result. Hence there is a need to determine the effectiveness of early CI on QoL from the recently published articles. Thus, this review will help

understand if CI improves and builds up the QoL when done early in life. It will provide evidence to the audiologist, which will help them counsel parents about the effectiveness of early CI.

1.2 Aim of the Study

This systematic review aimed to determine the effectiveness of early cochlear implantation on quality of life.

1.3 Research Question

To do a systematic review on the effectiveness of early cochlear implantation on quality of life. For the systematic review, PICOS review question was used, which included:

- **Population**: Children with severe to profound hearing loss
- **Intervention**: Cochlear implant
- **Comparison**: To compare the quality of life in children based on their age of implantation
- **Outcome**: Quality of life

Chapter 2
Methods

2.1 Research Design

The Preferred Reporting Items for Systematic Review and Meta-analyses statement (PRISMA) criteria were used to conduct the systematic review.

2.2 Eligibility criteria to select the studies for systematic review

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:

- The study should have at least ten participants.
- Studies with children who have undergone cochlear implantation before 12 months of age and 12-36 months were included for the systematic review.
- Studies in which the outcome was measured in terms of quality of life were included.
- Only English language papers were reviewed.

Further, studies with participants having a cognitive deficit and other co-morbid disorders were excluded from the review**.**

2.3 Search strategy

The literature search was conducted in the following electronic databases (Pub med, Google Scholar, J stage, Research Gate, Science direct), and from the website (AIISH repository) published from 2015 to October 2020 using Boolean operators such as 'AND,' 'OR' 'NOT.' By scanning databases that included Audiology and Otolaryngology journals, we were able to find relevant papers. The keywords used for the search string for all databases were 'cochlear implantation,' 'less than one

year,' pediatric, children, and for methodology 'quality of life,''Health-related quality of life'.

2.4 Study selection

The studies for systematic review were selected in two stages. The two investigators were involved in the literature search. The shortlisted studies were assembled using the Rayyan QCRI systematic review online software, and duplicates were removed. The first stage involved reviewing all the selected articles for eligibility based on the title and abstract. Studies were chosen based on the technique, data, intervention, result quality, and if they satisfied all the inclusion criteria. The selection in the second stage was based on the full-length article.

2.5 Data extraction

For each of the selected articles, data were extracted using a specific design. The selected data included: study demographics (mean age of implantation), aim of the study, respondent (on child or parent), details of the questionnaire, and qualitative results from the questionnaire.

2.6 Methodological quality appraisal

The studies included in the systematic review were subjected to a methodological quality assessment. We used the National Institute of Health (NIH) Quality assessment tool for Observational Cohort and Cross-Sectional studies and Quality assessment tool of case-control studies for the chosen studies. The following criteria: Design, research population, sample bias, information gathering, variables, blinding, and dropouts were all covered by the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional studies. The NIH Quality Assessment Tool for Case-Control studies includes design, target population, selection bias, information gathering, information on the case and control separately, measures of

exposure, blinding, and key potential confounding variables. Based on the above parameters, an overall rating of 'good,' 'fair,' or 'poor' is given based on the above parameters. All studies were rated individually.

Chapter 3

Results

The present study aimed to do a systematic review on the effectiveness of early cochlear implantation (CI) on QoL. A total of 340 articles were obtained after reviewing through all the databases, of which 52 duplicates were eliminated. The titles and abstracts of the remaining 288 articles were screened to exclude 243 as they did not fulfill the review objectives. Thus, 45 articles were included for the next step. Full-text articles were retrieved for the 45 shortlisted abstracts. Based on the full-text, 37 articles were eliminated as either there was no mention of the age of implantation, or they were in a language other than English. Finally, eight articles were included for the data extraction process and the final review. Figure 3.1 shows the schematic representation of the systematic search process that was followed.

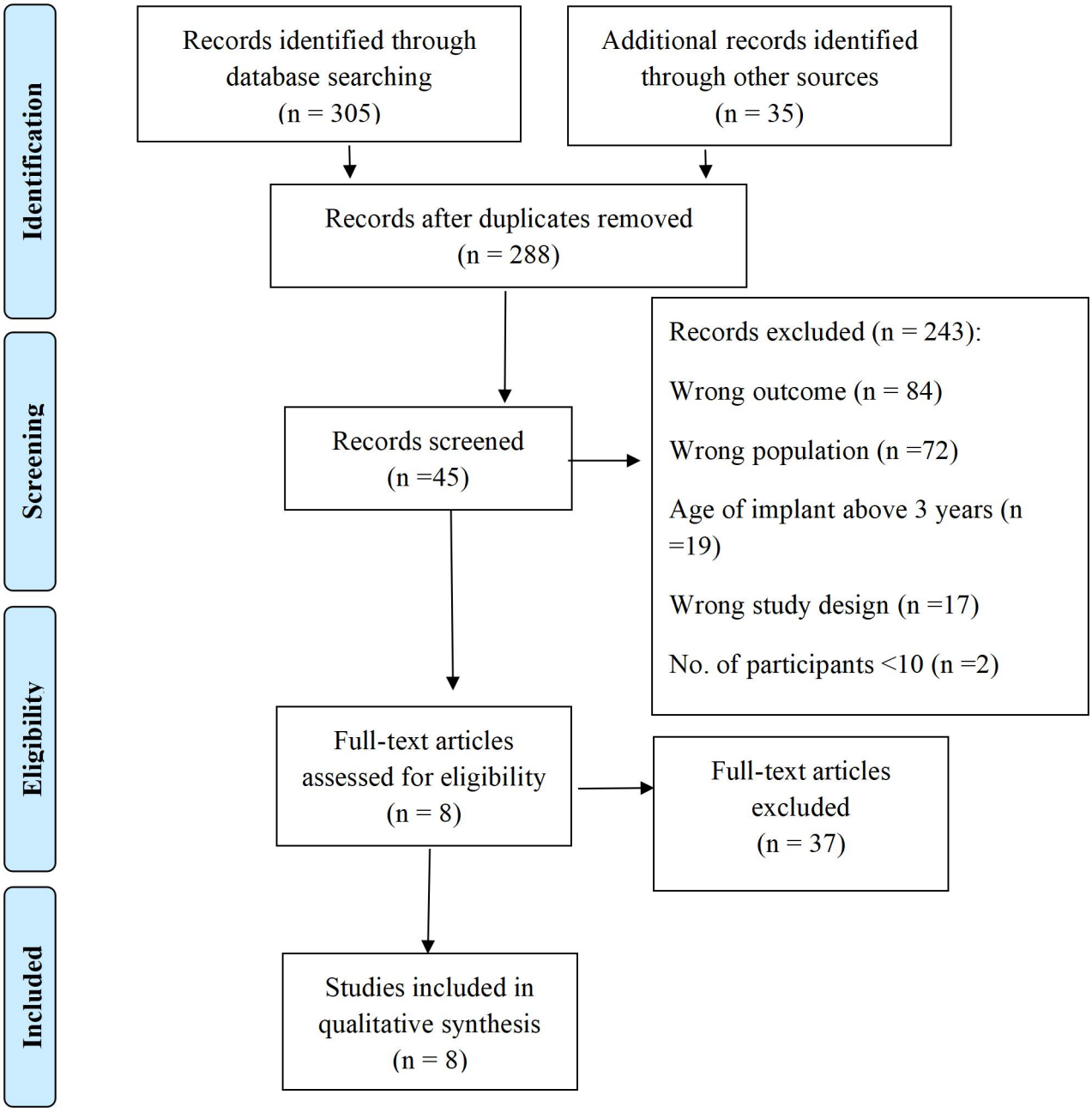

Figure 3.1

PRISMA flow chart of search results

3.1 General Characteristics

Population: The participants included in all the studies were children with severe to profound hearing loss. Two of these studies compared children with normal hearing and children with hearing loss (Vermıslı Peker et al., 2020; Haukedal et al., 2020). The remaining six studies included only children with severe to profound hearing loss with CI (Kumar et al., , 2015; Almeida et al., 2015; Singh et al., 2015; Razafimahefa-Raoelina et al., 2016; Zhao et al., 2019; Artières-Sterkers et al., 2020).

Intervention: In this study, the intervention of interest was CI. All the selected articles included children with CI as participants. One study mentioned bilateral, unilateral, and bimodal users separately (Singh et al., 2015).

Comparators: Adults, children aged < 2, and children aged > 2 years were used as comparators in one study (Artières-Sterkers et al., 2020). All the remaining studies compared children based on their age of implantation, and three of them referenced CI use for at least six months, one year, and three years respectively (Zhao et al., 2019; Almeida et al., 2015; Artières-Sterkers et al., 2020).

Outcomes: QoL was the primary outcome of interest in this study. Therefore, in all the studies, questionnaires were utilized to assess the QoL of children with CI.

Subjective: All subjective outcomes were reported by either the children or their parents or caregivers. The majority of the questionnaires used in the studies were validated and reliable and were reported using a Likert scale. Seven studies used a five-point Likert scale (Kumar et al., 2015; Almeida et al., 2015; Singh et al., 2015; Razafimahefa-Raoelina et al., 2016; Zhao et al., 2019; Vermıslı Peker et al., 2020; Haukedal et al., 2020).

3.2 Results of Data Extraction

Table 3.1 shows the details of participants, respondents, and questionnaire used to assess QoL for each study included in the systematic review. Table 3.2 shows the details of study objectives, information related to CI, and the outcome of questionnaires in the selected studies.

Table 3.1

The details of participants, respondents, and questionnaire used to assess QoL for the studies included in the systematic review

S. No.	Title and Author	Participants	Respondent	Questionnaire/s used to assess QoL
1	American parent perspectives on quality of life in pediatric cochlear implant recipients (Kumar et al., 2015).	33 families of children	Parents	• Parental proxy Health-related Quality of life (HRQoL) assessment, Children with Cochlear Implants: Parental Perspectives
2	Quality of life evaluation in children with cochlear implants (Almeida et al., 2015).	15 parents (14 mothers and one father).	Parents	• Glendonald Auditory Screening Procedure (GASP) • Children with Cochlear Implants: Parental Perspective (CCIPP)
3	One-year experience with the Cochlear™ paediatric implanted recipient observational	159 children	Parents and children	• Children using hearing implants Quality of Life (CuHI-QoL)

	study (Cochlear P-IROS) in New Delhi, India (Singh et al., 2015).			
4	Self-and parental assessment of quality of life in child cochlear implant bearers (Razafimahefa-Raoelina et al., 2016).	32 children	Parents and Children	• KIDSCREEN-27 generic QoL questionnaire
5	Health-related quality of life in Mandarin-speaking children with cochlear implants (Zhao et al., 2019).	51 children	Parents	• Mandarin Children with Cochlear Implants: Parental Perspectives, (M-CCIPP)

6	Quality of life and parental care burden in cochlear implanted children (Vermişli Peker et al., 2020)	Case Group - 34 children Control Group - 68 children	Parents and Children	• Children with Cochlear Implants: Parental Perspectives Questionnaire (CCIPP) • Parental Perspective Questionnaire (PPQ) • The KINDL for 4-7 Year-old Children • The World Health Organisation Quality of Life Questionnaire (WHOQOL-BREF) was used to determine the QoL of the parents.
7	The French National Cochlear Implant Registry (EPIIC): Results, quality of life, questionnaires, academic and professional life (Artières-Sterkers et al., 2020).	936 children	Children	• The APHAB questionnaire (Abbreviated Profile of Hearing Aid Benefit).
8	Health-related quality of life with cochlear implants: the children's perspective. (Haukedal et al., 2020).	168 children	Children	• PedsQL 4.0 Generic Core Scale

Table 3.2

Study objectives, CI information, and the outcome of questionnaires for the studies included in the systematic review

S. no.	Authors	Study objective	CI information (mean)	Outcome
1	Kumar et al, 2015	The study used a validated CI-specific questionnaire to examine parental opinions on condition-specific HRQoL in children with CIs and correlate findings with demographic characteristics.	• Chronological age= 9.85 years • CI activation= 2.47 years • Average CI experience = 7.47 years	Parents assessed most HRQoL domains favorably, although education and the impacts of implantation got significantly lower favourable ratings. Parents reported positive HRQoL and good functional usage of CI across demographic characteristics. However, demographic characteristics (chronological age, CI activation age, and length of CI usage) did not correlate substantially with psychosocial outcomes.
2	Almeida et al., 2015	This study aimed to assess the	• Age of children for	Cochlear implants increased children's QoL

		QoL of children with CI from their parents' perspectives to see if there are any characteristics of these children's and their families' QoL linked to CI use and the development of hearing abilities.	data collection period = 90.5 months. • CI activation= 54.4 months • Use of CI =35.7 months	in terms of self-reliance and social interactions in all 15 children. There was no link between the time of cochlear implants activation (months) and any of the (CCIPP) questionnaire domains. Children who had used CI for less than 24 months had greater percentages in the communication domain than those who had used one for more than 24 months. Thus, it showed a negative connection between the auditory category (<24 months and > 24 months) and the implant outcomes.
3	Singh et al., 2015	The goal of this study was to highlight the preliminary outcomes of a five-year	• Age of implantation = 4.95 years.	In the age 0-3 years group, the CAP-II score improved from 0 at baseline to 3 at six months post-implant and 5 at 12 months

		prospective study one year after surgery. The study also compared the patient-related outcomes of CI in unilateral, bilateral, and bimodal configurations, such as educational placement, QoL, and client satisfaction.		post-implant. However, it was not statistically significant because of the fewer number of children. However, the same tendency was statistically significant for 3-6 years and 6-10 years. As measured by the questionnaire, the entire group of children's QoL improved significantly from baseline to six months and twelve months. After six and twelve months, the CuHIQoL questionnaire examining parent expectations revealed a statistically significant change to lower expectations.
4	Razafimahefa-Raoeli na et al., 2016).	The goal of this study was to use the KIDSCREEN-27 tool to assess QoL in prelingual CI users based	• Age of implantation =23.75 months	Half of the children were unable to complete the questionnaire owing to a disability. Non-respondent children performed worse in

		on a combination of self-and parental assessment.		school and language than respondent children. The QoL of implanted and non-implanted children was comparable: Cohen d, 0 to 0.4, that is, it showed psychological well-being and peers and social support to be weak to moderate. Early CI provides a QoL comparable to the general population in children with prelingual hearing loss.
5	Zhao et al., 2019	The study's goal was to assess the Health-related QoL of children with CI, investigate the probable links between demographic characteristics and Health-related QoL, and determine the	• Age of implantation =24.90 months • Age at assessment= 36.90 months	Health-related QoL was assessed using M-CCIPP. There was an improvement in social relations after the use of CI. But it showed lower scores for education. Age of implantation, age at assessment, single-child status, and Health-related QoL all had no

		Health-related QoL's developmental trajectories.		significant association. Although most domains showed more substantial progress in the first three months of CI usage, all domains showed a significant increase in CI use duration. According to the findings, results also showed that communication advanced the fastest, but education progressed at a slower pace.
6	Vermi̇şli̇ Peker et al., 2020	The goal of this study was to evaluate the QoL and parental care burden of cochlear-implanted children and their parents to healthy peers and their parents.	**Case Groups** • Age of the children=63.9 months • Parents= 33.8 years. **Control Groups**	In CI children, the PPQ social relationship sub-scale and KINDL sub-scale scores had a favourable connection. The Case Group's QoL was found to be lower than the Control Group's, while the Case Group's Case burden was found to be greater than the Control Group's.

			• Age of the children= 61.3 months • Parents= 36.6 years.	
7	Artières-Sterkers et al., 2020	The study aimed to assess hearing overall performance, monosyllabic or disyllabic word perception, speech intelligibility, and self-assessment questionnaire of cochlear implant benefit in children and adults after one, two, and three years of CI.	• The median age of implantation for children = 3.37 years.	This study confirms the maximum impact on adult performance after the first year of follow-up and the progressive growth in children's performance. Because of the advantages of enrolling in integrating or specialised schools, the rate of out-of-school children dropped. Study also showed that compared to the CI alone condition, the contralateral hearing aid improved QoL performance in all follow-up sessions.
8	Haukedal et al., 2020	The purpose of this study was to	• Age of implantation	Older children outperformed younger

	examine if the different individual or contextual factors influenced HR-QoL in a group of CI children. The latter were predicted to follow the same language and socio-emotional development patterns as children with normal hearing.	(deaf after 12 months, 49.7 months) • Age of implantation (HI before 12 months, 19.3 months)	children with a statistically valid relationship between age of testing and QoL total score, mental state, social functioning, and psychosocial health. Self-reported HR-QoL results revealed highly valid differences between the CI and NH groups in social and school functioning domains and total and psychosocial health scores. Better HR-QoL was associated with better spoken-language skills and being older at the time of the evaluation.

3.3 Quality Assessment

Quality assessment of the selected studies for the systematic review was done using the National Institute of Health (NIH) Quality assessment tool for Observational Cohort and Cross-Sectional Studies and Quality assessment tool of case-control studies (Appendix 1). All the selected research had defined aims and objectives, and the methodological quality ranged from good to fair. There were four Cohort studies included in the review. In one of the investigations (Zhao et al., 2019), the questionnaire was filled separately in a paper and pencil format at the time of each clinical consultation. In contrast, researchers gathered them in a face-to-face interview (Razafimahefa-Raoelina et al., 2016). However, the researchers did not quantify exposure at baseline in two of these studies. Selection and information bias was familiar sources of bias in the cross-sectional design of the included two studies. The studies did not state or explained their sample size. Almost all studies provided a clear definition of the outcome measures, which proved valid and reliable in most situations. Two research (Singh et al., 2015; Razafimahefa-Raoelina et al., 2016) used both self-reported and parent-reported questionnaires, three studies (Kumar et al., 2015; Almeida et al., 2015; Zhao et al., (2019) filled solely by the parents, and one study (Artières-Sterkers et al., 2020) used self-reported questionnaires, which could cause social desirability bias. Both case-control studies' (Peker et al., 2020; Haukedal et al., 2020) design and methodological quality were fair, although the sample size in one of the investigations was small. The details of the quality assessment tool for Observational Cohort and Cross-Sectional studies are given in Table 3.3. The details of the Quality assessment tool of Case-Control Studies are given in Table 3.4.

Table 3.3

Quality assessment tool for Observational Cohort and Cross-Sectional studies

Authors/Year	(Kumar et al., 2015)	(Almeida et al., 2015)	(Singh et al., 2015)	(Razafimahefa-Raoelina et al., 2016)	(Zhao et al., 2019)	(Artières-Sterkers et al., 2020)
Q1	YES	YES	YES	YES	YES	YES
Q2	YES	YES	YES	YES	YES	YES
Q3	YES	YES	YES	YES	YES	YES
Q4	YES	YES	YES	YES	YES	NA
Q5	NO	NO	NO	NO	NO	NO
Q6	NA	NA	YES	NA	NA	NA
Q7	NO	NA	NA	NA	NA	NA
Q8	NA	NA	NA	NA	NA	NA
Q9	NA	YES	YES	YES	YES	YES
Q10	NA	NA	NA	NA	NA	NA
Q11	YES	YES	YES	YES	YES	YES
Q12	NA	NA	NA	NA	NA	NA
Q13	NA	NA	NA	NA	NA	NA
Q14	YES	YES	YES	YES	YES	YES
	FAIR	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**FAIR**

Table 3.4

Quality assessment tool of Case-Control Studies

Authors/Year	(Vermişli Peker et al., 2020)	(Haukedal et al., 2020)
Q1	YES	YES
Q2	YES	YES
Q3	YES	YES
Q4	YES	YES
Q5	YES	YES
Q6	YES	YES
Q7	NA	NA
Q8	NO	NO
Q9	NR	YES
Q10	YES	YES
Q11	NA	NA
Q12	YES	YES
	FAIR	**FAIR**

Chapter 5

Discussion

This systematic review aimed to determine the effectiveness of early CI on QoL. To fulfil the aim, 340 research articles were initially selected for this systematic review. Based on the selection criteria, eight studies were shortlisted. Among the eight articles, only a few sections from the articles were selected for the systematic review based on the need of the study.

Several studies on QoL in children, adults, and the old population have been published. There have not been many studies on the impact of CI on children's QoL. This study focused on the QoL for the implanted pediatric population. The majority of the studies contained a wide range of age group classification at the time of implantation, making it difficult to compare and focus just on the age of implantation. The majority of the studies showed a lower number of subjects implanted before the age of 12 months. In the present systematic review, we included studies that compared a) CI group to the general population, b) studies that examined the age of CI implantation to a wide range of comparison groups, and c) the experience with CI in older and younger groups.

In the present systematic review, one study found that CI at a younger age with prelingual hearing loss had a better QoL (Artières-Sterkers et al., 2020), while another study found that QoL improved significantly for all children in the group (Singh et al., 2015). Three studies found no link between the age of implantation and QoL. (Kumar et al., 2015; Zhao et al., 2019; Haukedal et al., 2020). Furthermore, two research evaluated QoL between CI and NH groups (Razafimahefa-Raoelina et al.,

2016; Vermisli Peker et al., 2020) in which one of the studies found that QoL was lower in the CI group than in the NH group (Vermisli Peker et al., 2020). In contrast, in another study they showed CI during the first three years of life improved QoL comparable to the NH group (Razafimahefa-Raoelina et al., 2016).

QoL was studied using a questionnaire in all the studies. In few studies, the respondents were children with CI (Singh et al., 2015; Razafimahefa-Raoelina et al., 2016; Vermi̇sli̇ Peker et al., 2020; Artières-Sterkers et al., 2020; Haukedal et al., 2020) and in few parents of the children with CI (Kumar et al., 2015; Almeida et al., 2015; Singh et al., 2015; Razafimahefa-Raoelina et al., 2016; Zhao et al., 2019; Vermi̇sli̇ Peker et al., 2020). An additional data on factors that may influence HRQoL, such as language specification, economic status, parental education, or educational modifications, would have given better information on QoL, but none of these five studies collected data on it. (Kumar et al., 2015; Almeida et al., 2015; Singh et al., 2015; Razafimahefa-Raoelina et al., 2016; Peker et al., 2020).

It was noted that there was no significant link between HRQoL dimensions and common demographic variables associated with performance outcomes in paediatric CI patients in three selected studies (Kumar et al., 2015; Zhao et al., 2019; Haukedal et al., 2020). The demographic variables that were taken into consideration in the studies were: chronologic age, age at CI activation, duration of CI use (Kumar et al., 2015), age of implantation, evaluation age, single child status (Zhao et al., 2019), age at implantation, the onset of deafness (whether the hearing loss occurred before or after 12 months), monosyllable word repetition test scores, or nonverbal IQ. (Haukedal et al., 2020). After one year of CI use, Zhao et al. (2019) could not gather long-term development trends. There may have been a significant effect of implant

age on QoL outcomes due to the homogeneity of the group in terms of implantation age. These findings are supported by the evidence that the duration of CI use and the participants' chronological age at testing revealed an indirect relationship with total QoL. Studies have shown no correlation between total QoL and the age at which HL was diagnosed or the date of surgery (Warner-Czyz et al., 2009). After CI, all the children, irrespective of the implant age, report an improvement in their QoL. Age, gender, or schooling did not affect reported benefits (Dev et al., 2019). After the first three months of implantation, parent's expectations began to fall (Singh et al., 2015). This study is supported by Byčkova et al. (2018), where according to parents, QoL increases following the CI, particularly in communication, social interactions, and child support.

Almeida et al. (2015) reported that CI enhances the child's QoL from the parent's perspective, particularly self-confidence and social relationships. The study revealed the dimensions of well-being, happiness, and social relations to have a negative association between the auditory category and the effects of the implant domains. However, the authors did not mention the results for each age group. Similar results have been reported by Huttunen et al. (2009). They reported that parents were most pleased with their child's improvement in social relationships, communication, general functioning with the aid of hearing, and self-reliance.

Razafimahefa-Raoelina et al. (2016) reported in their study that CI during the first three years of life improved QoL in children with prelingual hearing loss to levels comparable to the normal-hearing population. They also reported that parents undervalued their child's QoL. According to the data that backs up these conclusions,

QoL scores improved with earlier implantation and more prolonged usage of CI (Loy et al., 2010).

Vermıslı Peker et al. (2020) reported that children with CI had a lower overall QoL and self-esteem, poorer school and social interactions, and mental and physical well-being than healthy children. These results do not agree with the literature (Warner-Czyz et al., 2009). Studies have shown that both older and younger CI users and their parents rated QoL comparable to their normal-hearing peers. (Loy et al., 2010).

Further, several papers offered limited information about a child's experience with CI, the length of follow-up, and the stimulation supplied to each child. It is not easy to draw clear conclusions based on QoL, mainly when QoL instruments are self-reported at a young age. To effectively answer this essential subject, the study design should include highly structured inclusion.

Second, there are only a few reviews on the QoL of pediatric CI patients'. As a result, the gaps in the literature were most apparent in this review when it came to obstacles. Even though a few articles looked at QoL in older children, this review focused on younger children. In particular, CI < 12-36 months was a considerably understudied topic in the literature among CI patients.

Finally, QoL in children with CI varied greatly across various dimensions. Early detection and rehabilitation will improve auditory abilities and a better QoL in younger children. It will also aid the child's integration into schools and provide them with a stable academic environment. If the child's auditory stimulation and surroundings are good, implanting them later (> 24-36 months) will also produce similar results.

Chapter 6

Summary and Conclusions

The present study aimed to conduct a systematic review to determine the effectiveness of early cochlear implantation on quality of life. About 340 research articles were initially selected, and later eight articles were finalized for the systematic review. QoL was measured through questionnaires in all the selected studies. Results showed that early detection and rehabilitation would improve auditory abilities and a better QoL in younger children. If the child's auditory stimulation and environment provide sufficient auditory information, implanting them later (> 24-36 months) will also produce similar results.

5.1 Implication of the Study

The topic effectiveness of early cochlear implantation on quality of life is both understudied and rarely examined qualitatively. This review identified several critical factors concerning the effectiveness of early CI on QoL. Early detection and rehabilitation improved auditory ability and quality of life in younger children. However review also showed that, if the child's auditory stimulation and surroundings provided adequate auditory information, implant at a later age also (> 24-36 months) produced similar outcomes on QoL. Thus, it can be implied from the present systematic review that CI can be recommended at a later age also, provided that the child gets adequate auditory stimulation.

5.2 Limitations of the Study

The limitation of the present systematic review was that it included studies in which the implant was done before the age of three years.

5.3 Future Direction

More studies are required to draw any firm comparisons among the QoL in early CI. To fully comprehend the context and varying levels of effect of CI on QoL, studies with extended follow-up periods may be included. Further, comprehensive studies that explore perceptions and experiences of CI from various groups (gender, ethnicity, social class, and age) may be included in future studies.

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APPENDIX 1

(NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated?			
2. Was the study population clearly specified and defined?			
3. Was the participation rate of eligible persons at least 50%?			
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?			

5. Was a sample size justification, power description, or variance and effect estimates provided?			
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?			
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?			
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?			
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?			
10. Was the exposure(s) assessed more than once over time?			
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study			

participants?			
12. Were the outcome assessors blinded to the exposure status of participants?			
13. Was loss to follow-up after baseline 20% or less?			
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?			

(NIH) Quality Assessment Tool for Case-Control Studies

Criteria	Yes	No	Other (CD, NR, NA)*
1. Was the research question or objective in this paper clearly stated and appropriate?			
2. Was the study population clearly specified and defined?			
3. Did the authors include a sample size justification?			
4. Were controls selected or recruited from the same or similar population that gave rise to the cases (including the same timeframe)?			
5. Were the definitions, inclusion and exclusion criteria, algorithms or processes used to identify or select cases and controls valid, reliable, and implemented consistently across all study participants?			

6. Were the cases clearly defined and differentiated from controls?			
7. If less than 100 percent of eligible cases and/or controls were selected for the study, were the cases and/or controls randomly selected from those eligible?			
8. Was there use of concurrent controls?			
9. Were the investigators able to confirm that the exposure/risk occurred prior to the development of the condition or event that defined a participant as a case?			
10. Were the measures of exposure/risk clearly defined, valid, reliable, and implemented consistently (including the same time period) across all study participants?			
11. Were the assessors of exposure/risk blinded to the case or control status of participants?			
12. Were key potential confounding variables measured and adjusted statistically in the analyses? If matching was used, did the investigators account for matching during study analysis?			