REVIEW

Factors influencing rehabilitation and education in children who have cochlear implants: An integrative review

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ABSTRACT

Background: Several factors might impact the development of auditory, speech, and communication skills as well as academic performance in children with cochlear implants. These factors are important for these children's transition to mainstream education. A lack of understanding among school staff about cochlear implant technology and these children's special needs affects their school performance. Therefore, educational services need to include specialized sessions for nurses and teachers to meet the educational and special needs of these children.

Aim: To explore the factors influencing the rehabilitation and education of children who have cochlear implants and highlight empirical evidence that will guide the development of educational sessions for school nurses and teachers who encounter these students.

Methods: Whittemore and Knafl's framework for integrative review guided this work. An electronic search was conducted using the Cumulative Index to Nursing and Allied Health Literature, MEDLINE, and Academic Search Complete databases. Data was extracted and organized into the individual, interpersonal and organizational, and policy and environmental levels of the Socio-Ecological Model.

Results: The individual-level factors are age at implantation, abnormal inner ear morphology, presence of additional disabilities, and hours of daily device use. The interpersonal and organizational factors include lower socioeconomic status, support within the family, and lack of experts at mainstream schools. The policy and environmental level factors are a failure in implementing hearing screening programs, lack of community awareness, and lack of clear education policies within the schools.

Conclusions: Children face challenges at schools due to a lack of experts who are familiar with the needs of children with cochlear implants. To realize the children's needs and provide proper educational support by school staff, teaching and training sessions need to be.

Key Words: Cochlear implant, Children, Rehabilitation, Education, Schools

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1. INTRODUCTION

Hearing loss is a global health issue as it is the fourth leading cause of disability worldwide.[1] According to the World Health Organization,[1] about 466 million people have complained of hearing loss. The WHO[1] also estimated that 34 million of this population are children and 32 million are adults. Schmucker et al.[2] defined hearing loss as "hearing loss greater than 40 dB hearing levels (dB HL) in the better hearing ear in adults and greater than 30 dB HL in the better hearing ear in children." (p. 2) Hearing loss is one of the most significant disabilities affecting children medically, socially, and academically.[3] When hearing loss is detected at an earlier stage, intervention and management depend on the severity of hearing loss. If the severity of the hearing loss is mild, moderate, or severe sensorineural hearing loss (SNHL), the child will be fitted with hearing aids; however, if a child is diagnosed with severe to profound SNHL, the child will be a candidate for a cochlear implant.[4]

Cochlear implant technology is the main method of choice to treat children born with severe to profound SNHL, especially those who gain minimal benefits from the use of hearing aids.[5] In severe to profound SNHL, the hair cells within the inner ear are damaged and cannot effectively detect surrounding sounds.[6] A cochlear implant replaces these damaged hair cells and sends electrical signals throughout the brain, which are translated as sound.[5] Since 1981, over 550,000 people around the world have received cochlear implants.[7] According to the National Institute on Deafness and Other Communication Disorders,[8] around 65,000 children in the United States have had cochlear implants. These implants provide positive outcomes for children with hearing loss. These outcomes include a positive impact on rehabilitation and auditory-verbal therapy training, such as improving speech perception, speech production, and reading skills, especially for school-aged children.[9] Magro et al.[10] stated that a cochlear implant is a highly effective and expensive device. To reduce the cost of the device, which is a burden on the government and families, education and awareness are key in bringing community attention to the importance of cochlear implant devices and their value for patients.[10]

2. METHODOLOGY

Whittemore and Knafl's[11] integrative review framework will guide this review. This framework includes five stages: problem identification, literature search, data evaluation, data analysis, and presentation of the results. This integrative review is guided by a clear problem: A lack of understanding among school nurses and teachers about cochlear implants and the needs of children with cochlear implants negatively affects these children's school performance.

2.1 Literature search

In this integrative review, an electronic search was conducted using Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, and Academic Search Complete databases. The keywords used to conduct this search were *"cochlear implant*," pediatric*, paediatric*, child*, rehab*, therapy, educat*,* and *school*. The Boolean operators AND and OR were used to narrow or broaden the search. The inclusion criteria were (a) peer-reviewed articles, (b) articles published between 2011 and 2021, (c) articles written in English, (d) articles that focused on children, (e) primary research studies, (f) qualitative, quantitative, and mix methods studies, and (g) studies focused on factors influencing rehabilitation and education of children with cochlear implants. The initial search generated 509 articles.

2.2 Data evaluation

The 509 articles were evaluated for inclusion in this review. Eighty-five duplicated articles were removed using Covidence Systematic Review Software. After applying limiters, inclusion criteria, and exclusion criteria to the remaining 424 articles, 91 articles remained for possible inclusion. After reviewing the titles and abstracts, 72 articles were excluded as they were not relevant to this integrative review. The full text of the 19 remaining articles was reviewed, and six articles were excluded because they did not discuss factors influencing rehabilitation and education of children with cochlear implants. A hand search was also conducted among the reference lists of the remaining peer-reviewed articles. The overall search revealed 13 articles that were appropriate for inclusion in this review. The Mixed Method Appraisal Tool (MMAT) version 2018 was used to evaluate the various methodologies of the 13 articles. The critical appraisal of the 13 articles demonstrated that all studies met the MMAT criteria with the consensus of a second reviewer.

2.3 Data analysis

The data analysis stage consists of several steps: data reduction, data display, data comparison, and conclusion drawing and verification.[11] In the data reduction step, the main source is condensed to a single page containing comparable data extracted from individual sources following "subgroup classification." (p. 550)[11] For this integrative review, an extraction table was developed to analyze and summarize the results of the included articles. In the data display step, the extracted data from primary sources are usually transformed into certain factors or subgroups.[11] For this review, the data was categorized into positive and negative factors that affect the rehabilitation and education of children with cochlear implants.

Through the data comparison step, patterns, themes, or relationships are developed from the primary sources.[11] After patterns begin to emerge, a conceptual map that contains most of the variables or themes can be produced by grouping similar variables together.[11] The Socio-Ecological Model (SEM) was used in the data comparison stage in this review to guide the finding of intervening factors affecting the rehabilitation and education of children with cochlear implants. According to Golden et al.,[12] the SEM provides "visual depictions of dynamic relationships among individuals, groups, and their environments." (p. 9S) In health promotion, ecological models are used to analyze and select goals for both general and specific health behavior interventions on individual, organizational, policy, and environmental levels.[12]

In the conclusion drawing and verification step, each subgroup database is gradually developed to identify similarities and differences.[11] After each subgroup analysis has been completed, key components or findings from each subgroup are combined into an integrated summary of the issue, which indicates that the review process has been completed.[11] For this integrative review, the main themes have been developed at the individual, interpersonal and organizational, and policy and environmental levels of the SEM (see Figure 1).

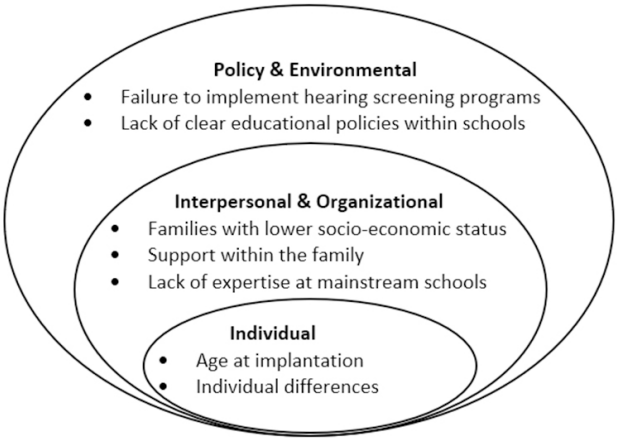

Figure 1. The primary themes at each level of SEM

3. RESULTS

The 13 articles included in this review were primary studies published between 2011 and 2021. Three of these studies were conducted in the Middle East: Turkey (n = 1) and Iran (n = 2). The other studies were conducted in different parts of the world: India (n = 2), China (n = 1), Malaysia (n = 1), Taiwan (n = 1), USA (n = 2), Australia (n = 1), Italy (n = 1), and South Africa (n = 1). The 13 studies included quantitative (n = 12) and qualitative (n = 1) designs. The 12 quantitative studies included cross-sectional, longitudinal, exploratory retrospective, descriptive cross-sectional trial, retrospective observational, cross-sectional observational, and observational cohort study designs. The qualitative study followed a phenomenological, non-experimental research design. The results of the 13 studies will be presented thematically, following the individual, interpersonal and organizational, and policy and environmental levels of the SEM.

3.1 Individual level factors

3.1.1 *Age at implantation*

Age at cochlear implantation was shown to be one of the main factors that influence auditory and language development. Cochlear implantation before three years of age is associated with age-appropriate speech and language development for children with severe to profound SNHL. Swami et al.[13] found that children with less than three years of auditory deprivation had good and significant outcome measures in the Meaningful Auditory Integration Scale (MAIS) and Meaningful Use of Speech Scale (MUSS). These children were also admitted to mainstream schools. Fan et al.[14] found that the test and evaluation of the recognition rate of closed monosyllables and disyllables were higher in children who had cochlear implantation at a younger age. The same researchers used the Category of Auditory Performance (CAP) and the Speech Intelligibility Rating (SIR) to evaluate the children's performance; the results showed that children with lower ages at cochlear implantation had a significantly higher results in both tests.

3.1.2 *Individual differences*

(1) Abnormal inner ear morphology

Abnormal inner ear morphology was assessed in several studies and found to be one of the factors negatively affecting auditory skills, speech and language, and educational outcomes of deaf children with cochlear implants. Inner ear malformation, such as eighth nerve hypoplasia, Mondini dysplasia, and labyrinthitis ossificans, could limit the auditory and spoken language outcomes of children with cochlear implants.[13,15,16] Swami et al.'s[13] study results showed a significant correlation between abnormal inner ear cochlear morphology and low scores in auditory response and speech perception. Inner ear malformation was noted in their study as being associated with poor language and speech outcomes.

(2) Presence of additional disability

The presence of other disabilities in addition to hearing loss in children with cochlear implants makes their progress complex and challenging. Two articles in this integrative review revealed that the presence of cognitive delay affects outcomes in terms of speech, language, and communication development.[16,17] Chu et al.[17] reported a significant relationship between cognitive function delay or disability and getting a low score on the receptive and expressive preschool language

scale (PLS) test in their six participants with cognitive delay. Nicastri et al.[16] highlighted the importance of aspects of cognitive function skills: flexibility, working memory, and inhibition of auditory and language processing. They noted that children with cognitive delays' learning ability, communication, and social interaction might influence and limit the benefits of cochlear implants, even with early implantation.

(3) Daily hours of cochlear implant device use

Children's performance after cochlear implantation might be affected positively or negatively by the length of daily device use.[13, 18, 19] Daily use of the devices helps children to participate in their home and school environments and improves their auditory function skills. The more hours spent using cochlear implant devices provides a greater opportunity for children to learn language and get the maximum benefit of the devices. However, Bayguzina et al.[18] found that recurrent malfunctioning of cochlear implant devices led to fewer hours of device use, which negatively impacted the auditory and language development of children. Similar results were reported by Wang et al.[19] They found a significant relationship between fewer hours of daily use of cochlear implant devices and delay in the development of auditory outcomes.

3.2 Interpersonal and organizational level factors

3.2.1 *Families with lower socio-economic status*

Family socioeconomic status (SES) was found to be one of the significant factors that influence the social and educational performance of children with cochlear implants.[17, 20–22] There is a direct relationship between SES and improving speech and language to the level needed to acquire the oral language ability that enables children to attend mainstream schools. Research findings show that children in families with lower SES are not able to achieve results similar to the positive results achieved by children of families with higher SES[18] due to poor family income, lower parental education level, and limited knowledge of parents.[22]

(1) Lower or poor family income

Lower or poor income are considered healthcare barriers as they affect the hearing outcomes and speech progress of children within low- or poor-income families. Family income plays an important role in access to care, diagnosis, use of amplification, cochlear implantation, and rehabilitation services.[18, 20, 22] Noblitt et al.'s[20] study found that only 10% of children from rural residences with a low household income had access to speech therapy services as opposed to 42% of urban children. The findings from the same study also showed that 67% of families with lower SES complained about the lack of local speech services as opposed to 22% of families with higher SES. A study by Sharma et al.[22] found that there was a significant correlation between the speech intelligibility rating (SIR) test and annual family incomes. They found that annual family incomes of more than $15,000 were associated with greater speech intelligibility in real-life situations among children compared to annual incomes between $7,500 and $15,000. In addition, Bayguzina et al.[18] found that the needs of families with lower incomes were higher than the needs of families with higher incomes.

(2) Lower parental education level

Another barrier that impacts the performance of children with cochlear implants is lower parental education level. Education levels of parents have been linked to their knowledge of rehabilitation programs and the capacity to help their deaf children in the home.[14, 18, 20, 22–24] Yoshinaga-Itano et al.[24] found that parental level of education has a direct impact on children's language development. These researchers reported that children of parents with a higher level of education had a significantly higher score on the assessed language measures: the Child Development Inventory (CDI) and the MacArther-Betes Communicative Development Inventories (Mac-CDI).

3.2.2 *Support within the family*

Support within the family is reported to be one of the more significant barriers that delay diagnosis and rehabilitation of children with hearing disabilities. Lack of family support can be due to a denial of a child's hearing loss[25] or a lower level of involvement in family activities by a child with hearing loss.[17] All participants in Moroe and Kathrada's[25] study noted that their families had conflicting attitudes about the issue. One of the mothers in their study stated that "they didn't want to accept the hearing loss or the cochlear implants. They gave support after a long long time." (p. 127) Another participant revealed that "they said that there is no one in their family who is disabled. And so they blamed my daughter. But we had hope and we could see changes after cochlears. So their denial was their own." (p. 127)

3.2.3 *Lack of expertise at mainstream schools*

Lack of expertise at mainstream schools is another barrier that restricts the educational achievement of children with cochlear implants. Goh et al.[15] stated that education was the most significant factor after implantation for parents in their study. These parents assumed that the effectiveness and success of cochlear implantation may be evaluated by a child's ability to attend mainstream school. However, in Moroe and Kathrada's[25] study, all parents and caregivers reported the difficulties they had in locating a school for their children. They also reported that many schools rejected them because of the schools' lack of expertise and poor understanding of cochlear implants.

3.3 Policy and environment level factors

The policy and environment level is the outer layer of the SEM, which includes local, state, and national laws and regulations that affect health practices. According to Olaniyan et al.,[26] access to healthcare services, consumption of healthcare services, and the adoption of healthy habits are all influenced by the policies that govern them. In this integrative review, only three studies reported barriers related to the policy and environment level in the SEM. The barriers at this level were found to be a failure in hearing screening program implementation, lack of community awareness,[14,23] and lack of clear education policies within schools.[25] Fan et al.[14] stated that some children in their study were discovered and diagnosed late due to the late implementation of hearing screening guidelines.

4. DISCUSSION

4.1 Individual level

4.1.1 *Age at implantation*

Many studies have shown that early age at implantation leads to better outcomes for children in terms of speech and language performance. Black et al.[27] have observed that the later the cochlear implantation, the poorer the development of receptive and expressive language scores. This suggests that children who are implanted at a younger age are more likely to have higher receptive and expressive language scores. Similarly, a recent study by Scarabello et al.[28] found that there was a significant correlation between younger age at implantation and better speech perception and expression of vocabulary. Further work by Choo et al.[29] asserted that early diagnosis and implantation allows children to perform similarly to normal hearing children in terms of auditory performance and attendance at mainstream schools. However, these positive impacts may be affected by the presence of additional disabilities or inner ear malformation.

4.1.2 *Individual differences*

(1) Abnormal inner ear morphology

Inner ear malformation has been significantly associated with lower receptive and expressive language scores.[27,30,31] This finding was supported by Shi et al.[32] They found that auditory and speech performance was significantly poor among 13 patients with cochlear common cavity deformity and 43 with cochlear nerve deficiency. The above results indicate that the auditory and speech development of patients with inner ear malformation is lower when compared to cochlear implant patients with normal inner ear structure. Children with abnormal inner ear morphology have been proven to have similar outcomes to children with additional disabilities.

(2) Presence of additional disability

According to Soman et al.,[10] the presence of an additional disability may negatively impact the appropriate age development of listening and spoken language abilities and educational performance even with early intervention. Cupples et al.[33] confirmed that children who have cochlear implants with additional disabilities have shown speech delay and lower scores across all outcome measures including the pre-school language scale (PLS) receptive and expressive language. The results of these studies suggest that the individual needs of each child need to be considered to provide the best rehabilitation and education services.

(3) Daily hours of cochlear implant device use

The maximum hours of daily device use are associated with successful auditory access to spoken language. The daily use of a device enhances auditory skills and later leads to an increase in the language input of the cochlear implant user.[34,35] Several studies have found that children with cochlear implants who wear their devices more hours per day have higher auditory skills, speech recognition abilities, and expressive and receptive language outcomes as compared to those who use their devices less frequently.[34,35] Additionally, daily cochlear implant use has been found to be an important factor that contributes to improvement in children's communication skills as well as their social and academic performance. de Jong et al.[34] found that 59% of the participants in their study who wore their devices for more than eight hours per day performed higher than children who wore them between two to eight hours. Contrera et al.'s[36] study found that reasons for inconsistent device use include the user not getting benefit from the device, negative feedback from peers, and transmitter coil-offs of the external device. These findings may help clinicians understand the reasons behind the irregular use of the devices.

4.2 Interpersonal and organizational level

4.2.1 *Families with lower socio-economic status*

All studies included in this integrative literature review emphasize the importance of SES. This status greatly influences children's outcomes post-implantation. A study by Panda et al.[37] showed that poor income and low educational level of parents were significantly associated with poor understanding of speech and poor auditory functions as measured by CAP scores. As well, the low educational level of parents in their study was associated with poor speech acquisition as measured by SIR scores. Parents play an important role in helping their children with implants achieve positive outcomes. A higher level of parental education is associated positively with higher expressive and receptive language skills,[38] higher integration into mainstream schools,[39] longer daily use of cochlear implant devices,[34] and higher communication and language input from parents

at home.[40]

4.2.2 *Support within the family*

Lack of support within the family makes the experience with cochlear implants more challenging for parents and children. Parents of children with cochlear implants may experience higher levels of fear, stress, and anxiety due to absence of support.[41] This will negatively impact parents' involvement in their children's rehabilitation.[41,42] Punch & Hyde[41] stated that presence of family support enhances parents' self-esteem and confidence, which positively impacts their engagement with their children.

Everyday interaction between parents and children is important for language development. Findings from a study by DesJardin et al.[43] highlighted the importance of engaging a child in literacy activities at home, such as reading books. They reported that the improvement of children's literacy capabilities was strongly affected by exposure to routine home literacy activities. The home environment and more interaction between a child and their family members facilitate the development of spoken language and social skills. Davenport and Holt[44] reported that more interaction between parents and children is associated with positive language, psychosocial, and executive function skills. These skills are essential for school-aged children and the academic success of children with cochlear implants.

4.2.3 *Lack of expertise at mainstream schools*

To maintain and support children with cochlear implants' academic achievement, lack of expertise at mainstream schools must be addressed. Finding a school with experienced teachers who can deal with students with cochlear implants is a challenge for the family.[42] Studies have shown that teachers find cochlear implant devices to be complex technologies that cochlear implant clinics do not provide enough information and guidance about to support them in their work.[42,45,46] Parents, teachers, and healthcare professionals working with children with cochlear implants should collaborate to improve teachers' understanding of cochlear implantation and meet the needs of children at schools.

4.3 Policy and environment level

The main themes found at the policy and environment level in this review are failure to implement hearing screening programs and lack of clear educational policies within schools. To overcome these barriers, several studies have identified some of the primary reasons that influence the implementation of newborn hearing screening services. Petrocchi-Bartal and Khoza-Shangase's[47] study found that newborn hearing screening was not implemented successfully in South Africa due to lack of equipment, lack of budget, lack of staff training, and shortage of staff. In contrast to Petrocchi-Bartal and Khoza-Shangase's[47] study, Cunningham et al.[48] investigated the reasons for not following-up on infants who had missed the screening or did not pass the newborn hearing test. These researchers found that lower educational levels, being teenaged, smoking, rescreening fee, lack of health insurance, and living in rural areas were the main reasons for failure to follow-up on a hearing screening program.

The lack of clear educational policies within schools negatively impacts the academic achievement of students with cochlear implants. According to Alegre de la Rosa and Villar Angulo,[49] policies related to the educational placement of children with cochlear implants in mainstream schools are unclear. Some studies have addressed the importance of implementing educational policies and providing qualified educational programs to train teachers dealing with students who have cochlear implants in the classroom.[49,50] Davenport and Alber-Morgan[50] asserted that even though "cochlear implant technology is advancing rapidly, there is still a lack of capacity at the school level in meeting the needs of children using these devices." (p. 42) Therefore, having clear educational policies is important to support children with cochlear implants in enhancing their language and promoting communication, social skills, and emotional and educational performance within the school environment.

5. Conclusion

To ensure the maximum benefit of cochlear implants, school nurses and teachers need to be experts in dealing with children with cochlear implants in schools. The findings of this integrative review show that children face challenges at school due to a lack of experts who are familiar with the needs of children with cochlear implant technology. To realize the children's needs and provide proper educational support by school staff, this integrative review recommends developing teaching and training sessions for school nurses and teachers. These sessions will maintain the rehabilitation and educational progress of children in the classroom. In addition, these sessions will enhance the collaboration and communication between the school, the parents, and the cochlear implant clinics.

Conflicts of Interest Disclosure

The authors declare no conflicts of interest.

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