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Paediatric cochlear implant recipients in SAARC countries-Demographics and outcomes

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Abstract
Introduction: The goals of this study were to provide insights on the demographics and status of paediatric cochlear implant (CI) recipients (age range: 0–12 years) three SAARC countries: India, Bangladesh, and Nepal, and to identify and compare quality indicators for early intervention in reference to JCIH 2019.
Methods: 881 pediatric cochlear implant recipients across 25 clinics were included in this study. The data were collected between January 2015 and July 2016. We assessed demographic parameters, educational attainment, hearing history and surgery, the trajectory of rehabilitation, and receptive and expressive language abilities.
Results: Among the findings, we observed that children tended to have a late age at implantation. A sizeable proportion of children had additional needs, which complicates their rehabilitative and educational progress. Bilingual households were surprisingly rare in the study cohort, given the multilingual environments of the three countries involved. In such cases, the second language tended to be English.
Conclusion: These findings show the unique environmental, linguistic, and medical challenges that exist for pediatric CI use in India, Bangladesh, and Nepal. We hope that this study may help shape audiological practise and policy decision-making in these three countries.

Keywords: Children, cochlear implant, SAARC, demographics

Introduction

India is one of the signatories of the intergovernmental organisation and geopolitical union of the South Asian Association for Regional Cooperation (SAARC) in South Asia, which also includes Afghanistan, Bangladesh, Bhutan, Nepal, the Maldives, Pakistan, and Sri Lanka. Problems like large populations, poor economies, poverty, inadequate access to healthcare, and internal/external conflicts are common among the SAARC countries. These problems can have a significant impact on the lives of large portions of the population, and even more so for people with disabilities (Mobility India, 2014) [24]. To reduce the impact of these issues on people with disabilities, the governments of these countries designated 1993 as the 'SAARC Year of Disabled Persons' and, since then, efforts have been made to improve their quality of life.

According to the census that was released by the Government of India in 2011, approximately 26.8 million people (2.21% of the 1.2-billion population) are affected by a hearing or sight impairment, have difficulties speaking and communicating, or have a physical disability or intellectual disability or mental illness or multiple disabilities. 19% of this entire group of people (i.e., 5 million people approximately) have a hearing impairment (20% within the age group 0-19 years; 23% within the age group 0–6 years) (Ministry of Statistics and Programme Implementation, 2017; Office of the Registrar General and Census Commissioner, 2013). In Nepal, the National Population and Housing Census 2011 showed that approximately 2% of the total population (Over 500,000 people) are also affected by one or more of these disabilities, with hearing impairment accounting for 15.4% of all the reported cases. Of the 92,012 children with a disability, 31.3% (28,800) have some form of hearing impairment with 6% of these children aged 0–4 years, 11.5% aged 5–9 years, and 13.8% aged 10–14 years (Central Bureau of Statistics, 2012; Central Bureau of Statistics, 2014) [12, 13]. The Bangladesh Bureau of Statistics (2014) [9], based on the Population and Housing Census 2011, reported that around 2 million people (1% of the population) have a disability (Speech, sight, hearing, physical, or intellectual).

Among this group, 180,000 people (9%) have a hearing impairment, of which 12% are 5–14 years old and approximately 2% are 0-4 years old.

Cochlear implantation has become a preferred choice of hearing restoration and audio-logical management in children with severe to profound hearing loss. Post implantation, children with profound hearing loss have shown a marked increase in auditory perception (Kirk *et al*. 2000) [20] and undergo accelerated development in their speech production skills compared to their hearing aid (HA) peers and compared to their peers who did not receive a cochlear implant (CI) when implantation occurred at a young age (Sharma *et al*. 2002; Tait *et al*. 2007; Geers and Nikolous 2013) [28, 30, 18]. Expressive and receptive language abilities have been shown to increase over time as paediatric CI users gain experience using their devices (Montag *et al*. 2014) [22]. An improvement in vocabulary acquisition and syntax development has been observed (Geers *et al*. 2003) [17], along with a higher proportion of children reaching the same linguistic abilities as their peers with normal hearing (NH) in comparison to children with HAs (Boothroyd *et al*. 1991) [11].

In recent years, there has been a marked increase in the number of paediatric CI recipients and CI programs in India, Bangladesh, and Nepal. Due to the absence of a National Registry of CI recipients, professionals working with CIs in these countries estimate that there are approximately 200 paediatric CI recipients in Bangladesh (across 2 CI programs), between 15,000 and 20,000 in India (Chundu *et al*. 2014) [15], and around 150 in Nepal (1 CI program). Jeyaraman (2013) [31] estimated that in India, 19% of the paediatric CI recipients were 0–2 years old, 47.5% were 2–5 years old, 22.5% were 5–7 years old, and 11% were 7–12 years old.

Even though the estimates show that these three SAARC countries have a sizeable number of paediatric CI recipients, studies on demographics and the outcomes of paediatric CI provision are fewer and/or limited in sample size because most of the studies were only conducted at specific centres or regions (Basheeth *et al*. 2006; Swami *et al*. 2013) [10, 29]. The lack of such demographic information hinders policymakers and professionals in these SAARC countries from designing effective and efficient solutions to problems that are related to rehabilitation of hearing impairment post cochlear implants. The infrastructure and processes are not in place that support the exchange of best clinical practices between colleagues and professional peers and that are necessary for making modifications to the schemes or service delivery models that are unique to the needs of each specific SAARC country to be met.

In 2019, the Joint Committee of Infant Hearing (JCIH) identified individualised family service plans signed by the parents within 41 days of the diagnosis as quality indicators for late identified children with hearing loss and first developmental assessment carried out at no later than 12 months for infants diagnosed as deaf or hard of hearing as quality indicators for an intervention program. Therefore, the study presented here had two aims: (1) to provide insight to the demographics and status of paediatric CI recipients (age range: 0–12 years) across the three SAARC countries, India, Bangladesh, and Nepal; (2) to identify and compare quality indicators for early intervention in reference to JCIH 2019.

Materials and Methods

The following tools, which were all designed to be independent of the language in which they are used, were chosen for this study because they are suitable to the CI recipients' multilingual background in the three SAARC countries, India, Nepal, and Bangladesh:

a) The Communication DEALL (ComDEALL) Development Checklist. This is a standardised developmental checklist used in India to assess receptive language; expressive language; the gross, fine, and oro-motor skills used in daily life; and the cognitive, social, and emotional skills of children aged 0–6 years (Karanth 2007) [19].
b) Categories of Auditory Performance (CAP) (Archbold *et al*. 1995) [1].
c) Speech Intelligibility Rating (SIR) (Allen *et al*. 2001).
d) The American Speech and Hearing Association's Your Child's Communication Development: Kindergarten through Fifth Grade. (https://www.asha.org/public/speech/development/communicationdevelopment/). Reading and writing subheadings were used for this study.
e) Auditory Speech Language (AuSpLan) communication categories (McClatchie & Therres 2005). This is an informal assessment tool widely used to predict outcome levels based on three components: (i) pre-implantation CI candidacy, (ii) pre-educational and support services, and (iii) auditory, and speech and language goals. There are three possible outcomes for AuSpLan: (A) 'auditory verbal/oral communicator', (B) 'auditory oral/verbal communicator with a visual assist that is not sign language', or (C) 'auditory oral/verbal skills assist primary visual communication'. These outcomes were estimated postoperatively in the study presented here and not preoperatively due to the lack of reports on the preoperative communication skills of the study cohort in the three SAARC countries.
f) Background of the CI recipients: (i) hearing history, and aspects of surgery, rehabilitation and aided hearing performance since receiving a CI and other hearing devices, i.e., the cause of hearing loss; date of the surgery; switch-on date; hearing aid usage prior to CI usage; usefulness of hearing aid usage; which ear was implanted with the CI; bilateral or unilateral implantation; bimodal and frequency modulation (FM) device usage; (ii) language usage and proficiency, i.e., language spoken by the mother, the father, and other family members of significance to the child, and the language spoken during hearing rehabilitation; (iii) educational history, i.e., grade at school and the primary language for instruction at school; and (iv) associated conditions that were obtained from clinical records.

These language tools were administered by three MED-EL clinical specialists, who travelled between India, Nepal, and Bangladesh to visit the clinics. Assessment was done during one-on-one interviews with the recipients and their families. Each assessment took approximately 1 hour.

The data of 955 paediatric recipients of a MED-EL CI were collected from 25 clinics (see Appendix 1) across the three countries; 57 CI recipients were excluded from the data analysis because they were implanted after their 12th birthday. Data collection occurred between January 2015 and July 2016.

Results

The data of 881 paediatric CI recipients who were of an age < 144 months, i.e., < 12 years, at the time of implantation were analysed in this study; 57% (*n* = 503) were males and 43% (*n* = 378) were females. At the time of reviewing their records, the children's mean chronological age was 69.3 months (range: 15–216 months), mean hearing age was 17.8 months (range: 0–154 months), and the mean of age at implantation was 52.1 months (range: 11–144 months).

A stratification by age at implantation of the 881 CI recipients is shown in Table 1.

Cause of hearing loss (n = 796; missing entries = 85)

According to clinical records, the most frequent cause of hearing loss was congenital (545 recipients), followed by Cytomegalovirus (CMV) or Rubella (147 recipients); unknown (64 recipients); consanguinity, hereditary, and neonatal conditions and infections (7 recipients); meningitis or seizures (12 recipients); Waardenburg syndrome (5 recipients); prenatal conditions, structural deformities, trauma, or acquired hearing loss (14 recipients); and dyssynchrony, progressive loss, and ototoxicity (2 recipients).

Hearing aid usage (n = 808; missing entries = 73)

435 of the 881 CI recipients (49%) did not use a hearing aid prior to cochlear implantation; the information on hearing aid usage was missing for 73 recipients (8%). The remaining 373 of the 881 CI recipients (42%) used a hearing aid over a period of 1 month to 10 years (mean: 18.2 months), of whom almost all (370 recipients) used a hearing aid for 1 year or less. Four children received amplification within 3 months after birth. Within the hearing aid usage group (i.e., the 373 recipients), the benefit of using a hearing aid was also considered. This information was missing for 32 of the 373 recipients (8%); 141 (38%) received no benefit or auditory awareness from the hearing aid, 156 (41%) gained awareness of loud sounds, 28 (7%) gained awareness of conversational speech, and 16 (4%) obtained benefit at the level of auditory discrimination at least with the hearing aid.

Bilateral vs unilateral hearing systems (n = 866; 15 missing entries)

856 CI recipients were unilaterally implanted, of whom 105 recipients (12%) were implanted in the left ear and 751 (ca. 88%) were implanted in the right ear. Ten, i.e., ca. 1% of the 866 records reviewed, were bilaterally implanted. Data on sequential or simultaneous bilateral implantation was not collected. There was no data available for 15 recipients, ca. 2% of the 866 records reviewed.

In the group of unilateral CI recipients, we were interested in the group's history of hearing aid usage and whether benefit could be derived from their hearing aid. Out of the 856 unilateral CI recipients, there were only 3 recipients for whom no information on hearing aid usage and benefit was available. Sixteen recipients were bimodal users – they used a hearing aid on the non-implanted side. Their records showed that benefit (at least sound discrimination) could be derived from their hearing aid before they underwent cochlear implantation. Only 47 (0.8%) wore a hearing aid on the non-implanted side. None of the recipients reported the use of an FM device together with a CI.

Attendance in an auditory rehabilitation programme (n = 572; 309 missing entries)

99 of the 881 CI recipients (11%) had < 50% attendance in auditory rehabilitation sessions. Three recipients did not attend any sessions at their implant centre. The minimum percentage of attendance amongst children with CAP score 5 was 10% and amongst children with CAP score 6 was 66%. There was no data available on recipients who had CAP score 7. For 309 recipients (35% of the 881 recipients whose records were analysed in this study), there was no data available on their auditory rehabilitation history.

Communication categories based on AuSpLan (n = 772 of whom 13 could not be tested; 109 missing entries, 13 could not be tested)

Categorisation of communication skills were available for 759 recipients; the records of the remaining 13 recipients stated that they could not be tested. 207 of the 759 recipients who were tested (27%) fell in the category 'auditory oral/verbal communicator' (category A); 457 (60%) in 'auditory/oral verbal communicator with visual assist but not sign language' (category B); 95 (12.5%) in 'auditory oral/verbal skills assist primary visual communication' (category C). Seven recipients who fell in category C were recommended for assessment of the Picture Exchange Communication Systems or other Alternative and Augmentative Communication Systems. Data for 109 recipients was not available.

Figure 2 shows the percentage distribution of the paediatric CI recipients across the three communication categories of the AuSpLan (A, B, and C), stratified across four ranges in age at implantation.

Parental preferences for monolingual or bilingual rehabilitation (n = 873; 8 missing entries)

1. Monolingual homes

842 recipients (96%) had families where the parents shared the same native language and used that language at home. Of those 842 families, 797 preferred monolingual rehabilitation (779 in the parents' shared native language and 18 in the local community's majority language) and 28 preferred bilingual rehabilitation (the parents' shared native language and English). There were 8 missing entries for home/native language and 8 missing entries for the language used during rehabilitation sessions.

2. Bilingual homes

Thirty-one recipients (3.5%) had families in which the parents used more than one language at home and some parents were bilingual themselves. Twenty-five of these families (80% of the 31 families) preferred bilingual rehabilitation: 23 recipients received rehabilitation in one of the parents' native languages along with English and there was one recipient who received rehabilitation in both parents' respective native languages. Six families (18% of 31 families) preferred monolingual rehabilitation: 5 recipients preferred rehabilitation in one of the parents' native languages or in a community language, and the remaining one recipient was rehabilitated in English only.

3. Homes in which the parent (s) were severely hard of hearing

The parents of two CI recipients were severely hard of hearing and used sign language. The children received monolingual rehabilitation in a spoken language with no support offered in sign language.

School placement (n = 595; 200 entries were missing; 86 children with a chronological age <below 3 years)

1. **267 recipients were aged between 3 to 5 years. Within this group**

- 102 had records where the information on school placement was not available: for one recipient, the information was missing
- 15 did not attend any form of formal schooling
- 1 was home schooled
- 9 attended "regional + English" dual-medium schools, i.e., the primary language of instruction was a regional language with most of the content delivered in this language, and the secondary language of instruction was English
- 6 attended "English + regional" dual-medium schools, i.e., the primary language of instruction was English, and the secondary language of instruction was a regional language
- 120 attended "regional only"-medium schools
- 14 attended "English only"-medium schools

2. **528 children were aged between 5 and 18 years. Within this group**

- 98 had records where this information was missing
- 1 attended private tuition
- 1 recipient required instruction in sign language
- 5 not attending any kind of formal schooling
- 29 attended "regional + English" dual-medium schools
- 333 attended "regional only"-medium schools
- 46 attended "English only"-medium schools
- 15 attended "English + regional" dual-medium schools

Grade level literacy skills (n = 620; missing entries = 260 could not be tested)

The grade level literacy skills of the CI recipients were assessed with the literacy development checklist and were plotted against their respective 'chronological age- based academic grades' in reference to an article published in a website (urbanPro, 2011) [27].

While analysing the data on reading level and writing level, no statistically significant difference was found between the two levels. Hence, the data on reading and writing levels were clubbed and the data was analysed as literacy level.

Nursery to primary school group (chronological age 30-125 months)

- 799 fall in the "nursery to primary school group
- One recipient could not be tested in class 1 and the reason was not stated in their records
- 238 had records where information was missing
- 128 were sub-grouped as 'Not applicable' for literacy level analysis by the test administrators or rehabilitation professional
- 173 did not attend school in this group
- 258 were analysed for grade level literacy skills (Figure 3)

Middle school, high school, and college group (chronological age of 126-221 months)

- *2 recipients who fit the chronological age criteria to attend college (i.e. 209-221 months) are in literacy 10
- *3 recipients who fit the chronological age criteria of high school (i.e 186-209 months) are in middle school
- *25–100% of recipients who fit the chronological age criteria to attend middle school classes (i.e., 126-185 months) are attending classes more than one grade below
- *the total number of recipients in the middle school group is 4-12
- *8, 4, and 6 recipients' literacy levels were missing in class 6, 7, and 8, respectively, and literacy levels for one recipient were missing in both class 9 and in class 10
- *The percentage of recipients whose literacy development is in progress increased from 17% at 23 months post-implantation to 88% at 72–95 months post-implantation and then decreases gradually to 87%, 67%, and 50% at 96–119 months, 120–143 months, and 144–167 months post-implantation, respectively
- The percentage of 'not applicable' for school is 17%, 20%, and 12% at 0–23 months, 24–47 months, and 48–59 months, and then remains at 0% the percentage of recipients who had not acquired any literacy skills sharply declined from 25% to 3% at 0–23 months and 24–47 months and remained 0% for all implant age groups.

Receptive language skills (n = 612; 286 missing entries)

The language ages of the CI recipients aged 0–72 months, which were assessed with the ComDEALL checklist, were plotted against their respective chronological ages in ranges in Figure 4.

Expressive language skills (n = 644; 254 missing entries)

The expressive language age ranges of the CI recipients aged 0-72 months, which were assessed with the ComDEALL checklist, were plotted against their respective chronological age ranges, and are shown in Figure 5.

Auditory Perception Skills (n=763; missing entries= 118)

The auditory perception skills of the CI recipients were determined using the Categories of Auditory Performance (CAP) rating scale. The recipients' raw CAP scores were plotted across (1) their hearing age (see Figure 6): CAP score 1-4, indicate the recipients' auditory perception skill is between awareness and discrimination stages, whereas 5, 6, and 7 indicate auditory perception skill between phrase identification and sentence comprehension while using telephone; (2) The recipients' communication categories of the AuSpLan (for description see results section 3.5) across their categorised age at implantation groups (see Figure 7); (3) the recipients' communication categories across their categorised implant age groups (see Figure 8); (4) the recipients' cognitive skill age group (see Figure 9).

Speech intelligibility (N = 762, missing data = 136)

The speech intelligibility skills of the CI recipients were determined using the Speech Intelligibility Rating (SIR) scale: score 1 indicates poor intelligibility of speech, whereas score 5 indicates intelligible speech. SIR score was plotted on age at implantation (Figure 10), the communication categories of the AuSpLan (Figure 11), and hearing age (Figure 12).

Quality indicator for outcomes

The data of paediatric CI recipients who achieved a CAP score of 5, 6, and 7 were grouped together (*n* = 90) and analysed to report the quality indicators for good outcomes. Seven percent (*n* = 34) of the 472 recipients who had attendance records, achieved these scores during the review process of this study and 3% (*n* = 15) achieved SIR scores 4 or 5.

The minimum percentage of attendance at rehabilitation sessions for this group was 10% and 82 recipients were identified who only attended 10% of their scheduled rehabilitation sessions; that was the lowest attendance rate found from reviewing the study cohort's records. The average percentage of attendance was 74% and 82 recipients were identified who attended 74% of their scheduled rehabilitation sessions.

Discussion

Outcomes of cochlear implantation are affected by a number of intrinsic (age at implantation, age at onset of hearing loss, the cause of hearing loss, medical conditions, neural survival, cognition, and additional disabilities) and extrinsic factors (functional use of hearing aids, language or communicative intent, oral-motor skills, educational programs, available support services; the child's behaviour, attention span or abilities to focus; compliance with hearing aids; social or family dynamics; and second language exposure) (McClathie & Therres, 2003) [21]. The present study provides evidence for age at implantation as an important predictor for outcomes after cochlear implantation in paediatric CI recipients with a pre-lingual age of onset of hearing loss (see Figures 7 & 9).

Intrinsic factors

The World Health Organization (WHO 2015) categorizes congenital causes, CMV/Rubella/TMV, neonatal infections and conditions, and meningitis as 'preventable causes' of hearing loss. A large proportion of CI recipients in this study were reported to have such conditions which could have been prevented (as seen in Section 3.1). The results of this study also indicate that CI candidacy criteria has expanded to include children with syndromic, trauma, acquired conditions, structural deformities, dysynchrony, progressive loss, and ototoxicity in these countries.

The age at implantation is a robust indicator of post-implantation outcomes with a CI. The results obtained in this study are in agreement with those obtained by Jeyaraman (2013) [31]: the percentage of CI recipients once grouped in terms of age at implantation followed a similar trend as observed in Jeyaraman (2013) [31] and a large percentage of children fell in the 2–5 years group. Furthermore, the mean age at implantation is high at 52.1 months (4.4 years), which calls for concern because the children cannot benefit from the natural advantage that early implantation provides. Late-implanted children need appropriate and intensive rehabilitation and educational support in order to achieve better outcomes with a CI.

Extrinsic factors

The use of hearing aids prior to implantation varied from 1 month to 10 years, which shows that many CI candidates do not have access even though their hearing loss was identified. Around 7 CI recipients who had a congenital cause of hearing loss and had auditory skills that were above closed-set identification with hearing aids received a CI, which indicated that the criteria for cochlear implantation have been expanded under certain circumstances. However, which CI candidacy criteria change over time was not further explored in this study.

The benefits of bimodal and bilateral hearing with the use of FM devices in conjunction with a CI are well established in the literature as providing improved speech perception in noise and/or localization (Ching *et al*. 2007) [14]. Results showed that a meagre proportion of unilateral CI recipients were bilateral or bimodal users. None of the participants in this study used an FM device in conjunction with a CI. The fact that more than 50% of the participants in this study were of school-going age is a point of concern because that indicates that these children face difficulty in the adverse listening environment of a traditional school. While CI and ALDs systems are available through the CI programs in the three SAARC countries (India, Nepal, and Bangladesh), the factors that prevent the recipients from gaining access to these options should be explored to maximize auditory benefits for children with a hearing impairment in all acoustic environments. The governments of the three SAARC nations and clinical programs may have to design, implement, and maintain schemes or protocols to provide these possibilities to paediatric CI recipients and their families at an appropriate time in the future.

Hearing age is an important contributor to auditory and speech outcomes as shown by Figures 4 and 11. The protocols of most CI programs mandate enrolment to rehabilitation services for a minimum of one-year post-implantation. One fifth of CI recipients were reported to have less than 50% attendance in the first 1 or 2 years of post-implantation rehabilitation. Possible reasons for the high attendance rates observed in the rehabilitation programs could be the implementation of protocols which include parental counselling as part of the programs, the general motivation of the parents to see progress in their children, and the establishment of satellite centres to reach out to their clients in rural areas. The present study also shows that strong rehabilitation support is needed beyond the mandated periods of rehabilitation.

Outcomes with a CI

Many initiatives are taken towards training and establishment of listening and speaking programs for CI recipients in the three SAARC countries. In the present study, a large proportion of the CI recipients fell under the communication category of 'auditory/oral verbal communicator with visual assist but not sign language' and a portion of the CI recipients required alternative communication methods like sign language or alternative augmentative communication ('auditory oral/verbal skills assist primary visual communication'), as seen in Figures 7 and 10. This is consistent with the fact that not all children had an age at implantation < 2 years old, and some of the recipients had moderate to severe delays in receptive and expressive language development; see Figures 4 and 5. This reflects inadequacies in the rehabilitation support systems that are currently in place in the three countries. It should be noted that these countries have not denied these individuals their right to hear by not restricting cochlear implants to only children without additional or complex needs. What is noteworthy is that while a lot of initiatives are taken towards training and establishment of listening and spoken language communication programs, similar opportunities are not provided for other communication approaches (sign Language, oral approaches with visual assist and AAC). The implication is that the probability is high that an individual child may not be supported in an approach that would suit his/her skills and needs. This is a major concern that requires immediate addressing.

Only a small percentage of families in this study were bilingual, which is very interesting considering the multilingual environment of India. Families tend to introduce English into their children's lives, even when the families themselves do not speak English, which may be to enhance future educational prospects. It seems appropriate to consider bilingual rehabilitation approaches with emphasis on English as a second language. Furthermore, deaf families should be provided access to support services in learning sign language and to communication through sign language.

Regarding school placement, a significant portion of children between the ages of 3–5 years did not attend any type of formal schooling, which is acceptable because the Indian government does not mandate public schooling for this age group. Amongst the group of 5- to 12-year-olds, a smaller percentage of children did not attend school and the reasons for this should be further explored to ensure that there is a right to education for all children.

The outcome of cochlear implantation depends on a complex interaction between the intrinsic and extrinsic factors that are active in any individual child, and the outcome is not restricted to the implant technology itself. It has been observed in this study that only a small percentage of children have achieved auditory perception skills that crossed higher levels of audition (see Figure 7), speech intelligibility skills that are beyond single word intelligibility (see Figures 10 and 11), age appropriate receptive and expressive language (Figures 4 and 5), and grade appropriate literacy skills (see Figure 3). It is interesting to note that there was no sharp increase in CAP score as the cognitive skills increased. Instead, the spread of CAP score decreased as the cognitive skills age increased (as seen in Figure 8). This adds to the evidence that while cognitive skills might be delayed in paediatric cochlear implant recipients, it is not a strong indicator of auditory outcomes. Investigations into the contribution of other additional factors towards delays are beyond the scope of this study and will be analysed in future work. However, it is largely understood that, in general, a lot of work is required to curtail the impeding effects of these factors in the three SAARC countries, India, Nepal, and Bangladesh.

Quality indicator for outcomes

The Universal Newborn Hearing Screening Program (2010), through its 1-3-6 hearing plan, recommends the identification of hearing loss, audiological management, and rehabilitation within 6 months of neonatal life. Within 3 months of age, 0.4% received amplification; 7% of the CI recipients who attended rehabilitation achieved high auditory outcomes and 3% achieved speech intelligibility outcomes. Since the current data included the percentage of rehabilitation sessions attended and did not include the number of parents who signed individualised educational plans within 41 days, it cannot be directly compared to the quality indicators by JCIH (2019) for late identified children with hearing loss.

Table 1: Stratification of the 881 CI recipients into age groups by age at implantation whose records were reviewed in this study

Age group (months)	n	% of CI recipients in the study
0–12	11	1.2
13–24	103	11.5
25–36	141	15.7
37–48	158	17.5
49–60	177	19.7
61–72	159	17.7
73–84	54	6
85–144	78	8.6

Table 2: Number of CI recipients categorised as 'literacy skills development in progress', 'no literacy skills', or 'not eligible for school' across different implant age groups (in months) and as percentages of the total number of recipients in each age group.

Age group (months)	0–23	24–47	48–59	60–71	72–95	96–119	120–143	144–167
Total number of recipients in each age group	713	88	20	12	1	8	3	2
Categorisation of literary skills								
Not eligible for school	125	18	3	0	0	0	0	0
Not eligible for school (as a percentage of the total)	17	20	12	0	0	0	0	0
No literacy skills	186	3	0	0	0	0	0	0
No literacy skills (as a percentage of the total)	26	3	0	0	0	0	0	0
Literacy skills development in progress	166	47	17	11	17	7	2	1
Literacy skills development in progress (as a percentage of the total)	23	53	83	91	100	88	67	50

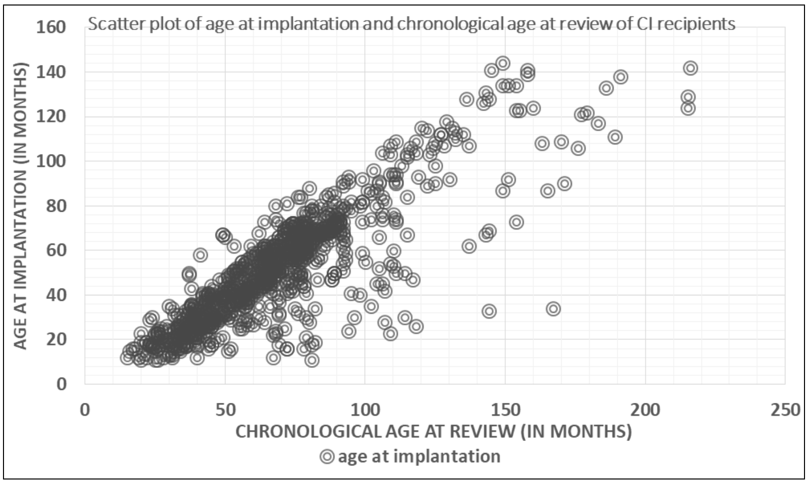

Fig 1: Age at implantation (in months) and chronological age at review (in months) of the CI recipients

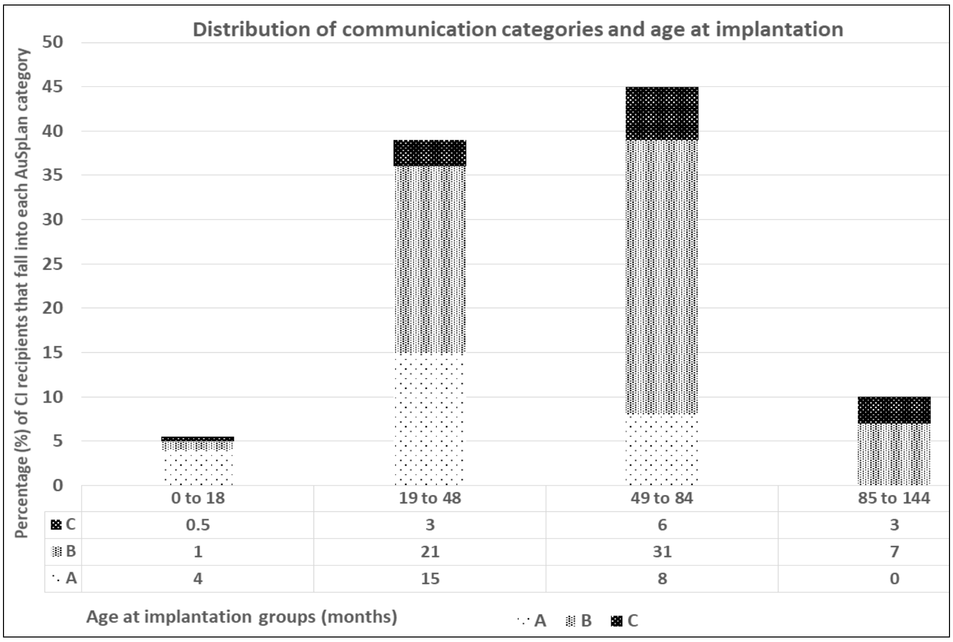

Fig 2: The percentage distribution of paediatric CI recipients across the three communication categories of AuSpLan (A, B, C) and four ranges in age at implantation. Category A: auditory oral/verbal communicator. Category B: auditory/oral verbal communicator with visual assist but not sign language. Category C: auditory oral/verbal skills assist primary visual communication

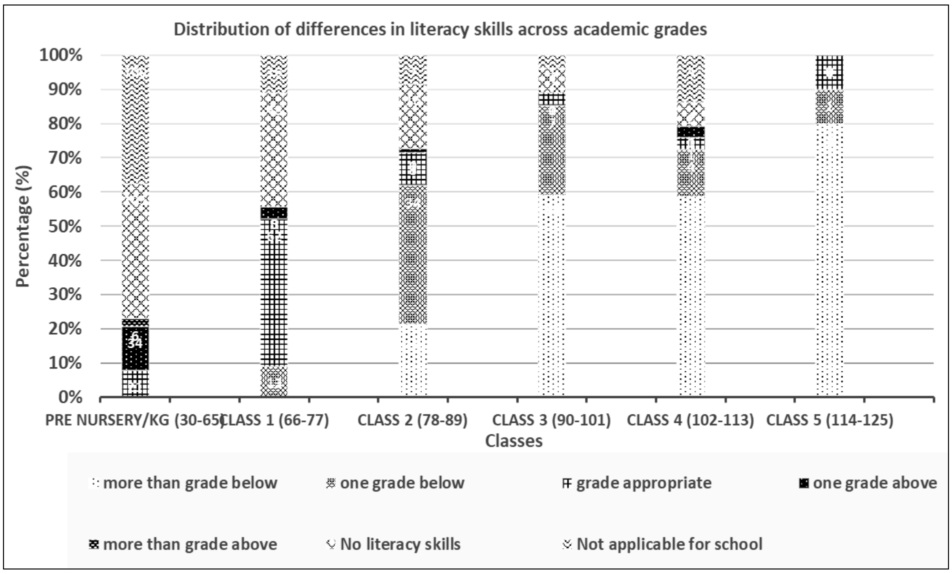

Fig 3: Distribution of differences in literacy skills across academic grades

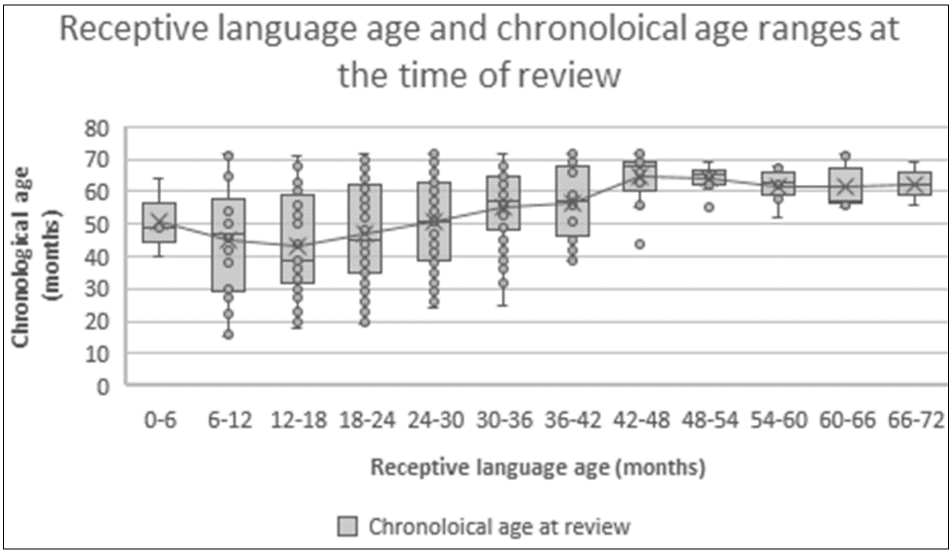

Fig 4: Receptive language age range (in months) and chronological age range (in months at the time of review

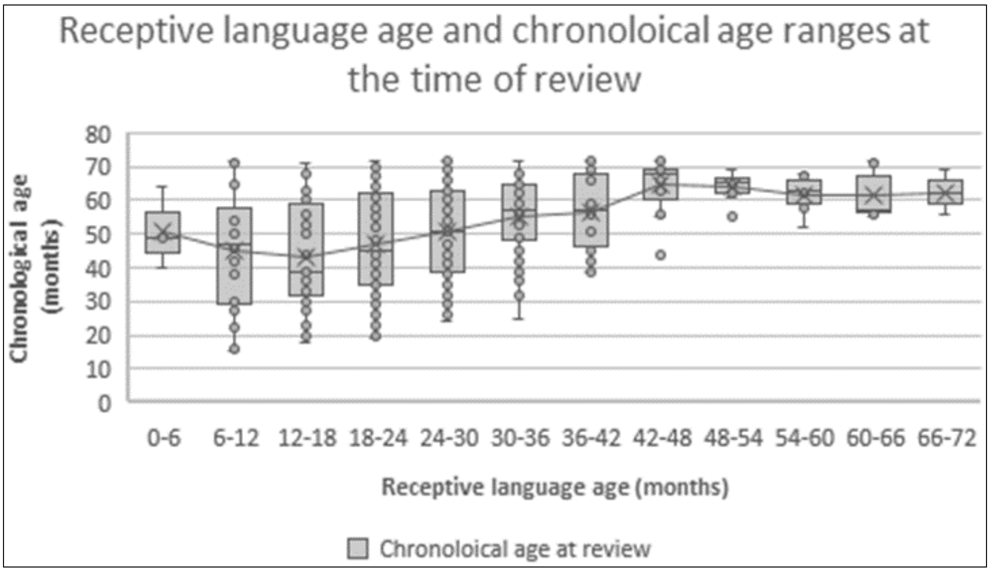

Fig 5: Expressive language age range (in months) and chronological age (in months) at the time of review

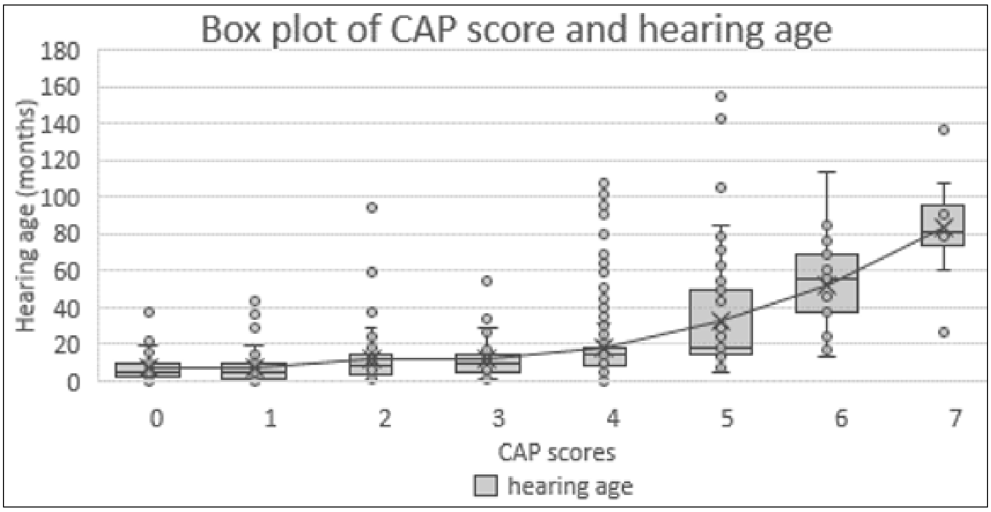

Fig 6: Box lot of CAP scores and hearing age groups (in months)

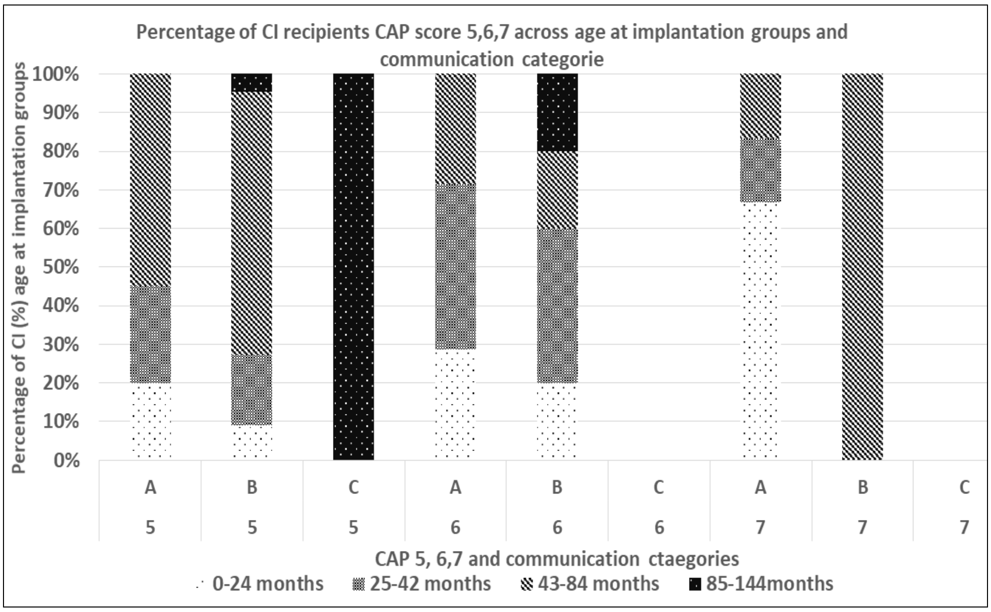

Fig 7: Percentage of CI recipients who obtained CAP scores 5, 6, and 7 across different communication categories of the AuSpLan. The CI recipients were grouped according to age at implantation

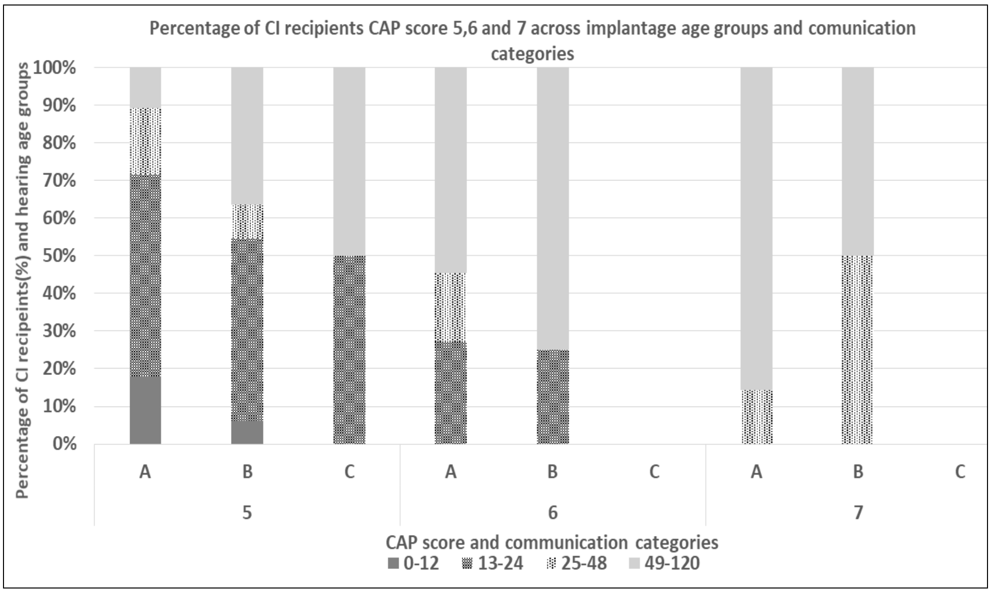

Fig 8: Percentage of CI recipients who obtained CAP scores 5, 6, and 7 across different communication categories of the AuSpLan. The CI recipients were grouped according to implant age groups

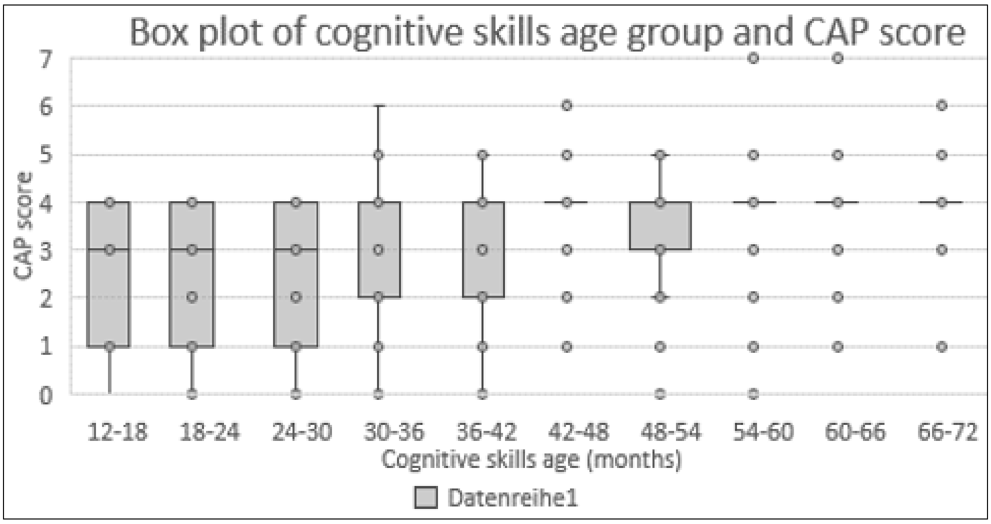

Fig 9: Cognitive skills age groups and the mean CAP score achieved within each age group

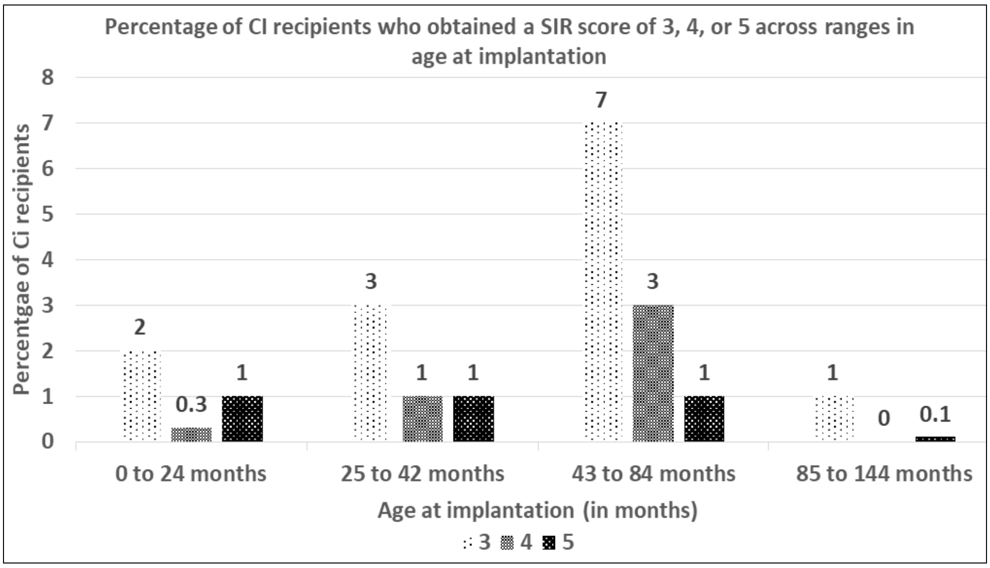

Fig 10: Percentage of CI recipients who obtained a SIR score of 3, 4, or 5 across ranges in age at implantation

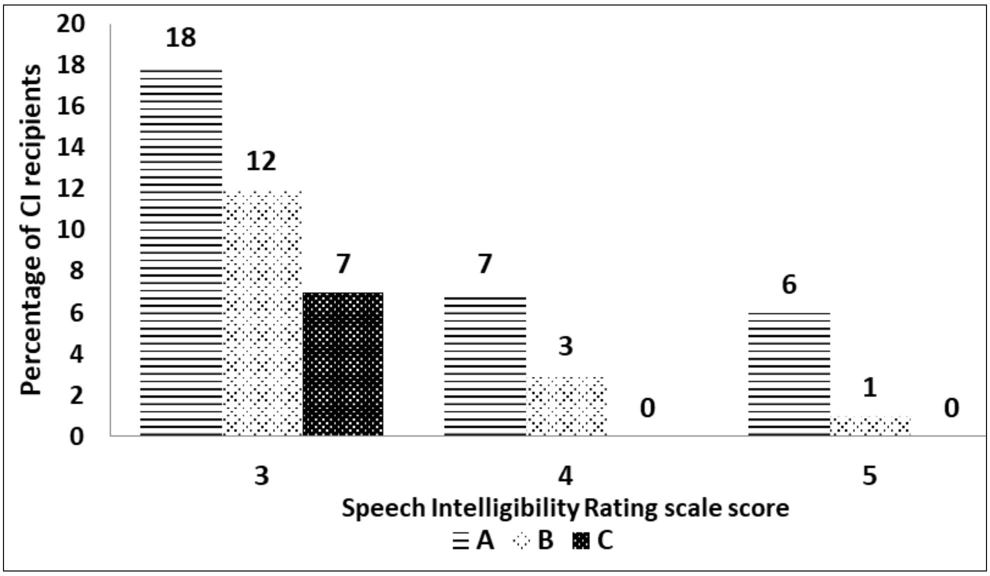

Fig 11: Percentage of CI recipients with an SIR score of 3, 4, or 5 across different communication categories of AuSpLan

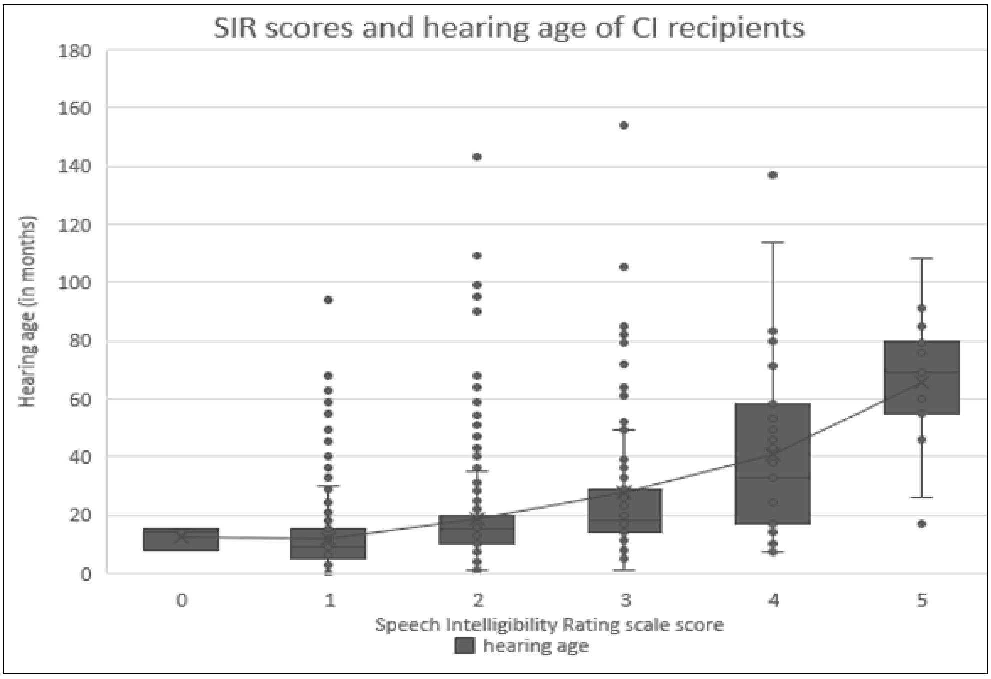

Fig 12: SIR scores and hearing age in the CI recipients

Conclusion

This study included a large representative sample of paediatric CI recipients from CI programs across the SAARC countries of India, Nepal, and Bangladesh. Post-implantation auditory rehabilitation is a long-term process that requires commitment beyond a 3-year period, especially if the CI recipients have additional disabilities/needs (AuSpLan chart reference). Under current circumstances in these three countries, wherein children tend to have a late age at implantation and a sizeable population of children with additional needs, the current programs may have to review and strengthen their protocols to ensure every CI recipient can derive maximum benefit from their device.

The current status and distribution of CI recipients in these countries should be of help to professionals and policymakers in identifying factors that exert considerable influence on the clinical outcomes of cochlear implantation and in designing effective clinical protocols, and national and international policies of CI programs for the paediatric population. As SAARC countries may share similar difficulties in implementing delivery of professional expertise and clinical services to children with hearing impairment, through their cooperative policy of sharing best practices between SAARC members like India, Nepal, and Bangladesh, the problem of severe to profound hearing impairment might be alleviated in the future.

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Conflicts of interest

This project was designed and funded by MED-EL India.

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Appendix 1: The clinics in India, Nepal, and Bangladesh from which the records of 955 paediatric recipients of MED-EL CI devices were collected

India		
1	Shruti clinic	Surat
2	Command Hospital Air Force	Bengaluru
3	Madras ENT Research Foundation	Chennai
4	Hearing Aid Centre	Coimbatore
5	Care hospital	Hyderabad
6	Dr. Manoj's ENT Super Speciality Institute and Research Centre	Kozhikode
7	Santhwana Hospital Pvt Ltd	Trivandrum
8	Post Graduate Institute of Medical Education and Research	Chandigarh
9	Prime Clinic	New Delhi
10	SpHear Speech and hearing Clinic	New Delhi
11	Army Hospital Research and Referral	New Delhi
12	All India Institute of Medical Sciences	New Delhi
13	Hearing Point	Noida
14	ASHA Speech and Hearing Clinic	New Delhi
15	Audicomm	Uttar Pradesh
16	JK Electronic Ear	Jammu
17	Hearing Aid Centre	Madurai
18	Hearing Aid Centre	Trichy
19	INHS Ashwini	Mumbai
20	KEM Hospital	Pune
21	Mathur Radios and Engineering works	Lucknow
22	All India Institute of Medical Sciences	Jodhpur
23	B J Medical College and Civil Hospital	Gujarat
24		
Nepal		
	Tribhuvan University teaching Hospital	Kathmandu
Bangladesh		
	Combined Military Hospital	Dhaka