Auditory Outcomes of Cochlear Implantation among Pediatric Patients under the Philippine National Cochlear Implant Program

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ABSTRACT

Background. The National Cochlear Implant Program (NCIP) is a national program that addresses the increasing prevalence of hearing loss, especially in the pediatric population here in the Philippines. In its pilot implementation, it included three tertiary hospitals to represent Luzon, Visayas, and Mindanao, and was able to enroll 20 patients who successfully underwent cochlear implantation (CI).

Objectives. The aim of this study is to evaluate the auditory outcomes of the patients who underwent cochlear implantation under the NCIP using the Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Questionnaire and Categories of Auditory Performance (CAP) score questionnaire.

Methods. This is a retrospective cohort study including all recipients of the cochlear implants, under NCIP from December 2019 to December 2021, except one with incomplete data during the course of his follow up. The outcomes measured included the PEACH Questionnaire score and CAP Questionnaire score and were compared on various factors which included patient's sex and age, parents' socioeconomic status, duration of hearing aid use prior to CI, pre-CI imaging findings, and CI electrode placement using nonparametric statistical tests.

Results. The mean PEACH score of the 19 patients was 53.59% ± 12.76% (range: 30% - 75%) while the mean CAP score was 3.16 ± 1.04 (range: 1 - 4.3). Parents of the included patients who have a higher educational background and those in which the electrode was located on the ideal location, scala tympani, have a statistically significant higher PEACH score (p-value of 0.017 and 0.012, respectively). In comparing the CAP scores, those who have unremarkable or normal preoperative imaging have a statistically significant higher score (p-value 0.013).

Conclusion. Patients who had normal preoperative imaging, proper placement of electrodes, and those patients with parents belonging to a higher educational background had statistically significant better auditory outcomes after cochlear implantation. Patients who had the cochlear implantation before 36 months of age and hearing aid use of 7 to 18 months prior to cochlear implantation had higher PEACH and CAP scores, however these were not statistically significant. Further studies with a larger sample size is recommended.

Keywords: pediatric hearing loss, cochlear implantation, PEACH score, CAP score

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INTRODUCTION

It has been predicted that by the year 2050, one in every ten people will experience hearing loss that is debilitating and affects activities of daily living.[1] A worrisome finding of the WHO report is that over 80% of those suffering from hearing loss are living in low- to middle-income countries (LMICs).[1] In the latest national survey of hearing loss in the country, the overall rate of moderate hearing loss was 15% and the rates increases by age.[2] As for congenital hearing loss that is bilateral and profound, this occurs in 1.3 per 1000 live births worldwide.[3] The prompt treatment and management among infants and children suffering from profound hearing loss is essential to prevent further deterioration in learning and developmental skills. In the Philippines, which is classified as an LMIC, the access to hearing rehabilitation has been limited. To address this, the Philippine National Ear Institute (PNEI) started the Philippine National Cochlear Implant Program (NCIP) in 2019. The aim of the program is the prevention of hearing disability among children with bilateral hearing impairment who have shown little or no benefit with hearing aid amplification through starting a cochlear implant program in partnership with the national health insurance body, PhilHealth, to reach out to citizens throughout the Philippines who might benefit from a cochlear implant. The pilot program included three tertiary hospitals to represent Luzon, Visayas, and Mindanao. These hospitals are the following: University of the Philippines-Philippine General Hospital (UP-PGH), in Manila, Corazon Locsin Montelibano Memorial Regional Hospital (CLMMRH) in Bacolod City, Negros Occidental, and The Southern Philippines Medical Center (SPMC), in Davao.

Since the start of its implementation, 20 patients successfully underwent cochlear implantation. They were all admitted and underwent the surgery at the Philippine General Hospital.

The aim of this study is to evaluate the auditory outcomes of patients who are part of the NCIP. The outcomes measured include the Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Questionnaire score and Categories of Auditory Performance (CAP) score, and its possible association on various factors which include patient's sex and age, parents' age and educational attainment, duration of hearing aid use prior to cochlear implantation, pre-cochlear implantation hearing test results, pre- and post-cochlear implantation imaging findings, and surgical outcomes.

Significance of the Study

Hearing loss in LMIC countries has been dubbed as a silent epidemic. Early intervention especially among children through hearing rehabilitation is crucial. This study is part of the pilot program under the Philippine National Ear Institute entitled National Cochlear Implant Program, which aims to provide accessible and affordable cochlear implants to children deemed as candidates for the procedure. With the results of this study, we will be able to identify the value of cochlear implantation in our patients with hearing loss and describe their demographic characteristics and identify factors that may be unique to our local setting. Given the results, PNEI in partnership with our national health insurance body, will be able to create a Philhealth package in order to cover the costs of cochlear implantation in the country.

OBJECTIVES

This study aims to evaluate the auditory outcomes of the patients who underwent cochlear implantation under the National Cochlear Implant Program completed last 2021.

The specific objectives are the following:

1. To describe the demographic and clinical data of patients included in the NCIP such as age upon cochlear implantation (CI), sex, socioeconomic status, duration of hearing aid use prior to CI, pre-CI imaging findings, and CI electrode placement
2. To determine the PEACH and CAP scores of patients after cochlear implantation
3. To determine if the patient's demographic and clinical characteristics affect the auditory outcomes of patients who underwent CI

METHODS

Study Design

A retrospective study was done to evaluate the auditory outcomes among patients included in the National Cochlear Implant Program. This study was approved by the University of the Philippines Manila Research and Ethics Board (UPMREB) with approval code (UPMREB CODE:2023-0574-01). The study included all 20 recipients of the cochlear implants under the NCIP from December 2019 to December 2021.

The inclusion criteria for patient selection in the program are as follows:

- Age less than 5 years old
- Hearing screening using Otoacoustic Emissions (OAE) or Automated Auditory Brainstem Response (AABR) test done within one month of age with Newborn Hearing Screening Reference Center (NHSRC) registry card
- Confirmatory testing with three months of age with Auditory Brainstem Response (ABR), Auditory Steady-State Response (ASSR), and Visual Reinforcement Audiometry (VRA) revealing bilateral severe to profound hearing loss
- Started intervention in the form of hearing aid trial within six months

The exclusion criteria for the study include the following:

- Has other comorbidities or congenital defects.
- Has craniomaxillofacial defects such as microtia, anotia, cochlear aplasia.

The process of selection of participants to be included in the program involved identifying children from Luzon, Visayas, and Mindanao with bilateral severe to profound hearing loss on testing within three months of age using ABR, ASSR, and VRA and those who have subsequently underwent initiation of hearing aid trial within six months of age. The patients were subsequently directed to designated partner hospitals for further evaluation. These comprehensive assessments included audiological, radiological, neurophysiological, and other medical examinations to ascertain the extent and etiology of hearing loss, identify any associated abnormalities, and assess potential surgical risks. Approval was done by committee meetings held regularly.

All patients underwent cochlear implantation under general anesthesia. Majority of the patients underwent placement of the electrodes via the scala tympani approach except two in which the scala vestibuli approach was utilized because of difficulty locating the round window intraoperatively. Telemetry was done intraoperatively with good impedance noted for all patients.

Demographic and clinical data of patients such as age upon cochlear implantation (CI), sex, parents' educational attainment, monthly income class as per Philippine Institute for Development Studies suggested classification, duration of hearing aid use prior to CI, pre-CI imaging findings, and CI electrode placement were gathered.[4] Patients were followed up after one week for inspection of postoperative site and removal of bandage; after two weeks for the switching on of the device; and at one month, six months, and 12 months for monitoring of speech therapy measurement of auditory outcomes using the PEACH and CAP scores.

To determine the auditory outcomes after cochlear implantation, patient's parents were asked to answer two assessment tools - the Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Questionnaire and Categories of Auditory Performance (CAP). The PEACH is a 13-item questionnaire which is used to evaluate the effectiveness of amplification for infants and children with hearing impairment. The CAP is an eight-point scale which evaluates auditory performance from "0" or "no awareness of environmental sound" to "7" or "use of the telephone with known speaker". Scores from the PEACH and CAP assessment tools were determined at one month, six months, and 12 months. The scores taken from each follow up assessment were averaged and compared to the variables identified in this study.

Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Questionnaire

The Parent's Evaluation of Aural/Oral Performance of Children (PEACH) questionnaire is a tool that comprises items suited for evaluation of functional auditory performance of children of a wide range of age and degree of hearing loss. It can be used with no limitations placed on age or duration of hearing aid experience by utilizing the parents' observation on the child's aural and oral abilities in daily life. It is a validated tool/questionnaire that can be used for patients whose age ranges from infants as young as one month old and with school-aged children, who have mild to profound severity of hearing loss. It includes 14 questions answered by the parents in a scale of 0 (Never) to 4 (Always) reflecting the parents' observation of the child's listening behavior over the past week in terms of hearing-assistive device usage (daily routine of use, awareness of device malfunction), listening comfort (response to loud sounds), listening to speech in relatively quiet situations (respond to name in quiet, respond to verbal instructions in quiet, follow a story read aloud, participate in conversations in quiet, recognize familiar voices, participate in conversation on a telephone), listening to speech in situations that are noisy or when multiple talkers are present (respond to name in noise, respond to verbal instructions in noise, participate in conversations in noisy situations, participate in conversations in cars/buses/trains), and awareness and recognition of environmental sounds. The scores are averaged and is multiply by 100 to get a percentage score.[5]

In a study conducted in India by Rout et al., PEACH questionnaire was used to evaluate functional language performance of children who received cochlear implants. They found that early intervention with CI increased the functional hearing and linguistic performance of the children. The authors also concluded that PEACH is a feasible evaluation tool that clinicians can use to obtain valuable data about children's auditory performance in real life.[6]

Categories of Auditory Performance (CAP) score

The Categories of Auditory Performance (CAP) scale is a tool comprising of a hierarchical scale of auditory perceptive ability ranging from 0 "displays no awareness of environmental sounds" to 7 "can use the telephone with a familiar talker", in increasing difficulty. In contrast with more technical measures, this scale can be easily understood and used even by non-specialist professionals and parents. Archbold et al. used this tool to evaluate hearing outcomes of post-cochlear implantation pediatric patients in their everyday life. They also evaluated the CAP score and found out that it was a valid tool and has a very high inter-user reliability in measuring outcomes for post CI pediatric patients.[7]

Data Collection

Data obtained from the Philippine National Ear Institute registry, and the hospital records from the Philippine General Hospital were reviewed. One patient was excluded from the study due to incomplete in-patient records. Data collected include the patient's age upon cochlear implantation (CI), sex, socioeconomic status, duration of hearing aid use prior to CI, pre-CI imaging findings, and CI electrode placement. PEACH and CAP scores after cochlear implantation were also obtained in the patient's record on their subsequent follow-up. The patient excluded in this current study was only able to follow up one week post operative for surgical site

assessment but was unable to follow up thereafter, including the suggested interval of one month, six months and 12 months to measure hearing auditory outcomes, despite efforts to contact the patient for the follow up.

Data Analysis

Data was encoded using Microsoft Excel 2019 for Mac Version 16.78.3 (Microsoft Corp., Redmond WA, USA). Data for categorical variables were summarized in frequency counts and percentages while summary measures were presented in terms of mean and standard deviation. Descriptive statistics such as means, frequencies, and ranges of the sample population were used for the demographic characteristics and scores on both PEACH and CAP questionnaires. Differences in mean PEACH and CAP scores among variables identified were measured using Mann Whitney U Test and Kruskal-Wallis Test. A p-value of <0.05 is considered statistically significant.

RESULTS

Table 1 presents a summary of the characteristics of the 19 patients who were included in the NCIP from December 2019 to December 2021. The mean age at cochlear implantation was 37.05 months ± 14.88 (range: 12 months to 61 months). Among these patients, 11 (57.9%) were females and 8 (42.1%) were males. Among the parents of the CI patients, the majority were high school graduates (n=12, 63.16%) and most of them were from the middle-income class (n=10, 52.63%).

All 19 (100%) patients had pre-implantation profound hearing loss on ABR and ASSR, and had aided thresholds below the speech spectrum. On preoperative imaging (either with Temporal Bone CT or MRI), 12 (63.16%) had unremarkable imaging findings while the rest (n=7, 36.84%) had findings which includes either one or more of the following: superior semicircular canal dehiscence, high-riding jugular bulb, middle ear effusion, patulous internal acoustic canal, enlarged vestibular aqueduct with aplasia of lateral semicircular canal, vascular loops. Twelve patients (63.16%) underwent cochlear implantation within six months of hearing aid fitting and use.

Ten patients (52.63%) were implanted on the right ear while 9 (47.37%) were implanted on the left ear. Eighteen patients (94.74%) had complete electrode insertion. Majority (n=17, 89.47%) of the patients had their CI electrodes placed on the scala tympani, while the remaining two (10.53%) had the CI electrodes placed on the scala vestibuli as the surgeon was not able to identify the round window intra-operatively. All had good impedance and NRT on intra-operative telemetry.

The PEACH and CAP scores of the patient were taken postoperatively during the patient's follow-up consultation at one month, six months, and 12 months after the surgery. The questionnaires were administered to the parents/guardians during their consultation. The mean PEACH score of the 19 patients was 53.59% ± 12.76% (range: 30% - 75%) while the mean CAP score was 3.16 ± 1.04 (range: 1 - 4.3) (Table 2).

The patient's demographic and clinical characteristics, and mean PEACH scores were analyzed to determine any effect of the variables on the auditory outcome. The patients with the following characteristics had higher PEACH scores: those who underwent CI between 12-36 months of age, female sex, those who have parents with higher education

Table 1. Characteristics of Patients who Underwent Cochlear Implantation under the NCIP from December 2019 to December 2021 (N=19)

Variables	n (%)
Age upon CI (in months)	
<12	0 (0)
12-36	9 (47.37)
>36	10 (52.63)
Sex	
Male	8 (42.11)
Female	11 (57.89)
Educational attainment	
Elementary graduate	0 (0)
High school graduate	12 (63.16)
College graduate	7 (36.84)
Income class (Monthly income in PhP)	
Low-income class (<24, 000)	4 (21.05)
Middle-income class (24,000 – 145,000)	10 (52.63)
High-income class (>145,000)	5 (26.32)
Preoperative imaging findings	
Normal findings	12 (63.16)
With abnormal finding/s	7 (36.84)
Duration of hearing aid use prior to CI (in months)	
0-6	12 (63.16)
7-12	2 (10.53)
13-18	4 (21.05)
19-24	1 (5.26)
Electrode placement	
Scala tympani	17 (89.47)
Scala vestibuli	2 (10.53)

Table 2. PEACH and CAP Scores of Patients who Underwent Cochlear Implantation under the NCIP from December 2019 to December 2021 (N=19)

	Descriptive Statistics (N=19)
Parents' Evaluation of Aural/Oral Performance of Children (PEACH) Score	
Mean	53.59%
Standard Deviation	12.76%
Median	55%
Mode	45%
Range	30% – 75%
Categories of Auditory Performance (CAP) Score	
Mean	3.16
Standard Deviation	1.04
Median	3.5
Mode	4
Range	1 – 4.3

attainment and income class, those with noted pathologies on preoperative imaging, hearing aid use of 7 to 12 months and 13 to 18 months prior to CI, and when the CI electrode is placed on the scala tympani. However, only the educational attainment of the parents and the CI electrode placement were statistically significant with a p-value of 0.017 and 0.012, respectively (Table 3).

The patient's demographic and clinical characteristics and mean CAP scores were analyzed as well to determine any effect of the variables on the auditory outcome. The patients with the following characteristics had higher CAP scores: those who underwent CI at more than three years of age, male sex, those who have parents with higher educational attainment and income class, those with normal preoperative imaging, hearing aid use of 7 to 18 months prior to CI, and when the CI electrode is placed on the scala tympani. However, only those with a normal preoperative imaging was statistically significant with a p-value of 0.013. There was no statistically significant difference on CAP scores among the rest of the patient variables (Table 3).

DISCUSSION

Prediction of post implantation benefit should be individualized and based on comprehensive preoperative assessment. Factors that are known to influence outcomes can be divided into these main categories: patient characteristics, the patient's environment, and the baseline status and surgical management of the auditory system.[8]

Age at Implantation

Age at cochlear implantation is noted to have a significant effect in the postoperative outcomes of patients. In a study by Patni et al., it is noted that patients implanted below two years of age had significantly improved hearing scores as compared to those implanted between the ages of two to five and those implanted after five years of age, especially during the first two years post-implantation.[9]

Several studies also had a similar finding of better clinical outcomes for those who underwent cochlear implantation at an earlier age. Using many outcome measurement tools such as Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) and Category of Auditory Performance (CAP), multiple studies also had similar findings that implantation before age 1 had a significant improvement in hearing after implantation.[9-12] Roland et al. added that some deaf children were able to reach their full hearing potential after implantation when implanted before 12 months of age.[11]

In our study, patients who underwent cochlear device implantation before 36 months or three years of age had higher PEACH scores as compared to those implanted at a later age. The opposite is true with regard to the CAP score in which those who were implanted after the age of 36 months had a higher CAP score. One factor that can be considered

Table 3. Mean PEACH and CAP Scores among the Different Demographic and Patient Variables of Patients who Underwent Cochlear Device Implantation Under the NCIP from December 2019 to December 2021 (N=19)

Variables	PEACH score % (n)	*p*-value	CAP score (n)	*p*-value
Age upon CI (in months)		0.604		0.842
<12	n/a		n/a	
12-36	54.79 ± 13.91 (9)		3.04 ± 1.19 (9)	
>36	52.5 ± 12.29 (10)		3.27 ± 0.94 (10)	
Sex		0.492		0.968
Male	52.06 ± 14.96 (8)		3.27 ± 0.79 (8)	
Female	54.70 ± 11.54 (11)		3.08 ± 1.22 (11)	
Educational attainment		**0.017**		0.432
Elementary graduate	n/a		n/a	
High school graduate	48.80 ± 11.92 (12)		2.99 ± 1.14 (12)	
College graduate	61.79 ± 10.20 (7)		3.45 ± 0.83 (7)	
Income class (Monthly income in PhP)		0.429		0.061
Low-income class (<24, 000)	53.28 ± 10.10 (4)		3.625 ± 0.75 (4)	
Middle-income class (24,000 – 145,000)	50.29 ± 13.48 (10)		2.63 ± 1.11 (10)	
High-income class (>145,000)	60.42 ± 12.74 (5)		3.83 ± 0.41 (5)	
Preoperative imaging findings		0.773		**0.013**
Normal findings	53.40 ± 12.45 (12)		3.65 ± 0.53 (12)	
With abnormal finding/s	53.90 ± 14.30 (7)		2.31 ± 1.18 (7)	
Duration of hearing aid use prior to CI (in months)		0.099		0.390
0-6	48.3 ± 12.03 (12)		3.21 ± 0.95 (12)	
7-12	63.44 ± 16.35 (2)		3.25 ± 1.06 (2)	
13-18	63.44 ± 7.00 (4)		3.5 ± 1.04 (4)	
19-24	57.5 (1)		1 (1)	
Electrode placement		**0.012**		0.292
Scala tympani	56.51 ± 9.84 (17)		3.24 ± 1.06 (17)	
Scala vestibuli	28.75 ± 1.77 (2)		2.5 ± 0.71 (2)	

with these results is the electrode placement of the cochlear device into either the scala tympani or scala vestibuli. Ideal placement of the CI electrode is at the scala tympani. One patient in the 13-36 months age group had the electrodes inserted on the scala vestibuli. This patient scored the lowest on the PEACH questionnaire and among the lowest scores in the CAP questionnaire and may have skewed the results.

Sex

Based on our results, there was no statistically significant difference in the mean PEACH and CAP scores between males and females. Up to this date, the effect of sex on outcomes of cochlear implantation on children is not yet well-studied. On adults who underwent cochlear implantation, Lenarz and colleagues found out that men showed better functional hearing outcomes as they tended to perform slightly better in complex listening situations such as recognizing speech in noise.[13]

Pre-cochlear Implantation Hearing Status

All of the patients included in this study had profound hearing loss on both ears with aided thresholds tests below the speech spectrum. Multiple studies have agreed that pediatric patients receiving cochlear implants scored better on different hearing outcome measures and had better speech perception and language outcomes when they have greater amounts of preoperative residual hearing.[14,15] Although Phan et al. had a similar finding, they found out that even patients with more severe degree of hearing loss benefited from cochlear implantation as the very-limited residual pre-implant hearing may still facilitate speech discrimination abilities in the time period immediately following implantation.[16]

Parents' Age/ Educational Attainment/ Economic Status

In our study, the patients who have better socioeconomic status had better PEACH and CAP scores as compared with those who are in the lower socioeconomic class. Our study saw a statistically significant difference in the mean PEACH scores of patients whose parents finished college (p-value 0.028). According to the Philippine Institute for Development Studies, the government defines the middle-income class as those earning incomes between two to 12 times the poverty line or around ₱24,000 and ₱145,000.[4] The PEACH and CAP scores also are higher for patients whose families fall on the higher income classes, although not statistically significant. This is consistent with data from existing literature. Jeddi et al. noted in their study that the age at cochlear implantation decreases as the level of the parents' economic circumstances increases. They also found out in their study that patients undergo cochlear implantation at an earlier age when the parents achieve a higher level of education attributing to the increased knowledge about symptoms and the effects of hearing loss, which in turn results in earlier referral and management such as doing cochlear implantation.[17]

Ozcebe et al. and Jafari et al. also had a similar finding that children living in a family with a favorable socioeconomic condition are more likely to be diagnosed early with hearing loss and are to receive earlier intervention as compared to those with low socioeconomic status.[18,19]

Parental age may not be directly related to the clinical outcomes of cochlear implantation in pediatric patients but it is still an important consideration as older parental age related to a more delayed diagnosis in hearing loss.[20]

Hearing Aid Use Prior to Cochlear Implantation

Before receiving cochlear implants, patients usually undergo a trial of hearing aid, often as a part of the CI candidacy process. Currently, there are no established guidelines on preoperative hearing aid use duration before cochlear implantation. Cochlear implantation is mainly offered if there is no significant improvement in the hearing capabilities even after hearing aid use.

In this study, there were no significant differences in the mean PEACH and CAP scores among the subgroups with different durations of preoperative hearing aid use. There is limited knowledge comparing outcomes of cochlear implant patients with different preoperative hearing aid use duration. However, especially with older children who received cochlear implantation at a later age, prolonged use of hearing aid prior to implantation shows a positive effect in hearing outcomes. This may be caused by the auditory development supported by the use of hearing aids prior to surgery since patients would have less period that they are deprived of sound. Preoperative hearing aid use was also noted to sensitize the vestibulocochlear nerve and the rest of the auditory pathway which resulted in better hearing abilities compared to those who were not able to use hearing aids preoperatively.[21-23]

Pre- and Post-operative Cochlear Implantation Imaging

Peri-operative imaging is useful in cochlear implantation. Preoperatively, anatomical abnormalities or variations can be identified and be used to plan the surgical approach for the procedure. Intra- and post-operative imaging can be used to identify electrode placement and also be used to monitor the device after the procedure. In a study by Patni et al., they noted that the majority have normal inner ear anatomy noted on imaging, and that they scored higher on different hearing outcomes measures although the difference as compared to those with cochleovestibular anatomical abnormalities were not significant.[9] The non-significant difference may be due to better understanding of the cochlear anatomy preoperatively using imaging and use of other ancillary measures such as Intraoperative Neural Response Telemetry (NRT) and skull radiographs and confirming the position of electrodes intra-operatively.[9] These results were also reflected in our study, wherein patients who had normal preoperative imaging, either via temporal bone CT scan or MRI, had better CAP scores postoperatively.

Electrode Placement during Cochlear Implantation

Based on the results of our study, there is a statistically significant difference in mean PEACH scores between the patients implanted on the scala tympani vis-à-vis the scala vestibuli, with the former having higher mean PEACH scores. This is congruent with the study of Cohen et al. in which they note that complete and proper insertion of the electrode into the scala tympani is the objective of cochlear implant surgery. Malposition, whether intra or extracochlear, leads to poorer hearing outcomes.[24] Finley and Skinner also agree on the importance of electrode placement in hearing outcomes. They found out in their study that electrode insertion depth and scalar placement accounted for the variability in outcome scores observed across cochlear implant patients. They found a negative correlation between electrode placement depth and word recognition scores. Scalar placement was also noted to play a significant role. Lower outcome scores were noted for those in which the electrode has greater contacts located in the scala vestibuli vs scala tympani.[25]

Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. The small sample size included in the pilot implementation of the NCIP may limit the generalizability of the results to the broader population. Future studies with larger, more diverse samples and prospective designs are warranted to validate and extend these findings.

CONCLUSION

In this study, the following factors are associated with statistically significant better auditory outcomes in terms of PEACH and CAP scores: patients who had normal preoperative imaging, proper placement of electrodes, and those patients with parents who have higher educational attainment.

As with several studies, evidence showed that cochlear device implantation at a younger age results in better auditory outcomes. In this current study, those who had cochlear implantation before 36 months of age showed higher PEACH scores, although statistically not significant. Other factors such as operative technique and electrode placement into the scala vestibuli could also be a confounding factor as to why the results are not consistent with other previous studies.

Early intervention in children through hearing rehabilitation is crucial. Data on the hearing outcomes can help the stakeholders recognize any part of the hearing evaluation and follow-up procedure that need further streamlining and improvement. The results of this study could also be used to support the inclusion of cochlear implantation program in the 'Z' benefit package of PhilHealth for hearing impaired children in our country once there is data showing the feasibility, safety, and good outcomes of the patients undergoing cochlear implantation and subsequent speech therapy.

Overall, data from this initial study can be used in further researches regarding cochlear implantation in the Philippines, and for further development of the National Cochlear Implantation Program.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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REFERENCES

1. World Health Organization. Deafness and hearing loss [Internet]. 2023 [cited 2023 Feb 6]. Available from: https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss
2. Newall JP, Martinez N, Swanepoel DW, McMahon CM. A national survey of hearing loss in the Philippines. Asia Pac J Public Health. 2020 Jul;32(5):235-41. doi.org/10.1177/1010539520937086. PMID: 32608243.
3. Santos-Cortez RL, Chiong CM. Cost-analysis of universal newborn hearing screening in the Philippines. Acta Medica Philipp. 2013 Dec 31;47(4):52-7. doi.org/10.47895/amp.v47i4.1267.
4. Philippine Institute for Development Studies. Understanding Social Classes in the Philippines: Which Class Do You Belong to?; [cited February 6, 2023]. Available from: https://pids.gov.ph/details/news/in-the-news/understanding-social-classes-in-the-philippines-which-class-do-you-belong-to
5. Ching TY, Hill M. The parents' evaluation of aural/oral performance of children (PEACH) scale: normative data. J Am Acad Audiol. 2007 Mar;18(03):220-35. doi.org/10.3766/jaaa.18.3.4. PMID: 17479615.
6. Kumar S, Rout N, Kumar N, Chatterjee I, Selvakumaran H. Performance of indian children with cochlear implant on PEACH scale. ISRN Otolaryngol. 2013 Mar 4;2013:1-6. doi.org/10.1155/2013/565096. PMID: 23724276. PMCID: PMC3658423.
7. Archbold S, Lutman ME, Nikolopoulos T. Categories of auditory performance: inter-user reliability. Br J Audiol. 1998 Feb;32(1):7-12. doi.org/10.3109/03005364000000045. PMID: 9643302.
8. Selleck AM, Park LR, Brown KD. Factors Influencing Pediatric Cochlear Implant Outcomes. Otol Amp Neurotol. 2019 Oct;40(9): 1148-52. doi.org/10.1097/mao.0000000000002342. PMID: 31436630.
9. Patni P, Dalmia D, T U, Katakdhond H, Bhagavan K. Factors affecting outcome of cochlear implant: an observational study. Int J Otorhinolaryngol Head Neck Surg. 2020 Sep 23;6(10):1811. doi.org/10.18203/issn.2454-5929.ijohns20204180
10. Waltzman SB, Roland JT. Cochlear implantation in children younger than 12 months. Pediatrics. 2005 Oct 1;116(4):e487-e493. doi.org/10.1542/peds.2005-0282. PMID: 16199675.
11. Roland JT, Cosetti M, Wang KH, Immerman S, Waltzman SB. Cochlear implantation in the very young child: long-term safety and efficacy. Laryngoscope. 2009 Nov;119(11):2205-10. doi.org/10.1002/lary.20489. PMID: 19507225.
12. Colletti V, Carner M, Miorelli V, Guida M, Colletti L, Fiorino FG. Cochlear implantation at under 12 months: report on 10 patients.

Laryngoscope. 2005 Mar;115(3):445-9. doi.org/10.1097/01.mlg.0000157838.61497.e7. PMID: 15744155.
13. Lenarz M, Sönmez H, Joseph G, Büchner A, Lenarz T. Effect of gender on the hearing performance of adult cochlear implant patients. Laryngoscope. 2012 Feb 28;122(5):1126-9. doi.org/10.1002/lary.23214. PMID: 22374914.
14. Cowan RS, DelDot J, Barker EJ, Sarant JZ, Pegg P, Dettman S, Galvin KL, Rance G, Hollow R, Dowell RC, Pyman B, Gibson WP, Clark GM. Speech perception results for children with implants with different levels of preoperative residual hearing. Am J Otol. 1997;18(6 Suppl):125-6. PMID: 9391629.
15. Nicholas JG, Geers AE. Effects of early auditory experience on the spoken language of deaf children at 3 years of age. Ear Hear. 2006 Jun;27(3):286-98. doi.org/10.1097/01.aud.0000215973.76912.c6. PMID: 16672797. PMCID: PMC2880472.
16. Phan J, Houston DM, Ruffin C, Ting J, Holt RF. Factors affecting speech discrimination in children with cochlear implants: evidence from early-implanted infants. J Am Acad Audiol. 2016 Jun;27(06):480-8. doi.org/10.3766/jaaa.15088. PMCID: PMC5675533. PMID: 27310406.
17. Jeddi Z, Jafari Z, Motasaddi Zarandy M. Effects of parents' level of education and economic status on the age at cochlear implantation in children. Iran J Otorhinolaryngol. 2012;24(66):7-15. PMID: 24303378. PMCID: PMC3846204.
18. Ozcebe E, Sevinc S, Belgin E. The ages of suspicion, identification, amplification and intervention in children with hearing loss. Int J Pediatr Otorhinolaryngol. 2005 Aug;69(8):1081-7. doi.org/10.1016/j.ijporl.2005.03.002. PMID: 16005351.
19. Jafari Z, Malayeri S, Ashayeri H. The ages of suspicion, diagnosis, amplification, and intervention in deaf children. Int J Pediatr Otorhinolaryngol. 2007 Jan;71(1):35-40. doi.org/10.1016/j.ijporl.2006.08.014. PMID: 16997387.
20. Shanker A, Rojas-Ramirez MV, Jacobs JA, Shinn JB, Lester C, Westgate PM, Bush ML. Assessment of factors involved in non-adherence to infant hearing diagnostic testing. J Early Hear Detect Interv. 2019:1-8.
21. Hopyan T, Peretz I, Chan LP, Papsin BC, Gordon KA. Children using cochlear implants capitalize on acoustical hearing for music perception. Front Psychol. 2012;3. doi.org/10.3389/fpsyg.2012.00425. PMID: 23133430. PMCID: PMC3490327.
22. Nickerson A, Davidson LS, Uchanski RM. Preimplant hearing aid fittings and aided audibility for pediatric cochlear implant recipients. J Am Acad Audiol. 2019 Sep;30(08):703-11. doi.org/10.3766/jaaa.17126. PMID: 31044697. PMCID: PMC6750978.
23. Battmer RD, Gupta SP, Allum-Mecklenburg DJ, Lenarz T. Factors influencing cochlear implant perceptual performance in 132 adults. Ann Otol Rhinol Amp Laryngol. 1995;Supplement(166):185-7.
24. Cohen O, Sichel JY, Shaul C, Chen I, Roland JT, Perez R. The importance of intraoperative plain radiographs during cochlear implant surgery in patients with normal anatomy. Appl Sci. 2021 Apr 30;11(9):4144. doi.org/10.3390/app11094144
25. Finley CC, Holden TA, Holden LK, Whiting BR, Chole RA, Neely GJ, Hullar TE, Skinner MW. Role of electrode placement as a contributor to variability in cochlear implant outcomes. Otol Amp Neurotol. 2008 Oct;29(7):920-8. doi.org/10.1097/mao.0b013e318184f492. PMID: 18667935. PMCID: PMC2663852.