DEVELOPMENT OF A PROFILING TOOL FOR COCHLEAR IMPLANT CANDIDACY IN INDIAN CHILDREN: CORRELATION WITH SPEECH-LANGUAGE AND AIDED AUDIOGRAM OUTCOMES

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CERTIFICATE

This is to certify that this dissertation entitled **'Development Of Profiling Tool For Cochlear Implant Candidacy In Indian Children : Correlation With Speech And Language Skills And Aided Audiogram Outcomes'** is a bonafide work submitted as part of fulfilment of the degree of Master of Science (Audiology) of the student with Registration Number **P01II24S023011.** This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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This is to certify that this dissertation entitled **'Development Of Profiling Tool For Cochlear Implant Candidacy In Indian Children : Correlation With Speech And Language Skills And Aided Audiogram Outcomes'** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **'Development Of Profiling Tool For Cochlear Implant Candidacy In Indian Children : Correlation With Speech And Language Skills And Aided Audiogram Outcomes'** is the result of my own study under the guidance of Dr. P Manjula, Professor of Audiology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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ABSTRACT

The study employed a retrospective correlational design and was conducted at the AIISH, Mysuru. A profiling tool having 13 candidacy factors was developed based on a existing literature. The data were taken retrospectively from clinical records of 146 children with bilateral severe to profound hearing loss who had undergone unilateral cochlear implantation and completed at least one year of post-implant habilitation therapy at AIISH. Post-implant outcome measures at one year included receptive language age (RLA) and expressive language age (ELA) assessed using the Assessment Checklist of Speech-Language Skills (ACSLS); cochlear implant-aided pure-tone average, and speech identification scores (SIS). Cochlear implantation was associated with clinically significant improvement across all outcome measures. Duration of deafness and age at implantation were the strongest and most consistent predictors of post-implant language outcomes, with duration of deafness accounting for the largest independent contribution to receptive language age. Learning style emerged as the most significant predictor of speech identification score, while medical and radiological status and pre-implant hearing aid use adequacy significantly predicted CI aided thresholds. Family structure and support were also significant predictors of functional speech perception. The overall profiling tool's total score was statistically significant but had limited standalone validity across outcome domains (AUC range: 0.496–0.618), indicating that individual domain-specific ratings are more clinically informative than the composite score alone. The findings demonstrate that the adapted profiling tool is best used as a structured profiling framework for counselling and planning rather than as a standalone screening instrument.

Keywords: *cochlear implantation; candidacy profiling, Children's Implant Profile, speech-language outcomes, SIS, auditory habilitatio*

Chapter 1

INTRODUCTION

The World Health Organisation (WHO, 2021) estimates over 1.5 billion people worldwide experience some degree of hearing loss, with disabling hearing loss affecting more than 430 million individuals globally. In children, congenital sensorineural hearing loss (SNHL) is among the most prevalent developmental conditions, occurring in approximately 1 to 3 per 1000 live births worldwide (Finitzo et al., 1998; Korver et al., 2017).According to the National Sample Survey Organization (NSSO, 2013), 291 out of every lakh people had moderate hearing loss, while national estimates for congenital hearing impairment among newborns range from 1.59 to 8.8 per 1000 (Verma et al., 2022).

These kids are at danger of long-term communicative, educational, and social disadvantage if prompt and efficient assistance is not provided. They also face severe delays in learning spoken language. Thus, early detection and treatment of hearing loss in children is seen as a top public health priority.

1.1 Cochlear Implantation as a Rehabilitative Intervention

For children with bilateral severe to profound sensorineural hearing loss who get insufficient benefit from conventional hearing aids, cochlear implantation has emerged as an effective rehabilitative intervention.

Theefficacy of cochlear implantation in children is well established. Following implantation and rehabilitation, most children show significant improvements in aided hearing thresholds, , speech perception, and spoken language development (Niparko et al., 2010; Wilson & Dorman, 2008). Large-scale longitudinal studies have documented that children with cochlear implants can achieve meaningful gains in spoken language, with some reaching age-appropriate language levels under optimal conditions (Niparko et al., 2010).

Over the past 20 years, cochlear implantation has grown significantly in India; by 2018, there were 25,000 procedures performed annually, up from about 5,000 in 2011 (Garg et al., 2011; Kumar & Kameswaran, 2018). Government-funded initiatives like the Assistance to Disabled Persons (ADIP) program and state-level cochlear implant programs, which seek to make the surgery accessible to families with low incomes, have further helped this spread.

Despite these advances, cochlear implantation is not a straightforward solution that guarantees uniform outcomes for all children. Post-implant outcomes vary considerably across individuals. Even among children who are broadly similar in terms of hearing loss severity. This variability is a central challenge in the clinical management of paediatric cochlear implantees.

1.2 Factors Influencing Cochlear Implant Outcomes in Children

Research has consistently demonstrated that post-implant auditory, speech, and language outcomes in children are shaped by the interacting pre-implant, peri-operative, and post-implant factors/ variables rather than by any single factor in isolation (Edwards et al, 2003). Among the most reliably identified predictors, age at implantation is considered important (Daya et al., 1999; Nikolopoulos, Dyar, et al., 2004). Younger children, particularly those implanted before 12 to 18 months of age, consistently outperform later-implanted peers on measures of speech perception, receptive and expressive language, and spoken vocabulary, reflecting the role of the sensitive period for auditory cortical development (Tomblin et al., 2005; Nicholas & Geers, 2007). The duration of auditory deprivation prior to implantation, which is closely related to age at implantation, also negatively influences post-implant progress. With longer deprivation associated with slower and less complete auditory and language development (Nikolopoulos, Gibbin, & Dyar, 2004; Hota, 2019).

Beyond these demographic variables, a range of medical, audiological, developmental, family-related, educational, and rehabilitative factors have been shown to contribute to outcome variability independently. Factors such as medical and radiological (cochlear anatomy, the presence of inner ear malformations, cochlear nerve status and surgery related aetiology such as post-meningitic ossification) influence the technical feasibility of implantation and also the degree of benefit achievable (Farhood et al., 2017; Maturi et al., 2024). Findings from pre-implant audiological assessments, such as aided hearing thresholds and pre-implant speech perception abilities, are important indicators of residual auditory function and sensory deprivation (Nickerson et al., 2019; Brown & Gifford, 2021). The rate of spoken language development following implantation is related to pre-implant speech and language skills which are an indication of the child's early language experience, benefit from hearing aids and communicative environment before surgery (Nicholas & Geers, 2007; Percy-Smith et al., 2013).

Family-related variables, in particular family support quality, parental participation in rehabilitation, and home language environment, are consistently found to be important determinants of post-implant outcomes (DesJardin, 2006; DesJardin & Eisenberg, 2007; Niparko et al., 2010). The long-term trajectory of auditory and communicative development is also affected by the educational placement of the child and the availability of specialist support services in school and the community, with children in well-resourced auditory-oral environments generally doing better than those in less supportive settings (Archbold et al., 2002; Moog & Geers, 2010). The child's cognitive abilities and learning style, such as attention, working memory, executive functioning and engagement in adult-directed learning activities, also make independent contributions to speech perception and language outcomes, with poorer neurocognitive profiles associated with slower post-implant progress.(Kronenberger et al., 2014; Nikolopoulos, Dyar, & Gibbin, 2004). Post-implant rehabilitation services, including cochlear implant mapping, speech-language therapy and habilitation, are also a critical determinant of functional benefit. The device itself does not confer one with communication skills without consistent and expert habilitation (Moeller, 2000; Ching et al., 2015).

A planned, methodical approach to pre-implant evaluation that goes beyond audiological criteria alone is required due to the multifaceted character of cochlear implant outcomes. Candidacy profiling methods that capture the variety of clinical, developmental, family, and environmental characteristics pertinent to predicting cochlear implant outcomes in children have been developed as a result of this need. The sections that follow go over a few of these tools.

1.3 The Children's Implant Profile and Its Modifications

The Children's Implant Profile (ChIP), originally developed by Hellman et al. (1991), was one of the first structured tools which was designed to assist multidisciplinary teams inassessing paediatric cochlear implant candidacy. The ChIP was derived from a retrospective analysis of 36 pediatric cochlear implant users and identified 11 key domains influencing implant success, including chronological age, duration of deafness, medical and radiological status, multiple handicapping conditions, functional hearing, speech and language abilities, family support, family expectations, educational environment, support services, and cognitive and learning style. Each factor was rated as no concern, mild-to-moderate concern, or great concern, enabling clinicians to generate a comprehensive candidacy profile rather than relying solely on audiological criteria.

Since its introduction, the ChIP has undergone multiple modifications to improve its quantitative rigour, clinical applicability, and predictive validity. Daya et al. (1999) developed the Graded Profile Analysis (GPA), which introduced numerical scoring to the original framework and demonstrated that total GPA scores were associated with candidacy decisions and post-implant speech perception outcomes, with duration of deafness accounting for approximately 24% of outcome variance. Nikolopoulos et al. (2004) developed the Nottingham Children's Implant Profile (NChIP), which organised 12 candidacy factors into a structured four-level framework and found that learning style was the most consistent predictor of speech perception outcomes three- and four- years post-implantation, with duration of deafness, age at implantation, and family support also contributing significantly. Edwards et al. (2009) developed the Great Ormond Street Hospital Children's Implant Profile (GOSHChIP), which expanded the profile to 19 factors and placed greater emphasis on the predictive associations between profile domains and post-implant speech and language performance. Additional modifications such as the Children's Hospital of Philadelphia (CHOP) modified ChIP (Lazaridis et al., 2010), the modified prognosis tool (O'Brien et al., 2012) and the AuSpLan framework (McClatchie & Therres, 2009) have increasingly shifted candidacy profiling from a descriptive multidisciplinary discussion to more structured outcome prediction and planning of rehabilitation.

Despite these advances, all existing ChIP-based profiling tools were developed and validated primarily in Western pediatric cochlear implant populations. However, their direct applicability to the Indian context is limited as the sociolinguistic environment, family structures, educational systems, access to health care and rehabilitation services and the typical clinical profile of children presenting for cochlear implantation in India are different.

1.4 Cochlear Implantation in the Indian Context

Children with hearing loss in India face a distinctive set of clinical, social, and systemic (infrastructure, healthcare access, or institutional setups) challenges that differentiate them from cochlear implant populations in Western countries. Late diagnosis is common, arising from the absence of universal newborn hearing screening in many states, limited awareness of early intervention among families and primary healthcare providers, and geographical barriers to audiological services in rural regions (Ravi & Gunjawate, 2020). As a result, many Indian youngsters receive their implants later in life than their Western counterparts, which results in lengthier periods of auditory deprivation during the procedure. Pre-implant language assessment and post-implant rehabilitation planning are made more difficult by India's multilingual population. This is because children may be exposed to various languages at home, at school, and in therapy settings, which makes it difficult to use standardized Western language examinations. Family structures in India are diverse.In india there are extended family systems, varying levels of parental educational attainment and literacy, and heterogeneous socioeconomic backgrounds that influence access to and engagement with rehabilitation services. Educational environments for children with hearing impairment range from well-resourced integrated mainstream schools in urban centres to poorly equipped special schools or home-based education in rural and semi-urban areas, with wide variation in the availability of trained teachers of the deaf, assistive devices, and specialist support. Post-implant rehabilitation resources, including cochlear implant mapping clinics, speech-language therapy, and auditory-verbal therapy services, are concentrated primarily in major cities and tertiary healthcare institutions, leaving many implanted children in smaller towns and rural areas with limited or inconsistent access to follow-up care (Manjula et al., 2025).

A nationwide survey by Manjula et al., in 2025, documented considerable variation across Indian pediatric cochlear implant centres in candidacy criteria, audiological assessment protocols, hearing aid benefit evaluation methods, and post-implant outcome measures. While all participating centres used a broad test-battery approach for candidacy assessment and agreed on the importance of bilateral severe-to-profound hearing loss and poor aided benefit as candidacy indicators, the specific tools, criteria, and practices used varied markedly across centres, making systematic comparison of candidates and outcomes across programmes difficult. The authors concluded that India requires a standardised, culturally adapted profiling system for paediatric cochlear implant candidacy and outcome measurement. Despite the growing volume of cochlear implant surgery performed in India, there remains a critical gap in validated, India-specific tools for structured candidacy assessment and outcome prediction.

1.5 Need for the Present Study

The absence of a validated profiling tool adapted for the Indian paediatric cochlear implant population has significant clinical implications. Without a structured, evidence-based candidacy profile, multidisciplinary teams in Indian cochlear implant programmes face challenges in conducting consistent and comprehensive pre-implant evaluations, providing accurate outcome-based counselling to families, identifying children at elevated risk for poor outcomes who may benefit from additional pre-implant intervention, and systematically documenting the range of clinical and contextual factors influencing post-implant progress. These limitations affect the quality and ability of cochlear implant programmes to show outcomes, benchmark performance, and refine rehabilitation pathways based on empirical evidence.

International ChIP-based profiling tools provide a strong conceptual foundation by demonstrating that pre-implant candidacy factors across medical, audiological, developmental, family, educational, and rehabilitative domains are meaningfully associated with post-implant auditory and language outcomes. However, they cannot be applied directly in the Indian setting without adaptation to local clinical criteria, assessment tools available in the Indian context, the linguistic and cultural composition of families, and the particular patterns of educational placement and rehabilitation access that characterise the Indian cochlear implant population. Validated Indian outcome measures, such as the Assessment Checklist of Speech-Language Skills (ACSLS; Swapna, 2007) and Assessment of Language Development - Manipal Manual (ALD-MM; Lakkanna et al., 2021), which provide age-referenced receptive and expressive language scores for Indian children, offer a clinically appropriate framework for evaluating post-implant speech and language outcomes in this population. However, their integration into a structured predictive profiling system has not yet been systematically examined.

The present study was therefore designed to address this gap by developing and validating a structured profiling tool for cochlear implant candidacy in children, adapted for the Indian context from the Children's Implant Profile and its modifications, and by systematically examining the predictive relationships between pre-implant ChIP factor ratings and post-implant speech-language and audiological outcomes in a sample of children who had undergone unilateral cochlear implantation and attending intervention at the All India Institute of Speech and Hearing (AIISH), Mysuru. The study was conducted at AIISH, which provided access to a large retrospective dataset with comprehensive pre-implant assessment records and standardised post-implant outcome data.

1.6 Aim of the Study

The present study aimed to develop a structured profiling and scoring system based on the Children's Implant Profile (ChIP) for use in the Indian context, and to examine its ability to predict speech-language and audiological outcomes in children following cochlear implantation.

1.7 Objectives of the Study

The following objectives were framed to fulfil the aim of the study:

1. To create a profiling tool for cochlear implant candidacy in children for the Indian context.
2. To examine the predictive accuracy of the profile tool by comparing it with the Assessment Checklist of Speech-Language Skills (ACSLS) scores and aided audiometry scores at one- year post-implantation.
3. To identify the main pre-implant profiling factors linked to favourable speech-language and audiological outcomes in children following cochlear implantation.

Chapter 2

REVIEW OF LITERATURE

The assessment of pediatric cochlear implant candidacy has evolved from reliance on isolated audiological criteria to the use of structured multidimensional profiling systems. This shift occurred because a wide range of interacting factors, including age at implantation, duration of deafness, medical and radiological findings, speech and language abilities, cognitive status, family support, educational environment, and access to rehabilitation services, influence cochlear implant outcomes in children. In response to this complexity, several profile-based tools were developed, beginning with the Children's Implant Profile (ChIP) and followed by several modified versions. The ChIP was intended to assist multidisciplinary teams in identifying potential candidates for implantation who would benefit from the device. The following section presents these profiling models in chronological order and outlines their contribution to the assessment and prediction of cochlear implant outcomes in children.

The review of literature is presented under the following sections: (1) development and evolution of the Children's Implant Profile and its modified versions, (2) factors influencing cochlear implant outcomes in children, including chronological age at implantation, duration of deafness, medical and radiological status, audiological assessment and aided benefit, pre-implant speech and language abilities, additional disabilities, family structure and support, educational environment, availability of support services, expectations of the family and child, cognitive abilities, and learning style and child engagement, and (3) relevance of these factors to the development of the present profiling tool in the Indian context.

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2.1.1 Development of the Children's Implant Profile (ChIP)

Hellman et al. (1991) developed the Children's Implant Profile (ChIP) as a structured clinical tool to help multidisciplinary teams assess the candidacy of children with profound hearing loss for cochlear implantation. The authors emphasised that cochlear implantation is not only a surgical procedure but also a long-term habilitative process requiring audiological, educational, and psychosocial support. They proposed that implant success depends on multiple interacting factors rather than solely on hearing loss severity. (Hellman et al., 1991).

The ChIP was derived from a retrospective analysis of 36 pediatric cochlear implant users at the Children's Hearing Institute at the Manhattan Eye, Ear and Throat Hospital in 1991. By comparing children with successful outcomes to poor performers and non-users, the authors identified 11 key domains that influence implant success. These included chronological age, duration of deafness, medical and radiological status, multiple handicapping conditions, functional hearing, speech and language abilities, family support, family expectations, educational environment, support services, and cognitive and learning style. Each factor was rated as no concern, mild-to-moderate concern, or great concern, allowing clinicians to generate an overall profile of the child's readiness for implantation.

An important feature of the ChIP is its holistic and flexible approach. The profile was not intended to be a rigid checklist, but rather a framework to guide clinical decision-making and parental counselling. It considers environmental and psychosocial factors alongside audiological and medical findings, thereby promoting a more comprehensive assessment.

2.1.2 Graded Profile Analysis as a Modification of the Children's Implant Profile

In order to measure pre-implant candidacy characteristics and investigate their connections with cochlear implant results, Daya et al. (1999) presented the Graded Profile Analysis (GPA), a version of the original Children's Implant Profile (ChIP). The researchers realized that a number of interrelated medical, audiological, developmental, and environmental factors affect a child's eligibility for a cochlear implant.

The Graded Profile Analysis (GPA) offered a more organized, measurable method of evaluating candidates than the initial Children's Implant Profile created by Hellman et al. (1991). Daya et al. increased the profile to 14 categories by include developmental milestones, social skills, and distinct evaluations for parent and child expectations, whereas the original ChIP contained 11 broad elements graded according to the degree of worry.In addition, the GPA converted qualitative concern levels into numerical scores, enabling objective comparisons across candidates and statistical examination of the relationships between pre-implant profiles, candidacy decisions, and post-implant outcomes. (Daya et al., 1999). Each GPA category was rated as no concern, mild concern, or great concern, and these ratings were converted into numerical values of +1, 0, and −1, respectively. The total GPA score could therefore range from −14 to +14. In their retrospective study of 109 children assessed at The Hospital for Sick Children in Toronto, 80 were implanted, and 29 were not. The findings showed a strong association between GPA scores and candidacy decisions, i.e., children with scores below 5 were not implanted, those with scores between 5 and 8 formed a borderline group, and about 95% of children with scores between 9 and 14 were implanted unless contraindicated for medical reasons or parental consent was not obtained.

The authors also found that higher GPA scores were associated with faster improvement in speech perception outcomes after implantation. Children in the higher GPA group showed significantly greater progress on measures such as TAC, PBK Phonemes, and PBK Words, although even borderline candidates showed some benefit.

2.1.3 Nottingham Children's Implant Profile (NChIP)

Nikolopoulos, Dyar, et al. (2004) developed the Nottingham Children's Implant Profile (NChIP) as an adaptation of the original ChIP to provide a more structured framework for assessing pediatric cochlear implant candidates. The authors noted that, although ChIP was widely used, there was limited published evidence on its application in large pediatric samples. Compared with the original ChIP by Hellman et al. (1991) and the GPA by Daya et al. (1999), the Nottingham Children's Implant Profile (NChIP) retained the multidimensional approach to candidacy assessment. It did, however, offer a more methodical arrangement of elements into four levels: factual, investigative, extrinsic, and intrinsic. The NChIP concentrated more on analyzing each candidacy component separately and using the profile as an organized casework and counseling tool than the GPA, which placed more emphasis on numerical grading and overall profile totals. Without restricting candidacy decisions to a single cumulative score, this enabled for more transparent interdisciplinary discussion of individual areas of concern, including language and speech ability, duration of deafness, and learning style (Nikolopoulos, Dyar, et al., 2004).The study included the first 200 profoundly deaf children implanted through the Nottingham Paediatric Cochlear Implant Programme. The NChIP comprised 12 factors grouped into four levels. Each factor was rated as no concern, mild to moderate concern, or great concern by the relevant professional, allowing multidisciplinary information to be combined into a single profile. The results showed that pre-implant speech and language abilities were the most frequent area of mild to moderate concern, followed by duration of deafness and learning style. At the same time, chronological age emerged as the most common area of major concern.

The authors emphasised that the NChIP should not be treated as a rigid pass-fail test, but rather as a structured profile to guide discussion, counselling, and decision-making. Overall, the NChIP was presented as a practical and flexible framework for comprehensive pediatric cochlear implant assessment.

2.1.4 Great Ormond Street Hospital Children's Implant Profile (GOSHChIP)

Edwards, Thomas, and Rajput developed the Great Ormond Street Hospital Children's Implant Profile (GOSHChIP) in 2009 as a refined modification of earlier profiling tools, such as the original ChIP and the NChIP. The aim was to improve the objectivity of pediatric cochlear implant candidacy assessment and to examine whether pre-implant profiling factors were associated with post-implant outcomes. The authors noted that, although such tools were widely used in multidisciplinary practice, there was limited empirical evidence linking profile scores with later speech and language performance.

Compared with earlier ChIP-based versions, the GOSHChIP represented a further refinement of profile-based candidacy assessment by placing greater emphasis on objectivity and predictive power. While the original ChIP, GPA, and NChIP primarily served as structured frameworks for multidisciplinary discussion and candidate selection, the GOSHChIP revised factor definitions, expanded some domains, and examined their statistical relationships with post-implant speech perception and intelligibility outcomes. In particular, it gave greater attention to factors such as cognitive ability, hearing aid use, communication mode, and behavioural characteristics, thereby moving the profile beyond descriptive casework toward a more prognostic tool for counselling.

The study included 70 children implanted at Great Ormond Street Hospital between 1992 and 2006. The GOSHChIP assessed nine domains. Post-implant outcomes were measured using standardised tools such as the Categories of Auditory Performance (CAP), Speech Intelligibility Rating (SIR), and language assessments. The results showed that younger age at implantation, shorter duration of deafness, and better cognitive ability were associated with more favourable auditory, speech, and language outcomes. Further, it was also found that family support and educational placement had an important influence on rehabilitation success, while additional disabilities were generally associated with poorer outcomes.

2.1.5 Evaluation of Modified Children's Implant Profile in Candidacy Selection

In 2003, Edwards evaluated whether a modified version of the Children's Implant Profile (ChIP) was effective in selecting appropriate pediatric cochlear implant candidates. The study was based on the concern that, although structured profiling tools were increasingly used in clinical practice, there was limited evidence showing whether later outcomes justified selection decisions based on such profiles. The modified ChIP retained the multidimensional approach of the original profile.

Compared with earlier ChIP-based frameworks, this modified version placed greater emphasis on assessing whether post-implant outcomes supported pre-implant profile ratings. While the original ChIP, GPA, and NChIP primarily served as structured tools for candidate assessment and multidisciplinary discussion, Edwards' modified ChIP focused more directly on evaluating the appropriateness of candidacy decisions in relation to later auditory and speech performance. Thus, this version marked an important shift from descriptive profiling toward outcome-based validation of the profile, while retaining the multidimensional, clinically guided nature of earlier ChIP models.

Post-implant outcomes were assessed using standardised clinical measures of auditory performance and speech intelligibility collected during follow-up. The study found that children with fewer pre-implant areas of concern on the modified ChIP generally achieved better auditory and speech outcomes. In contrast, children with multiple concerns showed slower progress and poorer speech intelligibility. In particular, pre-implant language ability, cognitive skills, presence of additional disabilities, family support, and educational environment appeared to strongly influence post-implant progress.

Edwards emphasised that the modified ChIP should not be used as a rigid screening test, but rather as a framework for multidisciplinary decision-making and parental counselling. The profile enabled clinicians to consider non-audiological factors systematically and helped families develop realistic expectations for outcomes and rehabilitation demands.

2.1.6 The CHOP mChIP

Lazaridis, T., & Marsh (2010). examined the use of a modified Children's Implant Profile in the cochlear implant candidacy process at The Children's Hospital of Philadelphia (CHOP). The study was undertaken because, despite the long-standing use of ChIP in pediatric cochlear implant programs, there was limited evidence regarding its role in actual clinical decision-making.

Compared with earlier ChIP-based versions, the CHOP-modified ChIP introduced much greater detail in the assessment process by expanding the profile from a smaller set of broad domains to a larger set of specific items across disciplines. While earlier ChIP-based versions emphasised a structured, multidisciplinary evaluation, Lazaridis et al. highlighted that candidacy decisions could not be fully explained by profile scores alone. Thus, this version differed from previous models by showing that, although structured scoring was useful, real-life cochlear implant recommendations still depended on the interaction of multiple clinical, audiological, linguistic, and psychosocial factors, and could not be reduced to a single cutoff score.

Using a retrospective design, the authors reviewed 121 children evaluated for cochlear implantation, of whom 107 had complete mChIP data. All children underwent multidisciplinary assessment involving audiology, speech-language pathology, social work, education, and otolaryngology.

The CHOP mChIP differed from the original ChIP by expanding the number of assessment areas from 11 to 31, allowing greater detail in domains such as speech-language abilities and additional disabilities. Results showed that 87 children were recommended for implantation and 20 were not. Although there was a moderate relationship between the mean mChIP score and team recommendation, no single cutoff score accurately classified all cases. The authors emphasised that cochlear implant candidacy decisions could not be reduced to a numerical score alone. No single professional domain dominated the process, and the findings highlighted the interrelated influence of audiological, linguistic, educational, and psychosocial factors.

The mChIP was therefore viewed not as a rigid selection tool, but as a framework to guide multidisciplinary judgment, identify modifiable concerns, and support family counselling.

2.1.7 Modified Prognosis Tool Based on the Children's Implant Profile

Graham O'Brien et al.(2012) developed a prognostic tool based on a modified version of the Children's Implant Profile (ChIP) to improve objectivity in pediatric cochlear implant evaluation and to predict post-implant communication outcomes. The authors noted that, although cochlear implantation had become an established intervention for children with severe to profound hearing loss, predicting outcomes remained difficult because of the combined influence of medical, audiological, speech-language, psychological, and educational factors.

Compared with the earlier ChIP-based versions, the modified prognosis tool developed by Graham O'Brien et al. represented a more advanced attempt to convert profile-based assessment into a formal prediction model. While the original ChIP, GPA, NChIP, GOSHChIP, and other modified versions mainly supported multidisciplinary discussion, candidate selection, and counselling, this model explicitly linked pre-implant profile domains with predicted post-implant communication outcome groups using statistical methods such as regression and CART analysis. Thus, it moved beyond descriptive or semi-quantitative profiling toward a more structured prognostic system that could guide both candidacy decisions and postoperative rehabilitation planning.

The study was conducted at the Children's Hospital Boston Cochlear Implant Program and included 106 children with at least 2 years of post-implant follow-up. The modified profile, known as mChIP-CHB, consisted of five domains—medical, audiological, speech-language, psychological, and educational—further divided into 35 clinical characteristics.

Statistical analyses showed that children who later became successful auditory-oral communicators generally had lower concern scores across all domains. Among the five domains, the speech-language and medical constructs emerged as the strongest predictors of post-implant communication outcomes. The authors concluded that the tool was useful not as a strict eligibility criterion, but as a structured framework to support multidisciplinary decision-making, parental counselling, and rehabilitation planning.

2.1.8 AuSpLan (Auditory Speech Language) Framework for Cochlear Implant Candidacy and Outcome Prediction

McClatchie and Therres developed the AuSpLan (Auditory Speech Language) framework as a comprehensive program to guide cochlear implant candidacy, predict communication outcomes, and plan post-implant rehabilitation. The foundation of the paradigm was the notion that children with cochlear implants' hearing, speech, and language development should be viewed collectively rather than as distinct areas. Pre-implant candidacy evaluation and outcome prediction, educational placement and support planning, and structured therapy goals for auditory, speech, and language development are the three primary components of AuSpLan. Interdisciplinary team members evaluate the child's skills, expectations, and family circumstances during the candidacy evaluation process. They then categorize the child into one of four prognosis levels: A, B, C, or D (McClatchie & Therres, 2009).

The anticipated long-term communication consequences are represented by these four tiers. Children who are expected to become oral or auditory-verbal communicators are classified as Level A; children who are likely to rely on both auditory and visual input are classified as Level B; children who primarily rely on visual communication with limited auditory benefit are classified as Level C; and children who are unlikely to significantly benefit from cochlear implantation are classified as Level D. The framework demonstrated good predictive value in a longitudinal study of 80 prelingually deaf children who were implanted between the ages of two and five. The majority of the children's outcomes were in line with their pre-implant evaluations. Additionally, the framework offered developmental timetables, showing that children at Level A generally advanced more quickly while those at Levels B and C demonstrated slower or more constrained communicative skills.Compared with the earlier ChIP-based versions, the AuSpLan framework extended profiling beyond pre-implant candidacy assessment into post-implant goal setting, educational planning, and long-term developmental monitoring. While the original ChIP and its later modifications mainly focused on identifying preoperative concerns and predicting benefit, AuSpLan linked candidacy levels directly to expected communication outcomes, educational placement, and structured auditory, speech, and language milestones. Thus, it broadened the role of profiling from candidate selection alone to a more comprehensive framework for counselling, rehabilitation planning, and monitoring progress after implantation.

2.1.9 Indian Study on Cochlear Implant Candidacy and Outcome Measures

A survey was carried out by Manjula, Geetha, Jawahar Antony, and Megha (2025) to record the audiological evaluation procedures, qualifying standards, and outcome metrics utilized by pediatric cochlear implant facilities in India. The finding is extremely pertinent to cochlear implant programs in India. They gathered answers to a 39-item survey from 20 audiologists employed by various cochlear implant facilities around the US. The results demonstrated that while cochlear implantation is becoming more widely available in India, candidate selection and outcome evaluation procedures are still inconsistent.The results indicated broad agreement regarding the use of a test-battery approach for candidacy assessment. All centres reported using conditioned-play audiometry, immittance evaluation, and auditory brainstem response testing, while most also used behavioural-observation audiometry and otoacoustic emissions. All centres considered bilateral severe-to-profound hearing loss and poor aided benefit as key audiological indicators of candidacy. However, there was considerable variation in the additional tools used to assess hearing aid benefit, such as aided audiograms, developmental checklists, parental reports, MAIS, IT-MAIS, CAP, SIR, and PEACH. Variation was also observed in speech perception criteria and test presentation levels, making comparison across centres difficult.

For post-implant outcome evaluation, most centres used a combination of aided audiograms, speech recognition tests, and auditory development scales, usually beginning three months after switch-on and continuing at three-month intervals. However, the tools and materials varied widely across centres due to linguistic diversity and the lack of standardised measures in many Indian languages. The authors concluded that although there is general agreement on the importance of structured audiological assessment, India urgently needs a uniform protocol for profiling and outcome measurement. This study strongly supports the development of an Indian-specific cochlear implant profiling tool. It provides direct justification for the present research, which aims to create a culturally and clinically relevant profiling system for the Indian context.

A clear shift from straightforward multidisciplinary profiling to more structured, quantified, and outcome-oriented approaches to cochlear implant candidacy and rehabilitation planning is evident in the evolution from the original ChIP to later modifications like the GPA, NChIP, GOSHChIP, CHOP mChIP, the modified prognosis tool, and the AuSpLan framework.. These models collectively emphasised that candidacy depends not only on audiological status, but also on linguistic, cognitive, family, educational, and rehabilitative factors. There is still considerable variation across Indian cochlear implant centres in candidacy criteria, hearing aid benefit assessment, and post-implant outcome measures. This highlights that, although international ChIP-based models provide a strong conceptual foundation, there remains a clear need for an Indian-specific, standardised profiling tool that is better aligned with the linguistic, clinical, and rehabilitative realities of children in India.

The outcome of cochlear implantation in children is influenced by multiple interacting factors rather than by audiological status alone. Although cochlear implantation provides access to hearing, the extent to which a child benefits from the device depends on demographic, medical, audiological, linguistic, cognitive, family, educational, and rehabilitative variables. Therefore, it is important to examine these factors individually to understand their contributions to post-implant auditory, speech, and language outcomes. The following section reviews the major factors reported in the literature to influence cochlear implant outcomes in children.

2.2.1Importance of Age at Implantation in Cochlear Implant Candidacy

Age at implantation is one of the most important factors influencing cochlear implant outcomes in children. Earlier implantation is consistently associated with better auditory, speech, and language development, largely because younger children benefit from greater neural plasticity during the sensitive period for auditory learning. As a result, age at implantation is widely regarded as a key variable in both candidacy assessment and prognosis.

In a study by Nikolopoulos, Gibbin, and Dyar (2004) using the Nottingham Children's Implant Profile (NChIP), implantation was identified as a significant predictor of long-term speech perception outcomes in prelingually deaf children. Younger implantation age was associated with better Categories of Auditory Performance (CAP) and Connected Discourse Tracking (CDT) scores, and regression analysis confirmed its independent contribution to outcome variance. Similarly, Tomblin et al. (2005)reported that children implanted during infancy showed faster expressive language growth than those implanted later, with age at initial stimulation accounting for a meaningful proportion of the variance in language growth. Their findings were supported by neurophysiological evidence showing that early auditory stimulation promotes more typical cortical maturation, whereas delayed implantation is associated with less efficient auditory pathway development.

Evidence from Indian studies also supports the importance of early implantation. Manjula et al. (2025), in asurvey of pediatric cochlear implant centres, found that most audiologists considered age at implantation and duration of deafness to be the most critical factors in candidacy decisions. The study also noted that several government-supported cochlear implant schemes in India prioritise younger children. Together, these studies confirm that chronological age at implantation is a major determinant of post-implant success and an essential factor in cochlear implant profiling. Additional Indian evidence also supports the importance of early implantation. Gaurav, Sharma, and Singh (2019) (Singhal et al., 2020) compared children implanted at or before five years of age with those implanted after five years and found significantly higher CAP and MAIS scores at one-year post-implantation in the earlier-implanted group. At the same time, the authors observed that later-implanted children also showed meaningful benefit, with scores exceeding 80% of the maximum possible value, indicating that cochlear implantation remains effective beyond 5 years. The study concluded that age at implantation is useful for predicting auditory outcomes and for counselling families in clinical practice.

2.2.2 Importance of Duration of Deafness in Cochlear Implant Candidacy

The duration of deafness, or auditory deprivation, is an important predictor of cochlear implant outcomes and should be included in any structured candidacy profile. It refers to the length of time a child's auditory system has been deprived of meaningful sound before implantation. In general, shorter deafness duration is associated with better auditory skill development, faster growth in speech perception, and stronger speech intelligibility. In contrast, longer deprivation is associated with slower, poorer progress.

Strong evidence for this comes from the study by Nikolopoulos, Gibbin, and Dyar (2004). They found that it significantly predicted long-term speech perception, including duration of deafness as a core factor in the Nottingham Children's Implant Profile (NChIP), and found that it significantly predicted long-term speech-perception outcomes. A shorter duration of deafness was associated with better performance on the Categories of Auditory Performance and open-set speech perception, and regression analysis showed that it explained a substantial portion of the outcome variance, even after controlling for other factors. Similar support is reflected in the Great Ormond Street Hospital Children's Implant Profile work, where the investigators identified duration of deafness as one of the important variables contributing to differences in post-implant performance. These studies show that the duration of deprivation is not just a background detail but a clinically meaningful factor in outcome prediction, where Hota (2019)reported that longer duration of auditory deprivation was negatively associated with both auditory performance and speech intelligibility in prelingually deaf children after cochlear implantation, with the relationship becoming clearer over follow-up. This is especially relevant because the outcomes were measured using practical clinical tools, such as the Categories of Auditory Performance and the Speech Intelligibility Rating. Overall, the literature strongly justifies including duration of deafness in an Indian cochlear implant candidacy profile, as it helps predict likely progress, guide counselling, and plan rehabilitation needs more realistically.

2.2.3 Importance of Medical and Radiological Factors in Cochlear Implant Candidacy

Medical and radiological factors are a major part ofcochlear implant candidacy .These factors affect both surgical feasibility and later auditory and speech outcomes. Unlike variables such as age or duration of deafness, these factors reflect the structural integrity of the auditory system, including the cochlea, cochlear nerve, and central auditory pathways.

One of the most studied radiological factors is the presence of inner ear malformations. Farhood et al. (2017) in a systematic review reported that children with inner ear malformations had higher rates of surgical complications, such as cerebrospinal fluid gusher and incomplete electrode insertion. Although many of these children still obtained auditory benefit, outcomes were highly variable and often poorer than in children with normal cochlear anatomy, underscoring the value of radiological classification for prognosis and surgical planning.

Similarly, cochlear nerve deficiency (CND) has been shown to produce varied outcomes. In a systematic review and meta-analysis by Maturi et al. (2024), it was reported that some children with bilateral CND achieved open-set speech perception, while many others showed minimal or no measurable auditory benefit, with outcomes strongly influenced by whether the nerve was hypoplastic or aplastic on imaging. These findings underline the importance of MRI-based nerve assessment in candidacy profiling, with no measurable auditory benefit and non-measurable.

Medical aetiology also interacts with radiological findings. In post-meningitic deafness, meningitis may cause labyrinthitis ossificans and partial or complete cochlear ossification. Studies such as those by Altuntaş et al. (2021) show that extensive ossification is associated with greater surgical difficulty and poorer speech-perception outcomes, making CT and MRI essential for planning. Beyond structural abnormalities, etiologies such as congenital cytomegalovirus infection and syndromic hearing loss may involve broader neurological or developmental problems that reduce auditory and language gains even when peripheral stimulation is adequate.

Thus, pre-implant radiological evaluation using high-resolution CT for bony anatomy and MRI for neural and intracranial structures is crucialnot only for confirming surgical candidacy but also for predicting likely rehabilitation benefit. Children with normal cochlear patency and intact cochlear nerves generally have better prognoses, whereas common cavity malformations, cochlear nerve hypoplasia/aplasia, or major central abnormalities may indicate limited benefit.

2.2.4 Importance of Audiological Assessment and Aided Benefit in Cochlear Implant Candidacy

Audiological assessment is a importantpart of pediatric cochlear implant candidacy because it provides objective evidence about the degree of hearing loss, benefit from hearing aids, and functional auditory abilities. Standard candidacy evaluation typically includes behavioural and objective audiometry, aided audiograms, speech perception testing, and auditory behaviour measures.

Evidence from both international and Indian studies supports the importance of this factor. Manjula et al. (2025) reported in a nationwide Indian survey that all paediatric cochlear implant centres used behavioural audiometry/conditioned play audiometry, auditory brainstem response, and aided audiograms, although criteria and test material varied considerably across centres. The survey also showed that many clinicians relied on aided thresholds outside the speech spectrum and had poor aided speech perception when making candidacy decisions. In Indian outcome research, Gupta (Gupta, 2012) found that residual hearing at the time of implantation significantly influenced post-implant auditory and speech outcomes, with better preoperative audiological profiles associated with higher CAP, MAIS, and SIR scores. Functional auditory behaviour has also been shown to be important; Robbins et al. (1991) demonstrated that the Meaningful Auditory Integration Scale (MAIS) is a reliable and clinically useful measure of how children use sound in everyday situations, especially when formal speech testing is difficult.

More recent evidence has expanded the role of aided benefit assessment. Nickerson et al. (2019) reported that better pre-implant aided speech audibility was significantly associated with better post-implant speech perception in noise, showing that hearing aid verification and aided audibility should be part of candidacy work-up. On a similar note, Brown and Gifford (2021)argued that many children with residual hearing and measurable aided speech perception can still achieve better outcomes with cochlear implants than with hearing aids alone, supporting broader audiological criteria.

Taken together, these studies show that audiological assessment and aided benefit are essential predictors of cochlear implant outcomes. In the Indian context, where audiological practices and languages vary widely, including aided audiograms, speech perception measures, and auditory development scales within a structured profile is especially important for improving consistency, transparency, and outcome prediction.

2.2.5 Importance of Pre-implant Speech and Language Abilities in Cochlear Implant Candidacy

Pre-implant speech and language abilities are an important indicator of a child's communicative effectiveness for cochlear implantation. They reflect the child's early auditory experience, benefit from amplification, parent-child interaction, and opportunities for language learning before surgery. Children who enter implantation with stronger pre-implant communication skills generally show faster auditory-verbal progress and better spoken language outcomes after implantation. Thus, assessment of pre-implant speech and language is essential in candidacy profiling because it helps estimate both learning potential and the likely pace of rehabilitation.

Several studies support this relationship. Nicholas and Geers reported that children implanted before major spoken language delay had developed were more likely to achieve age-appropriate language by preschool age, whereas children implanted after 24 months with greater pre-implant delays were less likely to catch up with hearing peers. In the study by Niparko et al. (2010), better baseline language scores were associated with stronger later language performance and faster post-implant growth. Percy-Smith et al. (2013) also showed that children with better early communication abilities and earlier hearing aid use had better comprehension.

Gupta (2012) identified residual hearing and preoperative auditory performance as significant predictors of cochlear implant outcomes, with children showing better preoperative communicative profiles achieving higher CAP, MAIS, and SIR scores. In practice, pre-implant speech and language abilities are assessed using tools such as the Preschool Language Scale, the Reynell Developmental Language Scales, vocabulary tests, and parent-report measures, which help identify children with marked delays who may need more intensive intervention. In the Indian context, where delayed diagnosis, reduced early intervention, and multilingual environments often limit pre-implant language exposure, systematic assessment of this factor is especially important.

2.2.6 Role of Additional Disabilities in Cochlear Implant Candidacy

Additional disabilities are an important consideration in pediatric cochlear implant candidacy. Additional Disabilities influence auditory learning, cognitive processing, language development, and adaptive functioning. Children with severe to profound hearing loss may also present with additional problems such as developmental delay, intellectual disability, cerebral palsy, autism spectrum disorder, visual impairment, motor disorders, or genetic syndromes, all of which can affect post-implant progress. For this reason, the presence of additional disabilities has been widely recognised as a key factor in predicting outcomes and in candidacy profiling.

Caragli et al (2023) reviewed 61 studies and found that most children with additional disabilities benefited from cochlear implantation through improved environmental sound awareness, non-verbal communication, and adaptive functioning, although expressive and receptive language developed more slowly and less fully than in children without comorbidities. The review also noted that about 20 to 40% of children with severe to profound hearing loss have significant additional disabilities, making this a major clinical subgroup. Similarly, Palmieri, Forli, and Berrettini (Palmieri et al., 2014) reviewed 41 studies and reported improvements in auditory perception, speech perception, language, behaviour, and social functioning after implantation, but gains were generally smaller and slower than in children with hearing loss alone. Both reviews showed that outcomes vary according to the type and severity of the additional disability.

2.2.7 Importance of Family Structure and Support in Cochlear Implant Candidacy

Family structure and support are important determining factorof cochlear implant outcomes because they influence the child’s language environment, consistency of device use, and participation in rehabilitation., Family-related variables are potentially modifiable and therefore highly relevant in candidacy assessment. As a result, family support is now widely recognised as a key domain in cochlear implant profiling, since it affects not only immediate post-implant adjustment but also long-term auditory, speech, and language development. Several studies highlight this relationship.

DesJardin (2006) showed that mothers with higher self-efficacy used more facilitative communication strategies, which were positively associated with children’s receptive and expressive language outcomes. DesJardin and Eisenberg (2007) further reported that greater maternal involvement and responsiveness were linked to larger vocabulary, better syntactic development, and stronger expressive language in children with cochlear implants. At the level of the wider family environment, Holt (Holt et al., 2012) found that children from more organised and supportive families had better vocabulary and executive functioning, whereas family conflict and excessive control were associated with poorer outcomes. Similarly, Niparko et al. (2010) in the CDaCI study reported that the quality of parent-child interaction and socioeconomic status significantly predicted growth in spoken language over time.

2.2.8 Importance of Educational Environment in Cochlear Implant Candidacy

Educational environment is an important factor in cochlear implant candidacy because much of a child's listening, language learning, and social participation occurs in school. After implantation, the quality of school placement, classroom communication opportunities, teacher support, and access to rehabilitation can strongly influence auditory, speech, language, and academic development. For this reason, the educational environment should be considered a key domain in cochlear implant profiling rather than a secondary background factor.

Several studies support this view. Archbold et al. (2002) reported that many implanted children moved into mainstream settings and that children in mainstream schools with appropriate support showed better spoken language and social integration. Moog and Geers (2010) found that children enrolled in auditory-oral preschool programs achieved higher language scores than those in total communication or special education settings. In mainstream school contexts, Mukari et. al.(2007) showed that children could achieve age-appropriate academic levels when adequate educational support was available, while Choi et al. (2020) reported better academic and psychosocial outcomes in inclusive schools with trained teachers and speech-language support. Together, these studies show that educational placement and support services have a direct impact on post-implant progress.

Classroom conditions and technological support are also important. Iglehart et al. (2019) showed that background noise, reverberation, and poor listening conditions can reduce speech understanding in implanted children, while Wolfe et al. (2013) demonstrated that frequency modulation (FM) systems and classroom audio distribution systems improve speech recognition in noise, attention, and participation. Indian evidence similarly suggests that children in mainstream schools with regular speech therapy and parental support perform better than those in poorly resourced settings, where lack of trained teachers, poor acoustics, and absence of assistive devices may restrict benefit. Therefore, assessing the educational environment is essential for candidacy profiling, especially in India, where school resources vary widely and strongly influence the rehabilitation outcomes.

2.2.9 Availability of Support Services and Rehabilitation Access

The availability of support services and rehabilitation is a major factor in cochlear implant candidacy, as implantation is only the beginning of a long-term habilitative process. Successful outcomes depend on consistent audiological follow-up, device programming, speech-language therapy, auditory-verbal intervention, parental counselling, and educational support. When these services are limited or inconsistent,children with otherwise favourable audiological and medical profiles may show reduced benefit. In the Indian context, Manjula et al. (2025) reported a wide variation across paediatric cochlear implant centres in assessment protocols, outcome measures, and follow-up practices, highlighting that differences in institutional resources, linguistic diversity, and regional infrastructure can affect post-implant progress.

International evidence also shows that access to structured rehabilitation improves outcomes. Ching et al. (2015) found that children who received early and consistent intervention, including amplification, cochlear implantation, speech and language training, and educational support, achieved better spoken language outcomes at the population level. Moeller (2000) similarly showed that early and sustained participation in comprehensive intervention programs was associated with stronger vocabulary and verbal reasoning skills, while delayed or inconsistent services were linked to poorer outcomes. Ching et al. (2013) further demonstrated that access to early educational and auditory intervention programs contributed significantly to better speech and language development, emphasising that early identification alone is insufficient unless it is followed by effective rehabilitation.

The family impact of rehabilitation access is also important. Cejas et al. (2022) reported that parents of children with cochlear implants experienced considerable stress related to repeated follow-up visits, therapy demands, and device management, and that limited professional support could indirectly affect outcomes through reduced adherence and weaker home-based stimulation. Taken together, these studies show that availability, continuity, and quality of rehabilitation services are strong determinants of auditory and communicative development.

2.2.10 Role of Family and Child Expectations in Cochlear Implant Outcomes

Family and child expectations are an important psychosocial factor in cochlear implant outcomes as they influence rehabilitation engagement, coping, and long-term satisfaction. Edwards (2003) showed that concern ratings regarding family and child expectations in the modified ChIP significantly affected candidacy decisions and were associated with post-implant speech perception and language outcomes. Similarly, Nicholas and Geers (2003) reported that parental satisfaction was closely linked to children's speech and language achievement, suggesting that expectations and perceptions can shape the quality of family support during rehabilitation.

Later studies further confirmed this relationship. Kumar et al. (2015) found that parents generally held positive expectations about communication and independence after implantation, although expectations regarding education and long-term outcomes were less certain. McRackan et al. (2022) used the CIQOL-Expectations instrument and showed that many candidates had unrealistically high expectations before implantation, especially for listening and social participation, and that these expectations could be modified through structured pre-implant counselling.

Psychosocial studies also show that expectations affect caregivers' well-being. Yiğit et al. (2018) reported improved maternal life satisfaction after implantation, especially in families with regular follow-up and strong rehabilitation involvement, whereas socioeconomic difficulties and limited support were associated with lower satisfaction.

2.2.11 Role of Cognitive Learning Style and Cognitive Abilities in Cochlear Implant Outcomes

Cognitive learning style and cognitive abilities are important determinants of cochlear implant outcomes because they influence how children attend to, process, and learn from auditory input. Hearing loss in early childhood affects not only language exposure but also broader neurocognitive processes, including attention, working memory, executive functioning, and information processing. Pisoni (2000) argued that traditional audiological variables explain only part of the variability in implant outcomes and proposed that differences in perception, learning, memory, and information-processing capacity are also critical. Similarly, research found that preschool children with cochlear implants showed poorer working memory and inhibition–concentration than normal-hearing peers, indicating that cognitive vulnerabilities may emerge early and act as independent risk factors for learning (Beer et al., 2014; Kronenberger et al., 2014).

Longitudinal and review evidence further support the role of cognition in post-implant progress. Niparko et al. (2010) reported that baseline cognitive status significantly predicted spoken language growth over three years, with children showing age-appropriate cognitive abilities achieving faster gains in receptive and expressive language. Kronenberger in 2019 and Beer et al in 2014 reviewed the literature and concluded that roughly one-third of children with cochlear implants show clinically significant delays in executive functioning, particularly in working memory, attention regulation, and processing speed, all of which increase listening effort and make language learning more difficult. In addition, the investigators found that children with cochlear implants were two to five times more likely than normal-hearing peers to show deficits in working memory, attention, sequential processing, and problem-solving. Other research cited in the literature has also shown that weaker memory, rehearsal speed, and sequence learning are associated with poorer speech perception and slower vocabulary growth.

2.2.12 Role of Learning Style, Motivation, and Child Engagement in Cochlear Implant Outcomes

Learning style, motivation, and child engagement are important behavioural factors in cochlear implant outcomes because implantation requires the child's active participation in listening, therapy, and daily communication. Children who are attentive, motivated, and willing to participate are more likely to benefit from auditory input and rehabilitation, whereas low engagement and poor participation can limit auditory learning. Svirsky et al. (2004) showed that even among children with similar ages at implantation and device experience, language growth varied considerably, suggesting that differences in learning behaviour and responsiveness to auditory input contribute to outcome variability.

Long-term studies also highlight the importance of engagement in communication and education. Geers et al. (2011) reported that children who remained actively involved in spoken-language-based educational settings achieved better speech, language, reading, and social outcomes in adolescence. DesJardin and Eisenberg (2007) also found that children who were more attentive and responsive during parent–child interaction showed stronger expressive and receptive language abilities. In addition, Walker et al.(Walker et al., 2013) reported that children who were more cooperative and behaviourally regulated had longer daily device use, indicating that motivation and behavioural compliance affect auditory exposure and learning opportunities.

Psychosocial and family influences are also relevant. Cejas et al. (2022) found that higher parenting stress was associated with reduced therapy participation and lower home practice, indirectly affecting child engagement. The literature therefore suggests that curiosity, persistence, active participation, and positive learning attitudes support better rehabilitation outcomes, while passive learning style, behavioural challenges, and inconsistent participation may slow progress.

The literature reviewed indicates that cochlear implant outcomes are shaped by a combination of hearing loss, child-, family-, clinical-, and environmental-related factors. Variables such as age at implantation, duration of deafness, medical and radiological status, aided benefit, pre-implant speech and language abilities, additional disabilities, family support, educational environment, rehabilitation access, expectations, and cognitive-learning factors have all been shown to influence post-implant progress to varying degrees. Therefore, these factors were included in the present study to develop a comprehensive profiling tool that reflects the multidimensional nature of cochlear implant candidacy and helps predict speech-language and aided audiogram outcomes more meaningfully in Indian children.

Chapter 3

METHOD

The objective of the study was to develop a structured profiling tool for cochlear implant candidacy in children and to examine its relationship with post-implant speech-language and audiological outcomes. For this, the study was carried out in three phases: Phase I, Phase II, and Phase III. Phase I involved developing and validating the candidacy profiling tool. Phase II involved the retrospective application of the profiling tool to children with bilateral severe-to-profound hearing loss who had undergone unilateral cochlear implantation, and the collection of post-implant outcome measures. Phase III involved Predictive Analysis of Profiling Factors for Post-Implant Outcomes.

3.1 Research Design

The present study adopted a retrospective and correlational research design (Portney & Watkins, 2009). Retrospective data were obtained from existing clinical records and assessment reports of children with bilateral severe to profound hearing loss who had undergone unilateral cochlear implantation.

The study was conducted at the All India Institute of Speech and Hearing (AIISH), Mysuru. Data required for the study were obtained retrospectively from multiple sources within the institute, including individual case files maintained in the Medical Records Section, records available at the Implantable Hearing Devices Unit, and parent-reported information collected through telephonic interviews with the caregivers or parents of the implanted children. Thus, the study incorporated radiological, medical, audiological, developmental, psychosocial, and environmental information to develop a comprehensive candidacy.

The data were collected at a single point in time from existing records and parent interviews, with no follow-up measurements conducted.

3.2 Phase I: Development of the Profiling Tool

Phase I involved the development and content validation of the cochlear implant candidacy profiling tool for children. The initial profiling tool was developed based on a review of the literature on factors influencing cochlear implant outcomes in children and on previously published candidacy profiling models such as the Children's Implant Profile (ChIP) and its revised versions. The aim of this phase was to identify the major multidimensional factors to be considered when assessing candidacy for cochlear implantation and predicting post-implant outcomes.

Based on the literature reviewed, 13 domains were included in the profiling tool. These were chronological age at implantation, duration of deafness, medical and radiological status, audiological assessment findings, hearing aid use, pre-implant speech and language abilities, presence of additional disabilities, family structure and support, educational environment, availability of support services and rehabilitation access, expectations of the family and child, cognitive ability, and learning style & child engagement. These domains were selected to ensure that the profiling tool covered audiological, medical, audiological, linguistic, cognitive, psychosocial, educational, and rehabilitative factors relevant to cochlear implant outcomes.

Each domain in the profiling tool was rated on a three-point ordinal scale: 0 = no concern, 1 = moderate concern, and 2 = major concern. A score of 0 indicated favourable conditions with minimal expected risk to post-implant outcomes. In contrast, a score of 2 indicated significant risk factors that could adversely influence speech-language and audiological performance. The total profiling score is obtained by summing the scores across all 13 domains, with a possible total of 39. Higher total scores indicated greater cumulative concern and a potentially less favourable prognosis. The investigator scored all domains to ensure uniformity and consistency in interpretation.

After the profiling tool was compiled, it underwent content validation. The tool was sent to five experienced audiologists & speech-language pathologists who were involved in cochlear implant rehabilitation for expert evaluation. The experts were asked to assess each domain based on necessity, clarity of wording, comprehensiveness, and sufficiency. Based on their suggestions, the following modifications were made. The audiological assessment section was split into two, with a section introduced for hearing aid use. In the medical and radiological section, factors that concern about the auditory nerve were included such as hypoplasticity and absence of auditory nerve for the rating. The third, the influence of bilingual parents, was included in the family structure and support section to improve clarity and contextual appropriateness.

3.3 Phase II: Development of Predictive Criteria

3.3.1 Participants

The sample for the present study consisted of data from 146 children with bilateral severe to profound hearing loss who had undergone unilateral cochlear implantation. All participants had received implantation between 1 year and 6 years and had completed at least 1 year of post-implant auditory-verbal therapy at the time of data collection. The participants were selected retrospectively from the clinical records available at the All India Institute of Speech and Hearing (AIISH), Mysuru. The sample included children who had received regular follow-up services and rehabilitation support through the institute.

3.3.2 Inclusion Criteria

The following criteria were used for the selection of participants in the present study:

1. Children with bilateral severe to profound hearing loss who had undergone unilateral cochlear implantation
2. Children who had completed a minimum of one year of post-implant habilitation.
3. Availability of complete pre-implant assessment records in the case files from the Medical Records Section.
4. Availability of standardised post-implant outcome assessment reports at one year following implantation.

3.3.3 Exclusion Criteria

The following criteria were applied to exclude participants from the study:

1. Children who had received bilateral cochlear implants
2. Children who were lost to follow-up before completion of the one-year post-implant outcome assessment.

3.3.4 Ethical Considerations

The present study was conducted after obtaining approval from the Ethical Committee of the All-India Institute of Speech and Hearing (AIISH), Mysuru. (Given in the appendix). The study adhered to The Ethical Guidelines For Bio Behavioural Research Involving Human Subjects (Version 2). Informed consent was obtained from the parents or legal guardians of all participating children before data collection during the telephonic interviews. The purpose of the study, the procedures involved, and the confidentiality of information were clearly explained to the parents by telephone before obtaining consent.

All personal and clinical information collected from medical records and parent interviews was kept strictly confidential. Participant identities were anonymised using case numbers, and the data were used only for research purposes. Access to records and data files was restricted to the investigator and authorised supervisors. Participation was voluntary, and parents had the right to withdraw consent at any stage without affecting the clinical services that the child was receiving.

3.3.5 Sources of Data

Information required for the study was obtained from three primary sources. 1) The first source was the individual case files maintained in the Medical Records Section of AIISH, Mysuru. These records provided information regarding chronological age at implantation, duration of deafness, audiological assessment findings, pre-implant speech and language abilities, presence of additional disabilities, and cognitive ability. 2) The second source was the records available at the Implantable Hearing Devices Unit (IHDU) of AIISH, Mysuru, from which data related to medical and radiological status, including inner ear anatomy and surgical considerations, were obtained. 3) The third source was telephonic interviews with parents or primary caregivers. Through that information, regarding the educational environment, availability of support services, family expectations, and learning style, was collected. Data from each of the three sources for each participant were tabulated for analysis.

3.3.6 Outcome Measures

The post-implant outcome measures were obtained from the case files to assess performance at one year following cochlear implantation for all participants. Only children who had completed one year of implant use and the corresponding outcome assessments were included in the study. The outcome measures included speech-language outcomes and audiological outcomes.

Speech and language outcomes were assessed using the Assessment Checklist of Speech-Language Skills (ACSLS) developed by Swapna et al (2007). For the present study, receptive and expressive language ages were extracted from the one-year post-implant assessment records. These measures were used as indicators of post-implant speech-language development.

Audiological outcomes were assessed using aided audiometric thresholds and speech identification scores (SIS) obtained at one-year post-implant. Aided thresholds for the implanted ear were obtained at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. From these thresholds, aided Pure Tone Average (PTA) was calculated and used as an indicator of functional auditory performance. The sound field SIS were obtained in the implanted ear at 40 dB HL. Depending on the child's auditory and linguistic abilities, testing was conducted in closed-set format, and the obtained percentage score was recorded in the case files. This information on the performance outcome for each case was tabulated.

3.4 Procedure

The study was carried out systematically and in a structured manner. Initially, the list of children who had undergone cochlear implantation was obtained from the Aural Rehabilitation Unit of the Department of Audiology at AIISH, Mysuru. The identified cases were screened according to predefined inclusion and exclusion criteria, and data from only those who met the inclusion criteria were included in the study.

Following sample selection, retrospective data extraction was carried out in multiple stages. Information regarding age at implantation, duration of deafness, audiological assessment findings, pre-implant speech and language abilities, presence of additional disabilities, and cognitive ability was obtained from the case files maintained in the Medical Records Section. Data related to radiological status, including details of inner ear anatomy, surgical considerations, and implant-related findings, were obtained from records available at the Implantable Hearing Devices Unit. Simultaneously, information regarding the educational environment, availability of support services, family expectations, and learning style was collected through telephonic interviews with parents or primary caregivers. During the telephonic interview, the study's purpose was explained, and consent was reconfirmed before collecting information. A questionnaire used for the purpose is enclosed in the Appendix.

Post-implant outcome measures, including receptive and expressive language ages, aided audiometric thresholds, and speech identification scores at one-year post-implant, were extracted from the case records of each participant.

3.5 Scoring of the Profiling Tool

After collecting all required information from records and parent interviews, the investigator scored each of the 13 domains of the profiling tool using the predefined three-point rating system. In this system, a score of 0 indicated no concern, 1 indicated moderate concern, and 2 indicated major concern. Each domain score reflected the extent to which that factor was expected to influence post-implant outcomes.

The total profiling score for each participant was obtained by summing the scores across all 13 domains. The possible total score ranged from 0 to 24, with higher scores indicating greater cumulative concern and potentially less favourable post-implant outcomes. Scoring of all domains was carried out uniformly by the investigator to ensure consistency in interpretation.

This phase involved splitting the sample. The total sample of children with unilateral cochlear implants was divided into two groups. The first group served as the development sample to derive predictive criteria, while the second served as the validation sample to test the applicability of the derived model.

An initial attempt was made to validate the profiling tool's predictive criteria using Receiver Operating Characteristic (ROC) curve analysis on a separate validation sub-sample. However, the ROC curve analysis revealed inadequate discriminative accuracy, with both sensitivity and specificity of the profiling tool being unacceptably low. Hence, it was determined that the profiling tool did not yield sufficiently reliable cut-off criteria for classifying children into favourable and less favourable outcome categories. Therefore, the approach was revised, and the entire sample of 146 participants was used as the development sample to derive predictive criteria.

Using the development sample, statistical analysis was conducted to examine correlations among individual domain scores, total profiling scores, and post-implant outcome measures. The analysis was also done to identify the domains that significantly predicted speech-language and audiological outcomes. Based on these findings, attempts were made to establish cut-off ranges to classify children into good-performing and poor-performing profiling categories. Regression modelling techniques were used to determine the predictive strength of each domain and the overall profiling score.

3.6 Phase III: Predictive Analysis of Profiling Factors for Post-Implant Outcomes

Phase III involved evaluating the predictive validity and discriminative performance of the developed profiling criteria using Receiver Operating Characteristic (ROC) curve analysis. The total profiling score was examined for its ability to classify children into favourable and less favourable post-implant outcome categories based on speech-language and audiological outcome measures. The discriminative accuracy of the profiling tool was assessed using the Area Under the Curve (AUC) and sensitivity and specificity. These analyses were conducted to determine whether the profiling tool could reliably differentiate children according to expected post-implant performance and to examine the clinical applicability of the developed predictive criteria.

3.7 Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics software (Version 29.0 for Windows). Prior toanalysis, the distributions of all continuous variables were examined using the Shapiro–Wilk test for normality. All continuous variableswere found to be non-normally distributed ($p < 0.05$). Accordingly, non-parametric statistical methods were employed throughout the study. Descriptive statistics, including mean, standard deviation, median, and interquartile range (IQR), were computed to characterise the distribution of profiling tool scores and outcome measures across the sample. The frequency distribution of 'concern' ratings across the 13 profiling tool domains was tabulated to examine the pattern of pre-implant risk profiles in the study sample.

To examine the relationship between individual profiling tool domain scores and post-implant outcomes, Spearman rank-order correlation coefficients (ρ) were computed between each of the 13 profiling tool factors and the four outcome variables: post-implant receptive language age (RLA), expressive language age (ELA), aided pure-tone average (PTA), and speech identification score (SIS). The Support Services domain was excluded from all inferential analyses because it had zero variance across the sample. To assess the collective and independent predictive contributions of the profiling tool factors, Ordinary Least Squares (OLS) multiple regression models were constructed separately for each of the four outcome variables, with the 13 eligible profiling tool factors entered simultaneously as predictors. To evaluate the discriminative validity of the profiling tool's total score in classifying children into good and poor outcome categories, Receiver Operating Characteristic (ROC) curve analyses were conducted, with the area under the curve (AUC) used as the primary index of discriminative accuracy. A significance level of $\alpha = 0.05$ was adopted for all statistical tests unless otherwise stated.

Chapter 4

RESULTS

The present study aimed to adapt and validate the Children's Implant Profile for use in the Indian context, and to examine the predictive value of a pre-implant profiling tool for cochlear implant candidacy in children, and factors for speech and language outcomes in children with cochlear implants (CI). Data were obtained from 157 case records. After excluding cases with incomplete data, 146 participants formed the primary analytical dataset. Descriptive statistics were done to summarise the data. All continuous variables were non-normally distributed, as confirmed by the Shapiro-Wilk test ($p < 0.05$). Therefore, non-parametric statistical methods, viz., Spearman rank-order correlation and Ordinary Least Squares (OLS) multiple regression, were applied for multivariate analyses. The results are presented in the following sections corresponding to each study objective.

The results of the present study are presented under the following sections:

I. Distribution of the Profiling Tool Factor Ratings in the Sample

II. Pre- versus Post- implant Language Outcomes and Aided Audiometric Outcomes

III. Correlation of profiling tool for cochlear implant candidacy in children’s factors with Post-implant Outcome Variables

IV. Clinical Utility of the Total Profile Score in Predicting the outcomes from Cochlear Implant.

V. Role of each Profiling Factor in Predicting Cochlear Implant Outcomes

VI. Summary of Findings Across All Objectives

4.1. Distribution of the profiling tool Factor Ratings in the Sample

The first objective of the study was to examine if modification or revision of the existing profiling and scoring system, from the profiling tool for cochlear implant candidacy in children, was required for the Indian context. The adapted profiling tool employed 13 factors rated on a three-point concern scale (0 = No Concern, 1 = Mild to Moderate Concern, 2 = Great Concern). Table 4.1 presents the descriptive characteristics of the sample, and Table 4.2 presents the frequency distribution of 'concern' ratings across all 13 profiling tool factors in the study sample (n = 146).

Table 4.1

Descriptive statistics of the profiling tool for cochlear implant candidacy in children: Profile factors and outcome measures

Factors/Outcome	n	Mean	SD	Median	IQR
1. Age at Implantation (years)	146	3.60	1.39	3.10	2.11–5.00
< 2 years	20 (13.7%)	1.4	0.3	1.2	
2 to 4 years	77 (52.7%)	3.1	0.6	2.9	2.10–3.05
4 to 6 years	48 (32.9%)	5.1	0.6	5.3	4.00–5.02
6+ years	1 (0.7%)	7.0	—	—	
2. Unaided PTA (dB HL)	146	88.97	5.76	88.75	86.25–92.50

3. CI aided PTA (dB HL)	146	25.16	9.20	23.75	17.50–30.00
4. Post-implant SIS (%)	146	72.97	16.03	77.50	67.50–80.00
5. Pre-implant RLA (years)	146	0.93	0.87	0.55	0.50–1.20
6. Pre-implant ELA (years)	146	0.72	0.55	0.55	0.50–0.80
7. 1-year Post-implant RLA (years)	146	2.53	1.10	2.50	1.80–2.80
8. 1-year Post-implant ELA (years)	146	1.87	0.83	1.55	1.20–2.20

Note: RLA = Receptive Language Age; ELA = Expressive Language Age; PTA4 = Pure Tone Average thresholds at 500, 1000, 2000 and 4000 Hz; SIS = Speech Identification Score, SD= standard deviation.

The sample consisted of 146 implanted children with a mean age at implantation of 3.60 years (SD = 1.39; Median = 3.10 years). The majority of children were implanted between 2 and 4 years of age (n = 77; 52.7%), followed by those implanted between 4 and 6 years (n = 48; 32.9%), below 2 years (n = 20; 13.7%), and one child implanted at 7 years. Pre-implant Receptive Language Age (RLA) had a median of 0.55 years, and Expressive Language Age (ELA) had a median of 0.55 years, indicating substantial language delays relative to Implantation Age at the time of implantation. The mean unaided Pure Tone Average (PTA) in the implant ear was 88.97 dB HL (SD = 5.76), confirming that the sample comprised children with severe-to-profound sensorineural hearing loss, consistent with the candidacy criteria for cochlear implantation. Further, it was noted that all factors/variables were non-normally distributed according to the Shapiro-Wilk test ($p < 0.05$); hence, non-parametric statistics were applied.

Table 4.2

Frequency distribution of ‘concern’ ratings across the 13 Indian profiling tool for cochlear implant candidacy in children (n = 146)

Factors in profiling tool for cochlear implant candidacy in children	No Concern (0)	Mild to Moderate Concern (1)	Great Concern (2)
Implant Age	65 (44.5%)	81 (55.5%)	0 (0.0%)
Duration of Deafness	126 (86.3%)	20 (13.7%)	0 (0.0%)
Medical/Radiological	133 (90.4%)	13 (8.9%)	1 (0.7%)
Audiological Assessment	127 (87.0%)	13 (8.9%)	6 (4.1%)
Language Score	79 (54.1%)	65 (44.5%)	2 (1.4%)
Hearing Aid Use	122 (83.6%)	23 (15.8%)	1 (0.7%)
Multiple Disabilities	132 (89.8%)	13 (8.8%)	1 (0.7%)
Family Structure	117 (80.1%)	29 (19.9%)	0 (0.0%)
Educational Environment	36 (24.7%)	93 (63.7%)	17 (11.6%)
Support Services	146 (100.0%)	0 (0.0%)	0 (0.0%)
Expectations	5 (3.4%)	135 (92.5%)	6 (4.1%)

Learning Style	95 (65.1%)	47 (32.2%)	4 (2.7%)
Cognitive Abilities	141 (96.6%)	4 (2.7%)	1 (0.7%)

Note: Values represent frequency (percentage). Profiling tool for cochlear implant candidacy in children = Children's Implant Profile.

As depicted in Table 4.2, the distribution of 'concern' ratings varied across profiling tools for cochlear implant candidacy in children. The expectation factor was the most consistently rated, with 92.5% of children rated Mild-to-Moderate Concern, suggesting that families consistently held moderately high but not unrealistic expectations. Educational Environment was the factor most frequently rated as Mild-to-Moderate Concern (63.7%) and Great Concern (11.6%), showing the heterogeneity of schooling options available for children with hearing impairment. Implantation Age showed Mild-to-Moderate Concern in 55.5% of children. The Language Score showed Mild-to-Moderate Concern in 44.5% of children, showing the language delay typical at the time of implantation. Support Services showed zero variance, with all 146 children rated at No Concern, reflecting the uniform access to professional support services at AIISH. Multiple Disabilities/Multiple Handicaps was rated as No Concern in 89.8% of participants (n = 132), with 8.8% rated as Mild-to-Moderate Concern (n = 13) and 0.7% as Great Concern (n = 1). Medical/Radiological concerns, Audiological Assessment, and Cognitive Abilities showed very low rates of concern, indicating generally favourable pre-implant medical and cognitive profiles in this sample.

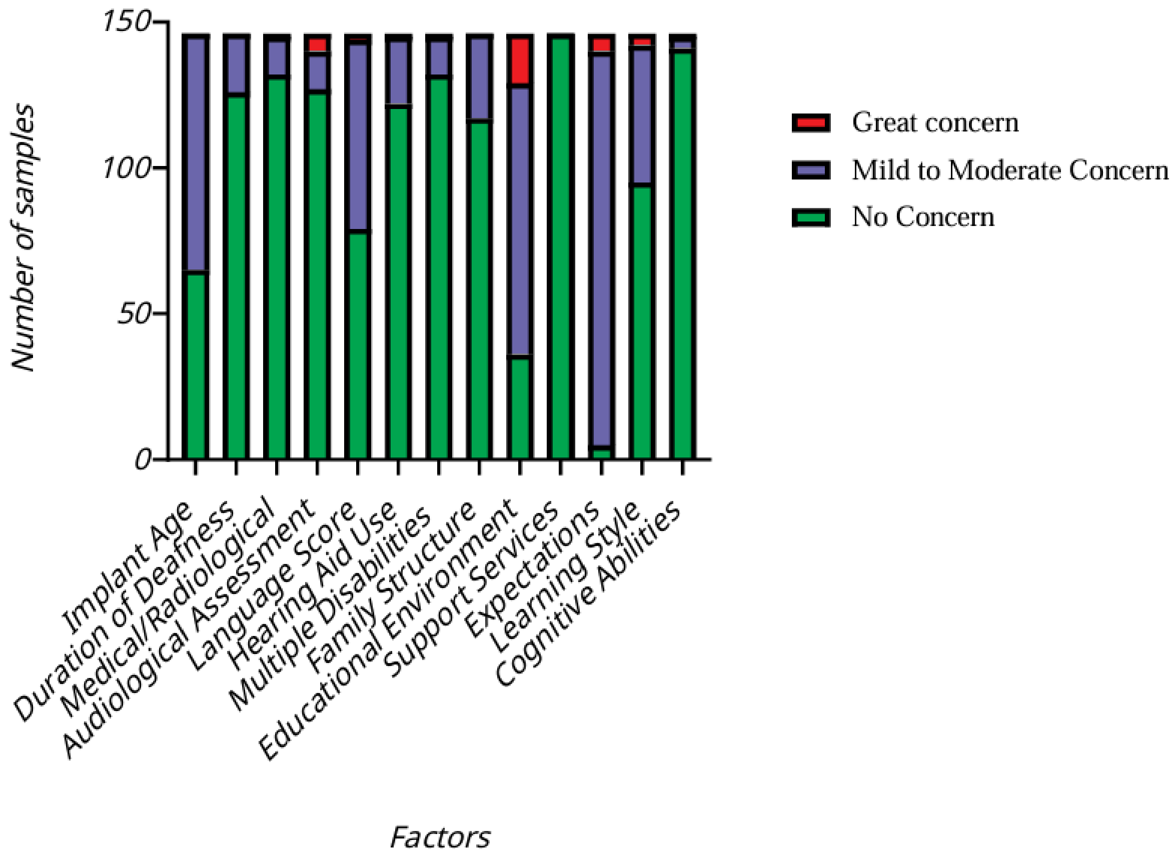


Figure 4.1 Distribution of 'concern' ratings across 13 profiling tool factors. The Expectations factor showed the highest proportion of Mild-to-Moderate Concern ratings (92.5%, n = 136), Educational Environment showed the greatest proportion of Great Concern ratings (12.2%, n = 18). Support Services demonstrated no variance, with 100% of children rated as No Concern.

4.2 . Pre- versus Post- implant Language Outcomes and Aided Audiometric Outcomes

The second objective was to confirm the predictive accuracy of the profiling tool for cochlear implant candidacy in children's scoring system by comparing outcomes assessed via the Assessment Checklist for Speech Language Skills (ACSLS) (Geetha, 2007) scores at one-year post-implant with pre-implant baselines. In the analysis, age-corrected language scores (RLA and ELA) were used as outcome measures, representing the child's language age relative to chronological age at the time of assessment.

Table 4.3

Pre- and post-implant corrected language age comparison (n = 146)

Language Age gap (Age-Corrected)	Median Pre-implant Score (Years)	Median Post-implant Score (Years)	Median Change over 1 Year
CA-RLA	2.50	1.90	-0.65 yrs
CA-ELA	2.50	2.00	-0.50 yrs

Note. Corrected age is the difference between the Chronological and the RLA or ELA. RLA = age-corrected Receptive Language Age (RLA − chronological age at assessment); ELA = age-corrected Expressive Language Age (ELA − chronological age at assessment). A negative change indicates the language gap narrowed.

As shown in Table 4.3, both RLA and ELA demonstrated significant changes from pre- to post-implantation. For the median gap between the receptive language age and chronological age decreased from 2.50 years pre-implant to 1.90 years post-implant, representing a median change of −0.65 years. Which means the gap between the Chronological age the Receptive language Age decreased post implantation.

For the median gap between the expressive language age and chronological age decreased from 2.50 years pre-implant to 2.00 years post-implant, representing a median change of −0.50 years. Which means the gap between the Chronological age the Expressive language Age decreased post implantation.

Aided Audiometric Outcomes

Table 4.4 presents a comparison of pre-implant hearing aid (HA) aided and post-implant CI-aided audiometric outcomes of the implanted ear. Pre-implant HA aided thresholds were obtained with the conventional hearing aid in the ear subsequently implanted, while post-implant outcomes were obtained with the cochlear implant.

Table 4.4

Comparison of hearing aid aided Pre-Implant and CI aided Post-implant Audiometric Outcomes (n = 146)

Outcome Measure	Median	IQR
Unaided PTA4 (dB HL)	88.75	86.25–92.50
Pre-Implant HA Aided PTA4 (dB HL)	62.50	55.00–71.25
Post-CI Aided PTA4 (dB HL)	23.75	17.50–30.00
Post-Implant SIS (%)	77.50	67.50–80.00

Note. PTA = Pure Tone Average (500, 1000, 2000, 4000 Hz); SIS = Speech Identification Score (%); SD = Standard Deviation; IQR = Interquartile Range.

The mean post-implant PTA4 was 25.14 dB HL (SD = 9.19; Median = 23.75 dB HL), representing a marked improvement from the mean pre-implant unaided PTA of 88.98 dB HL, viz., an average improvement of approximately 64 dB HL. The mean post-implant Speech Identification Score (SIS) was 72.90% (SD = 16.00; Median = 77.50), reflecting functional closed-set speech perception abilities across the majority of the cohort. The wide range of SIS (15%–100%) underscores the variability in speech perception outcomes, even without much variation in CI aided thresholds, characteristic of paediatric cochlear implantation and encourages the identification of pre-implant factors that can predict this variability.

4.3 Correlation of profiling tool for cochlear implant candidacy in children Factors with Post-implant Outcome Variables

Spearman rank-order correlations were computed between each of the 13 factors in the profiling tool for cochlear implant candidacy in children and the four post-implant outcome variables, viz., RLA, ELA, PTA4, and SIS (%). Table 4.5 represents the composite Spearman correlation matrix.

Table 4.5

Spearman correlation coefficients (ρ) between the 13 factors in profiling tool for cochlear implant candidacy in children and post-implant outcome (n = 146)

Profiling tool for cochlear implant candidacy in children Factors	Post-RLA ρ (p)	Post-ELA ρ (p)	Post-PTA ρ (p)	Post-SIS ρ (p)
Age at Implantation	**0.623** (p<0.001)**	**0.674** (p<0.001)**	-0.048 (p=0.566)	-0.008 (p=.928)
Duration of Deafness	**0.225** (p=0.006)**	**0.393** (p<0.001)**	0.011 (p=0.899)	**0.186* (p=0.024)**
Medical/Radiological	-0.034 (p=.684)	-0.064 (p=.445)	**0.23** (p=.005)**	-0.054 (p=.512)
Audiological Assessment	0.129 (p=.119)	**0.207* (p=.012)**	-0.057 (p=.492)	0.038 (p=.645)
Language Score	**0.361** (p<.001)**	**0.393** (p<.001)**	0.117 (p=.158)	-0.064 (p=.445)
Hearing Aid Use	-0.072 (p=.383)	-0.031 (p=.710)	**-0.183* (p=.026)**	-0.071 (p=.395)
Multiple Disabilities	-0.073 (p=.378)	-0.113 (p=.174)	**0.187* (p=.024)**	-0.051 (p=.544)
Family Structure and Support	**0.174* (p=.036)**	**0.168* (p=.043)**	0.023 (p=.781)	0.109 (p=.192)
Educational Environment	-0.024 (p=.777)	0.078 (p=.348)	**-0.208* (p=.012)**	**0.137† (p=.098)**

Support Services	— (zero var.)	— (zero var.)	— (zero var.)	— (zero var.)
Expectations of Family/Child	0.037 (p=.652)	0.084 (p=.312)	-0.116 (p=.161)	0.067 (p=.420)
Learning Style	0.009 (p=.915)	0.006 (p=.938)	0.049 (p=.556)	**-0.185* (p=.025)**
Cognitive Abilities	0.073 (p=.383)	0.121 (p=.146)	0.096 (p=.249)	0.052 (p=.530)
Profiling Tool Total Score	**0.301** (p<.001)**	**0.429** (p<.001)**	-0.085 (p=.305)	0.016 (p=.844)

*Note. ρ = Spearman's rank correlation coefficient; * p < 0.05; ** p < 0.01; ns = not significant; — = excluded (zero variance). RLA = Receptive Language Age; ELA = Expressive Language Age; PTA = Pure Tone Average (dB HL); SIS = Speech Identification Score (%), zero var.= No variance.*

Based on the significant p value, the effect size is classified as 0.10 – 0.29 as Small, 0.30 – 0.49 as Medium, and ≥ 0.50 as Large, given by Cohen (1988).

Age at Implantation was the strongest and most consistent correlate of post-implant language outcomes. Age at Implantation showed strong positive correlations with both post-RLA ($\rho = 0.623$, $p < .001$)(Large effect size) and post-ELA ($\rho = 0.674$, $p < .001$)(Large effect size) . Since the outcome variables represent the gap between chronological age and language age (i.e., higher scores indicate a larger lag), these positive correlations indicate that older age at implantation was associated with a greater residual language gap at one-year post-implant. This is consistent with the expectation that children implanted at an older age begin with a larger developmental deficit and, despite benefiting from implantation, retain a wider gap between their chronological and language age at the one-year follow-up point.

Language Score also demonstrated significant positive correlations with both post-RLA ($\rho = 0.361$, $p < .001$) (meduim effect size) and post-ELA ($\rho = 0.393$, $p <$

.001)(meduim effect size) , indicating that children with greater pre-implant language concerns (i.e., higher language age gap before implantation) continued to show a wider gap between chronological age and language age at one-year post-implant on both receptive and expressive measures.

Duration of Deafness showed significant positive correlations with post-RLA ($\rho = 0.225$, $p = .006$) (small effect size), post-ELA ($\rho = 0.393$, $p < .001$)(meduim effect size) , and post implant -SIS ($\rho = 0.186$, $p = .024$)(small effect size) , indicating that longer duration of deafness was associated with a wider gap between chronological age and language age at one year post-implant, as well as with higher speech identification scores.

Audiological Assessment showed a significant positive correlation with post-ELA ($\rho = 0.207$, $p = .012$)(small effect size) . This positive correlation indicates that greater audiological concern prior to implantation was associated with a wider expressive language gap at one-year post-implant, suggesting that children with more complex audiological profiles may experience relatively poorer expressive language improvement.

Family Structure showed correlations with both post-RLA ($\rho = -0.174$, $p = .036$)(small effect size) and post-ELA ($\rho = -0.168$, $p = .043$),(small effect size) indicating that greater family structure concern was associated with a larger gap between chronological age and both receptive and expressive measures at one-year post-implant.

Medical/Radiological concerns showed a significant positive correlation with post-PTA ($\rho = 0.230$, $p = .005$)(small effect size) , indicating that children with greater medical or radiological concerns had higher (i.e., poorer) post-implant hearing thresholds.

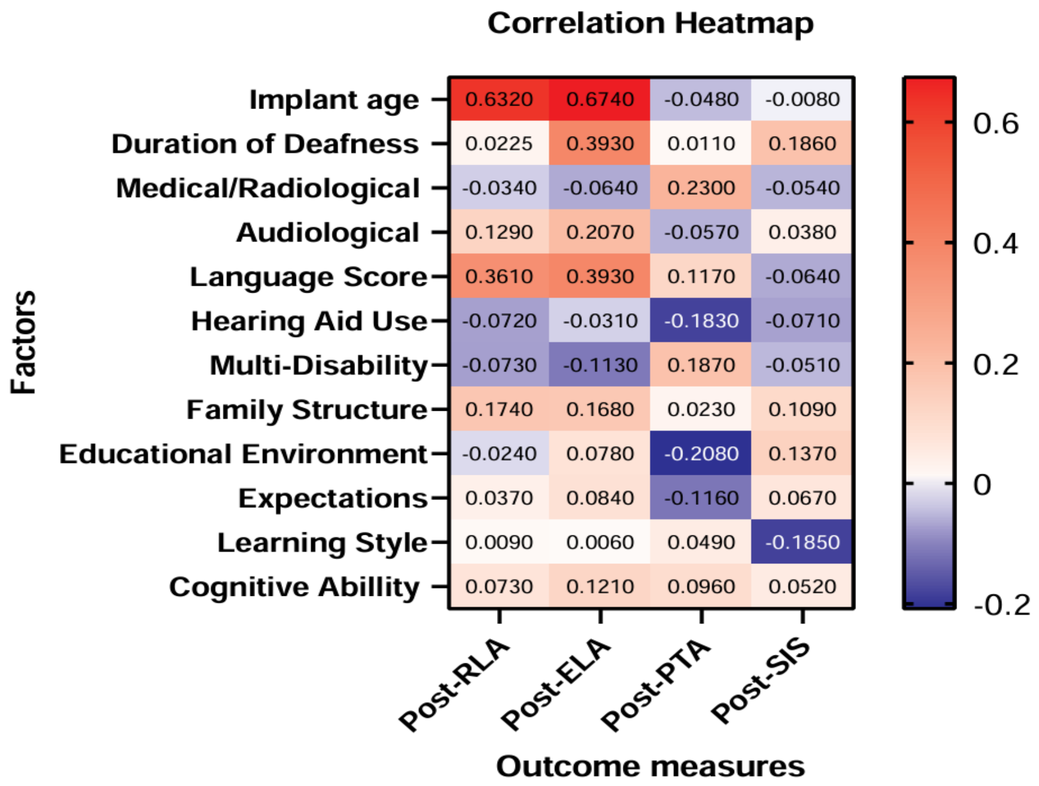
Hearing Aid Use showed a significant negative correlation with post-PTA ($\rho = -0.183$, $p = .026$)(small effect size) , indicating that adequate pre-implant hearing aid use was associated with better post-implant aided audiometric thresholds.

Multiple Disabilities showed a significant positive correlation with post-PTA (ρ = 0.187, $p = .024$)(small effect size) , indicating that children with additional disabilities tended to have poorer post-implant aided thresholds.

Educational Environment showed a significant negative correlation with post-PTA (ρ = −0.208, $p = .012$)(small effect size) , indicating that greater educational concern was associated with better (lower) post-implant audiometric thresholds.

The Profiling Tool Total Score was significantly correlated with both post-RLA (ρ = 0.301, $p < .001$) (medium effect size) and post-ELA (ρ = 0.429, $p < .001$)(medium effect size) . This suggests that children with a higher aggregate concern profile at the time of candidacy assessment demonstrate a wider gap between chronological age and language age, on both receptive and expressive measures, at one-year post-implant.

Figure 4.2 presents a Spearman rank-order correlation heat map depicting the associations between all 12 profiling tool factors and the four post-implant outcome variables.



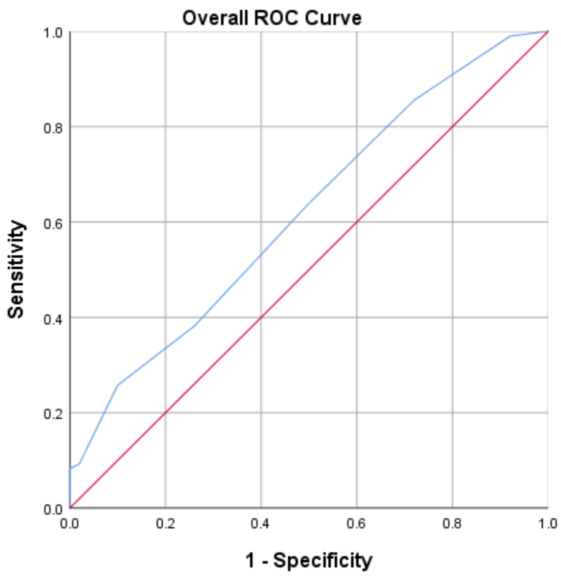
4.4 Clinical Utility of the Profile Total Score in Predicting Cochlear Implant Outcomes

To evaluate the profiling tool's ability to discriminate between children with good and poor post-implant outcomes, Receiver Operating Characteristic (ROC) analyses were conducted in SPSS (Version 29). The Profiles Total Score was used as the test variable, and four post-implant outcome variables served as the classification criterion:

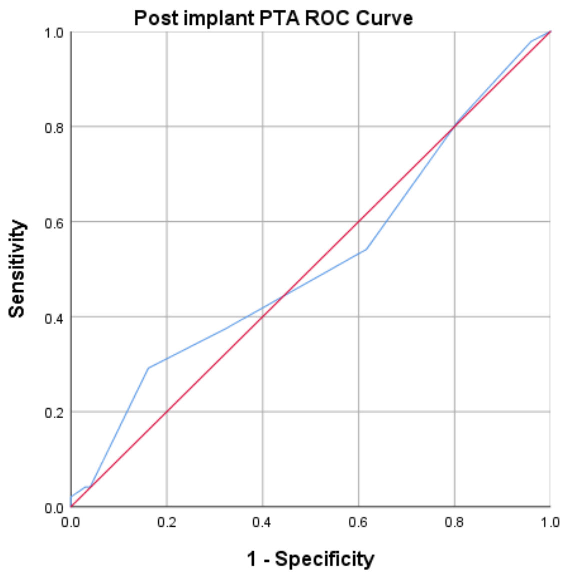
(1) overall functional outcome (final result), (2) post-implant pure-tone average (PTA), (3) speech identification score (SIS), (4) receptive language age (RLA), and (5) expressive language age (ELA). For each analysis, the Area Under the Curve (AUC) was computed as the primary index of discriminative accuracy.

Figure 4.2

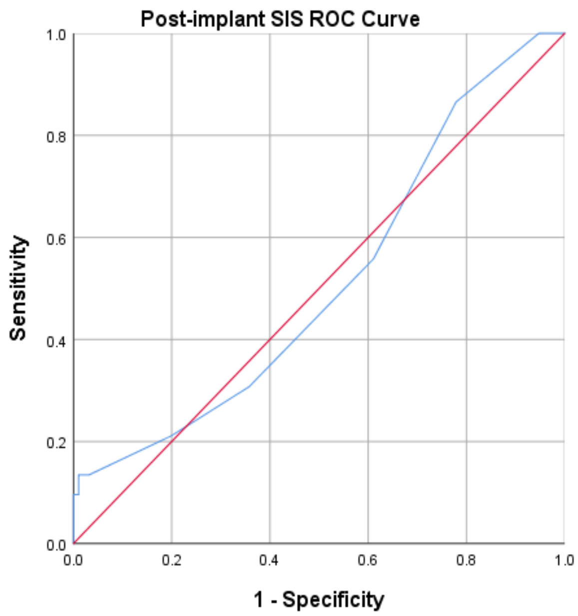
Presents the ROC curves for the outcome measures



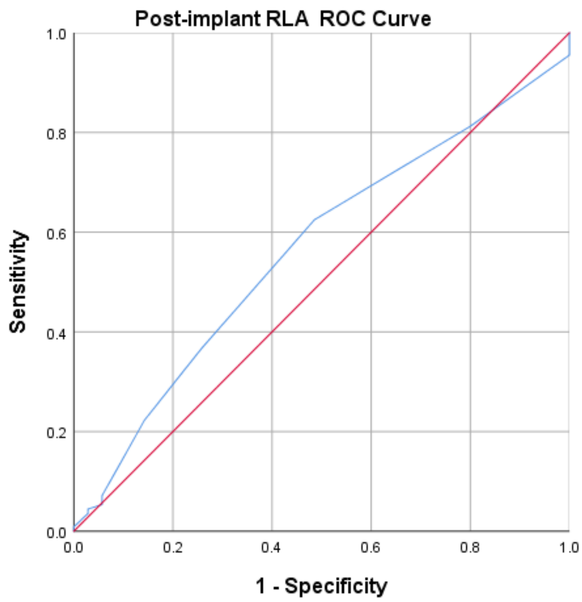
(a) ROC curve for Overall outcome measure



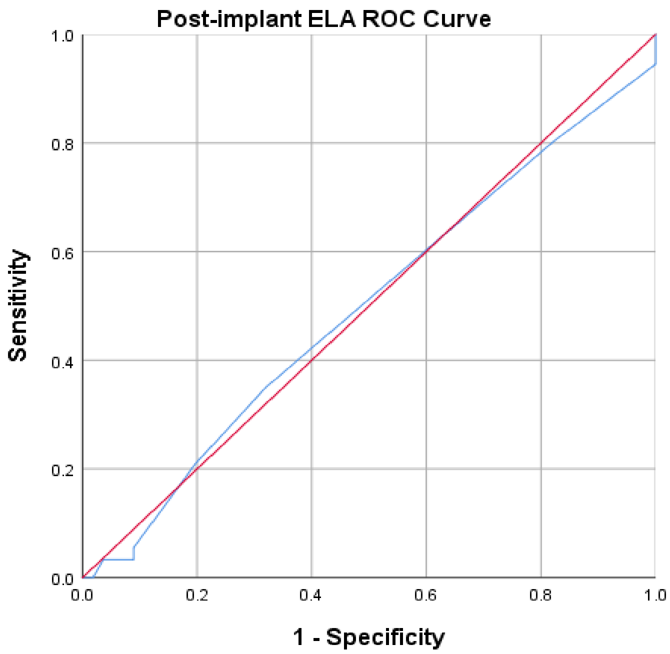
(b)ROC curve for the post-implant PTA



(c) ROC curve for post-implant SIS score



(d) ROC curve for post implant RLA



(e) ROC curve for post-implant ELA

Table 4.6

Area Under the Curve (AUC) for Indian profiling tool for Cochlear Implant Candidacy in children, Total Score predicting post-implant outcome categories (n = 146)

Outcome Variable	AUC
Overall Functional Outcome	0.618
Post-implant PTA	0.515
Post-implant SIS	0.513
Post-implant RLA	0.564
Post-implant ELA	0.496

Note. AUC = Area Under the Curve. AUC of 0.5 = chance level; AUC ≥ 0.7 = acceptable discrimination; AUC ≥ 0.8 = excellent. PTA = Pure Tone Audiometry

Average; SIS = Speech Identification Score; RLA = Receptive Language Age; ELA = Expressive Language Age.

As presented in Table 4.6, the ROC analyses revealed consistently poor discriminative validity for the Profiling tool Total Score. The highest AUC was obtained for the overall functional outcome classification (AUC = 0.618), which is only marginally above the chance threshold of 0.50. For post-implant PTA, the profiling tool Total Score yielded an AUC of 0.515, and for SIS an AUC of 0.513, both values indistinguishable from chance-level. For RLA and ELA, AUC values were 0.564 and 0.496, respectively, indicating that the Profiling tool Total Score performed no better than random classification in distinguishing children with good versus poor expressive language outcomes.

4.5 . Role of Profiling Factors in Predicting Cochlear Implant Outcomes in Children

OLS multiple regression models were attempted using the 12-profiling tool for cochlear implant candidacy in children, with factors (excluding Support Services due to zero variance), even though the factor correlations were marginal. Each factor was entered simultaneously as a predictor for each of the four outcome variables. Table 4.7 presents the model fit statistics, and Table 4.8 presents the regression coefficients for significant predictors across all four models.

Table 4.7

Summary of multiple regression model fit statistics for the four post-implant outcome variables (n=146)

Dependent Variable	R^2	Adj. R^2	F (12, 133)	df error	*p*
Post-implant RLA	0.482	0.435	10.227	133	< .0001

Post-implant ELA	0.602	0.566	16.658	133	< .0001
Post-implant PTA	0.181	0.107	2.438	133	.007
Post-implant SIS	0.158	0.082	2.069	133	.023

Note. R^2 = coefficient of determination; Adj. R^2 = R^2 adjusted for number of predictors; df = degrees of freedom. RLA = age-corrected Receptive Language Age (chronological age - RLA); ELA = age-corrected Expressive Language Age (chronological age - ELA).

All four regression models were significant (all $p \leq .023$), confirming that the profiling tool factors, considered together, meaningfully predict post-cochlear implant outcomes. The model for post-ELA yielded the strongest fit ($R^2 = 0.602$, Adj. $R^2 = 0.566$; $F[12, 133] = 16.658$, $p < .0001$), indicating that the 12 profiling factors collectively explained 60.2% of the variance in the expressive language gap at one-year post-implant. The post-RLA model also demonstrated strong explanatory power ($R^2 = 0.482$, Adj. $R^2 = 0.435$; $F[12, 133] = 10.227$, $p < .0001$), accounting for 48.2% of the variance in the receptive language gap. The models for Post-PTA ($R^2 = 0.181$, Adj. $R^2 = 0.107$; $F[12, 133] = 2.438$, $p = .007$) and Post-SIS ($R^2 = 0.158$, Adj. $R^2 = 0.082$; $F[12, 133] = 2.069$, $p = .023$) were statistically significant but explained a modest proportion of variance. This was consistent with the multifactorial nature of audiometric and speech-perception outcomes in paediatric cochlear implantation.

Table 4.8

Regression Coefficients (B) for Significant Profiling Tool Factors Across the Four Post-implant Outcome Models

Dependent variable	Predictor variable	B	SE	t	p
Post-implant Receptive Language Age (RLA)					
R^2 = .482, Adj. R^2 = .435, F(12,133) = 10.23, p < .0001					
	Implant Age	1.459	0.190	7.678	< .001
	Medical/Radiological	−1.371	0.564	−2.431	.016
	Language Score	0.361	0.173	2.083	.039
	Cognitive Abilities	1.837	0.633	2.901	.004
Post-implant Expressive Language Age (ELA)					
R^2 = .602, Adj. R^2 = .566, F(12,133) = 16.66, p < .0001					
	Implant Age	1.547	0.175	8.837	< .001
	Duration of Deafness	0.658	0.236	2.790	.006
	Medical/Radiological	−1.136	0.520	−2.185	.031
	Audiological Assessment	0.388	0.154	2.524	.013
	Language Score	0.321	0.160	2.007	.047
	Family Structure	−0.594	0.244	−2.439	.016
	Cognitive Abilities	1.338	0.584	2.293	.024
Post-implant Pure-Tone Average (PTA)					
R^2 = .181, Adj. R^2 = .107, F(12,133) = 2.44, p = .007					
	Hearing Aid Use	−5.916	1.996	−2.964	.004
Post-implant Speech Identification Score (SIS)					
R^2 = .158, Adj. R^2 = .082, F(12,133) = 2.07, p = .023					
	Family Structure	10.191	4.286	2.378	.019

Learning Style	−9.213	2.715	−3.393	< .001

*Note. B = unstandardised regression coefficient; SE = standard error; t = t-statistic. * p < .05; ** p < .01; *** p < .001. RLA = Receptive Language Age; ELA = Expressive Language Age; PTA = Pure-Tone Average (dB HL); SIS = Speech Identification Score (%). Only statistically significant predictors (p < .05) are displayed. All models were estimated on n = 146.*

4.6.1 Post-implant Receptive Language Age

For post-RLA, the regression model was significant [$F(12, 133) = 10.227$, $p < .0001$], explaining 48.2% of the variance ($R^2 = 0.482$, Adj. $R^2 = 0.435$). Implant Age was the strongest significant predictor ($B = 1.459$, $SE = 0.190$, $t = 7.678$, $p < .001$), indicating that an increase in the Implant Age concern rating was associated with an increase in the residual receptive language gap at one-year post-implant. Cognitive Abilities was also a significant positive predictor ($B = 1.837$, $SE = 0.633$, $t = 2.901$, $p = .004$), suggesting that children with greater cognitive concern scores showed a larger receptive language gap at follow-up.

Language Score was a significant predictor ($B = 0.361$, $SE = 0.173$, $t = 2.083$, $p = .039$), reflecting that greater pre-implant language concern was associated with a wider residual language gap. Medical/Radiological concerns showed a significant negative association with Post-RLA ($B = -1.371$, $SE = 0.564$, $t = -2.431$, $p = .016$), indicating that children with greater medical or radiological concerns actually presented with a smaller receptive language gap, a finding contrary to the literature. Hearing Aid Use ($B = -0.373$, $SE = 0.216$, $t = -1.730$, $p = .086$) and Family Structure ($B = -0.458$, $SE = 0.264$, $t = -1.734$, $p = .085$) showed marginal negative associations ($p < .10$), suggesting that better receptive language outcomes for children with adequate pre-implant hearing aid use and stronger family support.

4.6.2 Post-implant Expressive Language Age

The model for Post-ELA was significant [$R^2 = 0.602$, Adj. $R^2 = 0.566$; $F(12, 133) = 16.658$, $p < .0001$]. Implant Age was again the dominant predictor ($B = 1.547$, $SE = 0.175$, $t = 8.837$, $p < .001$), with increase in Implant Age concern corresponding increase in the expressive language gap was seen. Duration of Deafness emerged as a significant independent predictor of Post-ELA ($B = 0.658$, $SE = 0.236$, $t = 2.790$, $p = .006$), indicating that longer pre-implant deafness duration was associated with a wider expressive language gap. Cognitive Abilities ($B = 1.338$, $SE = 0.584$, $t = 2.293$, $p = .024$) and Language Score ($B = 0.321$, $SE = 0.160$, $t = 2.007$, $p = .047$) were significant positive predictors, indicating that greater pre-implant cognitive and language concerns were associated with poorer expressive language outcomes. Audiological Assessment was a significant positive predictor of Post-ELA ($B = 0.388$, $SE = 0.154$, $t = 2.524$, $p = .013$), indicating that greater audiological concern prior to implantation was associated with a wider expressive language gap at follow-up. Medical/Radiological concerns again showed a significant negative association ($B = -1.136$, $SE = 0.520$, $t = -2.185$, $p = .031$), consistent with the pattern observed for post-RLA. Family Structure was a significant predictor ($B = -0.594$, $SE = 0.244$, $t = -2.439$, $p = .016$), indicating that greater family structure concern was associated with a wider expressive language gap at one-year post-implant. This finding highlights the importance of family support in supporting expressive language development following cochlear implantation, consistent with findings in the broader literature (Alenzi et al., 2020).

4.6.3 Post-implant Pure-Tone Average

The regression model for Post-PTA was statistically significant [$F(12, 133) = 2.438$, $p = .007$], although with more modest explanatory power ($R^2 = 0.181$, Adj. $R^2 = 0.107$). Hearing Aid Use was the only significant independent predictor of post-implant aided thresholds ($B = -5.916$, $SE = 1.996$, $t = -2.964$, $p = .004$), indicating that greater concern about pre-implant hearing aid use adequacy was associated with poorer (higher) post-implant aided PTA. Conversely, adequate hearing aid use prior to implantation was associated with better (lower) post-implant aided thresholds.

4.6.4 Post-implant Speech Identification Score

For Post-SIS, the model was statistically significant ($F[12, 133] = 2.069$, $p = .023$), accounting for 15.8% of the variance ($R^2 = 0.158$, Adj. $R^2 = 0.082$). Learning Style was the strongest significant predictor of speech identification scores ($B = -9.213$, $SE = 2.715$, $t = -3.393$, $p < .001$), indicating that greater learning style concerns were robustly associated with lower speech identification scores at one year. Family Structure was a significant positive predictor ($B = 10.191$, $SE = 4.286$, $t = 2.378$, $p = .019$), such that children from families with lower family structure concerns (i.e., stronger and more supportive family environments) showed higher speech identification scores at one-year post-implant.

4.7 Summary of Findings Across All Objectives

Table 4.9 provides a summary of the findings with reference to the objectives of the present study.

Table 4.9: Summary of Findings

Objective	Finding / Analysis	Key Result (n = 146)	Interpretation
Adaptation and Validation of the Profiling Tool	**Profile factors**	**Factor rating distribution:** 13 factors rated; Support Services = 100% No Concern (zero variance, hence excluded from inferential analyses)	Uniform access to support services among all participants
	Expectations factor	92.5% rated Mild-to-Moderate Concern	Families generally held moderately high but realistic expectations regarding implantation outcomes
	Educational Environment factor	63.7% rated Mild-to-Moderate Concern and 11.6% rated Great Concern	Considerable variability existed in educational opportunities available to children with hearing impairment
	Implantation Age factor	55.5% rated Mild-to-Moderate Concern	Reflects relatively delayed implantation age within the cohort
	Medical/Radiological, Cognitive Abilities and Audiological Assessment factors	Low concern ratings (<10%)	Most children demonstrated favourable pre-implant medical, cognitive and audiological profiles
1. Predictive Accuracy of the Profiling Tool	**Pre- vs. Post- implant Language Outcomes**	a) Median CA-RLA gap reduced from 2.50 to 1.90 years	Receptive language deficits reduced following one year of cochlear implant use
		b) Median CA-ELA gap reduced from 2.50 to 2.00 years	Expressive language deficits reduced following implantation
	Aided audiogram PTA4	Median PTA4 improved from 88.75 dB HL (re: unaided) to 23.75 dB HL (re: CI-aided), i.e., 65 dB improvement	Cochlear implantation resulted in a substantial improvement in hearing thresholds

Objective	Finding / Analysis	Key Result (n = 146)	Interpretation
	Post-implant Speech Identification Score (SIS)	Median = 77.50%	Functional speech perception was achieved by most children, although outcomes remained variable
2. Association Between Profiling Factors and Outcomes	**Correlation with Post-RLA**	a) Age at Implantation (ρ = 0.623), b) Language Factor (ρ = 0.361), c) Duration of Deafness (ρ = 0.225) significantly correlated	Later implantation and greater pre-implant language concerns were associated with larger residual receptive language gaps
	Correlation with Post-ELA	a) Age at Implantation (ρ = 0.674), b) Duration of Deafness (ρ = 0.393), c) Language Factor (ρ = 0.393) significantly correlated	These factors were strongly associated with expressive language outcomes
	Correlation with Post-PTA	a) Medical/Radiological Factors, Hearing Aid Use, b) Multiple Disabilities c) Educational Environment significantly correlated	Several clinical and environmental factors influenced aided hearing thresholds
	Correlation with Post-SIS	a) Duration of Deafness b) Learning Style significantly correlated	Speech perception outcomes were associated with auditory experience and learning characteristics
	Total Profile Score	Significant correlations with a) Post-RLA (ρ = 0.301) b) Post-ELA (ρ = 0.429)	Higher overall concern ratings were associated with poorer language outcomes
Clinical Utility of the Total Profile Score	**ROC Curve Analysis (Clinical Utility of Total Profile Score)**	Overall Functional Outcome AUC = 0.618	Poor discriminative validity of the Total Profile Score
		PTA4 AUC = 0.515; SIS AUC = 0.513; RLA AUC = 0.564; ELA AUC = 0.496	
	Regression Model: Post-RLA	Significant model ($R^2 = 0.482$); Implant Age strongest predictor	Children implanted at a later age showed a larger gap

Objective	Finding / Analysis	Key Result (n = 146)	Interpretation
			between chronological age and the language age
Role of Individual Profiling Factors in Outcome Prediction	**Regression Model: Post-ELA**	Significant model ($R^2 = 0.602$); Implant Age strongest predictor	Children implanted at a later age showed a larger gap between chronological age and the language age
	Regression Model: Post-PTA	Significant model ($R^2 = 0.181$); Hearing Aid Use significant predictor	Adequate hearing aid use prior to implantation contributed to better aided thresholds
	Regression Model: Post-SIS	Significant model ($R^2 = 0.158$); Learning Style and Family Structure significant predictors	Speech perception outcomes were influenced by learning characteristics and family support

The present study examined the adaptation and validation of the profiling tool for cochlear implant candidacy in children within the Indian context and evaluated its utility in predicting post-implant outcomes. Descriptive analyses indicated variability in concern ratings across the 13 profiling factors. The Expectations and Educational Environment showed the highest proportions of concern ratings, whereas Support Services demonstrated no variance across participants. When comparing pre- and post- implant outcomes, reductions in receptive and expressive language gaps relative to chronological age were observed following one year of cochlear implant use. Audiometric outcomes also demonstrated substantial improvement, with post-implant aided thresholds markedly better than pre-implant unaided hearing levels and speech identification scores indicating functional speech perception abilities in the majority of children.

Correlation analyses identified significant associations between several profiling factors and post-implant outcomes. Age at Implantation emerged as the strongest correlate of both receptive and expressive language outcomes. Language Score, Duration of Deafness, Audiological Assessment, Family Structure, Medical/Radiological Factors, Hearing Aid Use, Multiple Disabilities, and Educational Environment demonstrated significant relationships with at least one outcome measure. Although the Profiling Tool Total Score was significantly correlated with post-implant language outcomes, ROC analyses indicated poor discriminative accuracy of the total score for classifying good versus poor outcomes. Multiple regression analyses demonstrated that the profiling factors collectively accounted for substantial variance in receptive and expressive language outcomes and smaller but significant proportions of variance in audiometric and speech perception outcomes. Implant Age consistently emerged as the strongest predictor of language outcomes, whereas Hearing Aid Use independently predicted post-implant aided thresholds, and Learning Style and Family Structure significantly predicted speech identification performance.

Chapter 5

DISCUSSION

The present study aimed to develop and validate a structured profiling tool for cochlear implant candidacy in children, adapted for the Indian context, and to examine the predictive value of the pre-implant profiling tool for cochlear implant candidacy, as well as factors associated with post-implant speech-language and audiological outcomes. The findings are discussed below in relation to the four study objectives and in light of existing national and international evidence.

5.1. Distribution of the Profiling Tool Factor Ratings in the Sample

The distribution of ‘concern’ ratings across the 13 profiling tool factors revealed clinically meaningful variation, consistent with the heterogeneity documented in the paediatric cochlear implant population in India and internationally. Implant Age was rated as Mild-to-Moderate Concern in 55.5% of children, a finding consistent with the relatively older mean age at implantation (Meaṇ = 3.60 years, SD = 1.39) observed in the present sample. This pattern reflects thetrend of delayed implantation in India, where barriers, including limited newborn hearing screening, awareness deficits, geographical inaccessibility, and financial constraints, contribute to late diagnosis and deferred intervention (Manjula et al., 2025). Research demonstrates that implantation before 12 to 18 months of age yields the most favourable auditory and spoken language outcomes as it utilizes the critical periods of neural plasticity (Niparko et al., 2010; Tomblin et al., 2005). The comparatively large proportion of children with Mild Concern on this factor in the present sample, therefore, represents a clinically significant finding that may have downstream effects on overall outcomes.

Educational Environment emerged as the factor with the highest proportion of Mild-to-Moderate Concern (63.7%) and the greatest frequency of Great Concern (11.6%) ratings among all 13 factors. This pattern reflects the considerable diversity of educational resources available for children with hearing impairment across India, where children may be placed in inclusive mainstream settings, special or open schools for the deaf, or home-schooling arrangements, often without standardised audiological support, assistive technology, or trained professionals (Choi et al., 2020; Mukari et al., 2007). The high rate of concern on this factor is significant given the evidence that educational placement and quality of acoustic environment have a substantial influence on post-implant auditory performance, vocabulary acquisition, and academic achievement (Archbold et al., 2002; Moog & Geers, 2010).

The Expectations factor showed the least variability, with 92.5% of families rated at Mild-to-Moderate Concern. This finding suggests that parents in this clinical population held moderately positive expectations, rather than unrealistically high ones, at the time of candidacy assessment. This is in partial agreement with McRackan et al. (2022), who reported that a subset of cochlear implant candidates had unrealistically elevated expectations, particularly regarding listening in noisy environments.

Support Services showed a zero variance, with all 146 children rated as No Concern. While this reflects the comprehensive rehabilitation infrastructure available at AIISH, it also means this factor cannot be used in predictive analyses.

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5.2. Pre- versus Post- implant Language Outcomes and Aided Audiometric Outcomes

The findings indicate meaningful reductions in the age-corrected language gap i.e., Chronological age minus RLA and Chronological age minus ELA, following one year of cochlear implant use. The median age-corrected Receptive Language Age (RLA) gap decreased from 2.50 years pre-implant to 1.90 years post-implant, representing a 0.65-year of gap reduction. This indicated that the gap between chronological age and receptive language age narrowed one-year post implantation. Similarly, the median age-corrected Expressive Language Age (ELA) gap reduced from 2.50 years to 2.00 years post-implant, a reduction of 0.50 years. These reductions in the language gap are clinically meaningful and are consistent with gains documented in the literature following cochlear implantation (Percy-Smith et al., 2013).

The CI-aided audiometric outcomes further confirm the clinical benefit of cochlear implantation in this sample. The mean post-implant PTA of 25.16 dB HL represented an average improvement of approximately 64 dB from the pre-implant unaided mean PTA of 88.97 dB HL, placing the majority of implanted children within the speech spectrum/banana and enabling meaningful access to conversational speech. The mean post-implant Speech Identification Score of 72.97% reflects functional closed-set speech perception in most participants, consistent with outcomes reported in Indian studies (Gupta, 2012; Hota, 2019), which documented similar improvements in aided thresholds and speech perception following cochlear implantation in prelingually deaf children.

5.3. Correlation of profiling tool for cochlear implant candidacy in children: Factors with Post-implant Outcome Variables

The Spearman correlation analyses revealed that among the 12 (Support services was not included as all participants were rated as ‘no concern’) factors included in the profiling tool, Age at Implantation was the strongest and most consistent correlate of post-implant language outcomes. Age at Implantation showed the highest correlations with both post-RLA ($\rho = 0.623$, $p < 0.001$) and post-ELA ($\rho = 0.674$, $p < 0.001$). Duration of Deafness also correlated significantly with post-RLA ($\rho = 0.225$, $p = .006$) and post-ELA ($\rho = 0.393$, $p < 0.001$). Since the outcome variables represent the gap between chronological age and language age (i.e., higher scores indicate a larger language lag), these positive correlations indicate that older age at implantation and longer duration of deafness were associated with a greater language gap at one-year post-implant. This is consistent with the expectation that children implanted at an older age begin with a larger deficit and retain a wider gap between their chronological and language ages at the one-year follow-up. This interpretation is supported by the regression findings. Wherein after controlling for all other profiling tool factors, Age at Implantation ($B = 1.459$, $SE = 0.190$, $t = 7.678$, $p < .001$) was the dominant predictor of post-RLA, with Language Score ($B = 0.361$, $p = .039$), Medical/Radiological concerns ($B = -1.371$, $p = .016$), and Cognitive Abilities ($B = 1.837$, $p = .004$) also emerging as significant predictors.

The strong predictive role of Duration of Deafness in the present study aligns with well-established international evidence. Nikolopoulos, Gibbin, and Dyar (2004) demonstrated that shorter auditory deprivation duration was among the most consistent predictors of long-term speech perception outcomes in the Nottingham Children's Implant Profile study. Hota (2019) similarly reported a significant negative relationship between the duration of deafness and both auditory performance and speech intelligibility in the sample. The present findings thus provide additional empirical evidence from a large retrospective Indian cohort for the inclusion of Duration of Deafness as a core factor in any candidacy profiling tool designed for the Indian context.

Learning Style showed a significant negative correlation with post-SIS ($\rho = -0.185$, $p = .025$). It remained the strongest independent predictor of Post-SIS in the regression model ($B = -9.213$, $SE = 2.715$, $t = -3.393$, $p < .001$). This finding indicates that greater concern about a child’s learning style, including behavioural engagement, attention, motivation, and responsiveness during learning activities, was associated with lower speech identification outcomes at 1-year post-implant. This aligns closely with findings from the NChIP study by Nikolopoulos et al. (2004), who identified learning style as one of the most consistent predictors of long-term speech perception outcomes three- and four- years post-implantation. The finding also correlates with the work of Geers et al. (2011) and DesJardin and Eisenberg (2007), who have demonstrated that children who were more behaviourally engaged, attentive, and cooperative during auditory-verbal activities showed faster development of spoken language.

Medical/Radiological concerns showed a significant positive correlation with post-PTA ($\rho = 0.230$, $p = .005$), indicating that children with greater medical or radiological concerns had poorer (i.e., worse) post-implant aided thresholds at the bivariate level. Notably,

Hearing Aid Use adequacy was the only significant independent predictor of Post-PTA in the multiple regression model ($B = -5.916$, $SE = 1.996$, $t = -2.964$, $p = .004$), indicating that adequate pre-implant hearing aid use was associated with better post-implant aided thresholds. This finding is consistent with Nickerson et al. (2019), who reported that better pre-implant aided audibility was associated with improved post-implant speech perception outcomes, and supports the inclusion of hearing aid adequacy as a clinically meaningful factor in the candidacy profile. Pre-implant hearing aid use may serve as a substitute for early auditory experience, consistent device use, and family compliance with audiological recommendations, all of which may stimulate the auditory pathway and enhance cochlear implant stimulation.

The profiling tool Total Score was significantly correlated with Post-RLA ($\rho = 0.301$, $p < .001$) and Post-ELA ($\rho = 0.429$, $p < .001$), indicating that the aggregate concern profile carried meaningful information about language outcomes at one year. However, the

ROC curve analyses revealed that the profiling tool Total Score had limited discriminative validity for distinguishing between children with good and poor outcomes.The AUC values ranging from 0.496 to 0.618suggests that while the total score provides useful clinical information when interpreted as part of a multidimensional profile, it does not constitute a sufficiently precise screening instrument on its own. This is consistent with observations from earlier ChIP-based studies, including Lazaridis et al. (2010) and Graham O'Brien et al. (2012), who noted that no single cutoff score could reliably classify all cochlear implant candidates and that clinical decision-making required integration of multiple domain-specific ratings and different weightage for different factors might steer a relationship in this direction.

5.4 Implications of Clinical Utility of the Profile Total Score in Predicting Cochlear Implant Outcomes

The multiple regression analyses confirmed that the 12 profiling tool factors collectively explained a significant and clinically meaningful proportion of variance in post-implant outcomes. The models accounted for 48.2% of the variance in post-RLA (R^2 = 0.482, Adj. R^2 = 0.435; $F[12, 133] = 10.227$, $p < .0001$) and 60.2% of the variance in post-ELA (R^2 = 0.602, Adj. R^2 = 0.566; $F[12, 133] = 16.658$, $p < .0001$). The models for post-PTA (R^2 = 0.181) and post-SIS (R^2 = 0.158) were statistically significant but explained a more modest proportion of variance. While these figures indicate that a portion of the variability in outcomes remains unexplained, the language models, in particular, demonstrate a strong, clinically meaningful predictive relationship. This is consistent with the multi-factorial nature of cochlear implant outcomes and with the explained variance reported in other profiling-based studies in this field. O'Brien et al. (2012) similarly reported that pre-implant profile domains explained only a portion of post-implant outcome variability, attributing the residual variance to post-implant rehabilitation quality, device programming, and factors not captured at the time of candidacy assessment.

The finding that Age at Implantation was the dominant predictor of post-RLA ($B = 1.459$, $p < .001$), with Duration of Deafness also emerging as a significant predictor of post-ELA ($B = 0.658$, $p = .006$), has important clinical implications. In the Indian context, reducing the duration of deafness through universal newborn hearing screening, early diagnosis, timely hearing aid fitting, and prompt referral for cochlear implantation is not only a clinical priority but also a public health imperative.

The differential pattern of predictors across outcome domains is particularly instructive. Language outcomes (RLA and ELA) were primarily driven by demographic and developmental factors, specifically Age at Implantation and Duration of Deafness. In contrast, audiometric outcomes (PTA) were predicted principally by Hearing Aid Use adequacy as the only statistically significant independent predictor in the regression model, while Medical/Radiological status showed a significant bivariate correlation with PTA but did not independently predict the outcome. Intrinsic child and family factors most strongly predicted speech identification outcomes (i.e., SIS), specifically Learning Style and Family Structure. This means different parts of a child's profile predict different results. Therefore, counselling and rehabilitation should be tailored to the specific goals for each child.

5.5. Relevance to the Indian Context

The present study is among the first to systematically validate a ChIP-based profiling tool against post-implant outcomes using a large, retrospective clinical dataset. The adapted profiling tool for cochlear implant candidacy in children incorporates culturally and contextually relevant factors, including the structure of family support systems in Indian households, the diversity of educational placement options, the variable availability of post-implant rehabilitation services, and the role of expectations shaped by socioeconomic and cultural norms. These contextual adaptations distinguish the present tool from previously published Western profiling instruments and address the specific need for standardised candidacy assessment criteria in India.

The present findings converge with Indian outcome research. Gupta (2012) reported that residual hearing and pre-implant auditory performance significantly predicted post-implant Categories of Auditory Performance (CAP), Meaningful Auditory Integration Scale (MAIS), and Speech Intelligibility Rating (SIR) scores in Indian children, while Hota (2019) identified duration of deafness as a negative predictor of both audiological performance and speech intelligibility. The present study extends this body of evidence by incorporating a broader range of pre-implant candidacy factors and examining their multivariate contributions to multiple outcome domains using a large, systematically collected retrospective sample.

Chapter 6

SUMMARY AND CONCLUSIONS

The present study aimed to develop a structured profiling and scoring system based on the Children's Implant Profile (ChIP) for use in the Indian context, and to examine its ability to predict speech-language and audiological outcomes in children following cochlear implantation. Three specific objectives were framed: (1) to create a profiling tool for cochlear implant candidacy in children for the Indian context; (2) to examine the predictive accuracy of the profile tool by comparing it with the Assessment Checklist of Speech-Language Skills (ACSLS) scores and aided audiometry scores at one-year post-implantation; and (3) to identify the main pre-implant profiling factors linked to favourable speech-language and audiological outcomes in children following cochlear implantation.

The study was conducted at the All-India Institute of Speech and Hearing (AIISH), Mysuru, using a retrospective correlational design. The profiling tool comprised 13 candidacy factors, including age at implantation, duration of deafness, medical and radiological status, hearing aid use, pre-implant speech and language abilities, family support, educational environment, learning style, and cognitive abilities. Each was rated on a three-point concern scale. The tool was content-validated by five experienced audiologists and speech-language pathologists prior to use.

Data were drawn from 146 children who had undergone unilateral cochlear implantation and completed at least one year of post-implant auditory-verbal therapy. The mean age at implantation was 3.60 years, and the majority of children were implanted between two and four years of age. Post-implant outcomes were assessed at one year post-implant using the Assessment Checklist of Speech-Language Skills (ACSLS) for receptive and expressive language ages, CI-aided pure-tone average (PTA), and speech identification scores (SIS). Non-parametric statistical methods - including Spearman rank-order correlations, OLS multiple regression, and ROC curve analysis were used for analyses.

The cochlear implantation in children resulted in substantial gains across all outcome measures. The median age-corrected Receptive Language Age (RLA) i.e., the gap between chronological age and RLA decreased from 2.50 years to 1.90 years post-implant (a reduction of 0.65 years). The median age-corrected Expressive Language Age (ELA), i.e., i.e., the gap between chronological age and ELA gap reduced from 2.50 years to 2.00 years (a reduction of 0.50 years), indicating that the language deficit narrowed meaningfully after one year of cochlear implant use. The median CI-aided PTA was 23.75dB HL, which reflected an improvement of approximately 65 dB from the pre-implant unaided baseline, and the median SIS was 77.50%. Age at Implantation was the strongest predictor of post-implant language outcomes, and Duration of Deafness was also a significant predictor of expressive language outcomes. Learning Style emerged as the most significant predictor of speech identification scores, while pre-implant Hearing Aid Use adequacy was the sole significant independent predictor of aided audiometric outcomes in the regression model. Family Structure and Support also significantly predicted speech identification performance. ROC curve analysis showed that the profiling tool's total score had limited stand-alone discriminative validity (AUC range: 0.496–0.618), suggesting that individual domain ratings are more clinically informative than the composite score alone.

The study demonstrates that the adapted profiling tool is a practical and meaningful framework for pre-implant candidacy assessment in the Indian context. It provides clinicians with a structured basis for counselling families, planning rehabilitation, and monitoring outcomes - and lays the groundwork for a standardised national approach to paediatric cochlear implant candidacy evaluation.

CONCLUSIONS

Based on the findings of the present study, the following inferences are drawn:

The adapted Profiling tool for candidacy, comprising of 13 multidimensional candidacy factors rated on a three-point concern scale, is a feasible and clinically applicable profiling tool for pre-implant counselling in paediatric cochlear implant assessment in the Indian context. The distribution of concern ratings across the 13 factors revealed clinically meaningful variability in most domains, with Age at Implantation, duration of deafness, learning style and Educational Environment emerging as areas of greatest concern in this sample.

Cochlear implantation was associated with clinically significant gains in receptive and expressive language, aided hearing thresholds, and speech identification scores at one-year post-implant. These findings confirm the efficacy of cochlear implantation as an intervention for severe-to-profound hearing loss in Indian children and validate the use of the ACSLS and aided audiometry as clinically relevant outcome measures.

Age at Implantation is the dominant predictor of post-implant language outcomes in this sample, as evidenced by the regression models ($B = 1.459$ for post-RLA; $B = 1.547$ for post-ELA; both $p < .001$). Duration of Deafness also emerged as a significant independent predictor for post-ELA ($B = 0.658$, $p = .006$). These findings confirm that early identification and timely implantation to minimise the duration of auditory deprivation provide support for prioritising younger candidates in Indian cochlear implant programmes.

Learning Style is the strongest independent predictor of post-implant Speech Identification Score, showing the importance of assessing child-specific behavioural, attentional, and motivational factors as part of candidacy evaluation. Children with learning style concerns should receive targeted behavioural and rehabilitative support in the post-implant period to optimise functional speech perception.

Pre-implant Hearing Aid Use adequacy is the primary significant independent predictor of post-implant aided audiometric outcomes in the regression model ($B = -5.916$, $p = .004$), confirming that adequate prior hearing aid use is associated with better post-implant aided thresholds. While Medical and Radiological status showed a significant bivariate correlation with post-PTA, it did not independently predict audiometric outcomes after controlling for all other profiling factors in the regression model. Nevertheless, comprehensive radiological evaluation, including high-resolution CT and MRI, remains an essential component of candidacy assessment for surgical planning. These findings highlight the importance of optimal pre-implant hearing aid fitting in improving post-implant auditory access.

Family Structure and Support is a significant predictor of post-implant Speech Identification Score, highlighting the critical role of parental involvement and the quality of the home language and rehabilitation environment in determining functional communication outcomes. Clinical programmes should incorporate family-centred counselling and caregiver training as integral components of the cochlear implant rehabilitation.

The Profiles' Total Score demonstrated statistically significant but limited discriminative validity across outcome domains (AUC range: 0.496–0.618), suggesting that while aggregate profiling provides useful clinical information, individual domain-specific ratings are more informative for outcome prediction and rehabilitation planning than a single composite score. The total score alone should not be used as the primary basis for candidacy decisions or prognosis.

The profiling tool provides a structured, multidimensional framework for paediatric cochlear implant candidacy assessment, grounded in empirical evidence from an Indian clinical population. It can serve as a standardised tool for multidisciplinary team evaluation, parental counselling, rehabilitation planning, and outcome monitoring across cochlear implant centres in India, addressing the critical gap identified by Manjula et al. (2025) in the uniformity of candidacy assessment practices nationally.

6.1 Future Directions

The present study provides a useful starting point for developing a structured candidacy profiling tool suited to the Indian cochlear implant context. At the same time, the findings highlight several directions for future research to build meaningfully on this work.

A notable feature of the present sample is that it predominantly included children who had completed one year of post-implant rehabilitation and demonstrated measurable progress. Children who discontinued follow-up or showed limited benefit were not captured in the dataset. This means the full range of outcomes — including poor performers — was not represented, likely reducing the tool's ability to distinguish between children with good and poor results clearly. The AUC values obtained in the ROC curve analyses (0.496–0.618) partly reflect this. Future studies would benefit from designs that include children across the full spectrum of post-implant outcomes, including those who show minimal progress, discontinue device use, or require alternative communication approaches.

The present study was conducted at a single national institution, limiting the extent to which the findings can be applied. All India Institute of Speech and Hearing offers a high standard of post-implant rehabilitation, as reflected in the zero variance observed on the Support Services factor. All 146 children were rated as No Concern, effectively removing this factor from any predictive analysis. In reality, many children across India receive cochlear implants at centres where rehabilitation support is far more limited. Future studies involving a range of settings, including government hospitals, charitable programs, and private centres in urban, semi-urban, and rural areas, would introduce greater variability in the profiling tool factors. Which would yield findings more representative of the broader Indian paediatric cochlear implant population.

Outcomes in the present study were assessed at one-year post-implantation. While this is a standard and clinically accepted time point, cochlear implant outcomes do not stabilise at one year - language development, speech perception, and academic progress continue to unfold over several years of device use. Longitudinal studies with follow-up assessments at two-, three-, and five-year post-implantation would clarify whether the predictive relationships identified in the present study persist over time, and whether the influence of pre-implant profiling tool factors grows, fades, or is moderated by the quality of post-implant rehabilitation as children develop.

The profiling tool's scoring system can be further refined. In its current form, all 13 eligible factors were given equal weight in the computation of the Total Score. However, the regression findings clearly showed that some factors mattered more than others for specific outcomes. Duration of Deafness and Age at Implantation were the strongest predictors of language outcomes, Learning Style most strongly predicted Speech Identification Score, and Medical/Radiological Status and Hearing Aid Use adequacy were most relevant for audiometric outcomes. A differential weightage system that reflects these domain-specific contributions would likely improve the tool's clinical utility.

The outcome measures used in the present study, while appropriate and well-validated for the Indian context, covered a limited range of post-implant functioning. Future studies would benefit from including a broader set of measures, such as the Meaningful Auditory Integration Scale (MAIS), Categories of Auditory Performance (CAP), speech intelligibility ratings, and assessments of pragmatic language, phonological awareness, and early literacy. Parent-reported measures such as the Parents' Evaluation of Aural/Oral Performance of Children (PEACH) would provide a more complete picture of how children function in everyday listening and communication environments and would strengthen the ecological relevance of any predictive model derived from the profiling tool.

6.2 Clinical Implications

The findings of the present study have several practical implications for cochlear implant programmes. The adapted profiling tool, comprising 13 multidimensional candidacy factors rated on a structured concern scale, which offers cochlear implant centres a feasible, standardised framework for pre-implant assessment beyond audiological criteria alone. In an Indian context where considerable variation exists across centres in candidacy assessment practices, as documented by Manjula et al. (2025), the availability of a contextually adapted profiling tool provides multidisciplinary teams with a common clinical idea for evaluating candidates, guiding family counselling, and planning post-implant rehabilitation. However, given the limited discriminative validity of the total profiling score observed in the ROC analyses, the tool is best used as a material for counselling parents or caregivers. It can serve as a structured profiling framework rather than a standalone screening instrument for candidacy decisions.

The differential pattern of predictors across outcome domains further informs the direction of rehabilitation planning. Learning Style emerged as the strongest predictor of post-implant speech identification outcomes, while Family Structure and Support were significant predictors of functional speech perception. These findings suggest that clinicians should systematically assess a child's behavioural engagement, attentional capacity, and learning readiness during candidacy evaluation, as children identified with learning style concerns may benefit from targeted behavioural intervention even prior to implantation.

Similarly, family-centred counselling and structured caregiver training should be integral components of the cochlear implant rehabilitation pathway, given the measurable contribution of family support to functional communication outcomes. The significance of pre-implant Hearing Aid Use adequacy as the sole independent predictor of audiometric outcomes emphasizes on the value of optimal hearing aid fitting.

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APPENDIX

Children's Implant Profile

		No concern	Mild to moderate concern	Great concern
1	Chronological age			
2	Duration of deafness			
3	Medical/radiological issues			
4	Audiological assessment			
5	Hearing aid use			
6	Speech and language abilities			
7	Multiple handicaps/disabilities			
8	Family structure and support			
9	Educational environment			
10	Availability of support services			
11	Expectations of family/child			
12	Cognitive ability			
13	Learning style			

Scoring

		No concern	Mild to moderate concern	Great concern
1	Chronological Age	2—5 years	5—8 years	>8 years
2	Duration Of Deafness	0—4 years	4—10 years	>10 years
3	Medical/Radiological Issues Background Indicators: • Does the child have any congenital abnormalities of the cochlea? • What is the aetiology of deafness? • Are there any radiological contraindications for proceeding with implant surgery? • Does the child have any other medical conditions?	Open/patent cochlea Normal auditory nerve	Partially ossified cochleae's Hypoplastic auditory nerve	• Completely ossified cochlea; • congenital malformation of the cochlea; • narrow internal auditory canal or atypical auditory nerve
4	Audio Logical Assessment Background Indicators: • Are the child's audio logical test results reliable? • Are the aided performance levels within the department's standard guidelines? • Has the child had an adequate trial with an appropriate and well-fitted hearing aid?	• Good reliability • Aided performance within guidelines • Adequate trial with appropriate hearing aid and auditory opportunities	• Aided performance approaching borderline • Limited history of hearing aid use and • auditory opportunities are not always available; • unreliable or inconsistent use of a hearing aid	• Poor reliability • Aided performance at borderline or better • History of poor hearing aid use and/or limited auditory opportunities
5	Hearing aid use	• Adequate trial with	• Limited history of hearing aid use and	• History of poor hearing aid use

	Are the aided performance levels within the department's standard guidelines? • Has the child had an adequate trial with an appropriate and well-fitted hearing aid?	appropriate hearing aid and auditory opportunities •	• Auditory opportunities are not always available; • Unreliable or inconsistent use of a hearing aid •	and/or limited auditory opportunities •
6	Speech and Language Abilities Background Information: • What is the child's approximate language age (LA) • What is the delay with regard to the child's chronological age (CA) • What is the child's most effective mode of communication? (oral, total communication, sign)	• Language age within 2 years of chronological age. • Formal language system in place	• 2—4 years delay between LA and CA. • Sign/gesture systems may be established or used as the primary means of an everyday communication system. • Not linguistically ready for formal assessment of spoken language skills	• >4 years delay between LA and CA. • No formal (rule-based) language
7	Multiple Handicaps/Disabilities Background Indicators: • Does the child have any diagnosed secondary conditions other than deafness? (e.g. motor difficulties, learning disabilities)	None or unrelated to the ability to learn to use the implant	Handicaps that are not cognitive in nature, e.g. acquired or progressive neurological deficit or delay —facial anomaly-syndromes (specify), visual impairment	Handicaps that are cognitive in nature, i.e. conditions which may affect the child's ability to participate in device programming, learn to use an implant

	• Does the child have any suspected but not yet confirmed secondary conditions other than deafness? (e.g. an autistic spectrum disorder or specific language impairment)			
8	Family Structure And Support	Supportive, extended family structure. Family communication in the same language mode as the child	• Supportive, immediate family structure. • Bilingual parents • Extended family or support not available locally. Parents can communicate with the child at present	• Limited family structure and limited support available at home • Parents are unable to communicate effectively with the child at present
9	Educational Environment Background Information: • Is the child already in an educational environment? • Is the current or prospective educational placement appropriate to the child's needs and abilities in general? • What range of linguistic/communication options is available at the school? • Is the school supportive of the child receiving a cochlear implant?	• Daycare, nursery or school is in place • supportive/able to provide flexible programming that matches the child's learning style and capabilities	• Daycare, nursery or school programme is not a good match with the child's capabilities, • but is flexible in securing additional services to support the implant user	Daycare, nursery, or school is not a good match for the child's abilities and is inflexible in its programme options, e.g., there is limited support for the use of sensory aids or auditory training.

10	Availability Of Support Services Background Information: • Does the child/family have access to a range of professionals in the areas of audiology, speech and language, and education of the hearing impaired? • Do these professionals have prior experience with profoundly deaf children and implanted children?	Access to experienced personnel on a frequent basis	• Access to personnel with some experience of working with profoundly deaf children • Outreach support from team professionals is developing	• Limited level of specialist support at the local level • Resistant to outreach support from team professionals
11	Expectations Of Family/Child Background Indicators: • Are the parents' expectations regarding the benefit from the implant realistic and appropriate? • Are the child's own expectations regarding benefit from the implant realistic and appropriate? • Is there a 'mismatch' between the expectations of the child's parents and primary caregivers?	• The implant will not provide normal hearing. • Child will probably function like a child with a severe hearing loss. • The process will take time	• The implant will allow the child to function as a child with a moderate hearing loss and reduce the need for educational support services. • There may be a mismatch between the expectations of parents/primary caregivers	The implant will provide normal hearing.
12	Cognitive Ability Background Information: • What is the child's cognitive intactness?	Age-appropriate non-language skills	Non-language skills are delayed but developing	Non-language skills are severely delayed

	• Is it developmentally appropriate for the child's chronological age? • Are the child's cognitive abilities delayed but appropriate for a child at a younger developmental stage? • Can the child recall and repeat an activity in a simple learning context?			
13	Learning Style Background Information: • Does the child have an internal or an external locus of control? • What is the child's temperamental style? • How does she/he cope with change, novelty or ambiguity?	• satisfactory learning style. • Attends well to adult or child-chosen activities	• learning style developmentally delayed. • The child attends well to self-chosen activities but may give variable attention to adult-chosen activities	• learning style is severely delayed. • Limited ability to sustain attention in new or familiar tasks