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Research Article

Early Detection and Intervention for Hearing Impairment in Vietnamese Children Aged 0-6 Years

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ABSTRACT
Hearing impairment during early childhood poses a significant challenge to speech and language development, with long-term consequences on cognitive and social integration. This study systematically investigates the prevalence, associated risk factors, and effectiveness of early intervention for hearing impairment in children aged 0-6 years who underwent audiological assessment at the Audiology Department of the National Otorhinolaryngology Hospital of Vietnam. A total of 72 children were comprehensively evaluated using a combination of objective and subjective audiological tests, including otoacoustic emissions (OAE), auditory brainstem response (ABR), and auditory steady-state response (ASSR). The findings reveal that 40.2% of children were diagnosed with hearing impairment before six months of age, reflecting the increasing impact of neonatal hearing screening programs. However, 29.1% of cases were only identified after three years of age, indicating a substantial delay in diagnosis for a significant proportion of children. Bilateral hearing loss was the predominant presentation, affecting 93.1% of the cases, with profound hearing loss accounting for 65.1% of the affected children. Notably, early intervention demonstrated a measurable impact on access to hearing rehabilitation. The proportion of children utilizing hearing aids increased from 4.5% before diagnosis to 20.9% following audiological evaluation, while cochlear implantation rates rose from 0% to 7.5% after diagnosis. This study underscores the critical importance of early hearing screening and prompt intervention to mitigate the developmental consequences of hearing impairment. Furthermore, it highlights the necessity of raising parental awareness and improving access to advanced audiological services to enhance early detection and effective management. The research provides new insights into the epidemiology of pediatric hearing impairment in Vietnam and emphasizes the urgent need for systematic neonatal hearing screening programs across healthcare facilities nationwide. Through these efforts, the study contributes to bridging the gap in early diagnosis and intervention, ultimately fostering better long-term outcomes for children with hearing impairment.

Keywords: Hearing Impairment, Early Detection, Early Intervention, Pediatric Audiology, Auditory Assessment (Oae, Abr, Assr)

INTRODUCTION

Hearing impairment in early childhood is a critical public health issue due to its profound impact on speech and language acquisition, cognitive development, and social integration [1]. The early years of life are a crucial period for auditory and linguistic development, and any delay in diagnosing and addressing hearing loss can lead to irreversible developmental deficits. Children with undiagnosed or untreated hearing impairment often experience substantial delays in speech and language skills, which subsequently affect their educational attainment, social interactions, and overall quality of life [2]. Without timely intervention, these challenges can persist into adulthood, resulting in long-term socioeconomic consequences and reduced opportunities for meaningful participation in society [3]. Therefore, early detection and appropriate intervention are essential for minimizing these negative outcomes and improving long-term developmental trajectories [4].

The global burden of childhood hearing loss is substantial. According to the World Health Organization, approximately 34 million children worldwide are affected by disabling hearing loss, with a disproportionate prevalence in low- and middle-income countries [1]. The lack of comprehensive screening programs in these regions contributes to delayed diagnosis and inadequate intervention [5]. In Vietnam, hearing loss represents a significant and ongoing challenge, with an estimated 1,600 children born annually with moderate-to-profound hearing impairment [6]. Despite recent advancements in neonatal hearing screening, disparities in early diagnosis and

access to intervention persist due to socioeconomic and geographic barriers [7].

Early detection of hearing impairment relies on advanced audiological assessment techniques, including otoacoustic emissions (OAE), auditory brainstem response (ABR), and auditory steady-state response (ASSR). These objective diagnostic methods are essential for identifying hearing loss in infants and young children who are unable to participate in conventional behavioral audiometry [8]. OAE testing is a rapid and non-invasive method to assess cochlear function and is widely used in newborn screening programs [9]. ABR testing evaluates neural responses to auditory stimuli, providing detailed information about the auditory pathway and enabling the identification of sensorineural hearing loss [10]. ASSR allows frequency-specific assessment of hearing thresholds, particularly useful for accurately diagnosing severe-to-profound hearing loss and guiding cochlear implant candidacy [11]. The combined application of these techniques enhances diagnostic precision and facilitates early intervention.

Timely intervention following early diagnosis is critical for optimizing language acquisition and cognitive outcomes. Effective intervention strategies include the use of hearing aids, cochlear implants, and speech therapy, which have been shown to significantly improve language development and social integration in children with hearing loss (Ching et al., 2018) [4]. Studies demonstrate that early intervention, particularly before six months of age, yields better linguistic and academic outcomes compared to delayed intervention [12]. In Vietnam, the adoption of these interventions remains inconsistent due to limited public awareness, economic challenges, and unequal access to specialized healthcare services [7].

The novelty of this research lies in its comprehensive analysis of a pediatric cohort using multiple advanced audiological assessment techniques. This study not only evaluates the effectiveness of existing screening protocols but also provides empirical evidence supporting the expansion of systematic neonatal hearing screening programs. Additionally, it emphasizes the critical role of parental education and improved healthcare access in facilitating early diagnosis and intervention. By advancing the understanding of hearing impairment and the effectiveness of early intervention, this research contributes to ongoing efforts to reduce the global burden of childhood hearing loss and promote equitable healthcare access [3].

METHODS

2.1. Study Design and Participants

This study employed a descriptive cross-sectional design to evaluate the prevalence, risk factors, and early intervention outcomes for hearing impairment in children. The study was conducted at the Audiology Department of the National Otorhinolaryngology Hospital of Vietnam between January 2021 and September 2021. A total of 72 children aged 0-6 years who presented with suspected hearing impairment were included. This hospital-based study was designed to comprehensively assess the hearing status of children through advanced audiological testing methods and to evaluate the impact of early intervention strategies, including the use of hearing aids and cochlear implants.

Participants were referred to the Audiology Department through neonatal hearing screening programs, pediatric clinics, and community healthcare services. Each child underwent a thorough clinical evaluation and a series of objective and subjective hearing assessments. Data collection involved a combination of patient interviews, caregiver-reported medical histories, and audiological test results. This design enabled the identification of patterns in early diagnosis and intervention while allowing a comprehensive analysis of factors affecting hearing outcomes.

2.2. Inclusion and Exclusion Criteria

Participants were selected based on specific inclusion and exclusion criteria to ensure the study's validity and reliability.

Inclusion Criteria:

Children aged 0-6 years diagnosed with unilateral or bilateral hearing impairment.

Children who had completed a full battery of audiological assessments, including OAE, ABR, and ASSR.

Children whose parents or legal guardians provided informed consent to participate in the study.

Exclusion Criteria:

Children with incomplete audiological evaluations or missing clinical data.

Children with significant neurological or developmental conditions unrelated to hearing impairment.

Cases where parental consent was not obtained or withdrawn during the study.

This rigorous inclusion and exclusion framework ensured the accuracy of the dataset and minimized potential confounding variables affecting the study outcomes.

2.3. Diagnostic Procedures

A comprehensive diagnostic protocol was utilized to assess hearing function accurately. This included objective audiological tests to evaluate auditory sensitivity and identify the degree and type of hearing loss.

Otoacoustic Emissions (OAE): This test was used to screen cochlear function, particularly the outer hair cells. OAE is a quick, non-invasive method suitable for detecting hearing loss in newborns and young children [9].

Auditory Brainstem Response (ABR): ABR testing was performed to assess the integrity of the auditory nerve and brainstem pathways. Both click and tone-burst stimuli were used to determine hearing thresholds across specific frequencies. ABR is considered a gold-standard diagnostic tool for identifying hearing impairment in infants [10].

Auditory Steady-State Response (ASSR): ASSR was employed to provide frequency-specific hearing thresholds, particularly in children with severe-to-profound hearing loss. This method allows for a more accurate estimation of hearing thresholds compared to ABR alone (Stapells, 2011) [11].

Tympanometry and Acoustic Reflex Testing: Tympanometry was conducted to evaluate middle ear function, while acoustic reflex testing assessed the integrity of the auditory pathway and the presence of conductive hearing loss.

Behavioral Audiometry: For children capable of providing conditioned responses, behavioral audiometry was performed to cross-validate findings from objective measures.

Diagnostic procedures were performed in a soundproof environment by experienced audiologists using calibrated equipment. Data from these tests were cross-referenced to confirm diagnoses and determine the severity and type of hearing impairment.

2.4. Ethical Approval

This study was conducted in full compliance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) of the National Otorhinolaryngology Hospital of Vietnam prior to participant recruitment. Informed consent was secured from all parents or legal guardians before enrolling their children in the study.

Confidentiality and anonymity of participant data were maintained throughout the research process. Participants retained the right to withdraw from the study at any stage without consequence. All collected data were securely stored and used exclusively for research purposes. Ethical safeguards ensured the protection of vulnerable pediatric populations and the integrity of the research process.

2.5. Data Analysis

Quantitative data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize demographic characteristics, audiological findings, and intervention rates.

Comparative analyses were conducted to evaluate differences in hearing outcomes based on age at diagnosis, severity of hearing loss, and type of intervention. Chi-square tests were used for categorical data, while independent t-tests and ANOVA were employed for continuous variables. A p-value of <0.05 was considered statistically significant.

Additionally, logistic regression models were used to assess the association between key risk factors (e.g., prenatal conditions, family history, neonatal complications) and the likelihood of severe hearing impairment. This analytical approach allowed for a robust evaluation of the study hypotheses and provided insights into the effectiveness of early intervention strategies in the Vietnamese pediatric population.

By integrating advanced statistical methods with comprehensive audiological assessments, this study provides novel insights into the early detection and intervention of hearing impairment. The findings contribute to improving screening protocols and enhancing clinical practices for pediatric audiology in resource-limited settings.

RESULTS AND DISCUSSION

3.1 Demographic Characteristics

Among the 72 participants, 49 (68.1%) were male and 23 (31.9%) were female, resulting in a male-to-female ratio of approximately 2:1.

The distribution of age at diagnosis is presented in Figure 1 and Table 1. Notably, 40.2% of children were diagnosed with hearing

impairment before six months of age, underscoring the positive impact of neonatal hearing screening programs. However, 29.1% of cases were identified after three years, indicating a substantial delay in diagnosis for a significant portion of the cohort. This delay highlights the necessity for improved public health outreach, early screening initiatives, and robust follow-up mechanisms to facilitate timely detection and intervention.

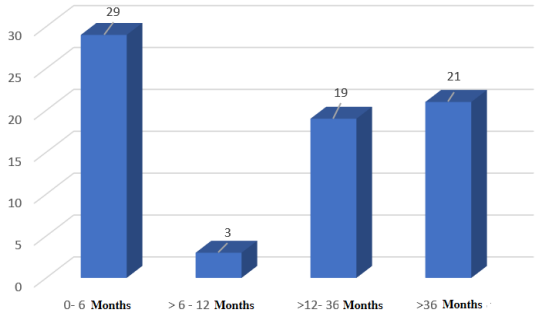

Figure 1. The distribution of age at diagnosis

Table 1: Age at Diagnosis

Age Group	Number of Cases	Percentage (%)
0 - 6 months	29	40.2
7 - 12 months	3	4.2
13 - 36 months	19	26.4
37 months - 6 years	21	29.1

Geographical analysis revealed that 62.5% of participants resided in urban areas, suggesting better access to specialized healthcare services compared to rural regions.

Risk factors associated with hearing impairment are detailed in Table 2. Family history (13.9%) and maternal infections (12.5%) were the most commonly reported risk factors, aligning with established literature on genetic and perinatal contributors to congenital hearing loss. Notably, 62.5% of cases reported no identifiable risk factors, emphasizing the complexity and multifactorial nature of pediatric hearing impairment.

Table 2: Risk Factors for Hearing Impairment

Risk Factor	Number of Cases	Percentage (%)
Maternal infections	9	12.5
Birth complications	6	8.3
Family history	10	13.9
No identified factors	45	62.5

A more detailed examination of maternal history (Table 3) revealed that rubella and influenza during pregnancy accounted for 2.8% and 6.9% of cases, respectively. Other maternal infections and fetal malnutrition each contributed to 1.4% of cases. These findings are consistent with previous research indicating the teratogenic impact of maternal infections on fetal auditory development.

Table 3: Maternal History-Related Risk Factors

Risk Factor	Number of Cases	Percentage (%)
Rubella	2	2.8
Undiagnosed viral exanthema	1	1.4
Influenza	5	6.9
Fetal malnutrition	1	1.4
Other infections (e.g., CMV)	1	1.4
No maternal risk factors	62	86.1

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Perinatal and postnatal risk factors (Table 4) included preterm birth (5.6%), neonatal asphyxia (2.8%), and neonatal meningitis (2.8%). Such findings reinforce the need for vigilant monitoring of neonates with high-risk medical histories.

Table 4: Perinatal and Postnatal Risk Factors

Risk Factor	Number of Cases	Percentage (%)
Neonatal asphyxia	2	2.8
Preterm birth	4	5.6
Mechanical ventilation	2	2.8
Hyperbilirubinemia	1	1.4
Craniofacial anomalies	2	2.8
Meningitis	2	2.8
No identified risk factors	59	81.9

The age of diagnosis is a crucial determinant of intervention outcomes. In our cohort, the mean age of hearing impairment diagnosis was 16.5 months, with 40.2% of cases detected by six months. This is significantly earlier than findings from comparable studies, where the mean diagnostic age exceeded 24 months. The ability to detect hearing loss as early as one month of age reflects the growing efficacy of neonatal hearing screening initiatives in Vietnam.

3.2 Prevalence, Severity of Hearing Impairment, and Intervention Outcomes

Bilateral hearing loss was the predominant condition, affecting 93.1% of the participants, with profound hearing loss accounting for 65.1% (Figure 2). These findings are consistent with international data indicating a high prevalence of bilateral, severe-to-profound hearing loss in pediatric populations.

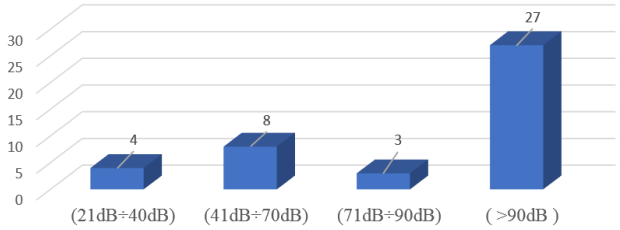

Figure 2. Bilateral hearing loss

Table 5: Audiological Assessment Methods

Method	Objective (n)	Subjective (n)
Tympanometry	67	0
Acoustic Reflex Thresholds	67	0
Otoacoustic Emissions (OAE)	67	0
Auditory Brainstem Response (ABR)	43	0
Auditory Steady-State Response (ASSR)	25	0
Conditioned Play Audiometry (CPA)	0	3

The use of advanced diagnostic modalities such as ABR and ASSR provided precise estimations of auditory thresholds, crucial for the development of individualized intervention plans. The majority of patients (58.1%) underwent a combination of ABR and ASSR, while 34.9% had ABR testing alone, and 7% were assessed using CPA (Table 6).

Table 6: Audiometric Testing for Bilateral Hearing Loss

Methodology	Number of Cases	Percentage (%)
ABR clicks + tone burst	15	34.9
ABR clicks + ASSR	25	58.1
CPA	3	7.0

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Intervention outcomes demonstrated a marked improvement in access to assistive devices following diagnosis (Table 7). Hearing aid utilization increased from 4.5% to 20.9%, and cochlear implantation from 0% to 7.5%, underscoring the efficacy of comprehensive audiological assessment and targeted intervention.

Table 7: Intervention Rates Before and After Diagnosis

Intervention	Pre-Diagnosis (n, %)	Post-Diagnosis (n, %)
Hearing aids	3 (4.5%)	14 (20.9%)
Cochlear implantation	0 (0%)	5 (7.5%)
Sign language	1 (1.5%)	3 (4.5%)
No intervention	63 (94.0%)	45 (67.1%)

These findings highlight the critical role of early detection and intervention in mitigating the adverse effects of pediatric hearing impairment and improving long-term auditory outcomes.

CONCLUSION

This study underscores the critical importance of early detection and timely intervention in mitigating the long-term impacts of hearing impairment in children. By employing advanced diagnostic methodologies, including OAE, ABR, and ASSR, this research provides robust evidence supporting the effectiveness of comprehensive audiological assessments in improving diagnostic accuracy and guiding intervention strategies. The findings highlight the urgent need to strengthen neonatal hearing screening programs and address disparities in healthcare access. Socioeconomic barriers and geographic inequities must be mitigated to ensure all children, particularly those in rural areas, receive timely and appropriate hearing rehabilitation. Furthermore, public health initiatives should focus on raising parental awareness about the significance of early hearing assessments to reduce delays in diagnosis and intervention. This research contributes valuable insights to the field of pediatric audiology in Vietnam, providing empirical evidence to inform policy development, improve clinical practices, and guide future research on optimizing hearing healthcare for children.

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