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**Original Research Article**

# A cross-sectional study of neonatal hearing impairment: understanding its prevalence and risk factors in a tertiary care hospital in Kerala, India

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## ABSTRACT

**Background:** Congenital hearing loss is one of the most prevalent sensory impairments with severe consequences when undetected. The objective of neonatal hearing screening is to identify hearing impairments shortly after birth to initiate treatment as soon as possible and to allow affected children to enjoy normal development. The aim of the study was to determine the prevalence and identify the predisposing factors of HI among neonates in a tertiary care centre in Idukki district of Kerala using a universal neonatal hearing screening (UNHS) program, in an attempt to initiate early interventions in affected neonates.
**Methods:** This was a cross-sectional study conducted in the department of ENT, Al Azhar Medical College and Super Specialty Hospital, Thodupuzha, Kerala over a period of 1 year involving 646 neonates. The study excluded any newborn whose parent/guardian did not give consent for the study, or neonates with microtia grade II and above.
**Results:** The overall prevalence of HL in neonates in our study was 3.1 in 1000 live births out of which 61% were males and 39% females. The risk factors found in our study were preterm babies, maternal age >35, low birth weight, teenage pregnancy, primigravida, and neonatal jaundice requiring blood transfusion.
**Conclusions:** In a standard neonatal population, both at-risk and non-at-risk neonates warrant the immediate adoption of a universal hearing screening program for all neonates in India. Hence, we would like to stress the importance of identifying infants with HL, administering early treatment and performing appropriate screening tests in infants at the right time period.

**Keywords:** Hearing impairment, Otoacoustic emissions, Neonates, Preterm, Low birth weight

## INTRODUCTION

Congenital hearing loss is one of the most prevalent sensory impairments with severe consequences when undetected. Hearing impairment (HI) can result in delays in language, communication and cognitive development. Early identification and intervention of hearing loss (HL) can prevent linguistic, educational and psychosocial problems.[1] Congenital or acquired HL may result in delayed developmental milestones leading to poor academic performance and personal-social and behavior problems due to deficits in speech and language acquisition. The objective of neonatal hearing screening is to identify HIs shortly after birth to initiate treatment as soon as possible and to allow affected children to enjoy normal development. When HL goes unidentified early in

life, it can adversely affect speech, language, academic, social and emotional development. World Health Organization (WHO) and the Joint Committee of Infant Hearing (JCIH) recommend that all infants should be screened before one month of age.[2,3] There is an evolving consensus that all infants should be screened for HL and appropriate interventions should be instituted by 6 months of age across the globe.[4] HL should be identified at no later than 3 months of age and children should receive appropriate intervention within 6 months of age. The vocabulary size of a 3-year-old with hearing impairment, when provided with intervention from birth, ranges from 300 to 700 words. If the intervention is initiated at 6 months, the vocabulary size ranges from 150 to 300 words. However, if the intervention is delayed until 2 years of age, the vocabulary size is limited to 0 to 50 words. In comparison, a typically developing 3-year-old child without hearing impairment has a vocabulary size ranging from 500 to 900 words.[5] However, the average age at which a child who has a profound bilateral sensorineural hearing loss (SNHL) is diagnosed at around 24 months, while HI of lesser degrees is often identified at an average age of 48 months, especially in rural areas due to the poor knowledge and awareness about HI and its relationship with speech and language development as well as lack of infrastructure.[6] Therefore, when HI goes unnoticed or gets diagnosed late in children, it leads to permanent impairment.

Otoacoustic emission (OAE) and brainstem evoked response audiometry (BERA) are considered to be indirect objective measures of peripheral auditory status.[7] Spontaneous OAEs are normal phenomena generated in the outer hair cells of cochlea in response to external stimuli received as sound waves. OAEs describe the response the cochlea emits in the form of acoustic energy, determined by the contractile activity of the outer hair cells and the mechanical and structural features of the basilar membrane, and are used as objective indicators of cochlear pathology.[8] An OAE detector identifies this low frequency but potentially audible sound waves through in-built microphones in the probe, which is inserted into the external auditory canal (EAC). OAE based neonatal screening induces evoked OAE in response to a stimulus as either clicks seen in transitory evoked otoacoustic emission (TEOAE) or as a distortion product obtained through the non-linear interaction of 2 stimuli of different frequencies seen in distortion product otoacoustic emission (DPOAE). The use of OAEs during the first few days after birth has proven to be a simple, rapid, accurate and cost-effective neonatal hearing screening technique.[9] It is non-invasive and can be repeated if satisfactory results are not obtained. BERA is an objective electro-physiological test which studies the electrical potential generated at different levels of the auditory system using electrodes placed on the scalp. As it is an expensive test, it is not economically feasible for all neonates in our country. According to the WHO Report on Hearing 2021, the prevalence of congenital HL in the southern state of Tamil Nadu was estimated to be 0.6%.[10] In this context, the present study was proposed to determine the prevalence and identify the predisposing factors of HI among neonates in a tertiary care teaching hospital in Idukki district of Kerala using a universal neonatal hearing screening (UNHS) program, in an attempt to initiate early interventions in affected neonates.

## METHODS

A cross-sectional study was done under the department of ENT, Al Azhar Medical College and Super Specialty Hospital, Thodupuzha, Kerala, which enrolled all the neonates delivered in the tertiary care centre, from July 2021 to June 2022 after Ethics committee aproval. This study included neonates delivered during the study duration, and excluded any newborn whose parent/guardian did not give consent for the study, or neonates with microtia grade II and above. All the neonates were subjected to routine ENT examination involving inspection of the pre-aural, pinna and post aural regions along with thorough history taking. Otoscopic examination of the external auditory canal and tympanic membrane was also done. DPOAE was performed by a trained and qualified audiologist in a soundproof audiology lab for all the neonates born in the hospital within 24-72 hours of birth or at least within 7 days of birth before discharge. Pediatric consultation was sought in relevant cases to rule out systemic and genetic causes of HL. All those neonates who had a refer result in the first screening were subjected to a repeat DPOAE screening after one month. A third DPOAE screening was repeated along with BERA after 3 months of birth for those babies who had a refer result upon second screening.

The data collection was carried out based on the records collected in the department of Audiology and ENT with prior permission from hospital authority and medical records department (MRD). Statistical analysis was done by entering data into Microsoft Excel©. Descriptive statistical methods was used to demonstrate the characteristics of the study population. Mean and standard deviation was calculated for continuous variables. The JCIH Guidelines 2019 were followed to identify and classify the potential risk factors. Selection bias was avoided by including all newborns in the study (universal sampling).

## RESULTS

The research encompassed a cohort of 646 neonates, with 394 (61%) identified as male and 252 (39%) identified as female. The presented demographic distribution offers a detailed portrayal of the gender composition of individuals participating in the study as in Table 1.

**Table 1: Demographic data of study participants.**

| Gender | Number (646) | Percentage |
|---|---|---|
| **Male** | 394 | 61 |
| **Female** | 252 | 39 |

The newborns that participated in the subsequent hearing screening, the prevalence of hearing loss was 64% demonstrated unilateral hearing loss in the right ear, 22% presented with bilateral hearing loss, and 14% exhibited unilateral hearing loss in the left ear (Table 2).

**Table 2: Hearing loss distribution among neonates reappearing for second screening.**

| Condition | Percentage |
|---|---|
| Unilateral hearing loss (right ear) | 64 |
| Bilateral hearing loss | 22 |
| Unilateral hearing loss (left ear) | 14 |

In our study, a total of 646 neonates were screened in three sessions as in Table 1. The sequence of screening is summarized in Figure 1. In our first session 614 neonates passed and 32 neonates had referred results as given in Table 3. And in the second session 21 passed and 7 were referred for third session. Four were lost in follow up. In the third session out of seven, two passed, three referred and two were lost in follow up. Then the 3 referred cases were subjected to BERA, in which 2 had hearing impairment. Prevalence of hearing impairment in our study is 0.31%.

**Table 3: Screening results of newborns.**

| Result | Screening 1 (n=646) | Screening 2 (n=32) | Screening 3 (n=7) |
|---|---|---|---|
| **Pass** | 614 | 21 | 2 |
| **Refer** | 32 | 7 | 3 |
| **Not tested/ lost follow-up** | 0 | 4 | 2 |

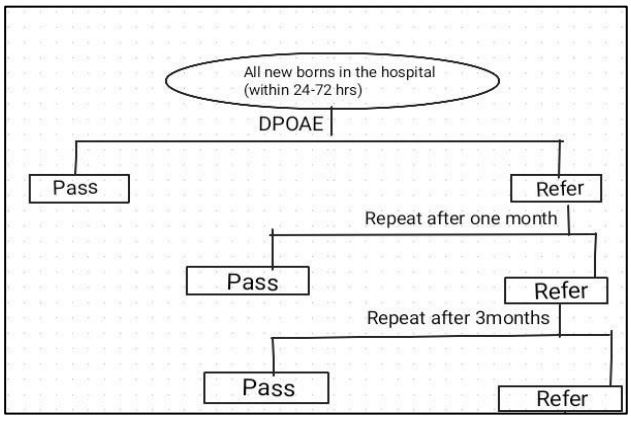


**Figure 1: Algorithm of newborn hearing screening.**

According to our study, the relative comparison of prevalence of hearing impairment among newborns shows that 61% of study participants are males which is more than females i.e. 39%.

Our study shows 64% of hearing loss among neonates who reappeared for second screening is unilateral which is in right ear. 22% shows bilateral hearing loss and 14% of hearing loss is in left ear. Hence 78% of hearing loss is unilateral (Figures 1 and 2).

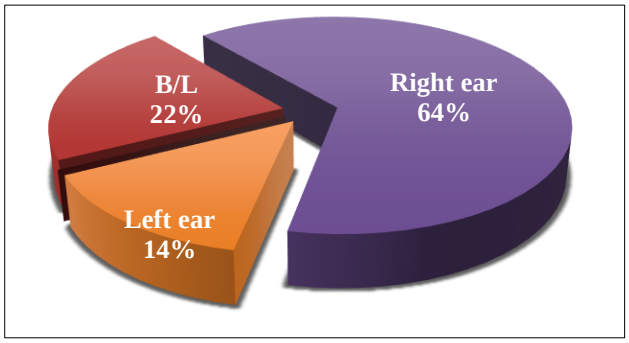


**Figure 2: Bilateral or unilateral hearing loss among neonates who reappeared for second screening.**

**Table 4: Risk factors based on JCIH guidelines for neonatal hearing impairment.**

| Risk factors based on JCIH guidelines for neonatal hearing impairment |
|---|
| The risk factors associated with neonatal hearing impairment, as outlined by the Joint Committee on Infant Hearing (JCIH) guidelines. A possible determinant of hearing impairment is a genetic predisposition, indicating the existence of a hereditary link. An additional risk factor to consider is the length of stay in the neonatal intensive care unit (NICU) exceeding a duration of five days. Newborns during the newborn phase who display a high level of bilirubin in their blood, to the extent that it requires a transfusion, are also at risk of experiencing unfavourable consequences. Several pharmaceutical substances, particularly those possessing ototoxic characteristics, possess the capacity to potentially contribute to the onset of auditory impairment. An additional noteworthy risk factor involves the occurrence of encephalopathy resulting from low oxygen saturation levels ($SpO_2$). Congenital abnormalities, such as microcephaly or hydrocephalus, are associated with an increased risk. Maternal illnesses that manifest during pregnancy, including those falling under the TORCH acronym (toxoplasmosis, rubella, cytomegalovirus, and herpes infections), possess the capacity to induce auditory impairment in neonates. Furthermore, it is important to acknowledge that premature birth is an acknowledged risk factor related to hearing impairment in neonates. |

The identification of risk variables was conducted in accordance with the JCIH criteria of 2019, as illustrated in Table 4. The establishment of the Joint Committee on Infant Hearing took place in the latter part of 1969, with its membership comprising individuals from the fields of audiology, otolaryngology, pediatrics and nursing. The panel was given the duty with a dual responsibility: firstly,

to provide recommendations on the timely detection of children who have or are vulnerable for hearing impairment, and secondly, to address the issue of newborn hearing assessment.[17]

Among this we found that neonatal jaundice requiring blood transfusion and those born preterm were more prone to hearing impairment (Table 5). Comparatively maternal age more >35, family history, and teenage pregnancies contributes less, so they can be marked as least common risk factors.

**Table 5: Risk factors for neonatal hearing impairment among study participants.**

| Others | Number (28) |
|---|---|
| **Preterm** | 9 |
| **Maternal age >35 years** | 1 |
| **Low birth weight** | 4 |
| **Teenage pregnancy** | 2 |
| **Primigravida** | 6 |
| **Neonatal jaundice (blood transfusion)** | 23(2) |
| **Family history** | 2 |
| **Ototoxic drugs** | 3 |
| **NICU admission >5 days** | 4 |
| **Comorbidities** | Congenital pneumonia, respiratory distress, laryngomalacia, Rh incompatibility |

## DISCUSSION

Our study examined newborn hearing screening on a sample of 646 neonates, employing a three-step screening process detailed in Figure 1 and Table 1. After the second and third screenings, two out of three referred neonates were confirmed with hearing impairment, giving a prevalence rate of 0.31%. This sample was slightly male-dominant (61%), and of the neonates with hearing impairment, 78% experienced unilateral hearing loss, most commonly in the right ear (Figure 2 and Table 2). The majority (95%) of the neonates (614) passed the first screening, with 32 requiring further assessment (Table 3). We identified a range of risk factors (Table 4) from the Joint Committee on Infant Hearing (JCIH) guidelines, including preterm birth and neonatal jaundice requiring blood transfusion (Table 5). Our results thus indicate that these were the most common risk factors, while maternal age above 35 years, family history of hearing impairment, and teenage pregnancies were relatively less common.

The sense of hearing holds significant importance as it acts as a fundamental mechanism for language acquisition and communication, hence forming the basis for several aspects of human development. Therefore, it can be argued that high levels of hearing loss significantly restrict an infant's ability to acquire spoken language.[5] The results highlight the significance of promptly identifying and rehabilitating individuals with hearing impairment (HI) as a fundamental element in fostering the advancement in vocabulary, words, and cognitive abilities, in children who are affected by this condition. The present research effort was conducted on neonates born at a tertiary care hospital in Idukki. A total of 646 newborns were considered in the study. We conducted a three-session distortion product otoacoustic emission (DPOAE) assessment. During the initial session, an entire group of 646 neonates were assessed. Out of them, 614 neonates successfully completed the test, whereas 32 neonates received refer results and were subsequently recommended to undergo a second session of distortion product otoacoustic emission (DPOAE) screening. The prevalence of HI in our study was estimated to be 0.31%. Similar results were obtained in studies conducted by Kunnath et al, which had a prevalence of 0.5%.[6] The study by Jose et al concluded that the prevalence of their study was 0.9%.[11] Arora et al showed that prevalence of HI was 0.25% in their study, which was also comparable to our study.[15] The study Augustine et al also had a similar prevalence of 0.41% in their study.[14] The incidence of congenital HL in the study conducted by Paul at Cochin was 0.7 per 100 live births.[12] According to the study conducted by Paul, the most common risk factors of HL are: use of ototoxic medications, prematurity, VLBW, and low APGAR score.[12]

In a multicenter study by NIHS, the four most common risk factors were use of ototoxic medications, VLBW, assisted ventilation for more than 5 days and low APGAR score. In the study conducted by Kunnath, the most common risk factors were pregnancy-induced hypertension, premature labour, lower segment caesarean section, LBW and congenital malformations.[6] According to the study conducted by Augustine et al, several risk factors for HL were identified.[14] These included consanguineous marriage, a history of intra-uterine infection, preterm, relatives with a history of HL, low birth weight that is low, and exposure to ototoxic substances. In this study, we identified several risk factors related with hearing loss (HL) based on the 2019 guidelines provided by the JCIH. These risk factors include preterm labor, low birth weight (LBW), newborn jaundice, exposure to ototoxic medications, being a first-time mother (primigravida), having a familial history of hearing loss, admission to the neonatal intensive care unit, being a teenager during pregnancy, and maternal age exceeding 35 years. The prevailing risk factors identified in recent investigations encompass LBW, premature birth, ototoxicity, and familial predisposition.

Although India has a National Program for Prevention and Control of Deafness (NPPCD), the program has not instituted a national level protocol for screening of deafness in neonates or infants. As the burden of deafness is significant in the population, it is crucial that India takes up a national guideline to prevent jeopardizing young lives. Inadequate data necessitate an organized plan to

prevent and combat this problem in a structured fashion. It is the need of the hour to have a holistic approach of a UNHS program for the early identification of affected individuals, for them to lead a normal life. Despite having national schemes, many families opt not to do the regular screening, owing to lack of time, inaccessibility to healthcare facilities or ignorance of future consequences. This calls for a strategical approach with proper health education and appropriate treatment policies to prevent any further untoward events.

***Limitations***

A limitation of this study is that the prevalence may be underestimated because the first screening test has a sensitivity of 97%.[18] Another limitation is that this study is an institutional-based study, and hence results may not be generalized to the community.

## CONCLUSION

In conclusion, it is crucial to emphasize the significance of detecting newborns with hearing loss, providing early intervention, and conducting appropriate screening assessments in infants at a heightened risk of hearing impairment within the appropriate timeframe. The present study investigated the incidence of HL among newborns in a tertiary care teaching hospital located in Thodupuzha, Idukki district, Kerala. The findings revealed an overall prevalence rate of 3.1 per every 1000 live births. In the context of a typical neonatal population, it is recommended that both at-risk and non-at-risk neonates in India should be subjected to a universal hearing screening program without delay. Limiting the screening to only the at-risk population introduces the possibility of a bias that may result in the exclusion of a larger group of neonates without identified risk factors who may have hearing impairment. There is a pressing requirement to implement a nationwide hearing screening program for neonates with congenital hearing loss. This program aims to identify hearing impairments at an early stage and provide appropriate interventions to mitigate the developmental difficulties faced by these infants. Ultimately, the goal is to enhance their overall quality of life.

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