



Original Article

Use of Otoacoustic Emissions as a Screening Tool in Early Detection of Hearing Loss in High-Risk Neonates

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ABSTRACT

Background: Hearing plays a critical role in speech, language development, and cognitive growth during early childhood. Hearing impairment in neonates often remains undetected during the early months of life, leading to delayed speech and language development. Early identification through newborn hearing screening programs can significantly reduce long-term developmental consequences. Otoacoustic Emission (OAE) testing is a rapid, non-invasive, and cost-effective screening method that evaluates cochlear outer hair cell function. This study evaluates the effectiveness of OAE as a screening tool in detecting hearing loss among high-risk neonates.

Aim: To evaluate the effectiveness of Otoacoustic Emissions (OAE) as a screening tool for early detection of hearing loss in high-risk neonates.

Materials and Methods: A prospective observational study was conducted among 140 high-risk neonates admitted to the Neonatal Intensive Care Unit (NICU) or born to high-risk mothers at a tertiary care hospital over a period of 12 months. Neonates with one or more risk factors as per Joint Committee on Infant Hearing (JCIH) criteria were included. OAE testing using Distortion Product Otoacoustic Emissions (DPOAE) was performed after 48 hours of birth in a quiet environment. Results were categorized as "Pass" or "Refer." Data were analysed using SPSS software.

Results: Out of 140 neonates screened, 118 (84.3%) passed the OAE test and 22 (15.7%) showed a "Refer" result. Hearing loss was significantly associated with risk factors such as prematurity, very low birth weight, hyperbilirubinemia requiring exchange transfusion, and NICU stay longer than five days.

Conclusion: OAE is an effective, simple, and non-invasive screening tool for early detection of hearing impairment in high-risk neonates. Implementation of routine newborn hearing screening using OAE can facilitate early diagnosis and timely intervention.

Keywords: Hearing Loss, Otoacoustic Emissions, Newborn Screening, High-Risk Neonates, Early Diagnosis.

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Received: 11-02-2026

Accepted: 09-03-2026

Available online: 23-03-2026

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INTRODUCTION

Hearing is a fundamental sensory function that plays a vital role in the development of speech, language, cognition, and social interaction in children. The ability to perceive sound enables infants to acquire linguistic skills, recognize environmental cues, and interact effectively with their surroundings. The development of the auditory system begins during fetal life and continues through early childhood, with the first few years of life representing a critical period for auditory pathway maturation and language acquisition. Adequate auditory stimulation during this phase is essential for the normal development of speech and communication abilities. When hearing impairment occurs during infancy,

particularly during the early developmental window, it can lead to delayed speech and language development, learning disabilities, and long-term psychosocial challenges. Early identification and timely intervention are therefore crucial to prevent irreversible developmental deficits and to ensure optimal communication outcomes.¹

Congenital hearing loss is one of the most common sensory disorders affecting newborns worldwide. The global prevalence of permanent congenital hearing impairment among healthy newborns is estimated to be approximately 1–3 per 1000 live births. However, the incidence is significantly higher in developing countries due to factors such as limited access to neonatal screening programs, higher prevalence of perinatal complications, and inadequate healthcare resources. In India, studies suggest that approximately 4–6 infants per 1000 live births are affected by significant hearing impairment. Despite the relatively high prevalence, neonatal hearing loss often remains undetected during the early months of life because behavioral responses to sound are difficult to assess in newborns. As a result, many children with hearing impairment are diagnosed only when speech delay becomes apparent, usually between 2–5 years of age, which is considerably later than the optimal time for intervention.^{2,3}

The burden of hearing impairment is even greater among high-risk neonates, particularly those admitted to neonatal intensive care units (NICUs). Research indicates that the incidence of hearing loss among NICU infants may be 10 to 20 times higher than that observed in the general newborn population. Various prenatal, perinatal, and postnatal factors contribute to neonatal hearing impairment. These risk factors include prematurity, very low birth weight, birth asphyxia, neonatal sepsis, hyperbilirubinemia requiring exchange transfusion, congenital infections such as TORCH infections, prolonged NICU stay, and exposure to ototoxic medications such as aminoglycosides and loop diuretics. These conditions can cause damage to the cochlear hair cells, auditory nerve, or central auditory pathways, resulting in sensorineural hearing loss. Early detection of hearing impairment in this vulnerable population is therefore essential for preventing long-term communication and developmental problems.⁴

Early diagnosis of hearing impairment allows timely intervention and significantly improves the developmental outcomes of affected children. Several studies have demonstrated that infants diagnosed with hearing loss and provided with appropriate rehabilitation before the age of six months show language development comparable to their normal-hearing peers. Conversely, delayed diagnosis beyond the first year of life may result in permanent deficits in speech, language, and cognitive development. Recognizing the importance of early detection, many countries have implemented Universal Newborn Hearing Screening (UNHS) programs aimed at identifying hearing impairment soon after birth. These programs emphasize the “1-3-6 rule,” which recommends hearing screening by one month of age, diagnostic confirmation by three months, and initiation of appropriate intervention by six months. Early screening programs have significantly improved the detection and management of neonatal hearing loss worldwide.⁵

Objective screening methods are essential for assessing hearing in neonates because infants cannot provide behavioural responses to auditory stimuli. Two widely used objective techniques for newborn hearing screening are Otoacoustic Emissions (OAE) and Auditory Brainstem Response (ABR) testing. Brainstem Evoked Response Audiometry (BERA), a form of ABR testing, is considered the gold standard for diagnosing hearing impairment because it evaluates the integrity of the auditory nerve and brainstem pathways. However, BERA requires specialized equipment, trained personnel, and relatively longer testing time, making it less feasible for large-scale screening in resource-limited healthcare settings.⁶

In contrast, Otoacoustic Emission (OAE) testing has emerged as a practical and efficient screening method for newborn hearing assessment. Otoacoustic emissions are low-intensity sounds generated by the outer hair cells of the cochlea as a byproduct of the active mechanical processes involved in sound amplification within the inner ear. These emissions travel backward through the middle ear and can be detected in the external auditory canal using a sensitive probe containing a microphone and speaker. The presence of OAEs indicates normal functioning of the cochlear outer hair cells, whereas their absence suggests cochlear dysfunction or conductive abnormalities within the auditory system. Because OAE testing is non-invasive, rapid, cost-effective, and easy to perform, it has become an important tool in newborn hearing screening programs, particularly in developing countries where access to advanced diagnostic equipment may be limited.⁷

In view of the high prevalence of hearing impairment among high-risk neonates and the need for early diagnosis, the present study aims to contribute to the development of improved neonatal hearing screening strategies in tertiary care settings.

AIM

To evaluate the effectiveness of Otoacoustic Emissions (OAE) as a screening tool for early detection of hearing loss in high-risk neonates.

OBJECTIVES

1. To determine the prevalence of hearing impairment among high-risk neonates using OAE screening.

2. To identify the association between specific risk factors and hearing loss among neonates.
3. To evaluate the usefulness of OAE as an early screening tool for neonatal hearing impairment.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective observational study to evaluate the usefulness of otoacoustic emissions (OAE) as a screening tool for early detection of hearing loss in high-risk neonates.

Study Setting

The study was carried out in the Department of Otorhinolaryngology in collaboration with the Neonatal Intensive Care Unit (NICU) of St Peters Medical College Hospital and Research Institute, Hosur.

Study Duration

The study was conducted over a period of 12 months.

Study Population

The study population included high-risk neonates admitted to the NICU or born to high-risk mothers during the study period. Neonates were selected based on the presence of one or more risk factors as defined by the Joint Committee on Infant Hearing (JCIH) guidelines.

Sample Size

The sample size was calculated using the formula:

$$N = \frac{Z^2 P(1 - P)}{d^2}$$

Where:

- **Z** = Standard normal variate at 95% confidence level (1.96)
- **P** = Prevalence of hearing impairment in high-risk infants (10%)
- **d** = Allowable error (5%)

Substituting the values:

$$N = \frac{(1.96)^2 \times 0.1 \times (1 - 0.1)}{(0.05)^2}$$

The calculated sample size was 138, which was rounded to 140 neonates for the study.

Inclusion Criteria

Neonates with one or more of the following high-risk factors according to JCIH criteria were included in the study:

- ❖ Prematurity
- ❖ NICU stay more than 5 days
- ❖ Very low birth weight
- ❖ Birth asphyxia
- ❖ Neonatal seizures
- ❖ Neonatal sepsis
- ❖ Hyperbilirubinemia requiring exchange transfusion
- ❖ Exposure to ototoxic drugs
- ❖ Maternal TORCH infections
- ❖ Congenital anomalies
- ❖ Family history of hearing loss

Exclusion Criteria

- ❖ Neonates with microtia or anotia
- ❖ Neonates with craniofacial anomalies affecting the ear
- ❖ Parents or guardians not willing to give consent

Procedure for Data Collection

After obtaining informed consent from parents or guardians, a detailed antenatal, perinatal, and neonatal history was recorded. Clinical examination of the neonates was performed to identify the presence of risk factors associated with hearing impairment. All neonates underwent otoscopic examination to rule out external ear abnormalities or obstruction of the ear canal. Otoacoustic Emission (OAE) testing using Distortion Product Otoacoustic Emissions (DPOAE) was

performed after 48 hours of birth or once the neonate was clinically stable. The test was conducted in a quiet environment using a calibrated OAE screening device.

A probe containing a miniature speaker and microphone was gently inserted into the external auditory canal. Acoustic stimuli were delivered, and the cochlear responses generated by the outer hair cells were recorded by the device.

The results of the screening test were categorized as:

- **Pass** – Normal cochlear outer hair cell function
- **Refer** – Possible hearing impairment requiring further evaluation

Neonates who showed a “Refer” result were advised to undergo confirmatory testing using Brainstem Evoked Response Audiometry (BERA).

Data Analysis

All collected data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software version 23. Categorical variables were expressed as frequency and percentage. Associations between risk factors and hearing screening outcomes were analysed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 140 high-risk neonates were included in the present study to evaluate the effectiveness of Otoacoustic Emission (OAE) screening for early detection of hearing loss.

Table 1: Gender Distribution of Study Population (n = 140)

Gender	Number	Percentage
Male	78	55.7%
Female	62	44.3%

Interpretation:

Among the 140 neonates screened, 78 (55.7%) were males and 62 (44.3%) were females, indicating a slight male predominance in the study population.

Table 2: Birth Weight Distribution

Birth Weight	Number	Percentage
<1500 g (Very Low Birth Weight)	18	12.9%
1500–2500 g (Low Birth Weight)	42	30%
>2500 g	80	57.1%

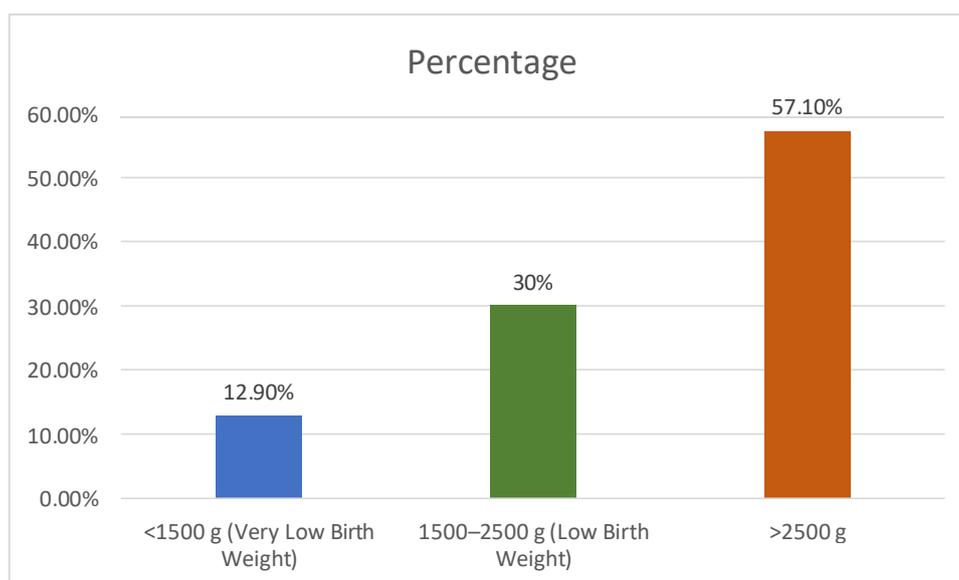


Fig 1: Birth Weight Distribution

Interpretation:

The majority of neonates (57.1%) had normal birth weight, while 30% were low birth weight and 12.9% were very low birth weight.

Table 3: Gestational Age Distribution

Gestational Age	Number	Percentage
Preterm (<37 weeks)	38	27.1%
Term (≥37 weeks)	102	72.9%

Interpretation:

Most neonates (72.9%) were born at term, while 27.1% were preterm.

Table 4: Distribution of High-Risk Factors

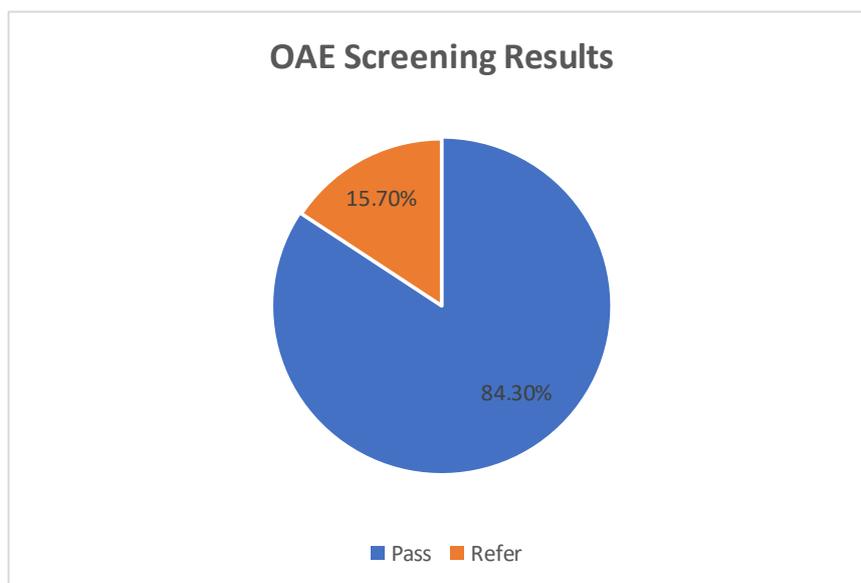
Risk Factor	Number	Percentage
Prematurity	38	27.1%
Low Birth Weight	42	30%
Birth Asphyxia	18	12.9%
Neonatal Sepsis	16	11.4%
Hyperbilirubinemia	14	10%
NICU stay >5 days	22	15.7%
Ototoxic drug exposure	12	8.6%

Interpretation:

Low birth weight (30%) and prematurity (27.1%) were the most common risk factors observed among the study population.

Table 5: OAE Screening Results

OAE Result	Number	Percentage
Pass	118	84.3%
Refer	22	15.7%

**Fig 2: OAE Screening Results****Interpretation:**

Out of the 140 neonates screened, 118 (84.3%) passed the OAE screening, while 22 (15.7%) showed a “Refer” result, indicating possible hearing impairment.

Table 6: Association Between Birth Weight and OAE Result

Birth Weight	Pass	Refer	Total	P value
<1500 g	12	6	18	0.03
1500–2500 g	34	8	42	
>2500 g	72	8	80	

Interpretation:

Very low birth weight neonates showed a higher proportion of abnormal OAE results compared to normal birth weight infants. The association between birth weight and OAE outcome was statistically significant ($p < 0.05$).

Table 7: Association Between Prematurity and OAE Result

Gestational Age	Pass	Refer	Total	P value
Preterm	28	10	38	0.02
Term	90	12	102	

Interpretation:

Preterm neonates demonstrated a higher rate of OAE “Refer” results compared to term neonates, suggesting a significant association between prematurity and hearing screening outcome.

Table 8: Association Between Hyperbilirubinemia and OAE Result

Hyperbilirubinemia	Pass	Refer	Total	P value
Present	8	6	14	0.01
Absent	110	16	126	

Interpretation:

Neonates with hyperbilirubinemia showed a significantly higher proportion of abnormal OAE results compared to those without hyperbilirubinemia, indicating a significant association with hearing impairment.

DISCUSSION

Early detection of hearing impairment in neonates is essential for normal speech, language, and cognitive development. Newborn hearing screening programs aim to identify hearing loss at the earliest possible stage so that appropriate rehabilitation can be initiated. In the present study, 140 high-risk neonates were screened using otoacoustic emissions (OAE) to evaluate its effectiveness as an early screening tool for hearing impairment.

In our study, 15.7% of neonates showed a “Refer” result on OAE screening, indicating possible hearing impairment requiring further evaluation. This finding is comparable to the results reported by Chawla et al., who observed abnormal OAE results in approximately 12–18% of high-risk neonates admitted to NICU. Their study highlighted the importance of screening high-risk newborns as the prevalence of hearing loss in this population is significantly higher than in the general newborn population. ⁸ Prematurity was identified as one of the major risk factors associated with abnormal OAE results in the present study. Among preterm neonates, a higher proportion showed abnormal screening outcomes compared with term neonates. Similar findings were reported by Poonual et al., who demonstrated that prematurity and prolonged NICU stay were strongly associated with neonatal hearing loss. The authors suggested that immature auditory pathways and increased exposure to medical interventions contribute to the increased risk of hearing impairment in preterm infants. ⁹ Low birth weight was another important risk factor observed in the present study. Very low birth weight infants showed a significantly higher proportion of abnormal OAE results. This observation is consistent with the findings of Khaimook et al., who reported that infants with birth weight less than 1500 g were at increased risk for hearing impairment due to physiological immaturity and associated perinatal complications. ¹⁰

Hyperbilirubinemia requiring exchange transfusion was also significantly associated with abnormal OAE results in our study. Elevated bilirubin levels are known to cause neurotoxicity affecting the auditory brainstem pathways. Amini et al. reported that neonates with severe hyperbilirubinemia demonstrated higher rates of hearing screening failure, emphasizing the importance of monitoring auditory function in such infants. ¹¹ Neonatal sepsis and exposure to ototoxic medications were additional risk factors identified in our study population. These findings are consistent with the study conducted by Pereira et al., which showed that sepsis, ototoxic drugs, and prolonged NICU admission were important contributors to sensorineural hearing loss among high-risk neonates. ¹²

The present study also demonstrates the usefulness of OAE as a screening tool for neonatal hearing assessment. OAE testing is quick, non-invasive, and does not require sedation, making it suitable for large-scale newborn screening programs. Kanji and Khoza-Shangase emphasized that combining OAE screening with confirmatory tests such as auditory brainstem response (ABR) improves the accuracy of neonatal hearing screening programs and reduces the likelihood of missed diagnoses. ¹³ Similar findings were reported by Bhat et al., who demonstrated that targeted screening of high-risk neonates using OAE allows early identification of hearing impairment and facilitates timely intervention. Their study concluded that early screening programs significantly reduce the age of diagnosis and improve language outcomes in affected children. ¹⁴

Studies conducted in tertiary care hospitals have also reported comparable screening outcomes. Kaveh et al. found that approximately 10–16% of high-risk neonates required further evaluation following initial OAE screening, which is

consistent with the findings of the present study.¹⁵ Furthermore, De Capua et al. highlighted that newborn hearing screening programs using OAE are effective in identifying infants with cochlear dysfunction, particularly when screening is performed after 48 hours of birth to minimize false-positive results caused by vernix or middle ear fluid.¹⁶

Overall, the findings of the present study support previous research indicating that high-risk neonates have a significantly increased risk of hearing impairment and that OAE screening is an effective and practical method for early detection. Early identification of hearing loss enables timely referral for diagnostic evaluation and early rehabilitative interventions, which are essential for improving speech and language outcomes.

CONCLUSION

The present study demonstrates that otoacoustic emission (OAE) screening is an effective, rapid, and non-invasive method for early detection of hearing impairment in high-risk neonates. A significant proportion of neonates with risk factors such as prematurity, very low birth weight, and hyperbilirubinemia showed abnormal screening outcomes. Early identification of hearing loss through OAE allows timely referral for confirmatory diagnostic testing such as BERA. Implementing routine newborn hearing screening programs in tertiary care hospitals can facilitate early diagnosis and early rehabilitation. Early detection and intervention are essential to improve speech, language, and overall developmental outcomes in affected children.

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