DOI: 10.7860/IJNMR/2026/87327.2473

Original Article

Paediatrics Section

Current Insights into Newborn Hearing Screening: A Prospective Observational Study from a Tertiary Care Hospital in Northern India

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ABSTRACT

Introduction: Hearing impairment is one of the most common congenital disorders and can significantly affect speech, language, and cognitive development if not identified early. Universal newborn hearing screening plays a vital role in early diagnosis and intervention. However, data on neonatal hearing loss from developing countries, including India, remain limited.

Aim: To determine the prevalence of screen positive hearing impairment among neonates attending a tertiary care hospital using Automated Auditory Brainstem Response (AABR) and its association with demographic variables and risk indicators.

Materials and Methods: This prospective observational study was conducted at a tertiary care hospital in Northern India from September 2023 to August 2025. A total of 404 neonates were screened using a two-stage AABR protocol. Neonates who failed or had an aborted first-stage AABR underwent second-stage AABR screening. Those who failed the second stage were referred for diagnostic Brainstem Evoked Response Audiometry (BERA) at three months of age. Chi-square test was used to determine the association between different factors and outcomes.

Results: Of the 404 neonates screened, AABR testing was aborted in 2 (0.5%), 62 (15.35%) failed, and 340 (84.15%) passed the first-stage screening. Of the 64 neonates who failed or had aborted tests, 37 underwent second-stage screening. Only 3 (8.11%) passed the second- stage AABR, while 34 (91.89%) failed. Overall, hearing impairment was detected in 34 neonates by two-stage screening, giving a prevalence of 8.42%, while the prevalence of confirmed hearing impairment was 0.74% (3/404). The association between neonatal morbidity and hearing abnormalities was highly significant (p-value <0.001).

Conclusion: The prevalence of screen positive hearing impairment observed in this study (8.42%) was higher than that reported in Western literature but comparable to that in recent Indian studies. Poor follow-up compliance remains a major challenge in implementing universal newborn hearing screening programs. Strengthening follow-up mechanisms and ensuring early intervention for screen-positive neonates are essential to reduce the burden of childhood hearing loss.

Keywords: Automated auditory brainstem response, Brainstem evoked response audiometry, Hearing impairment, Neonatal screening

INTRODUCTION

Hearing impairment in children represents a critical barrier to optimal development, affecting language acquisition, education, and overall cognitive growth. Global epidemiological data (2022) indicates that congenital or early-onset sensorineural hearing loss affects approximately 0.5-1.5 per 1000 newborns, with significant consequences for speech, language development, and academic achievement [1].

The fundamental nature of hearing as a precursor to communication cannot be overstated. The developmental sequence of hearing, speaking, reading, and writing means that undetected hearing loss creates cascading deficits in language acquisition [2]. Unfortunately, parental awareness of hearing impairment often lags behind concerns for vision or motor development, resulting in delayed diagnosis- frequently not until after two years of age when critical periods for intervention have passed [3]. This delay produces irreversible developmental consequences and profound psychological impacts on affected families.

Evidence from developed nations demonstrates that early detection through universal newborn hearing screening, coupled with timely intervention, substantially improves speech and language outcomes and enhances long-term socio-economic prospects [4]. The advent of reliable, objective screening technologies- particularly otoacoustic emissions and AABR testing- has enabled widespread implementation of screening programs, thereby dramatically reducing the age of hearing loss detection in countries with mandatory or routine screening protocols. In contrast, developing countries predominantly rely on family suspicion for detection, often delaying diagnosis beyond the critical six-month window established for optimal intervention. India exemplifies this challenge, where systematic screening remains absent in most healthcare facilities despite its potential for preventing secondary disabilities in speech, language, and cognition [5].

The Indian government's National Program for Prevention and Control of Deafness (NPPCD), launched in 2006, has expanded from 25 pilot districts to 587 districts across 36 states and union territories by 2024, aimed to eliminate preventable deafness and reduce overall prevalence to below 1%. However, implementation gaps persist, particularly in universal newborn screening [6].

In light of this, the present study established a newborn hearing screening program at a tertiary care centre in North India to

determining the frequency of congenital hearing loss among neonates and associated risk factors. There is comparatively less systematic prospective data from tertiary centres in Northern India, where the burden of undetected hearing loss may be high and healthcare access and follow-up patterns differ [7]. Thus, to determine the prevalence of screen positive hearing impairment among neonates attending a tertiary care hospital using AABR and its association with demographic variables and risk indicators. This study provides prospective data on newborn hearing screening using a two-stage AABR protocol followed by confirmatory BERA in a tertiary care hospital in Northern India.

MATERIALS AND METHODS

This prospective observational study was conducted between September 2023 and August 2025 (24 months) at the Department of Paediatrics, Vivekananda Polyclinic and Institute of Medical Sciences, Lucknow, Uttar Pradesh, India after Institutional Ethical Committee approval (VPIMS/ME/IEC/CC/SEP 2023). Informed consent was obtained from the guardians of all the participants.

Inclusion criteria: All preterm term and post-term babies born or admitted in the hospital were included in the study.

Exclusion criteria:

1. Babies more than one month of life;
2. Neonates with severe multiple anomalies incompatible with life;
3. Neonates with atresia or stenosis of external ear canals of both ears;
4. Those whose guardians refused to give consent.

Sample size: The sample size was calculated using the formula for low prevalence studies in a finite population. In a study by Jewel J et al., the failure rates in first newborn hearing screening was 6% (p-value=0.06) [8].

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

where "z" is a constant with a value 1.96 at 95% confidence, N is the size of finite population (~1000 births per year at our centre), "p" is the prevalence (6% or 0.06), and e is the precision level (10% or 0.10). Thus a 95% confidence and 80% power, the calculated sample size was 264. After adding for a contingency of 10% and rounding it off to the nearest hundred, the minimum sample size was 300.

Study Procedure

Detailed maternal medical and obstetric history was obtained from all the parents who consented to participate in the study. Details of gestation including complications during pregnancy, gestational age at delivery (preterm, term and post-term), mode of delivery and birth weight (AGA: Appropriate for gestational age, SGA: Small for gestational age or LGA: Large for gestational age) were noted. A thorough clinical examination was carried out. All neonates underwent a first hearing screening test before discharge using an AABR. The test was carried out in a designated room with quiet surroundings and preferably in mother's lap. The mother was instructed to feed the baby immediately before testing. Most neonates fell asleep after feeding. Neonates that did not sleep after feeding were sedated using syrup triclofos (25-30 mg/kg).

The tests were performed using the technique described by Taylor MJ [9]. Silver-silver chloride electrodes were used. The electrodes were applied according to the international 10-20 system of electrodes placement. Recordings were obtained using computerised electric response audiometer (MAICO MB11 Beraphone®). MB 11 tests hearing function by measuring the brainstem auditory- evoked response of the auditory pathway.

BERAphone® had spring-mounted, stainless steel electrodes, a headphone, and a preamplifier integrated into one unit, which was held to the infant's head after the three electrode sites on the head had been made more conductive by applying electrode gel. The BERAphone® hardware was particularly suitable for infants. The vertex electrode was located in an adjustable mounting, allowing the distance to the ground electrode to be varied to adjust for the different head sizes. The BERAphone® could be used for ages ranging from newborns to older children, depending on the size of their head. MB 11 BERAphone® performed a fixed- intensity (35 dB nHL) Auditory Brainstem Response (ABR) screening.

Brainstem potentials, BERA and ABR, were optimally measured in a quiet, sleeping patient. Sleep is conducive to improving the quality of recording and reducing the test time. An AABR "failed" test was designated as either "Refer" or as a "Positive" AABR test. An AABR "PASS" test was designated as either "pass" or as a "Negative" AABR test. A second AABR test was performed in "Positive" neonates after two weeks. All cases with a "Positive" test on both occasions were designated as Screen "Positive and the diagnosis were confirmed by BERA test at the age of three months.

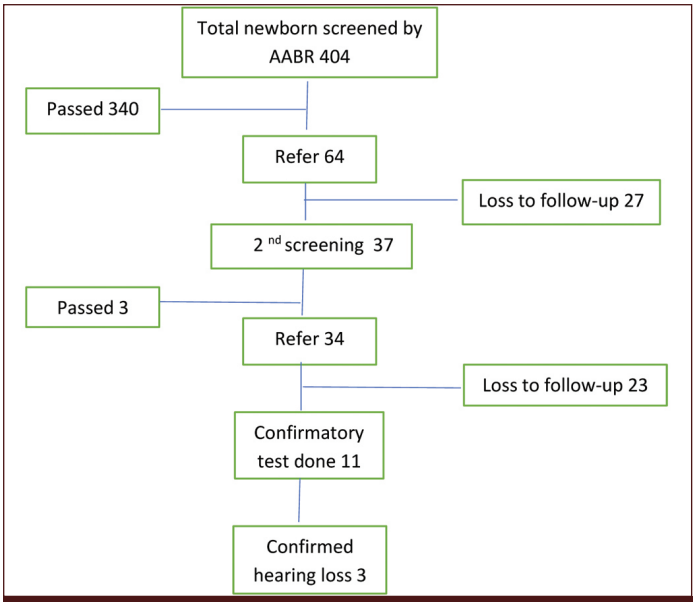
STATISTICAL ANALYSIS

Data were analysed using descriptive and inferential statistics. Statistical analysis such as mean, median, standard deviation and percentage distribution were conducted to describe the demographic variables. Chi-square test was used to determine the association between different factors and outcomes. Data were analysed using the Statistical Package for Social Sciences, version 21.0.

RESULTS

A total of 404 neonates were included in the study and subjected to a hearing screening test using an AABR on both ears. On the first screening, AABR was aborted in 2 (0.50%) neonates due to crying, 62 (15.35%) neonates failed the AABR screening, and the remaining 340 (84.15%) neonates passed the AABR screening. Of the 64 neonates who either failed or aborted the AABR test, 37 were subjected to a second screening and 27 were lost to follow-up [Table/Fig-1]. In the second screening, out of 37 neonates, only three (8.11%) passed the screening, and 34 (91.89%) neonates failed in the second screening. After the second screening, 34 (8.42%) neonates who failed the AABR screening test and had hearing abnormalities were classified as Group I for assessment of risk factors and variables while 343 (90.98%) neonates who passed the AABR screening test and had normal hearing were classified as Group II. Among 34 second screen positive cases, only 11 cases (32.3%) availed confirmatory test BERA while 23 cases (67.6%) lost to follow-up. Only three cases had confirmed hearing loss by BERA out of 34 second screen positive cases. Prevalence of two-stage screen positive cases was 8.42% (34/404) while prevalence of confirmed hearing impairment was 0.74% (3/404).

There was no significant association between hearing abnormalities and rural/urban area (p-value=0.098), gestational age (p-value=0.848), mode of delivery (p-value=0.122), complicated deliveries (p-value=0.860), or Apgar score at five minutes (p-value=0.140) [Table/Fig-2,3].



[Table/Fig-1]: Flow chart of screening results.

proportion of neonates with morbidity was significantly higher in Group I (44.12%) than in Group II (5.25%). The association between neonatal morbidity and hearing abnormalities was highly significant (p-value <0.001) [Table/Fig-4].

The proportion of neonates with congenital abnormalities was significantly higher in Group I 2 (5.88%) than in Group II 3 (0.87%). The association between incidence of congenital anomalies and hearing impairment was statistically significant (p-value=0.015) [Table/Fig-5].

DISCUSSION

The present prospective study evaluated newborn hearing screening among 404 neonates using a two-stage AABR protocol followed by confirmatory BERA. The first-stage screening identified 62 neonates (15.35%) who failed the AABR test, while two tests were aborted due to excessive crying. Among the 37 neonates who returned for the second screening, 34 (91.89%) continued to show abnormal results. The overall prevalence of second screen positive cases and confirmed hearing impairment in the present study were found to be 8.42% and 0.74%, respectively.

Variables	Group I (n=34) n (%)	Group II (n=343) n (%)	Total (n=377) n (%)	p-value
Place of residence				
Rural	9 (26.47)	53 (15.45)	62 (16.45)	0.098
Urban	25 (73.53)	290 (84.55)	315 (83.55)	
Gestational age				
Preterm	7 (20.59)	83 (24.19)	90 (23.87)	0.848
Term	27 (79.41)	259 (75.51)	286 (75.86)	
Post-term	0	1 (0.30)	1 (0.27)	
Birth weight				
Appropriate for Gestational Age (AGA)	26 (76.47)	293 (85.42)	319 (84.61)	0.076
Small for Gestational Age (SGA)	8 (23.52)	48 (13.99)	56 (14.85)	
Large for Gestational Age (LGA)	0	2 (0.58)	2 (0.54)	
Mode of delivery				
Lower Segment Caesarean Section (LSCS)	25 (73.53)	288 (83.97)	313 (83.02)	0.122
Normal Vaginal Delivery (NVD)	9 (26.47)	55 (16.03)	64 (16.98)	
Complications				
Complications in antenatal period	2 (5.88)	24 (7.00)	26 (6.90)	0.860
No complications in antenatal period	32 (94.12)	319 (93.00)	351 (93.10)	
Morbidity				
Morbidity	15 (44.12)	18 (5.25)	33 (8.75)	0.001
No morbidity	19 (55.88)	325 (94.75)	344 (91.25)	
Anomalies				
Congenital anomalies	2 (5.88)	3 (0.87)	5 (1.33)	0.015
No congenital anomalies	32 (94.12)	340 (99.13)	372 (98.67)	

[Table/Fig-2]: Comparison between two groups of study population.
Chi-square test applied. A p-value <0.05 was considered statistically significant; n=377 excludes the 27 lost to follow-up after first-stage AABR

Apgar score*		n (%)	n (%)	χ^2	p-value
≤7 (At 1 min)	41	9 (26.47)	32 (9.33)	9.377	0.002
≤7 (At 5 mins)	3	1 (2.94)	2 (0.58)	2.179	0.140

[Table/Fig-3]: Comparison between two groups of Apgar Score.
*abnormal Apgar which is <7 were included; Chi-square test applied. A p-value <0.05 was considered statistically significant.

The incidence of meningitis, Neonatal Hyperbilirubinaemia (NNH), Perinatal Asphyxia (PA), Respiratory Distress Syndrome (RDS), sepsis and meningitis was higher in Group I than in Group II. The

Risk factors	Group I (n=34) n (%)	Group II (n=343) n (%)	Total (n=377) n (%)
IUGR	0	1 (0.29)	1 (0.27)
Meningitis	1 (2.94)	0	1 (0.27)
Neonatal Hyperbilirubinaemia (NNH)	2 (5.88)	3 (0.87)	5 (1.33)
NNH/Sepsis	1 (2.94)	0	1 (0.27)
Perinatal Asphyxia (PA)/NNH	2 (5.88)	3 (0.87)	5 (1.33)

PA/Sepsis	1 (2.94)	1 (0.29)	2 (0.53)
PA	1 (2.94)	0	1 (0.27)
Respiratory Distress Syndrome (RDS)	2 (5.88)	4 (1.17)	6 (1.59)
RDS/Meconium	0	1 (0.29)	1 (0.27)
RDS/Sepsis	0	1 (0.29)	1 (0.27)
Rh incompatibility	0	1 (0.29)	1 (0.27)
Sepsis	3 (8.82)	1 (0.29)	4 (1.06
Sepsis/Hypoxic Ischemic Encephalopathy	0	1 (0.29)	1 (0.27
Sepsis/Meningitis	2 (5.88)	0	2 (0.53)
Shock/Chronic heart Failure	0	1 (0.29)	1 (0.27)
No morbidity	19 (55.88)	325 (94.75)	344 (91.25)
	χ^2=97.496 (df=15); p-value <0.001		

[Table/Fig-4]: Comparison between two groups of incidence of neonatal morbidity in study population.
Chi-square test applied. A p-value <0.05 was considered statistically significant.

Congenital anomalies	Group I (n=34)	Group II (n=343)	Total (n=377)
	n (%)	n (%)	n (%)
Congenital Heart Disease (CHD)	0	1 (0.29)	1 (0.27)
Diaphragmatic hernia	0	1 (0.29)	1 (0.27)
Down's syndrome	1 (2.94)	0	1 (0.27)
Meningomyelocele	1 (2.94)	0	1 (0.27)
Omphalocele	0	1 (0.29)	1 (0.27)
No congenital anomalies	32 (94.12)	340 (99.13)	372 (98.67)
	χ^2=5.928 (df=1); p-value=0.015		

[Table/Fig-5]: Comparison between two groups of incidence of congenital anomalies in study population.
Chi-square test applied. A p-value <0.05 was considered statistically significant.

The first-stage screening failure rate observed in the present study was comparable with findings from previous studies that have used AABR as a primary screening tool. For example, Psarommatis I et al., reported a first-screen positivity rate of approximately 17.1%, which was similar to the 15.35% observed in this study [10]. However, studies conducted in different settings have reported variable screening outcomes depending on the screening protocol, study population, and neonatal risk profile. The prevalence of hearing impairment reported in the present study appears higher than that documented in many Western populations, where congenital hearing loss was estimated to occur in approximately 0.5-1.5 per 1000 live births [1]. However, similar variations have been reported in developing countries due to differences in healthcare infrastructure, referral patterns, and prevalence of neonatal risk factors. Several Indian studies have also reported varying prevalence rates depending on whether screening was performed in a general neonatal population or in high-risk neonates. For instance, Kumar GA et al., reported a much lower prevalence (0.1%) of hearing impairment in a large cohort of screened neonates, while Roat S et al., reported higher incidence rates (5.5%) among neonates admitted to neonatal intensive care units [11,12]. These variations highlight the influence of neonatal risk factors and the characteristics of the screened population on the observed prevalence.

Another important finding of the present study was the high loss-to-follow-up rate after the first screening. A considerable proportion (42.1%) of neonates who failed the initial screening did not return for repeat evaluation. Loss-to-follow-up or confirmatory test after second screen was much higher (67.6%) in present study. Atherton KM et al., found loss to follow-up rate from 0.31% to 68% in a systematic review and meta-analysis [13]. This issue may be related to factors such as lack of parental awareness, geographical barriers, and limited accessibility of specialised diagnostic services.

In the present study, 26.47% cases out of 34 cases of second screen positive were found to have Apgar score ≤7. This was strongly associated risk factor for neonatal hearing loss as foetal hypoxia can damage the neonatal hearing system and lead to AABR abnormality. Pradhan M et al., in their study found that 23 (30.2%) babies of Apgar ≤7 had failure of hearing screening [14]. Joint committee on infant hearing (JCIH 2019) included low Apgar score and hyperbilirubinaemia as risk factors for hearing impairment which were also found in present study as associated risk factors [15]. The association between incidence of congenital anomalies and hearing impairment was statistically significant. Similar studies with varying prevalence and risk factors have been tabulated in [Table/Fig-6] [11,12,16,17].

Author	Publication year/ Place of study	Method	Sample size	Results	Risk factors
Present study	2026/Lucknow	AABR, BERA	404	1st screen failed-15.35%, Lost to follow-up 42.1% Prevalence -- 2nd screen failed 8.42% Hearing impairment 0.74%	Hyperbilirubinaemia PA sepsis
Kumar GA et al., [11]	2024/Chennai	OAE AABR BERA	1398	1st screen failed 29.7% Lost to follow-up 3.7% Prevalence 0.1%	Hyperbilirubinaemia PA NICU stay>5 days
Roat S et al., [12]	2024/Udaipur	OAE, AABR	750	1st screen failed 35.5% Incidence 5.5 % in high-risk	Low APGAR Prolong ventilation Low birth weight
Balasubramanian J et al., [16]	2020/Madurai	OAE, AABR	100 high-risk	1st screen failed 16.2% 2nd screen failed 2.06% AABR failed 3.06%	Severe birth asphyxia Craniofacial anomalies
Bhatia R and Gorwara R, [17]	2019/Udaipur	OAE, AABR	1114	1st screen failed 25.5% Lost to follow-up 9.47% Prevalence 0.8%	Low birth weight

[Table/Fig-6]: Comparison with previous studies [11,12,16,17].
AABR: Automated auditory brainstem response; BERA: Brainstem evoked response audiometry; OAE: Otoacoustic emission; NICU: Neonatal intensive care unit; PA: Perinatal asphyxia

The findings of the present study have important clinical and public health implications for neonatal care in developing countries. Early identification of hearing impairment through structured newborn hearing screening programs allows timely intervention, including audiological evaluation, hearing amplification, and speech-language therapy. Such early interventions are crucial for preventing long-term deficits in speech, language development, and cognitive performance. The relatively higher prevalence of hearing abnormalities observed in the present study highlights the need for strengthening universal newborn hearing screening initiatives at tertiary care hospitals and peripheral health facilities. Furthermore, the high loss-to-follow-up observed after the initial screening underscores the necessity of improving parental awareness, establishing effective tracking systems, and integrating hearing screening services with existing maternal and child health programs. Strengthening these strategies will facilitate early diagnosis and intervention, ultimately reducing the long-term burden of childhood hearing disability.

Limitation(s)

The study was conducted at a single tertiary care centre, which may limit the generalisability of the findings to a broader population. A high loss to follow-up rate after the first screening may have influenced the estimated prevalence of hearing impairment.

CONCLUSION(S)

This prospective observational study highlights the importance of early hearing screening in neonates using two-stage AABR protocol followed by confirmatory BERA. The study demonstrated a relatively higher prevalence of screen positive hearing impairment (8.42%). Neonatal morbidities such as hyperbilirubinaemia, PA, RDS, and sepsis were significantly associated with hearing abnormalities. However, a major challenge observed was poor follow-up compliance after the initial screening, leading to substantial loss to follow-up. These findings emphasise the need for strengthening universal newborn hearing screening programs, improving parental awareness, and establishing effective follow-up mechanisms to ensure early diagnosis and timely intervention, thereby minimising long-term speech and language disabilities in affected children.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jan 14, 2026
- Manual Googling: Mar 19, 2026
- iThenticate Software: Mar 24, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 09, 2026**
Date of Peer Review: **Feb 06, 2026**
Date of Acceptance: **Mar 25, 2026**
Date of Publishing: **Jun 30, 2026**