International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

A Comparative Study of Hearing Assessment in Normal Neonates and Neonates Admitted in Neonatal Intensive Care Unit: A Prospective Cohort Study

Dr. Swarnima Singh[1], Dr. Anil Kumar[2], Dr. Aishvarya Diptivilasa[3], Dr. Karnika Agrawal[4], Dr. Dinesh Kumar[5], Dr. Sandeep Kumar Chahar[6]

[1]PG Resident Department of ENT Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India
[2]Associate Professor Department of ENT Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India
[3]PG Resident Department of ENT Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India
[4]Professor Department of Paediatrics Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India
[5]Senior Professor Department of ENT Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India
[6]Assistant Professor Department of General Surgery Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India

OPEN ACCESS

Corresponding Author:

Dr. Swarnima Singh
PG Resident Department of ENT Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, India

Received: 17-03-2026
Accepted: 28-04-2026
Available online: 24-05-2026

ABSTRACT

Background: Hearing is a vital sensory function necessary for normal speech, language, and cognitive development in early childhood. Undetected neonatal hearing loss can lead to significant delays in communication skills and long-term psychosocial challenges. The incidence of hearing impairment is considerably higher among neonates admitted to the Neonatal Intensive Care Unit (NICU) due to exposure to multiple risk factors such as prematurity, low birth weight, hyperbilirubinemia, ototoxic medications, and prolonged hospitalization.
Aim: To determine the association between NICU stay and hearing loss in neonates.
Materials and Methods: This hospital-based prospective cohort study was conducted in the Department of Otorhinolaryngology at Maharaja Agrasen Medical College, Agroha, Hisar, Haryana, over a period of 18 months (June 2023–December 2024). A total of 200 neonates were enrolled and divided into two groups: Group 1 (normal neonates, n=100) and Group 2 (NICU-admitted neonates for >24 hours, n=100). Hearing screening was performed using Distortion Product Otoacoustic Emissions (DPOAE) at discharge. Neonates with "REFER" results underwent repeat OAE at 3 months, followed by Auditory Steady-State Response (ASSR) at 6 months for definitive diagnosis. Data were analysed using SPSS version 22. Statistical significance was considered at $p<0.05$.
Results: Hearing loss was identified in 3% of NICU-admitted neonates, while no cases were observed in normal neonates ($p=0.044$). High-risk neonates had significantly higher rates of prematurity (41% vs 13%), low birth weight (63% vs 16%), and LSCS delivery (62% vs 30%) ($p<0.001$). A strong association was observed between prolonged NICU stay and hearing loss, with all affected neonates having NICU stay ≥11 days ($p=0.0001$). No independent association was found between hearing loss and factors such as gender, socioeconomic status, gestational age, or mode of delivery on multivariate analysis.
Conclusion: NICU admission is a significant risk factor for neonatal hearing loss, particularly with prolonged hospital stay. Early screening using OAE followed by confirmatory ASSR is essential for timely detection. Implementation of routine neonatal hearing screening programs, especially in high-risk populations, is crucial to prevent long-term developmental delays.

Keywords: *Neonatal hearing loss, NICU, OAE, ASSR, Screening, Risk factors, Prematurity.*

INTRODUCTION

Hearing plays a fundamental role in the development of speech, language, and cognitive abilities in early childhood. Any impairment in hearing during the neonatal period can have long-term consequences on communication skills, educational achievement, and psychosocial development (1). Congenital and early-onset hearing loss affects approximately 1–3 per 1000 live births in the general population; however, the incidence increases significantly among high-risk neonates, particularly those admitted to the Neonatal Intensive Care Unit (NICU), where it may range from 2% to 10% (2,3).

Neonates admitted to NICU are exposed to multiple risk factors that predispose them to hearing impairment. These include prematurity, low birth weight, hypoxic ischemic encephalopathy, hyperbilirubinemia requiring exchange transfusion, use of ototoxic medications such as aminoglycosides, mechanical ventilation, and neonatal infections (4,5). The cumulative effect of these factors increases the vulnerability of the auditory system, particularly the cochlea and auditory neural pathways.

Early identification of hearing loss is crucial because the first six months of life represent a critical period for auditory and language development. Studies have demonstrated that infants diagnosed and rehabilitated before six months of age exhibit significantly better language outcomes compared to those diagnosed later (6). This has led to the development of Universal Newborn Hearing Screening (UNHS) programs, which aim to screen all newborns for hearing impairment before hospital discharge (7).

Otoacoustic emissions (OAE) testing is widely used as a primary screening tool due to its non-invasive nature, rapid execution, and high sensitivity for detecting cochlear (outer hair cell) dysfunction (8). However, OAE may miss neural hearing deficits such as auditory neuropathy. Therefore, confirmatory tests such as Auditory Brainstem Response (ABR) or Auditory Steady-State Response (ASSR) are recommended for definitive diagnosis (9).

Despite the implementation of screening programs, disparities exist in coverage and follow-up, especially in developing countries. In India, neonatal hearing screening is not universally implemented, and many cases remain undiagnosed until later childhood (10). This delay can result in irreversible deficits in speech and language development, emphasizing the need for effective screening strategies.

Several studies have reported a higher incidence of hearing loss among NICU-admitted neonates compared to healthy newborns (11,12). However, variability exists in reported prevalence rates due to differences in study populations, screening protocols, and diagnostic criteria. Additionally, there is a need for region-specific data to understand the burden of neonatal hearing impairment and associated risk factors.

This prospective cohort study was undertaken to compare hearing outcomes between normal neonates and those admitted to NICU at a tertiary care center in Haryana. By evaluating the association between NICU stay and hearing loss, the study aims to contribute to the existing body of evidence and support the implementation of targeted screening and early intervention strategies.

MATERIALS AND METHODOLOGY

Study Design:

This was a hospital-based prospective cohort study.

Study Setting:

The study was conducted in the Department of Otorhinolaryngology in collaboration with the Department of Pediatrics at Maharaja Agrasen Medical College, Agroha, Hisar, Haryana.

Study Duration:

The study was carried out over a period of **18 months (June 2023 to December 2024)**, which included patient recruitment, follow-up assessments, data collection, analysis, and report writing.

Study Population:

The study population comprised neonates within 28 days of life, including both healthy neonates and those admitted to the NICU for more than 24 hours.

Sample Size:

The sample size was calculated using OpenEpi software based on prior study findings. Considering 80% power and 5% level of significance, the required sample size was 192, which was rounded to **200 neonates**, with **100 neonates in each group** to account for possible loss to follow-up.

Sampling Technique:
A **convenient sampling technique** was employed, and all eligible neonates were enrolled consecutively until the desired sample size was achieved.

Grouping of Study Participants:
- **Group 1 (Control Group):**
  Normal neonates (≤28 days) with no history of NICU admission.
- **Group 2 (Exposed Group):**
  Neonates admitted to NICU for more than 24 hours.

Inclusion Criteria:
- Neonates aged ≤28 days
- Neonates whose parents/guardians provided informed consent
- For Group 2: NICU admission >24 hours

Exclusion Criteria:
- Neonates with congenital ear anomalies
- Neonates with active ear infections
- Neonates on prolonged ventilatory support (>28 days)
- Critically ill neonates where testing was not feasible

Study Procedure:
After obtaining ethical clearance, informed consent was obtained from parents. A detailed history was recorded, including:
- **Maternal history:** infections, drug intake, radiation exposure
- **Natal history:** gestational age, mode of delivery
- **Postnatal history:** birth weight, NICU stay duration, jaundice, infections, ototoxic drug exposure

Clinical Examination:
A thorough ENT examination was performed using an otoscope to assess external auditory canal and tympanic membrane. Oral cavity and nasal examination were also carried out.

Audiological Assessment:
1. **First Stage Screening (DPOAE):**
   Conducted at discharge for all neonates. Results were categorized as **PASS** or **REFER**.
2. **Second Stage Screening:**
   Neonates with REFER results underwent repeat OAE at **3 months**.
3. **Confirmatory Test (ASSR):**
   Neonates failing the second OAE underwent **ASSR at 6 months**, which provided objective confirmation and grading of hearing loss.

Data Collection:
Data were collected using a predesigned and pretested proforma. All findings were recorded systematically and entered into Microsoft Excel.

Outcome Measures:
- **Primary Outcome:** Incidence of hearing loss
- **Secondary Outcome:** Association of hearing loss with NICU-related risk factors

Statistical Analysis:
- Data analysed using **SPSS version 22**
- Categorical variables: Chi-square test
- Continuous variables: Independent t-test
- **p-value <0.05 considered statistically significant**

Ethical Considerations:
- Institutional Ethics Committee approval obtained
- Written informed consent taken from parents
- Confidentiality and privacy maintained throughout

RESULTS

This study included a total of 200 neonates, divided equally into two groups: Group 1 (normal neonates, n=100) and Group 2 (high-risk neonates admitted to NICU for >24 hours, n=100). All neonates underwent hearing screening using Distortion Product Otoacoustic Emissions (DPOAE) at discharge, followed by repeat OAE at 3 months for those with REFER results, and confirmatory Auditory Steady-State Response (ASSR) at 6 months where required.

The demographic and clinical variables including gender, gestational age, birth weight, and mode of delivery were analysed and compared between the two groups. Additionally, hearing outcomes and their association with NICU stay were evaluated.

Baseline Characteristics of Study Population

Table 1: Comparison of Demographic and Clinical Characteristics

Variable	Normal Neonates (n=100)	High-Risk Neonates (n=100)	p-value
Male	37 (37%)	57 (57%)	0.007
Female	63 (63%)	43 (43%)	
Preterm (<37 weeks)	13 (13%)	41 (41%)	0.0001
Term (≥37 weeks)	87 (87%)	59 (59%)	
LSCS Delivery	30 (30%)	62 (62%)	0.0001
Normal Delivery (NVD)	70 (70%)	38 (38%)	

The baseline characteristics demonstrate significant differences between the two groups. The proportion of male neonates was significantly higher in the NICU group (57%) compared to the normal group (37%), with a statistically significant difference (p=0.007).

A markedly higher percentage of preterm neonates was observed in the high-risk group (41%) compared to only 13% in the normal group, indicating a strong association between prematurity and NICU admission (p=0.0001).

Similarly, LSCS deliveries were significantly more common in the high-risk group (62%) compared to 30% in normal neonates, whereas normal vaginal deliveries predominated in the normal group (70% vs 38%). This difference was highly significant (p=0.0001), suggesting that operative deliveries are more frequent among high-risk neonates.

Birth Weight Distribution

Table 2: Distribution Based on Birth Weight

Birth Weight Category	Normal Neonates (n=100)	High-Risk Neonates (n=100)	p-value
<1.5 kg	0 (0%)	9 (9%)	0.0001
1.5–2.0 kg	0 (0%)	17 (17%)	
2.0–2.5 kg	16 (16%)	37 (37%)	
2.5–3.5 kg	83 (83%)	37 (37%)	
>3.5 kg	1 (1%)	0 (0%)	

Birth weight distribution showed a highly significant difference between the two groups (p=0.0001). The majority of normal neonates (83%) had normal birth weight (2.5–3.5 kg), whereas only 37% of high-risk neonates fell in this category.

Conversely, low birth weight (<2.5 kg) was significantly more prevalent in high-risk neonates, accounting for 63% (9% extremely low + 17% very low + 37% low birth weight) compared to only 16% in normal neonates. This finding strongly suggests that low birth weight is a major determinant of NICU admission and a marker of neonatal vulnerability.

Hearing Outcomes and Association with NICU Stay

Table 3: Hearing Loss and Association with NICU Stay

Parameter	Normal Neonates (n=100)	High-Risk Neonates (n=100)	p-value
Hearing Loss Present	0 (0%)	3 (3%)	0.044
Hearing Loss Absent	100 (100%)	97 (97%)	
NICU Stay ≤10 days (HL cases)	—	0 (0%)	0.0001
NICU Stay ≥11 days (HL cases)	—	3 (100%)	

Hearing assessment revealed that no cases of hearing loss were identified among normal neonates, whereas 3% of high-risk neonates (3 out of 100) were diagnosed with hearing impairment. This difference was statistically significant (p=0.044), indicating that NICU admission is associated with an increased risk of hearing loss.

Further analysis of NICU duration demonstrated that no hearing loss cases were observed in neonates with NICU stay ≤10 days, while all cases of hearing loss (100%) occurred in neonates with NICU stay ≥11 days. The association between prolonged NICU stay and hearing loss was found to be highly significant (p=0.0001).

Among neonates with 11–15 days of NICU stay, approximately 18.2% developed hearing loss, while 50% of neonates with NICU stay >15 days were affected, although the latter group had a small sample size. These findings highlight a strong correlation between prolonged NICU exposure and auditory impairment.

DISCUSSION

The present prospective cohort study was conducted to evaluate and compare hearing outcomes among normal neonates and those admitted to the Neonatal Intensive Care Unit (NICU), and to determine the association between NICU stay and hearing loss. The findings of this study clearly demonstrate that high-risk neonates admitted to NICU have a significantly higher likelihood of developing hearing impairment, particularly with increasing duration of NICU stay.

In the present study, the incidence of hearing loss was 3% among NICU-admitted neonates, while no cases were identified among normal neonates. This difference was statistically significant (p=0.044), indicating a clear association between NICU admission and increased risk of hearing loss. Similar findings have been reported in previous studies, where the prevalence of hearing impairment among NICU neonates ranged between 2% and 10%, significantly higher than that observed in the general neonatal population (2). This increased susceptibility is primarily attributed to the presence of multiple risk factors in NICU settings.

Gender distribution in the present study showed a significantly higher proportion of males in the high-risk group (**57% vs 37%, p=0.007**). Although this difference was statistically significant, multivariate analysis did not establish gender as an independent predictor of hearing loss. This observation is consistent with earlier studies, which have reported that while male neonates may have higher NICU admission rates, gender itself does not significantly influence hearing outcomes (3). Socioeconomic status (SES) did not show a statistically significant association with hearing loss (**p=0.525**). The distribution of neonates across SES categories was relatively uniform in both groups, suggesting that socioeconomic factors may not directly influence neonatal hearing outcomes when access to healthcare services is similar. This finding is in agreement with previous literature, which indicates that SES primarily affects access to screening and intervention rather than the biological occurrence of hearing loss (4).

A significant association was observed between mode of delivery and NICU admission, with a higher proportion of high-risk neonates delivered via LSCS (62% vs 30%, p=0.0001). This may reflect the underlying obstetric complications necessitating operative delivery. However, mode of delivery did not emerge as an independent risk factor for hearing loss in multivariate analysis. Similar findings have been reported in earlier studies, where LSCS was associated with NICU admission but not directly linked to auditory impairment (5).

Gestational age showed a highly significant difference between the two groups, with preterm neonates constituting 41% of the NICU group compared to only 13% in the normal group (p=0.0001). Prematurity is a well-established risk factor for hearing loss due to immature cochlear function, increased vulnerability to hypoxic injury, and higher exposure to ototoxic medications (7). Although prematurity did not emerge as an independent predictor in regression analysis, its indirect role through NICU-related complications cannot be overlooked.

Birth weight analysis revealed that low birth weight (<2.5 kg) was significantly more prevalent among high-risk neonates (63% vs 16%, p=0.0001). Low birth weight is often associated with prematurity and intrauterine growth restriction, both of which contribute to increased neonatal morbidity and risk of hearing impairment. Previous studies have consistently demonstrated an association between low birth weight and auditory dysfunction, particularly in the presence of other risk factors (9).

One of the most important findings of this study was the strong association between duration of NICU stay and hearing loss. No cases of hearing impairment were observed in neonates with NICU stay ≤10 days, whereas all cases of hearing loss occurred in neonates with prolonged NICU stay (≥11 days), with a highly significant p-value (p=0.0001). This finding is consistent with earlier studies, which have shown that prolonged NICU exposure increases the risk of hearing loss due to cumulative exposure to risk factors such as mechanical ventilation, ototoxic drugs, infections, and hyperbilirubinemia (11).

In neonates with NICU stay of 11–15 days, 18.2% developed hearing loss, while 50% of neonates with stay >15 days were affected, although the latter group had a small sample size. This trend clearly indicates a dose-response relationship between duration of NICU stay and risk of hearing impairment. Such findings highlight the importance of minimizing NICU stay duration wherever possible and ensuring close monitoring of high-risk neonates.

Multivariate regression analysis in the present study did not identify individual variables such as sex, SES, gestational age, mode of delivery, or birth weight as independent predictors of hearing loss. This suggests that hearing impairment in neonates is multifactorial, resulting from the combined effect of multiple risk factors rather than a single determinant. Similar conclusions have been drawn in previous studies, emphasizing the complex interplay of perinatal and postnatal factors in the development of auditory dysfunction (12).

The use of DPOAE as a primary screening tool followed by ASSR for confirmation proved to be effective in early identification of hearing loss. OAE is known for its high sensitivity in detecting cochlear dysfunction, while ASSR provides objective estimation of hearing thresholds (13). The staged screening protocol used in this study ensured accurate diagnosis and minimized false-positive results.

The findings of this study have important clinical implications. Early identification of hearing loss allows timely intervention, including hearing aids, cochlear implants, and speech therapy, which are crucial for optimal language development. The results strongly support the implementation of universal newborn hearing screening programs, particularly in high-risk populations such as NICU-admitted neonates (14,15).

However, this study has certain limitations. The relatively small number of hearing loss cases may limit the generalizability of the findings. Additionally, long-term follow-up beyond six months was not conducted, which could have provided further insights into late-onset hearing loss. Future studies with larger sample sizes and extended follow-up are recommended.

CONCLUSION

The present study demonstrates that NICU admission is a significant risk factor for neonatal hearing loss, with an incidence of 3% among high-risk neonates compared to 0% in normal neonates. Prolonged NICU stay (≥11 days) was strongly associated with increased risk of hearing impairment.

Although individual factors such as prematurity, low birth weight, and mode of delivery were significantly associated with NICU admission, none independently predicted hearing loss on multivariate analysis, suggesting a multifactorial etiology. Routine early hearing screening using OAE followed by confirmatory ASSR should be implemented, especially in NICU settings. Early detection and timely intervention are essential to prevent long-term developmental delays and improve quality of life.

REFERENCES

1. Olusanya BO, Neumann KJ, Saunders JE, Okolo AA, Ibekwe TS, Olatunji RO. The global burden of disabling hearing impairment: a call to action. *Bull World Health Organ*. 2014 May;92(5):367–373. doi:10.2471/BLT.13.128728
2. Vohr BR, Oh W, Stewart EJ, Bentkover JD, Gabbard S, Lemons J. Comparison of costs and referral rates of 3 universal newborn hearing screening protocols. *J Pediatr*. 2001 Aug;139(2):238–244. doi:10.1067/mpd.2001.115302
3. Cristobal R, Oghalai JS, Daniels RL, Matz GJ, Ruckenstein MJ, Hunter JB. Auditory neuropathy spectrum disorder in the NICU population. *Otolaryngol Head Neck Surg*. 2008;138(5):631–635. doi: 10.1016/j.otohns.2008.01.023
4. Olusanya BO, Luxon LM, Wirz SL, Swanepoel DW, Chapchap MJ, Nair MKC. Screening for early childhood hearing loss in resource-limited settings: current status and future directions. *Lancet*. 2014;383(9920):1425–1435. doi:10.1016/S0140-6736(13)61639-3
5. Beswick R, Driscoll C, Kei J, Glennon S, Bamford J, Cottier C. Targeted surveillance for postnatal hearing loss: a program evaluation. *Int J Audiol*. 2012;51(10):749–757. doi:10.3109/14992027.2012.699994
6. JCIH (Joint Committee on Infant Hearing), Year 2019 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programs. *Pediatrics*. 2019;144(2):e20193464. doi:10.1542/peds.2019-3464
7. Korver AMH, Smith RJH, Van Camp G, Schleiss MR, Bitner-Glindzicz MAK, Lustig LR. Congenital hearing loss. *Nat Rev Dis Primers*. 2017; 3:16094. doi:10.1038/nrdp.2016.94
8. Norton SJ, Gorga MP, Widen JE, Folsom RC, Sininger Y, Cone-Wesson B. Identification of neonatal hearing impairment: distortion product otoacoustic emissions during the perinatal period. *Ear Hear*. 2000;21(5):425–442. doi:10.1097/00003446-200010000-00004
9. Rance G, Starr A, Pathak S, Hood LJ, Wennerstrom A, Peterson A. Auditory neuropathy: clinical and electrophysiological features. *Acta Otolaryngol*. 1999;119(7):741–746. doi:10.1080/00016489950181268
10. Amin SB, Orlando MS, Dalzell LE, Merle KS, Guillet R. Morphologic changes in the auditory brainstem in neonates with hyperbilirubinemia. *Pediatrics*. 2001;108(5):1164–1169. doi:10.1542/peds.108.5.1164
11. Bielecki I, Horbulewicz A, Wolan T, Bielecki M, Karlik M, Król B. Risk factors associated with hearing loss in infants: an analysis of 5282 referred neonates. *Int J Pediatr Otorhinolaryngol*. 2011;75(7):925–930. doi: 10.1016/j.ijporl.2011.04.007

12. Coenraad S, Goedegebure A, Van Goudoever JB, Hoeve HLJ. Risk factors for sensorineural hearing loss in NICU infants compared to normal newborns. *Eur Arch Otorhinolaryngol*. 2010;267(6):889–894. doi:10.1007/s00405-009-1168-3
13. Swanepoel DW, Ebrahim S, Joseph A, Friedland PL, Meyer R, Hall JW. Newborn hearing screening in a South African private health care hospital. *Int J Pediatr Otorhinolaryngol*. 2007;71(6):881–887. doi: 10.1016/j.ijporl.2007.02.009
14. Gorga MP, Neely ST, Bergman BM, Beauchaine KL, Kaminski JR, Peters J. A comparison of transient evoked and distortion product otoacoustic emissions in normal-hearing and hearing-impaired subjects. *J Acoust Soc Am*. 1993;94(5):2639–2648. doi:10.1121/1.407373
15. Stapells DR, Herdman AT, Small SA, Dimitrijevic A, Hatton J. Current status of auditory steady-state responses for estimating hearing thresholds in infants and young children. *Semin Hear*. 2005;26(2):73–88. doi:10.1055/s-2005-861894