Original Article

A study to evaluate the burden of hearing loss and its correlation with risk factors among high-risk infants at a teaching institution, Jaipur

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Abstract

Introduction: Hearing loss is a global issue of hearing disability and early detection and rehabilitation of hearing loss are important for the development of speech and language skills in hearing-impaired infants. There are multiple risk factors that aid in hearing loss but some are potential factors that contribute toward hearing loss in infants. The aim of this study was to assess the burden of hearing loss and its correlation with risk factors among high-risk infants at a teaching institution in Jaipur, Rajasthan. **Method:** This study was carried out after approval of institutional ethics committee on a total of 320 high-risk infants at RUHS College of medical sciences and associated hospitals. Hearing loss was assessed by brainstem evoked response audiometry (BERA). Statistical analysis of data was done by cross-tabulation analysis with Pearson correlation and quantile regression. **Results:** Out of 320 high-risk infants, 59.69% of infants had normal hearing, 9.09% Unilaterally hearing impaired, 20.31% were bilaterally mild-moderate hearing loss, and 10.94% had severe-profound deafness. The prevalence of important risk factors viz. hyperbilirubinemia, low birth weight, appearance, pulse, grimace, activity, and respiration score, meconium aspiration, respiratory distress, and ventilation greater than five days were 86%, 58.9%, 40%, 36%, 29%, and 22%, respectively. **Conclusion:** In high-risk infants, hearing loss is a common hearing disorder. Because of this, early diagnosis of hearing loss gives them the best chance of developing functional speech. Brainstem evoked response audiometry is a simple, reliable, and effective technique for the assessment of auditory functions in infants.

Keywords: Auditory brain stem response, brainstem evoked response audiometry, hearing screening, infants, risk factors

Introduction

Hearing loss is defined as a disruption in the transmission of sounds from the outer ear to the brain. Auditory neuropathy is defined as impairment in hearing with normal outer ear and cochlea, but impaired nerve conduction in auditory pathways.[1,2] Hardani *et al*.[3] reported a 5.09% prevalence of hearing in infants. The World Health Organization stated as 0.5–5 per 1000 neonates and infants have congenital or early childhood onset sensorineural deafness or severe-to-profound hearing impairment.[4] Previous studies reported that the prevalence of hearing loss is higher in high-risk infants than in normal infants.[5-8]

A high-risk infant is a one who required more monitoring and care offered to healthy full-term neonates. Hence, high-risk infants are defined as those born pre or post-term, showing symptoms of systemic illnesses, small for gestational age, metabolic disease, and congenital malformations requiring prompt diagnosis, treatment, and follow-up.[9]

Heramba *et al*.[10] reported that in all risk variables of hearing impairment, the intra-uterine infection had the strongest significant association followed by family history, low APGAR

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score, craniofacial defects, consanguinity, post-natal infection, and low birth weight, respectively. Measles, rubella, viral hepatitis, tuberculosis, bacterial meningitis, diarrhea, and deaths among childrens from influenza and pneumonia are targeted for reductions.[11]

According to the US Department of Health, the future of infants with hearing loss hinges on early detection of the condition and proper management of it. The Joint Committee on Infant Hearing (JCIH)[12] identified 10 risk factors that identify infants who are at high risk for hearing impairment. These following included congenital infections, family history of hearing loss, craniofacial anomalies, hyperbilirubinemia, low birth weight, bacterial meningitis, ototoxic medications, low APGAR scores, and mechanical ventilation for at least five days.[12]

Several studies reported additional risk factors associated with hearing loss, such as premature birth, admission to intensive care units, respiratory distress, hypoxia, and intracranial haemorrhage, which are not mentioned in the JCIH.[13-17] Kountakis *et al*.[18] identified three risk factors among high-risk infants respiratory distress syndrome, retrolental fibroplasia, and duration of stay in the intensive care unit

Screening of high-risk factors for sensorineural damage of all newborns serves as the first line of defense in the medical examination, education, and rehabilitation of the hearing impaired.[19] The National Institutes of Health has advised universal hearing screening within the first three months of life in response to the findings of risk factor-based infant hearing screening.[20]

Early identification of infants with hearing loss reduces the need and cost for testing many babies in intensive care nurseries. This relationship between infant hearing loss and high-risk factors has prompted efforts to identify high-risk factors that will effectively screen infants for hearing problems. Early detection and treatment are key to successfully managing congenital and infant hearing loss. Early rehabilitation of hearing-impaired infants will also lower overall rehabilitation costs and enhance long-term communication function.[13,14]

There are very few studies[13-15] available in the literature this study was carried out to assess the burden of hearing loss and its correlation with risk factors among high-risk infants at a teaching institution in Jaipur, Rajasthan. By increasing the medical community's involvement at the primary care level through screening and follow-up by primary care physicians, the current newborn hearing screening system can be improved and strengthened.

Methods

This is an observational cross-sectional study carried out, after obtaining approval from the institutional ethics committee (RUHS-CMS/Ethics Comm./2021/69) and written informed consent from parents. This study was carried out on a total of 320 infants who were admitted to the intensive care unit in the Department of Pediatrics at RUHS College of Medical Sciences and Associated Hospital Jaipur. High-risk infants of either sex in the age group of 0–1 year were recruited based on inclusion and exclusion criteria. Detailed information regarding the gestational history of the mother, prenatal, natal, family history of deafness, and demographic details were taken. High-risk factors include in-utero infection (cytomegaly virus, syphilis, rubella, toxoplasmosis herpes simplex), family history of hereditary sensorineural hearing loss, infants with birth weight less than 2.5 kg and more than 4.0 kg, the birth of infants less than 37 weeks of gestation age and more than 42 weeks, mechanical ventilation more than 5 days, mother and infants on ototoxic medicines (Aminoglycosides, Loop diuretics), APGAR score (0–4 at 1 minute and 0–6 at 5 minutes), Alport syndrome, pandered syndrome, infants with respiratory distress, cyanosis, bacterial meningitis, seizure disorders otitis media, congenital heart disease, craniofacial animalia, hyperbilirubinemia, congenital malformation, microcephaly, birth asphyxia, cerebral palsy, mental retardation, cleft lip or palate, hydrocephalus. In this study, infants with head injuries, and severely ill were excluded. The sample size was calculated using the formula (4 P (1-P)/L2) at a 95% confidence interval and 5% allowable error considering the proportional of hearing loss 27.58, where *P* denotes the prevalence of hearing loss, L allowable error 320 was calculated. A total of 320 subjects were recruited. Sociodemographic data of the study population collected based on the demographic profile, most of the infants were up to 6 months old (96.6%). The majority of the infants were males (57.2%). All of the infants were from Jaipur (100%). The majority of infants' parents work in private firms (68.1%) and from urban areas of Jaipur (76.6%) [Figure 1].

High-risk infants who were developing hearing loss were assessed by brainstem evoked response audiometry (BERA). It is a non-invasive diagnostic method used to evaluate the early stage of hearing loss. Brainstem-evoked response audiometry was conducted on both ears of all infants. Brainstem-evoked responses were elicited on the Octopus NCV/EMG/EP-4 channel machine (model- CMEMG 01). Auditory brainstem

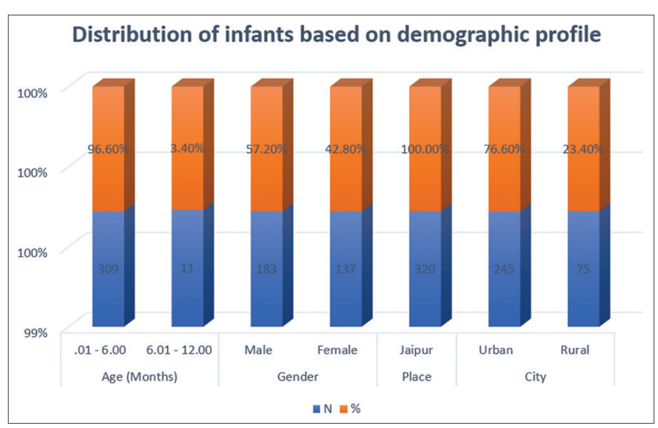

Figure 1: Sociodemographic distribution of the study population

response is defined as an electrical potential signal that spread from the brain in response to a sound stimulus to assess the functioning of auditory neuropathy by using electroencephalography.[14] The room was made soundproof for consideration of the factor of acoustic interference. Any source of electrical interference was also eliminated. Brainstem responses were evoked by click stimuli given into the ear through headphones at the rate of 20 clicks/second of 2 kHz frequency.

On average, a total of 2048 click responses were given. The responses were recorded from electrodes placed on the scalp. The scalp hair should be oil-free, the noninverting electrode was placed over the vertex of the head, and the position of inverting electrode was placed on the mastoid prominence. The placing of earthing electrodes is over the forehead for the proper functioning of the preamplifier. Electrodes that were positioned over the mastoid prominence should be symmetrical.[13-17] All the electrodes should be positioned toward the top of the head. This help in the separation of electrodes from the transducer cable. Additionally, it reduces the chance that the cable will become loose if the sleeping baby wakes up. Potentials recorded by the machine were from far-field hence they would be low in amplitude and very weak. Hence, ideal amplification of the signal was obtained by improving the signal.

All data collected and entered into Microsoft Excel and analyzed with the help of IBM SPSS 28 software and test of significance as $P < 0.05$. We have analyzed the data by applying frequency distribution, Pearson correlation, unpaired student test, and quintile regression.

Results

A total of 320 subjects were recruited based on inclusion and exclusion criteria at the Department of Pediatrics at a teaching hospital.

In this study out of 320 infants, 191 infants were bilaterally hearing present, 29 had unilaterally hearing impaired, 65 had bilaterally mild to moderate hearing loss, and 35 had severe to profound deafness [Table 1].

In this study, infants often had more than one risk factor, at an average of 2.39 factors per infant. The 96.9% (n = 125) had more than one risk factor and 3.1% (n = 4) had a single risk factor low birth weight, hyperbilirubinemia, APGAR score, meconium aspiration, respiratory distress, ventilation greater than 5 days, NICU stay greater than 12 days were most prevalent and neonatal sepsis, microcephaly, birth asphyxia, ototoxic medicine, family history of permanent childhood hearing loss, jaundice, seizure were less prevalent [Table 2].

Table 3 depicts that out of 320 infants, a total of 129 infants had low birth weights. In these infants, 53 had bilaterally hearing present, 16 had unilateral hearing impaired, 45 had bilaterally mild to moderate hearing loss, and 15 had severe to profound deafness.

Table 1: Burden of hearing loss among high-risk infant

Status of Hearing	*n*	%
Bilaterally Present (Bilateral BERA threshold <40 dB)	191	59.69%
Unilaterally hearing impaired (>40 dB)	29	9.06%
Bilaterally Mild-moderate hearing loss (bilateral threshold >40 dB and <80 dB)	65	20.31%
Severe-profound deafness (bilateral >80 dB threshold)	35	10.94%
Total	320	100%

Table 2: Risk factors distribution among high-risk infants

Risk factors		Number of infants (*n*)	Percentage
H/o Hyperbilirubinemia status		111	86.05%
Low birth weight		76	58.91%
APGAR score		52	40.31%
H/O meconium aspiration		47	36.43%
H/O Respiratory distress		29	22.48%
H/o Ventilation >5 days		22	17.05%
H/O NICU >than12 days		11	8.53%
H/o Birth Asphyxia		10	7.75%
H/o Neonatal Sepsis		9	6.98%
H/o Ototoxic Medicine		6	4.65%
Medicine name	Doses		
Aminoglycosides	>4 mg/kg/day	2	1.55
Gentamicin	6 mg/kg/day	1	0.775
Kanamycin	15 mg/kg/day	1	0.775
loop diuretics	240 mg/day	2	1.55
H/o Microcephaly		4	3.10%
H/o Seizures		3	2.33%
H/o Not Cried after birth		2	1.55%
H/o Craniofacial Abnormality		1	0.78%
H/o Jaundice		1	0.78
H/o Hydrocephalus		0	0.00%
H/o Family history of hearing loss		0	0.00%
H/o Developmental delay		0	0.00%

Out of 320 infants, a total of 70 had H/O meconium aspiration. Out of 70 infants, 32 had bilaterally hearing present, 11 had unilaterally hearing impaired, 12 had bilaterally mild to moderate hearing loss, and 15 had severe to profound deafness [Table 4].

Out of 320 infants, a total of 148 infants had H/O respiratory distress, 57 had bilaterally hearing present, 17 had unilaterally hearing impaired, 55 had bilaterally mild to moderate hearing loss, and 19 had severe to profound deafness [Table 5].

Out of 320 infants, a total of 145 infants had h/o hyperbilirubinemia, 47 had bilaterally hearing present, 21 had unilaterally hearing impaired, 55 had bilaterally mild to moderate hearing loss, and 22 had severe to profound deafness [Figure 2].

Out of 320 infants, a total of 21 infants had h/o ventilation >5 days, 1 had bilaterally hearing present, 4 had unilaterally hearing impaired, 11 had bilaterally mild to moderate hearing loss, and 5 had severe to profound deafness [Table 6].

APGAR score is a comprehensive screening tool to evaluate a newborn at birth based on five variables, i.e. heart rate, muscle tone, respiratory effort, muscle tone, reflex irritability, and color. The score is recorded at 1 and 5 minutes for all infants, and at 5-minute intervals thereafter until 20 minutes that have a score less than seven. Out of 320 infants, a total of 26 infants had low APGAR scores of less than seven in these 15 had bilaterally hearing present, 2 had unilaterally hearing impaired, 6 had bilaterally mild to moderate hearing loss, 3 had severe to profound deafness, and 194 have normal APGAR score [Table 7].

Figure 3 depicts a significant negative correlation observed between low birth weight, respiratory distress, hyperbilirubinemia, and meconium aspiration. These risk factors were significantly positively correlated with absolute and interpeak latencies [Figure 3].

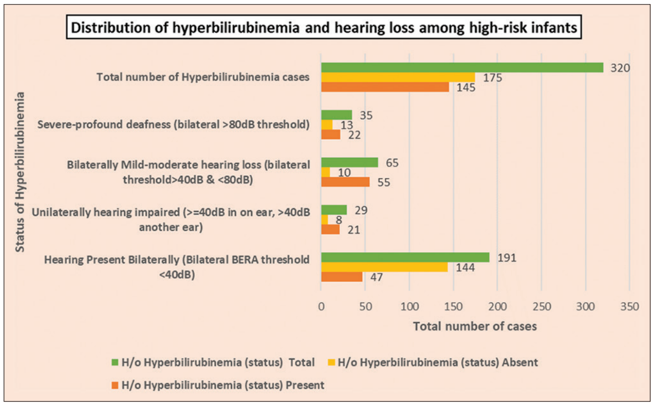

Figure 2: Distribution of hyperbilirubinemia and hearing loss among high risk infants

Table 3: Hearing loss distribution among low birth weight (LBW) among high-risk infants

Status of hearing loss	LBW (Status)		Total number of infants (N)
	Present	Absent	
Hearing Present Bilaterally (Bilateral BERA threshold <40 dB)			
Count	53	138	191
%	27.7%	72.3%	
Unilaterally hearing impaired (>40 dB in one ear, >40 dB another ear)			
Count	16	13	29
%	55.2%	44.8%	
Bilaterally Mild-moderate hearing loss (bilateral threshold >40 dB and <80 dB)			
Count	45	20	65
%	69.2%	30.8%	
Severe-profound deafness (bilateral >80 dB threshold)			
Count	15	20	35
%	42.9%	57.1%	
Total	129	191	320

Discussion

This study was conducted to assess the burden of hearing loss and its correlation with risk factors among high-risk infants at a teaching institution in Jaipur, Rajasthan. This study also increases awareness and educates parents about the risk factors and hearing loss among high-risk infants, and the importance of early intervention, and follow-up to incorporate surveillance procedures in daily practice by primary healthcare workers.

During the study period, 320 high-risk infants were recruited from the teaching hospital. The demographic profile, the majority of the infants were up to 6 months old (96.6%). The majority of the infants were males (57.2%) [Figure 1] similar to reported by Vashistha I *et al.*[21]

In the present study, burden of hearing loss among high-risk infants depicts that out of 320, a total of 191 had bilaterally hearing present and 129 infants have hearing loss. 9.06% ($n = 29$) have unilateral hearing loss, 20.31% ($n = 65$) have bilaterally mild to moderate hearing loss, and 10.94% ($n = 35$) [Table 1] have severe to profound hearing loss similar to study done by Mukherjee[22] *et al.*, Duara[23] *et al.*, and Gupta *et al.*[24]

The result of the present study reveals hyperbilirubinemia, low birth weight, APGAR score, meconium aspiration, respiratory distress, and ventilation greater than five days were most prevalent. A strong correlation was observed with interpeak latencies [Table 2] similar to studies conducted by Heramba *et al.*,[10] Halpern J *et al.*[25] and, Iiknur K *et al.*[26], and Kvestad E *et al.*,[27] reported that hearing impairment was significantly correlated with family history, intrauterine infection, postnatal infection, low APGAR score, craniofacial anomaly, and low birth weight.

In this study, a significant correlation was observed between low birth weight and hearing loss (APL for the left ear - 0.15, for the

Table 4: Distribution of meconium aspiration and hearing loss among high-risk infants

Hearing loss status	H/O meconium aspiration		Total number of infants *n*
	Present *n* (%)	Absent *n* (%)	
Hearing Present Bilaterally (Bilateral BERA threshold <40 dB)	32 (16.8%)	159 (83.2%)	191
Unilaterally hearing impaired (>40 dB in one-ear, >40 dB in another ear)	11 (37.9%)	18 (62.1%)	29
Bilaterally Mild-moderate hearing loss (bilateral threshold >40 dB and <80 dB)	12 (37.9%)	53 (62.1%)	65
Severe-profound deafness (bilateral >80 dB threshold)	15 (18.5%)	20 (81.5%)	35
Total	702	250	320

	Age (Months)	Weight (Kg)	Height (M)	H/O LOW BIRTH WEIGHT (Kg)	BMI	H/o Hyperbilirubinemia	H/O meconium aspiration	H/O Respiratory distress	H/o Congenital malformation	APL (LT)	IPL	APL (RT)
Age (Months)	1.00											
Weight (Kg)	-0.14	1.00										
Height (M)	-0.09	0.53***	1.00									
H/O LOW BIRTH WEIGHT (Kg) 8	-0.01	-0.07	-0.05	1.00								
BMI	-0.07	0.55***	-0.11*	-0.03	1.00							
H/o Hyperbilirubinemia	-0.04	0.29*	0.15*	-0.07	0.17*	1.00						
H/O meconium aspiration	0.10	0.21*	0.00	-0.15*	0.17*	0.46*	1.00					
H/O Respiratory distress	-0.07	0.27*	0.07	-0.09	0.25*	0.81***	0.56***	1.00				
H/o Congenital malformation	0.03	-0.01	0.08	0.01	-0.01	0.13*	-0.08	0.08	1.00			
APL (LT)	0.00	-0.17*	-0.04	-0.15*	-0.60***	0.48*	-0.38*	-0.23*	-0.02	1.00		
IPL	0.03	-0.22*	-0.13*	-0.22*	-0.32*	-0.61***	-0.68***	-0.80***	-0.05	0.45*	1.00	
APL (RT)	0.06	-0.24*	-0.12*	-0.21*	-0.65***	-0.47*	-0.43*	-0.28*	-0.02	0.47*	0.93***	1.00

Note: < 0.5 mild*, 0.5 moderate** and >0.5 to 0.1 severe***

Figure 3: Correlation of risk factors and hearing loss among high-risk infants

Table 5: Distribution of respiratory distress and hearing loss among high-risk infants

Hearing loss status	H/O Respiratory distress		Total number of infants (N)
	Present	Absent	
Hearing Present Bilaterally (Bilateral BERA threshold<40 dB)			
Count	57	134	191
%	29.8%	70.2%	
Unilaterally hearing impaired (>40 dB in one ear, >40 dB another ear)			
Count	17	12	29
%	58.6%	41.4%	
Bilaterally Mild-moderate hearing loss (bilateral threshold >40 dB and <80 dB)			
Count	55	10	65
%	84.6%	15.4%	
Severe-profound deafness (bilateral >80 dB threshold)			
Count	19	16	35
%	54.3%	45.7%	
Total	148	172	320

Table 6: Distribution of Invasive ventilation >5 days and hearing loss among high-risk infants

Hearing loss status	H/o Invasive Ventilation >5 days		Total number of infants (N)
	Present	Absent	
Hearing Present Bilaterally (Bilateral BERA threshold <40 dB)			
Count	1	190	191
%	0.52%	99.48%	
Unilaterally hearing impaired (>40 dB in one ear, >40 dB another ear)			
Count	4	25	29
%	13.79%	86.21%	
Bilaterally Mild-moderate hearing loss (bilateral threshold>40 dB and <80 dB)			
Count	11	54	65
%	16.92%	83.08%	
Severe-profound deafness (bilateral >80 dB threshold)			
Count	5	30	35
%	14.29%	85.71%	
Total	21	299	320

right ear - 0.22), and (IPL for both ears - 0.22) [Table 3, Figure 3]. Results were similar to Doğan IE *et al.*[26]

In this present study, strong correlation with meconium aspiration (APL for the left ear - 0.38, for right ear APL -0.43) (IPL for both ears -0.68) [Table 4, Figure 3] similar to those reported by Halpern J *et al.*[25]

In this study, respiratory distress was positively correlated [Table 5, Figure 3] with hearing loss similar to studies conducted by Kountakis SE *et al.*[28]

In this present study, strong correlation with hyperbilirubinemia (APL for the left ear- 0.48, for the right ear APL -0.47) and (IPL for both ears -0.61) [Figures 2 and 3] similar to the study done by Boskabadi H *et al.*,[29] Fouladinejad M.[30]

Results of the study reveal that the low APGAR score and ventilation >5 days [Table 7, Figure 3] were also risk factors for hearing loss similar study done by Kvestad E *et al.*,[27] Cristobal R *et al.*, and[31] Bielecki I *et al.*[32]

It is important to consider all risk factors of infants admitted to teaching hospitals. Hearing screening, diagnosis, intervention, and follow-up of hearing loss in high-risk infants are necessary steps of the neonatal hearing health program.

Implications: The findings of the current study have certain implications in practice:

Table 7: Distribution of APGAR score and hearing loss among high-risk infants

Hearing loss status	APGAR score (<7)		Total number of infants (N)
	Present	Absent	
Hearing Present Bilaterally (Bilateral BERA threshold <40 dB)			
Count	15	176	191
%	7.85%	92.15%	
Unilaterally hearing impaired (>40 dB in on ear, >40 dB another ear)			
Count	2	27	29
%	6.90%	93.10%	
Bilaterally Mild-moderate hearing loss (bilateral threshold >40 dB and <80 dB)			
Count	6	59	65
%	9.23%	90.77%	
Severe-profound deafness (bilateral >80 dB threshold)			
Count	3	32	35
%	8.57%	91.43%	
Total	26	194	320

1. The correlation between infants hearing loss and identification of high-risk characteristics that will effectively screen infants for hearing issues has motivated efforts to reduce the need for and cost of testing high-risk babies by identifying a subgroup containing the majority of the hearing loss infants.
2. It is essential to consider prevalent risk factors, i.e., hyperbilirubinemia, low birth weight, APGAR score, meconium aspiration, respiratory distress, and invasive ventilation greater than five days of infants. Results of this study depict a strong correlation was observed with interpeak latencies and prevalent risk factors.
3. The infant hearing health program's critical phases include hearing testing, diagnosis, and follow-up for newborns with risk factors for hearing loss.
4. Congenital and infant hearing loss is best managed when identified and treated early. Early rehabilitation of hearing-impaired infants will lower overall rehabilitation costs and enhance their ability to communicate in the long term.
5. Primary care physicians are aware of the risk factors and infants hearing loss. By increasing the primary level participation of the medical community in the newborn hearing screening and follow-up, the current system can be improved.
6. Primary care physician work and responsibilities will be helped by action-oriented resources that increased awareness and educate parents about the risk factors, hearing loss among high-risk infants, and the importance of early intervention, and follow-up s to incorporate surveillance procedures in daily practice by primary health care workers.

Limitations

Further extension of this study was on large sample size and multicentric study at Rajasthan. The screening was done by otoacoustic emission followed by BERA. It is crucial to implement a comprehensive plan for neonatal hearing screening in order to detect hearing loss early and intervene.

Conclusion

Hearing screening in high-risk infants has been important to early diagnosis and intervention to decrease the prevalence of hearing loss in India. Brainstem evoked response audiometry, which was an easily applicable, non-invasive procedure, useful both for screening and for quantitative audiometry in infants. In this study, we have observed that most of the infants with hearing loss have multiple risk factors viz. low birth weight, hyperbilirubinemia, low APGAR score (<7), meconium aspiration, respiratory distress, and ventilation greater than five days was the most prevalent, and statistically significant.

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Conflicts of interest

There are no conflicts of interest.

References

1. Luo RZ, Wen RJ, Huang ZY, Zhou JL, Wang XY, Chen Q. Audiological characteristics and localization of lesions in children with retro cochlear auditory nerve impairment. Arch Otolaryngology 1980;228:205-10.
2. Hood LJ, Berlin CI, Bordelon J, Rose K. Patients with auditory neuropathy/dys-synchrony lack efferent suppression of transient evoked otoacoustic emissions. J Am Acad Audiol 2003;14:302-13.
3. Hardani AK, Goodarzi E, Delphi M, Badfar G. Prevalence and risk factors for hearing loss in neonates admitted to the neonatal intensive care unit: A hospital study. Cureus 2020;12:e11207.
4. Singh V. Newborn hearing screening: Present scenario. Indian J Community Med 2015;40:62-5.
5. Simmons FB, McFarland WH. Jones FT. An automated hearing screening technique of newborns. Acta Otolaryngol 1979;87:1-8.
6. Galambos R. Hicks GE, Wilson MJ. Hearing loss in graduates of a tertiary intensive care nursery. Ear Hear I982;3:87-90.
7. Stein L, Ozdamar O, Kraus N, Paton J. Follow-up of infants screened by auditory brainstem response in the neonatal intensive care unit. J Pediatr 1983;103:447-53.
8. Morrison MD, Brewster L. Early detection of childhood hearing impairment-problems and possible solutions. J Otolaryngol 1978;7:484-9.
9. Raju TNK. The High-Risk Infant in Textbook of Clinical Pediatrics. Berlin, Heidelberg: Springer; 2012. p. 177–86.
10. Heramba Ganapathy S, Ravi Kumar A, Rajashekar B, Mandke K, Nagarajan R. Association of high risk factors and hearing impairment in infants-a hospital-based study. Indian J Otolaryngol Head Neck Surg 2022;74(Suppl 3):3933-8.
11. Healthy people 2000: National health promotion and disease prevention objectives and healthy schools. J Sch Health 1991;61:298-328.

12. Joint Committee on Infant Hearing 1994 Position Statement. American Academy of Pediatrics Joint Committee on Infant Hearing. Pediatrics 1995;95:152-6.
13. Shukla A, Hosamani P. Role of hearing screening in high-risk newborns. Indian J Otolaryngol Head Neck Surg 2022;74(Suppl 1):593-9.
14. Kalambe S, Gaurkar S, Jain S, Deshmukh P. Comparison of otoacoustic emission (OAE) and brainstem evoked response audiometry (BERA) in high risk infants and children under 5 years of age for hearing assessment in western India: A modification in screening protocol. Indian J Otolaryngol Head Neck Surg 2022;74(Suppl 3):4239-53.
15. Bernard PA, Pechere JC, Herbert R. Altered objective audiometry in aminoglycoside treated human neonates. Arch Otolaryngology 1980;228:205-10.
16. Champion S. Assessment of hearing in high risk infants, using brainstem evoked response audiometry. Indian J Otolaryngol Head Neck Surg 2021;73:383-8.
17. Duara S, Suter CM, Bessard KK, Gutberlet RL. Neonatal screening with auditory brainstem responses: Results of follow-up audiometry and risk factor evaluation. J Pediatr 1986;108:276-81.
18. Kountakis SE, Psifidis A, Chang CJ, Stiernberg CM. Risk factors associated with hearing loss in neonates. Am J Otolaryngol 1997;18:90-3.
19. Papas DG. A study of the high-risk registry for sensorineural hearing impairment. Arch Otolaryngology Head Neck Surg 1983;91:41-4.
20. Early identification of hearing impairment in infants and young children. NIH Consens Statement 1993;11:1-24.
21. Vashistha I, Aseri Y, Singh BK, Verma PC. Prevalence of hearing impairment in high risk infants. Indian J Otolaryngol Head Neck Surg 2015;68:214–7.
22. Mukherjee SS, Mukherjee S, Sarkar KD. Prevalence of hearing loss in high risk infants of mediocre socio-economic background at around one year of age and their correlation with risk factors. Indian J Otolaryngology Head Neck Surg 2013;65(Suppl 3):598-603.
23. Duara S, Suter CM, Bessard KK, Gutberlet RL. Neonatal screening with ABR: Results of follow up audiometry and risk factor evaluation. J Pediatr 1986;108:276–81.
24. Gupta AK, Anand NK, Raj H. Evaluation of risk factors for impairment in at-risk neonates by BERA. Indian J Pediatr 1991;58:849–55.
25. Halpern J, Hosford-Dunn H, Malachowski N. Four factors that accurately predict hearing loss in high-risk neonates. Ear Hear 1987;8:21-5.
26. Doğan IE , Balcı NC, Gündüz AG. Physiotherapy and rehabilitation approaches to premature infants in neonatal intensive care units. J Phys Med Rehabil Stud Rep 2022;4;1-5.
27. Kvestad E, Lie KK, Eskild A, Engdahl B. Sensorineural hearing loss in children: The association with Apgar score. A registry-based study of 392,371 children in Norway. Int J Pediatr Otorhinolaryngol 2014;78:1940-4.
28. Kountakis SE, Skoulas I, Phillips D, Chang CYJ. Risk factors for hearing loss in neonates: A prospective study. Am J Otolaryngology 2002;23:133–7.
29. Boskabadi H, Zakerihamidi M, Moradi A, Bakhshaee M. Risk factors for sensorineural hearing loss in neonatal hyperbilirubinemia. Iran J Otorhinolaryngol 2018;30:195.
30. Fouladinejad M, Sirati M, Taziki MH, Safaeian B, Alaee E. Prevalence of sensorineural hearing loss among neonatal hyperbilirubinemia. J Babol Univ Med Sci 2014;16:14–9.
31. Cristobal R, Oghalai JS. Hearing loss in children with very low birth weight: Current review of epidemiology and pathophysiology. Arch Dis Child Fetal Neonatal Ed 2008;93:F462-8.
32. Bielecki I, Horbulewicz A, Wolan T. Prevalence and risk factors for auditory neuropathy spectrum disorder in a screened newborn population at risk for hearing loss. Int J Pediatr Otorhinolaryngol 2012;76:1668-70.