ORIGINAL RESEARCH

Comparative study of hearing loss in premature infants versus normal infants

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ABSTRACT

Background: Disabling Hearing Loss is defined as hearing loss greater than 40 dB in the better hearing ear in adults (15 years or older) and greater than 30 dB in the better hearing ear in children (0–14 years). Otoacoustic emission tests (OAE) and automated auditory brainstem response tests (BERA) are the most effective two categories of objective screening tests. Both tests have a high sensitivity and specificity for detecting Hearing loss that is worse than 40 dB. **Objective**: Early detection of hearing loss in infants and to know the prevalence of hearing loss in infants and compare the hearing status of normal and preterm infant. **Methodology**: A Prospective observational study was in Bundelkhand Medical College, Sagar, M.P. conducted on 125 infants out of which 75 were premature and 50 were normal over a period of one year (Oct 2021 to Oct 2022). The infants were selected on the basis of inclusion and exclusion criteria, then informed consent was taken from the parents and all infants were categorized as premature infants and normal infants with the help of birth history and clinical examination. Screening was done with Otoacoustic Emission technique on two occasions (First visit within 6 months of age and Second visit after 1 month of first visit)and results were analysed. **Result**: The level of prematurity in total 19 infants : 16 out of 75 premature infants (21.3%) in comparison to 3 full-term infants out of 50 (6%) had abnormal hearing response on OAE. The distribution of abnormal Hearing and degree of prematurity was statistically significant (p-value = 0.046). [36% were very premature, 47% were moderately premature, and remaining 15% were full term. Among 19 newborns with abnormal OAE, there was history of admission to NICU. **Conclusion**: Hearing loss is a serious complication of premature birth, and its incidence declines as the foetus matures in the mother‘s womb.

INTRODUCTION

To be blind is to be isolated from the world; to be deaf is to be isolated from the other people. Hearing impairment can have an immense impact on psychosocial well-being whatever an individual‘s age, but the implications for deaf children are particularly profound(1).

Hearing is necessary to learn languages and speech and to develop cognitive skills. Hearing helps the developing child to learn to recognize sounds, identify objects and internalize concepts(2). As hearing is important for normal educational and social development, hearing loss can be devastating(3).

Over 5% of the world‘s population – or 430 million people – require rehabilitation to address their disabling hearing loss (432 million adults and thirty-four million children)(4–6). According to a range of studies and surveys conducted in different countries, around 0.5 to 5 in every 1000 neonates and infants have congenital or early childhood onset sensorineural deafness or severe-to-profound hearing impairment(4-6). The incidence of sensorineural hearing loss in preterm 4.34%(7).

Disabling Hearing Loss is defined as hearing loss greater than 40 dB in the better hearing ear in adults (15 years or older) and greater than 30 dB in the better hearing ear in children (0–14 years)(8-9). The prevalence of hearing loss in children is highest in South Asia, Asia Pacific, and Sub-Saharan Africa. India is one of the countries in South Asia(17). Permanent childhood hearing impairment (PCHI) is defined as a confirmed permanent bilateral hearing impairment ≥40 dbhl (hearing level) averaged over the frequencies of 0.5, 1, 2 and 4khz in the better hearing ear(10).

India launched the National Programme for Prevention and Control of Deafness in 2006(28). This programme is currently running in over 60 districts of the country and its aim is to identify babies with bilateral severe-profound hearing losses by 6 months of age and initiate rehabilitation by 9 months of age.

Under this programme, the following two-part protocol for infant hearing screening is being implemented(11):

a) Institution-based screening – to screen every baby born in a hospital or admitted there soon after birth using OAE. Those who fail the test are retested after 1 month. Those who fail the second screening are referred for ABR testing at the tertiary-level centres.
b) Community-based screening – to screen babies who are not born in hospitals. Such screening is carried out using a brief questionnaire and behavioural testing. The screening is performed when the baby attends for immunization at 6 weeks of age and onwards. A trained health care worker at the subcentre administers immunization and conducts the hearing screening. The protocol is repeated at every immunization. Any baby failing the screening is referred for formal OAE screening to the district hospital, and if they fail in OAE, they are then sent for ABR testing.

Otoacoustic Emissions (OAE) reflects the status of the cochlea (outer hair cells)(29,30). A probe microphone like that used in acoustic immittance measures the inaudible sounds reflected by vibratory motion in cochlea. OAE‘s are a by-product of sensory outer hair cell transduction and are reflected as echoes into the external auditory canal(29,30). OAE‘s are pre-neural in origin and directly dependant on outer hair cell integrity.

Brainstem Evoked Response Audiometry (BERA) is an objective test of audio logical function which measures activity from the auditory nerve up to the level of brainstem on stimulating with acoustic stimulus(12,13). It assesses the neural integrity of auditory pathway up to the brainstem. However, it is an indirect measure of hearing acuity.

MATERIALS AND METHOD

A Prospective observational study was conducted in Bundelkhand Medical College, Sagar (M.P.) on 125 infants out of which 75 were premature and 50 were normal over a period of one year (Oct 2021 to Oct 2022).

The infants are selected on the basis of inclusion and exclusion criteria, then informed consent was taken from the parents and all infants were categorized as premature infants or normal infants with the help of birth history and clinical examination. Screening was done with Otoacoustic Emission technique on two occasion and result was analysed.

INCLUSION CRITERIA

a) Infant of all gestational age
b) Infants of all gender

EXCLUSION CRITERIA

a) Infant aged more than 180 days at the time of enrolment in the study.
b) Infant with craniofacial anomalies.
c) Infant with meningitis.
d) Infant with septicaemia.
e) Congenital infection.
f) Parents who refuse for screening.
g) Infants whose parents refused to participate in the study

RESULTS AND OBSERVATIONS

In the present study, a total of 50 full-term infants/newborns and 75 premature infants/newborns were enrolled.

Table 1 : Classification of participants (n=125)

Premature	N	%
Full Term	50	**40.00**
Premature	75	**60.00**
Total	125	**100.00**

A total of 27.2% of the infant were born very preterm (28th – 32nd week), 32.8% of the infant were born moderate preterm (33-36th weeks), and the remaining 40% of participants were full terms (>36th week of gestation).

Table 2 : Categorization of participants by the degree of prematurity (n=125)

Premature Category	N	%
Very Preterm	34	**27.20**
Moderate Preterm	41	**32.80**
Full Term	50	**40.00**
Total	125	**100.00**

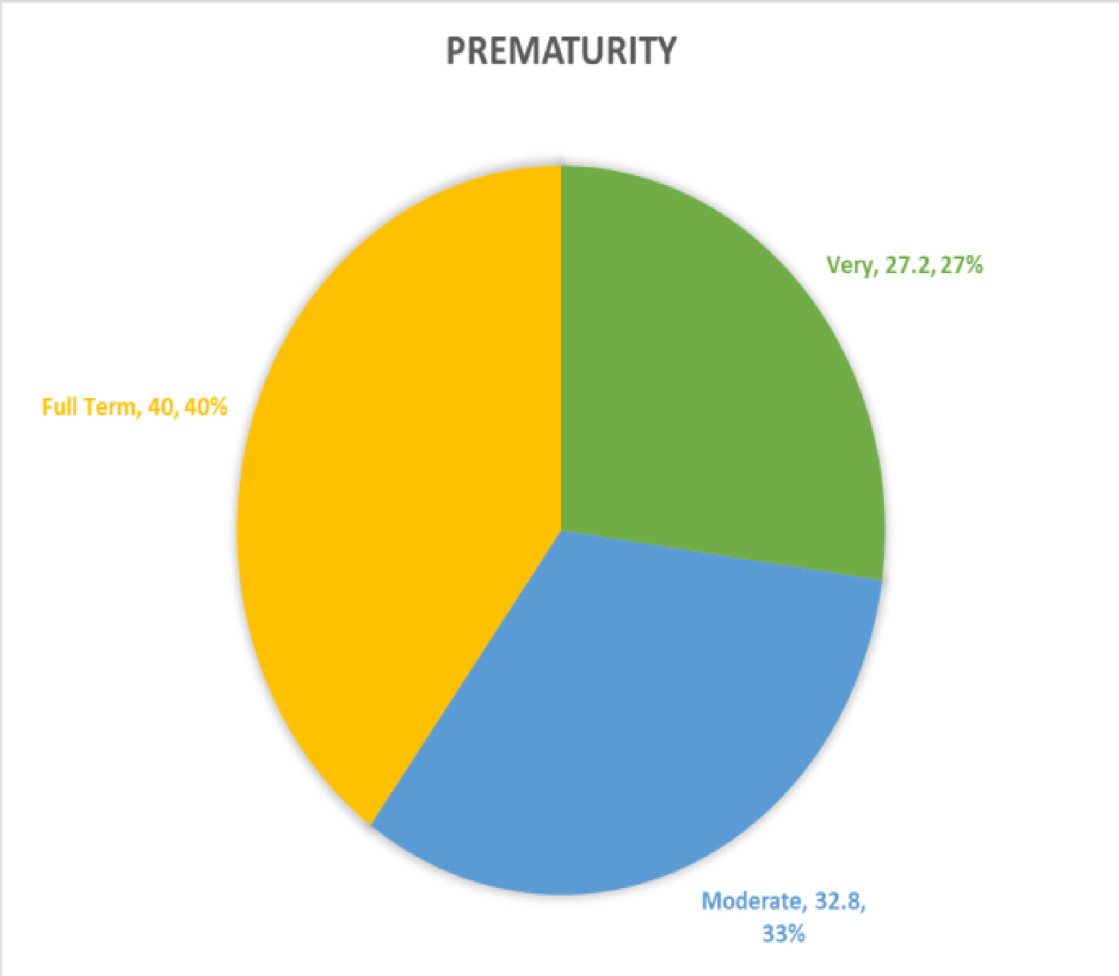

Figure 1 is a pie chart showing the distribution of participants by the degree of prematurity.

Table 3 shows the outcome of the Oto- acoustic emission testing on the first and second visits. We observed a 100.0% matching between the outcome of OAE testing at the first and second visits. Overall, 84.8% of participants 'passed' (bilaterally) on the first and second OAE testing. Further, a total of 19 patients (15.2%) participants had abnormal outcome on OAE (Left refer= 4.0%, Right Refer= 5.6%, and Bilateral refer = 5.6%).

Table 3 : Outcome of OAE test at 1st and 2nd visit (n=125)

OAE at	N	%
1st visit		
B/L Pass	106	**84.80**
Lt Refer	5	**4.00**
Rt Refer	7	**5.60**
B/L Refer	7	**5.60**
2nd Visit		
B/L Pass	106	**84.80**
Lt Refer	5	**4.00**
Rt Refer	7	**5.60**
B/L Refer	7	**5.60**
Total	125	**100.00**

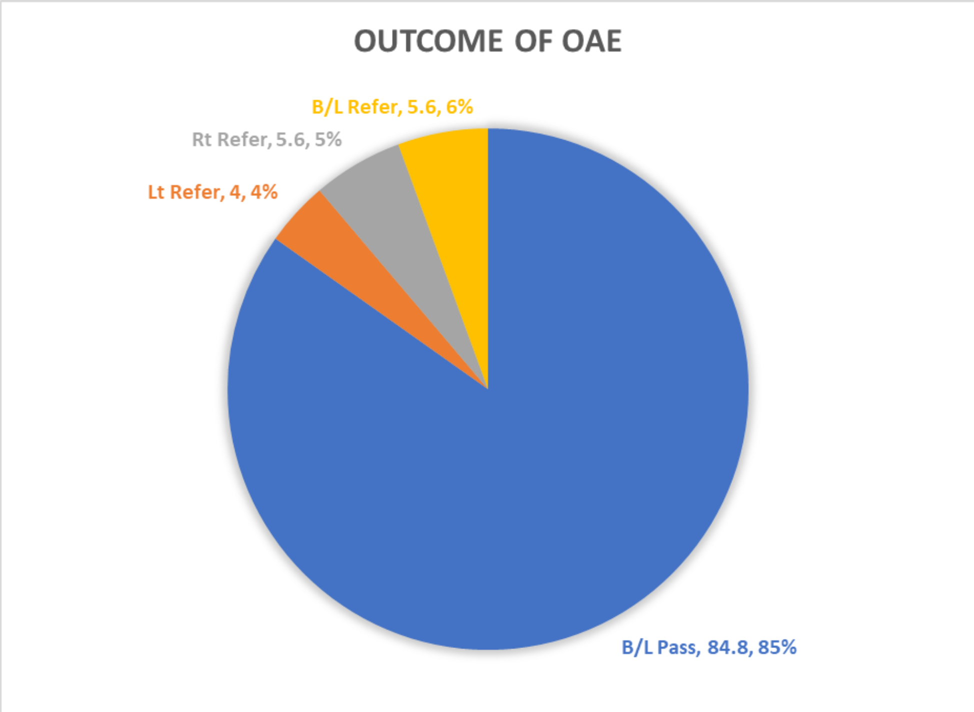

Figure 2 shows the outcome of OAE testing among participants.

Table 4 shows the age of the participants at the time of enrollment in the study. The mean age of the participants was 97 days (3 months) and it ranged from a minimum of 20 days to a maximum of 180 days.

Table 4 : Age group of participants (n=125)			
Age Group (days)	**Abnormal Hearing**		
	No	**YES**	**Total**
<=28	12	1	13
	11.32	**5.26**	**10.40**
29-90	37	6	43
	34.91	**31.58**	**34.40**
91-180	57	12	69
	53.77	**63.16**	**55.20**
Total	106	19	125
Pearson Chi2 = 0.88 P-value = 0.6449			

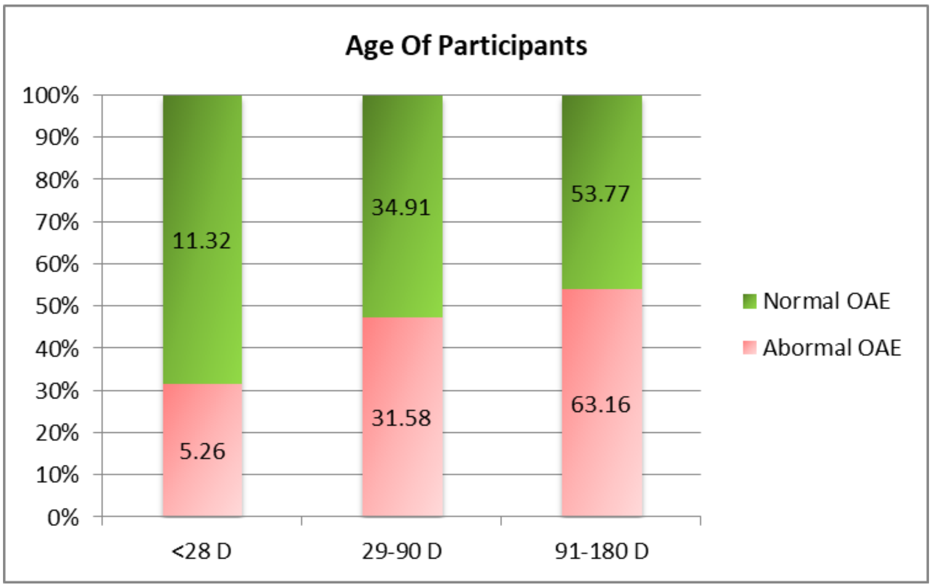

Figure 3: Age of participants

Overall, the mean weight of participants was 2193 grams, and the mean weight of participants having normal and abnormal OAE results was 2277 grams and 1726 grams. The difference in the mean weight of infants with normal and abnormal results on OAE was statistically significant (p = 0.0014).

Table 5 : Birthweight of the participants (n=125)

Birthweight Category	Abnormal Hearing		
	No	**YES**	**Total**
Extremely LBW	3	3	6
	2.83	**15.79**	**4.80**
Very LBW	7	3	10
	6.60	**15.79**	**8.00**
LBW	55	10	65
	51.89	**52.63**	**52.00**
Normal	41	3	44
	38.68	**15.79**	**35.20**
Total	106	19	125
Pearson chi2 = 9.7366 P-value = 0.021			
Mean	**2277**	**1726**	**2193**
T-test = 3.2798 P – value = 0.0014			

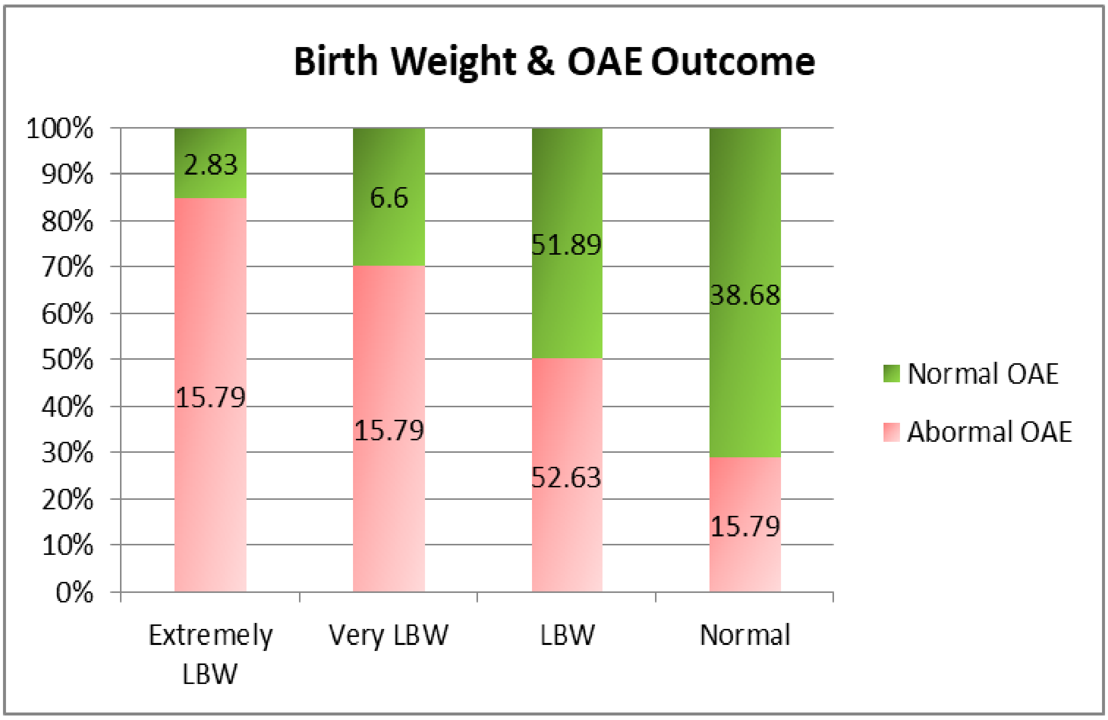

Fig 4: Birth weight

In the present study, all the 19 infants with abnormal OAE had a history of admission to NICU (p=0.0012).

Table 6 : Admission to NICU (n=125)

NICU	Abnormal Hearing		
	No	**YES**	**Total**
No	40	0	40
	37.74	**0.00**	**32.00**
Admitted	66	19	85
	62.26	**100.00**	**68.00**
Total	106	19	125
Pearson Chi2 = 10.54 P-value = **0.0012**			

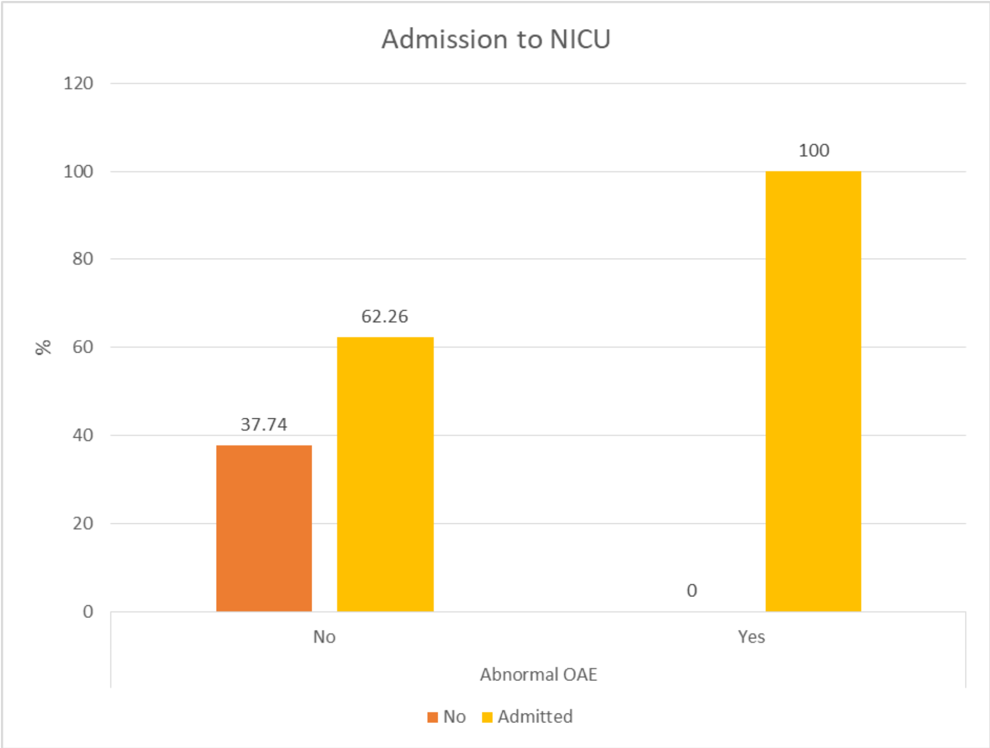

Fig 5: Admission to NICU

In the present study, 16 out of 75 premature infants (21.3%) in comparison to 3 full-term infants out of 50 (6%) had abnormal hearing response on OAE. Column wise, 84% of all participants with abnormal hearing were premature and remaining 15% were full-term.

Table 7 : Association of Prematurity and Abnormal Hearing (n=125)

Prematurity	Abnormal Hearing		
	No	**YES**	**Total**
Full Term	47	3	50
	44.34	**15.79**	**40.00**
Premature	59	16	75
	55.66	**84.21**	**60.00**
Total	106	19	125
Pearson Chi2 = 5.47 P-value = 0.0193			

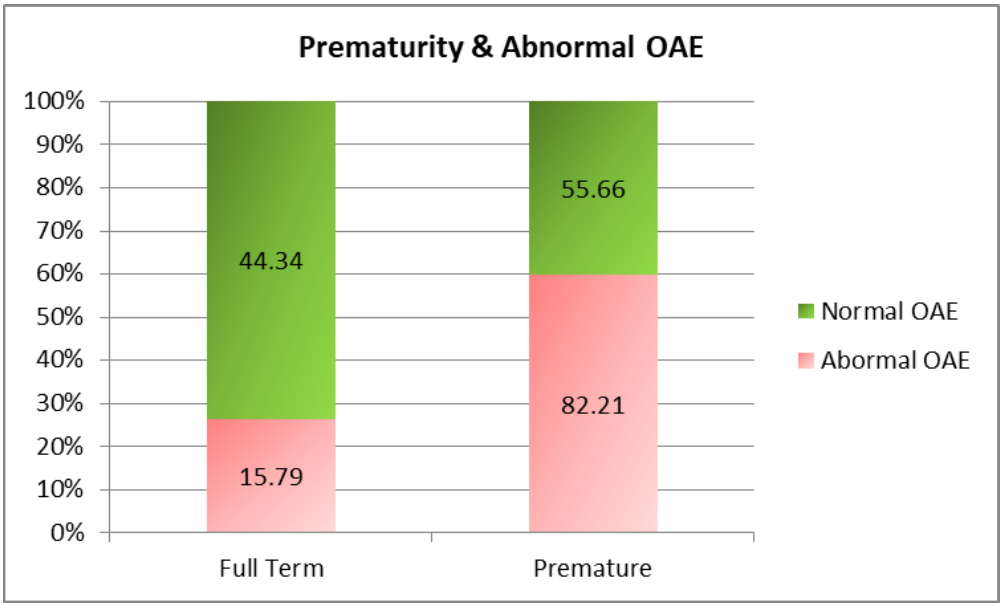

Figure 6: Prematurity and Abnormal OAE

Table 8 shows the distribution of abnormal hearing loss by the level of prematurity. Of the total 19 infants with abnormal hearing on OAE: 36% were very premature, 47% were moderately premature, and remaining 15% were full term. The distribution of abnormal HL and degree of prematurity was statistically significant (p-value = 0.046).

Table 8 : Degree of Prematurity and Abnormal Hearing (n=125)			
Premature Category	**Abnormal Hearing**		
	No	**YES**	**Total**
Very	27	7	34
	25.47	**36.84**	**27.20**
Moderate	32	9	41
	30.19	**47.37**	**32.80**
Full Term	47	3	50
	44.34	**15.79**	**40.00**
Total	106	19	125
Pearson Chi2 = 5.50 **P-value = 0.046**			

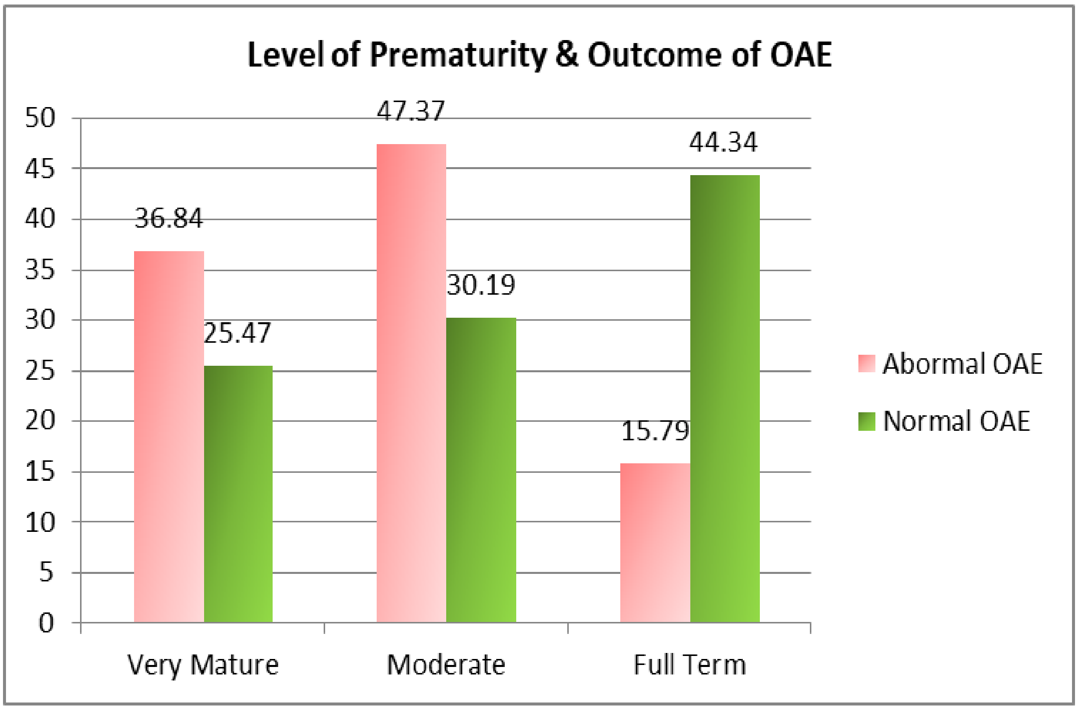

Fig 7: Level of Prematurity & Outcome of OAE

Table 9 : Prematurity and outcome of OAE (n=125)			
OAE at 1st visit	**Premature**		
	Full Term	**Premature**	**Total**
B/L Pass	47	59	106
	94.00	**78.67**	**84.80**
Lt Refer	0	5	5
	0.00	**6.67**	**4.00**
Rt Refer	1	6	7
	2.00	**8.00**	**5.60**
B/L Refer	2	5	7
	4.00	**6.67**	**5.60**
Total	50	75	125
Pearson Chi2 = 6.47 P-value = 0.037			

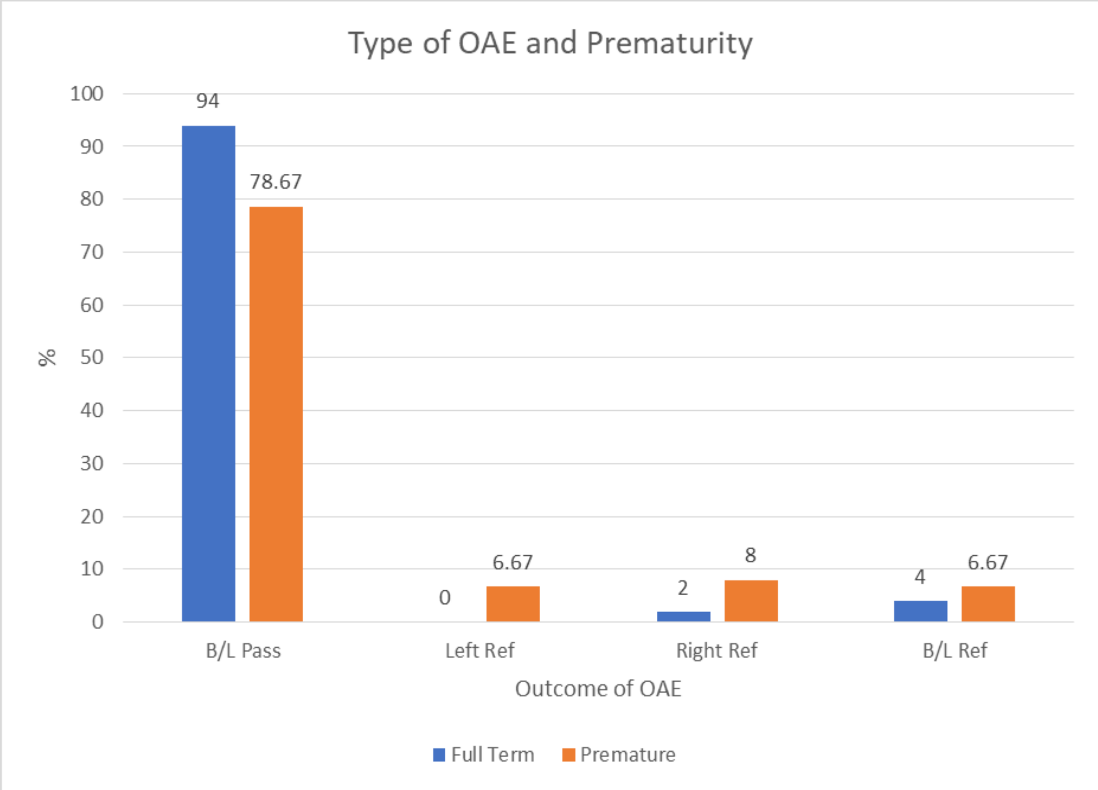

Fig 8: Type of OAE and Pre-maturity

Table 10 shows the results of the logistics regression. The odds of having an abnormal response to the OAE test among premature infants was 4.2 (95% CI **2.16- 15.45**). The odds of having an abnormal response to the OAE test decreased by 16% for every one-week increase in gestational age at birth (unadjusted odds ratio 0.84; 95% CI 0.73 **– 0.97**). The odds of having an abnormal response to the OAE test decreased by 14% for every 100-gram increase in birthweight (unadjusted odds ratio 0.86; 95% CI 0.79 **– 0.95**).

Table 10 : Logistic regression between abnormal hearing and prematurity

Factor	Odd's Ratio	p-value	[95% CI]
Premature			
Yes	4.24	0.028	**2.16- 15.45**
No	1	-	**-**
Gestational Age			
Per Week	0.84	0.024	**0.73 - 0.97**
Level of Prematurity			
Very	4.62	0.055	**1.96 - 17.02**
Moderate	4.40	0.035	**1.17- 14.54**
Full Term	1	.	
Birthweight			
Per 100 grams	0.86	0.002	**0.79 - 0.95**

DISCUSSION

Globally, more than one in ten births are preterm. Prematurity ranks second among all causes of death for kids under the age of five and is the primary cause among infants and neonates. . In low- and middle-income nations (LMICs), where preterm new-borns have a 7- fold higher risk of neonatal mortality and a 2.5-fold higher risk of post-neonatal mortality than their full-term counterparts(4,14,15).

Early auditory input deficits may result in poor academic performance as well as delays in speech, language, and general development. To lessen the effects of congenital Hearing Impairment, early identification and effective management are essential. Permanent Hearing Impairment (PHI) is a chronic hearing loss that develops in childhood and is influenced by both hereditary and environmental factors. PHI can also be acquired during pregnancy or the early years of life because of an infectious condition, or a premature birth. This explains why infants receiving care in the neonatal intensive care unit (NICU) have a higher prevalence of PHI.

Table 11 : Comparison of prevalence Among various studies (16,17,18,19)		
PREVALANCE	**NORMAL/ FULLTERM NEONATE (Per 1000)**	**HIGH RISK/PRETERM NEONATE (Per 1000)**
Our Study	6	21
Verma RR et al.	0.6 to 11.1	7 to 49
Nagapoornima P et al.	4.70	10.75
Parab SR et al.	1.69	10.69
Sachdeva K et al.	-	8.8

In the present study, the premature infants had more than 4 times higher odds (OR 4.2; 95% CI 2.16-15.45) of having an abnormal response to the OAE test in comparison to full-term neonate. More specifically, the odds ratio of having an abnormal response to the OAE test decreased by 16% for every oneweek increase in gestational age at birth (OR 0.84; 95% CI 0.73 – 0.97). Chant K. (2017) conducted a case control study and concluded that both low gestational age and low birthweight increased the odds ratio of the hearing impairment(20). Wroblewska-Seniuk K et al. (2017) reported that the hearing deficit was diagnosed in 11% of infants ≤25 wga, 5% at 26–27 wga, 3.46% at 28 wga and 2–3% at 29–32 wga(21). The most important risk factors were very low birth weight, low Apgar score and admission to NICU. Similar to our findings, Wroblewska-Seniuk K et al. also observed that both the prevalence and odds of hearing impairment were inversely related to the maturity of the baby(21). We also observed that low birthweight was independently associated with hearing impairment among study subjects. The odds ratio of having an abnormal response to the OAE test decreased by 14% for every 100-gram increase in birthweight (OR 0.86; 95% CI 0.79 – 0.95). In the present study, the mean weight of participants having normal and abnormal OAE results was 2277 grams and 1726 grams (p = 0.0014). Among the nineteen infants with abnormal OAE, 15.7% participants each were extremely and very low birth, 52% were LBW and remaining 15.7% were of normal birth weight. Dommelan PV et al. (2015) also reported that the prevalence of hearingg loss consistently increased with decreasing week of gestation and decreasing birth weight(22).

In the present study, based on statistical analysis, we observed that both GA and birth weight are independent risk factors for hearing impairment. In addition, we observed a negative relationship between gestational age, birth weight, and the incidence of hearing impairment. In other words, both GA and birth weight are inversely linked with neonatal hearing loss in a strong manner. Wroblewska-Seniuk K et al. (2017) also revealed that extremely low birth weight (VLBW 1500 g) is a risk factor for hearing impairment(23). This was evident in infants born between 29- and 32-weeks GA and in those born >33 weeks GA, and statistical analysis verified its importance.

Exposure to the continual background noise generated by modern lifesupport equipment in the NICU is an additional risk factor for hearing impairment. Robertson et al. demonstrated that admission to NICU and prolonged oxygen supplementation were associated with a significant prevalence of irreversible hearing loss among extremely preterm new-borns(24). Hille et al. shown similarly that assisted breathing for 5 days is an independent risk factor for hearing loss(25). Similarly, in our study, admission to the NICU for more than 5 days was a significant predictor of hearing impairment in most preterm infants.

Based on the study's findings, it is advised that a neonatal hearing screening programme be implemented during the first six weeks, with rescreening and confirmation by six months, with an eye toward early intervention. In India, the concept of early detection and intervention has yet to acquire attention. Nevertheless, considering the infrastructural limits of our nation and the fact that we still lack a newborn screening policy, we may begin by screening at-risk populations and subsequently establish universal screening over time. Newborn Hearing Screening allows for the early diagnosis of hearing problems, allowing for intervention prior to the age of six months(26,27).

A hearing health programme must consist of four phases: detection or hearing screening, audiological diagnosis, hearing aid fitting, and intervention by an audiologist - expert in educational audiology. Newborn Hearing Screening is a process, not an event, that offers parents and children with a follow-up, from pre-screening instructions to treatment and follow-up of the kid identified with hearing loss and the child's family.

CONCLUSION

The hearing loss is a serious complication of premature birth, and its incidence declines as the foetus matures in the mother‘s womb. This study highlights the critical need and relevance of neonatal hearing screening at national levels as well in other states of India where the universal screening for hearing loss is not performed. The screening protocol with Otoacoustic Emission is an extremely easy and helpful tool in the early identification and early intervention of congenital hearing loss in newborn.

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