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**ORIGINAL ARTICLE****Early Detection of Hearing Impairment Among High Risk Neonates in a Tertiary Care Hospital***Gurudutt Joshi<sup>1\*</sup>, Rajesh Goyani<sup>1</sup>**<sup>1</sup>Department of Pediatrics, Surat Municipal Institute of Medical Education and Research, Surat - 395007 (Gujarat) India.*

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**Abstract:**

*Background:* Hearing impairment has a devastating, detrimental and an invariably adverse impact on the development of the newborns and the psychological well-being of their families. It also adversely affects development of the central auditory nervous system, and can affect speech perception that interferes with growth in social, emotional, behavioural and cognitive spheres, academic achievement, vocational options, employment opportunities and economic self-sufficiency. *Objectives:* To find out incidence of hearing impairment in high risk neonates in Neonatal Intensive Care Unit (NICU), prevalence of hearing impairment with and without high risk factors in newborns and to correlate the risk factors with hearing impairment. *Material and Methods:* A cohort study was carried out at a tertiary care hospital of Surat, Gujarat, India consisting of 190 normal newborns and 163 newborns with high risk factors. These newborns underwent a systematized Transient Otoacoustic Emissions Examination (TOAE) and Brain Stem Evoked Audiometry (BERA) examination according to designed protocol and were followed up with repeated ear examinations. Data were recorded and analyzed statistically. *Results:* The incidence of hearing impairment in NICU, newborns were 3.6% and the prevalence of hearing impairment was 13%. Hearing impairment was statistically significant in newborns with high risk factors such as low birth weight, preterms < 32 weeks, birth asphyxia, hyperbilirubinemia with exchange transfusion, babies on ventilator for > 5 days when compared to normal newborns. *Conclusion:* Presence of risk factors in newborns predisposes them to hearing impairment more as compared to normal newborns and the more

the number of risk factors they are exposed to, the more will be the chances of hearing impairment.

**Keywords:** Brain Stem Evoked Audiometry, High Risk Neonates, Hearing Impairment, Transient Otoacoustic Emissions Examination

**Introduction:**

Hearing loss in infants should be recognized in time and appropriate otological and audiological interventions and rehabilitation should be instituted early, to take advantage of the plasticity of developing sensory system (critical period initial 0-3 years) [1]. Significant bilateral hearing loss is present in 1 to 3 per 1000 new born infants in the well-baby nursery population and in 2 to 4 per 100 infants in the intensive care unit population [2]. Studies done in India using different screening protocols for hearing loss have estimated the prevalence of neonatal hearing loss to vary between 1 and 8 per 1000 babies screened [3, 4]. The gravity of this problem can only be tackled if available restricted infrastructure is used to mainstream hearing-impaired people in regular education, vocational training and employment, by attending to hearing loss on time and instituting appropriate remedial measures [5]. The present study was undertaken to find out incidence of hearing impairment in high risk neonates in NICU, the prevalence of hearing impairment in the newborns with and without risk factors and to correlate these risk factors with hearing impairment.

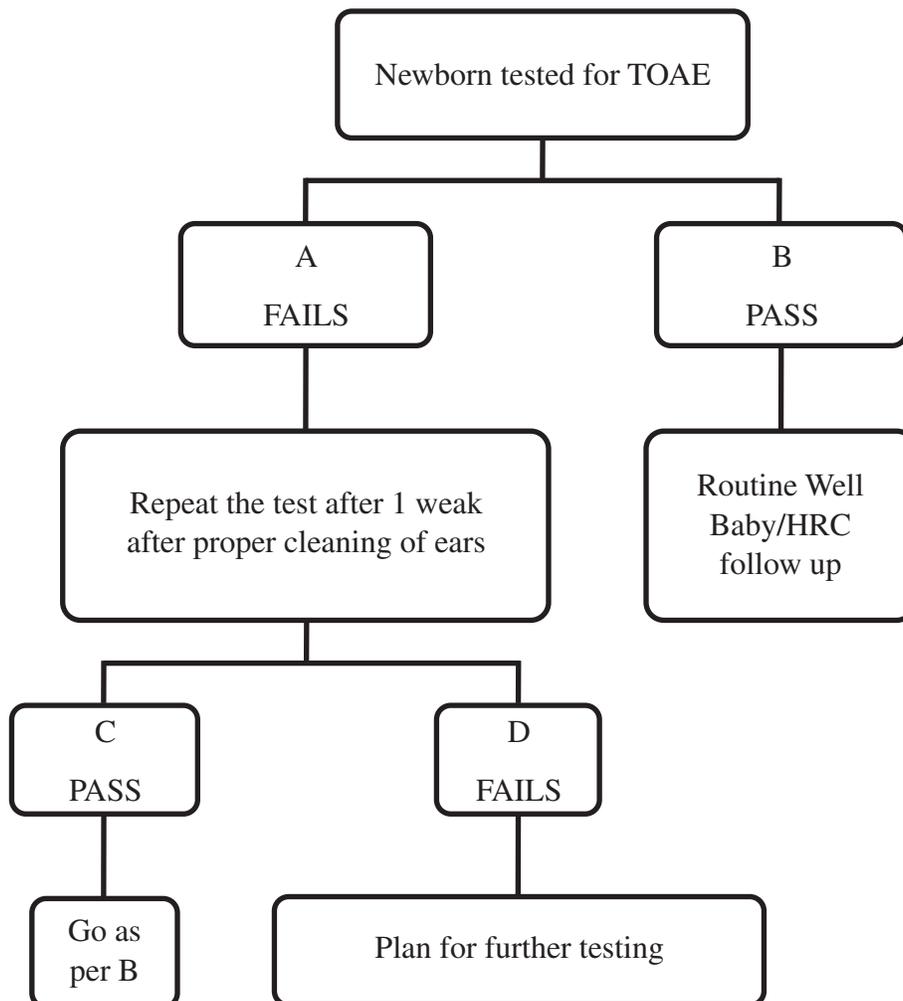
**Material and Methods:**

The study was a prospective cohort study carried out in NICU, high risk clinic and post natal clinic of Surat Municipal Institute of Medical Education and Research, Surat, Gujarat, India from August 2012 to October 2013. Study was approved by institutional ethics committee. High risk factors included in the study are as mentioned in (Table1).

**Inclusion Criteria:** Newborns, admitted from outside and from our institution. These included newborns without high risk factors from postnatal ward, and with high risk factors from NICU and high risk clinic.

**Exclusion Criteria:** Newborns once discharged and did not return, whose parents/relatives were not willing to undergo screening test for hearing, and those who expired during study period. A detailed socio-demographic profile of motherland babies was obtained.

All eligible newborns were examined in detail, thereafter; they were referred to ENT department for complete ear examination. On examination, if the newborn was having any wax or effusion in the ear or had any other problems they were detected, treated and then TOAE and BERA tests were carried out as per the protocol (Fig. 1).



**Fig. 1: Algorithm for testing of Hearing in the Newborn**

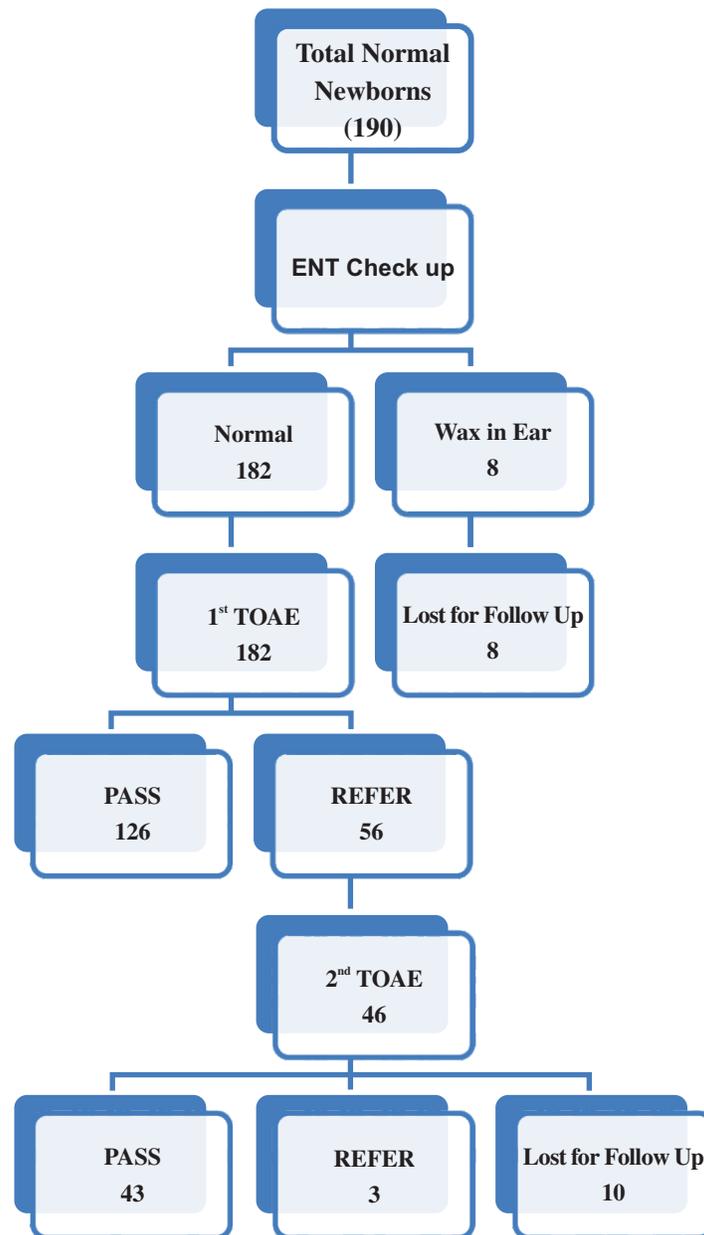
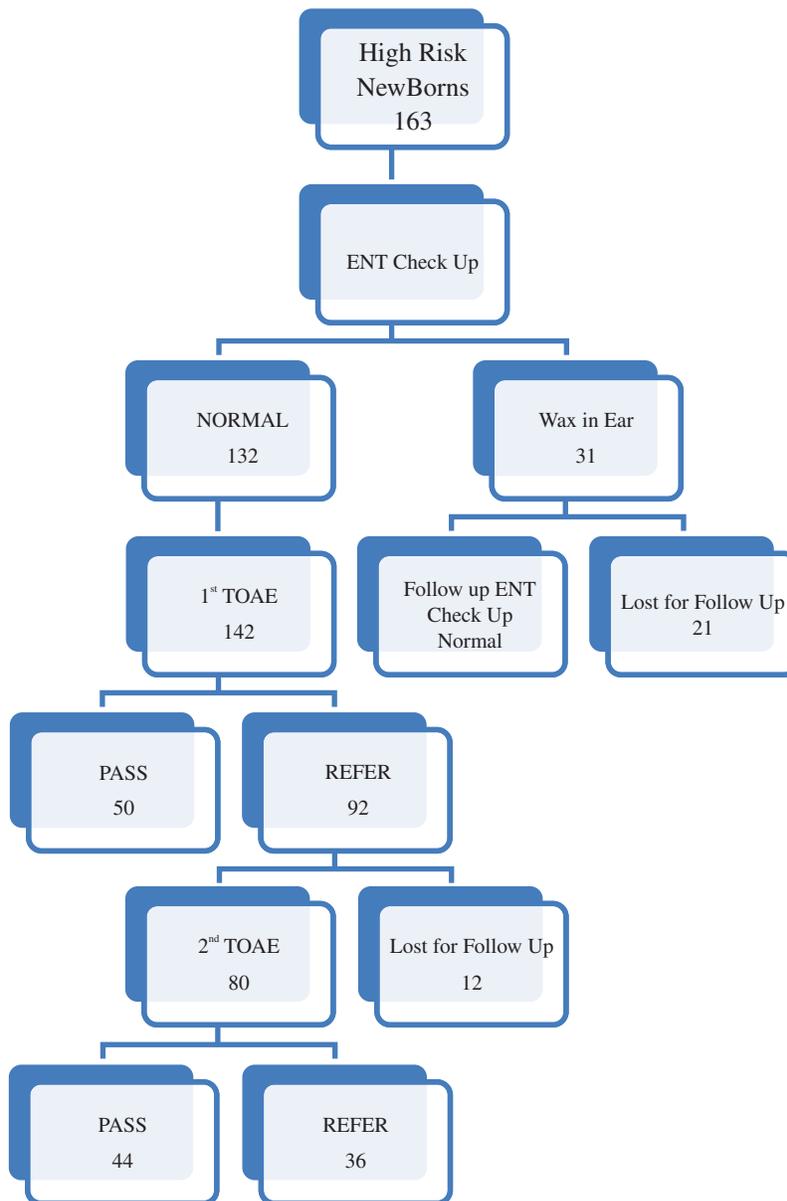


Fig. 2: Protocol for Hearing Testing in Normal Newborns



**Fig. 3: Protocol for Hearing Testing in High Risk Newborns**

Intelligent Hearing System SNSTR0101-800-IH was used for test. TOAE was performed when the newborn was comfortable and quiet in the sound proof audiometry room by audiologist. First TOAE examination was done before newborns were discharged from hospital, second TOAE examination, after one month of first TOAE and BERA was done three months after the second TOAE examination. If an infant's cochlea was

functioning normally, internally generated sounds were recorded and the result was labeled as “PASS” (Normal response) but when either cochlear hearing loss existed, or if cochlea did not generate a response or if, it did generate a response, but less than the level of “threshold” as compared to normal ear, the result was labeled as “REFERRED” and meant that it required next step of evaluation of hearing test protocol.

**Statistical Methods:**

Chi Square test, Z Test, Multivariate logistic Regression Analysis

**Results:**

A total of 353 neonates were included in the study, out of which 163 newborns were having risk factors and 190 were without risk factors for hearing impairment. Out of 163 newborns with risk factors, 33 were lost to follow up at various stages of study, thus actual newborns included were 130. Whereas out of 190 newborns without risk factors, 21 newborns were lost to follow up and hence 169 were actually included. Thus out of 300 newborns 57 % were males and 43 % were females, with male to female ratio of 1.3:1. In the study, maximum number of newborns was of gestational age range between 38-40 weeks (88 %) that is term newborns. We had two newborns of cleft lip and cleft palate, one of bacterial meningitis, three newborns of TORCH infections

[Toxoplasmosis Other (syphilis, varicella - zoster, parvovirus B19), Rubella, Cytomegalovirus (CMV) & Herpes] and no newborns having any family history of hearing loss, or any syndrome with hearing loss hence statistical analysis could not be performed in these newborns.

On comparing newborns with and without risk factors to presence of hearing impairment p value was < 0.05 on applying Z test, p value came < 0.001 and odds ratio was 21.319 and 95 % confidence interval (06.39, 71.13), so the difference of hearing impairment found between above two groups was statistically significant (Table 1).

On comparison of hearing impairment with frequency of presence of risk factors in newborns it was found to be statistically significant (p < 0.05), thus more the number of presence of risk factors in newborns more is hearing impairment (Table 2).

**Table 1: Association of High Risk Factors with Hearing Impairment in the Newborns**

Risk factor(s)	Hearing Impairment		Total
	Present (%)	Absent (%)	
Present* (At risk neonates)	36 (27.7)	94 (72.3)	130
Absent* (normal neonates)	03 (1.8)	167 (98.2)	170
Total	39 (13.0)	261 (87)	300

\*p<0.05

**Table 2 : Association between Frequencies of Risk Factors with Prevalence of Hearing Impairment in Newborns**

No. of Risk Factors for Hearing Impairment	Hearing Impairment		Total
	Present (%)	Absent (%)	
1*	20 (21.5)	73 (78.5)	93
2*	14 (41.2)	20 (58.8)	34
3*	2 (66.7)	1 (33.50)	3
Total	36.0	94.0	130

\*p<0.05

Mode of delivery did not affect the hearing impairment ( $p > 0.05$ ) (Table 3.1). However, comparison of groups of newborns weighing  $< 1.5\text{kg}$  with  $> 1.5\text{kg}$  (Table 3.2), those having risk factors and weighing  $< 1.5\text{kg}$  to those without risk factors and weighing  $< 1.5\text{kg}$  (Table 3.3), gestational age  $< 32$  weeks and gestational age  $> 32$

weeks (Table 3.4),  $p$  value was  $< 0.05$  indicating statistical significance. Maturity with and without risk factors did not affect the hearing impairment ( $p > 0.05$ ) (Table 3.5). Therefore, hearing impairment was more likely in those newborns  $< 1.5\text{kg}$ ,  $< 1.5\text{kg}$  with risk factors and  $< 32$  weeks with risk factors.

**Table 3: Comparison of Various Risk Factors with Hearing Impairment**

Type of Risk Factor	Hearing Impairment		Total	p value
	Present(%)	Absent(%)		
<b>3.1. Mode of delivery</b>				
Lower Segment Caesarian Section	6 (08.0)	69 (92.0)	075.0	$> 0.05$
Vaginal	33 (14.7)	192 (85.3)	225.0	
Total	39 (13.0)	261 (87.0)	300.0	
<b>3.2. Hearing Impairment in Newborns with Birth weight <math>\leq 1.5\text{ kg}</math> and <math>&gt; 1.5\text{kg}</math></b>				
$\leq 1.5\text{ kg}$	15 (21.4)	55 (78.6)	070.0	$< 0.05$
$> 1.5\text{ kg}$	24 (10.4)	206 (89.6)	230.0	
Total	39 (13.0)	261 (87.0)	300.0	
<b>3.3. Newborns of <math>\leq 1.5\text{ kg}</math> with and without High Risk Factors</b>				
$\leq 1.5\text{ kg}$ without other high risk factors	4 (10.5)	34 (89.5)	38.0	$< 0.05$
$\leq 1.5\text{ kg}$ with other high risk factors	11 (34.4)	21 (65.6)	32.0	
Total	15 (21.4)	55 (78.6)	70.0	
<b>3.4. Maturity</b>				
$\leq 32$ weeks	9 (26.5)	25 (73.5)	034.0	$> 0.05$
$> 32$ weeks	30 (11.3)	236 (88.7)	266.0	
Total	39 (13.0)	261 (87.0)	300.0	
<b>3.5. Maturity with and without Risk Factors</b>				
$\leq 32$ weeks without other high risk factors	1 (12.5)	7 (87.5)	08.0	$< 0.05$
$< 32$ weeks with other high risk factors	8 (30.8)	18 (69.2)	26.0	
Total	9 (26.5)	25 (73.5)	34.0	

On comparison of association of various other risk factors and hearing impairment it was found that presence of birth asphyxia (Table 4.1), newborns with hyperbilirubinemia (Table 4.2) and exchange transfusion and those newborns who were on ventilator for > 5 days (Table 4.3) had more chances of hearing impairment, as the p value was <0.05, which is statistically significant. There was no newborn with family history of hearing impairment in the study.

As newborns with TORCH infections, congenital anomalies and meningitis were very less in number, statistical analysis in these cases could not be carried out. Multivariate logistic regression analysis (Table 5) of risk factors lead to a statistically significant association in newborns with hyperbilirubinemia and exchange transfusion, those newborns who were on ventilator for > 5 days, birth weight < 1.5kg and gestational age < 32 weeks, indicating that risk factors independently can affect hearing in newborns.

**Table 4: Comparison of Various Risk Factors with Hearing Impairment**

No. of Risk Factors for Hearing Impairment	Hearing Impairment		Total	p value
	Present (%)	Absent (%)		
<b>4.1. Birth Asphyxia</b>				
Present	12 (35.3)	22 (64.7)	034.0	< 0.05
Absent	27 (10.2)	239 (89.8)	266.0	
Total	39 (13.0)	261 (87.0)	300.0	
<b>4.2. Newborns with and without Hyperbilirubinemia and Exchange Transfusion</b>				
With Hyperbilirubinemia and Exchange transfusion	5 (41.7)	7 (58.3)	012.0	< 0.05
Without Hyperbilirubinemia and Exchange transfusion	34 (11.8)	254 (88.2)	288.0	
Total	39 (13.0)	261 (87.0)	300.0	
<b>4.3. Newborns On Ventilator and without Ventilator</b>				
On Ventilator >5 days	5 (45.5)	6 (11.8)	011.0	< 0.05
Without Ventilator	34 (54.5)	255 (88.2)	289.0	
Total	39 (13.0)	261 (87.0)	300.0	

**Table 5: Multivariate Statistical Analysis of Risk Factors**

Newborns	SE	DF	Significance (p value)	95% Confidence Interval	
				Lower	Upper
Hyperbilirubinmia and Exchange Transfusion	0.905	1	0.023 (< 0.05)	0.022	0.748
Kernicterus	1.460	1	0.148	0.007	2.120
Meningitis	40193.009	1	1.000	----	----
Birth Asphyxia	0.530	1	0.000 (< 0.05)	0.027	0.215
On Ventilator > 5 days	0.800	1	0.027 (< 0.05)	0.036	0.819
Birth weight ≤ 1.5Kg	0.529	1	0.011 (< 0.05)	0.092	0.732
Gestational Age ≤ 32 wks.	0.565	1	0.028 (< 0.05)	0.096	0.875

SE: Standard Error, DF: Degree of Freedom

### Discussion:

Out of 190 normal newborns (without risk factors) (Fig. 2), 8 newborns were having wax in the ears so they were given necessary treatment for certain period and were recalled again for 1<sup>st</sup> TOAE examination after completion of that period, on follow up, however all these 8 newborns did not come back and were lost from the study. In remaining 182 newborns 1<sup>st</sup> TOAE examination was done, out of which 126 had result "PASS" while 56 had result "REFER". These 56 newborns were followed up for 2<sup>nd</sup> TOAE. Out of 56 newborns, 43 newborns had result "PASS" while 3 newborns had result "REFER" whereas 10 newborns did not come up and thus were lost to follow up. The 3 newborns of "REFER" category were called up for further evaluation by BERA. However, these 3 newborns didn't return for BERA examination within study period.

A total of 163 High Risk newborns (Fig. 3) from NICU were sent to ENT department for ear examination, of which 31 newborns were having wax in the ears so they were given treatment and recalled for follow up, from which 10 underwent

1<sup>st</sup> TOAE examination and 21 were lost to follow up. Thus 142 newborns had 1<sup>st</sup> TOAE examination, of these, 50 had result "PASS" while 92 had result "REFER". These 92 newborns were followed up for 2<sup>nd</sup> TOAE. However, 10 newborns were lost to follow up, and 2 expired during study period and thus 80 underwent 2<sup>nd</sup> TOAE. Out of these 80 newborns, 44 newborns had result "PASS" while 36 had result "REFER". These 36 newborns were called for further evaluation by BERA. Out of 36 newborns, BERA examination was performed in 17 newborns while 19 newborns didn't return for BERA examination and thus lost to follow up, within study period. In the BERA examination 2 newborns had normal result while 7 newborns had mild to moderate hearing loss, 6 had moderate to severe hearing loss and 2 had severe to profound hearing loss all of them were advised appropriate amplification device and regular speech therapy. In our study as very few newborns underwent BERA they were not included in statistical analysis. Many of the newborns did not return back for follow up testing protocol, as Surat is an industrious city having a large chunk of the

migratory population, which might have contributed to this category.

The prevalence of hearing impairment was 13% in our study similar to Shahnaz *et al* [7] whereas it was found 8% in Zumani *et al* [8], 3.2% in Elysee *et al* [9], 10% in Alwan *et al* [10] and 28% in Sayed *et al* [11]. The incidence of hearing impairment in NICU was 3.6% in our study, whereas it was 19%, 17%, 5%, and 1% in Gupta *et al* [12], Eden *et al* [13], Meyer *et al* [14] and Nagpoornima *et al* [15] respectively. In newborns < 32 weeks the hearing impairment was 26% in our study. In most of the studies gestational age was not included in risk factors but according to Joint committee on infant hearing 2007 (JCIH) [16], American Academy of Pediatrics Statement gestational age < 32 weeks is an independent risk factor for hearing impairment. Newborns with hyperbilirubinemia and exchange transfusion constituted around 41% in our study, Gisel *et al* [17], Zumani *et al*, Shahnaz *et al* and Muhammad *et al* had 17%, 16%, 29% and 26% of such newborns in their study respectively. The fact that childhood hearing loss has a serious impact on cognitive development, language acquisition and social integration has encouraged many researchers to find out if the hearing impairment in neonates had any pre-disposing risk factors and if detected early, would it be of any beneficial value for early referral and management [18].

The risk of hearing impairment increased in newborns as the number of high risk factors increased.

#### High Risk factors [6, 7, and 16]

1. Familial history of hearing loss.
2. Intrauterine infections (TORCH).
3. Craniofacial abnormalities including pinna anomalies and ear canal agenesis.
4. Hyperbilirubinemia requiring Exchange Transfusion or Kernicterus.
5. Bacterial Meningitis.
6. APGAR scores of less than 4 in the first minute or less than 6 in the fifth minute.
7. Mechanical ventilation for more than 5 days.
8. Birth Weight < 1.5kg.
9. Gestational Age < 32weeks.
10. Manifestations of Congenital Anomalies or Syndromes with hearing loss, such as Usher-Refsun Syndrome, Fetal Alcohol Syndrome (FAS).
11. Ventricular hemorrhage.

#### Conclusion:

Incidence of hearing impairment was 3.6% in newborns admitted in NICU which was as per the existing literature and text. Newborns in high risk group and with high risk factors had hearing impairment of 26.5% as compared to 1.6% incidence in newborns without high risk group.

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\***Author for Correspondence:** Dr. Gurudutt Joshi, Associate Professor, 602, Neel Ganga Apt. Opp. St. Xaviers High School, Near "Tanishq" Ghod Dod Road, Surat - 395007 (Gujarat) India.  
Cell: 09879185696 Email: joshigurudutt@yahoo.com