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Research Article

Clinical correlation between hearing impairment and developmental delay in infants: a prospective cohort study

Geethu Sukumarapilla[1]*, Sharanabasappa S Dhanwadkar[2], Shibily Ruhman M.[1]

[1]Department of Paediatrics, Dr. Somervel CSI Medical College, Trivandrum, India
[2]Department of Paediatrics, DM Wayanad Institute of Medical Science, Kerala, India

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***Correspondence:**
Dr. Geethu Sukumarapilla
E-mail: jeethsukumar@yahoo.in

ABSTRACT

Background: Significant hearing loss is a common disorder at birth, occurring in 1 to 6 per 1000 newborns. Hearing loss leads to delayed language development, difficulties with behavior and psychosocial interactions, and poor academic achievement. Universal newborn hearing screening (UNHS) identifies congenital hearing loss at an earlier age, allowing for earlier interventions. This study aims to assess hearing of all newborns in our hospital, and to find the prevalence of hearing impairment to find out the delay in development for those babies with hearing impairment, and its correlation.
Methods: A prospective cohort study conducted among 1000 newborns in our hospital that were screened for hearing loss. Hearing impaired babies were followed up and developmental assessment was done.
Results: The prevalence of hearing impairment was found to be 0.5%. All the hearing impaired term new born had developmental delay in all four domains.
Conclusions: Hearing impairment is a significant problem in newborn. Hearing impairment can cause delayed development in all domains. So all newborns should undergo hearing screening at birth, and should be kept under follow-up for developmental assessment.

Keywords: Automated auditory brainstem response (AABR), American Academy of Pediatrics (AAP), Automated brainstem response (ABR), Auditory neuropathy (AN), Brainstem evoked response audiometry (BERA), Central auditory processing disorder (CAPD)

INTRODUCTION

Significant hearing loss is a common disorder at birth, occurring in 1 to 6 per 1000 newborns.[1] Hearing loss leads to delayed language development, difficulties with behaviour and psychosocial interactions, and poor academic achievement.

Early intervention with speech and language therapy and amplification (e.g., hearing aids) improves language outcomes. Universal new-born hearing screening (UNHS) identifies congenital hearing loss at an earlier age, allowing for earlier interventions.

The present study is designed to know the impact of hearing impairment on developmental delay in infants selected from Dr SMCSI medical college during the study period. Only a few studies have been done regarding this particular topic.

Previous studies were done to find out the prevalence of hearing impairment in new born and also to find out the risk factors associated with it. However, no study has been carried out to find out the clinical correlation between hearing impairment and developmental delay in various domains of development.

Previous studies were done in different parts of the world showing the prevalence of hearing impairment in different age groups including infancy. A similar study has been done comparing the brainstem evoked response audiometry (BERA) in normal and developmentally

delayed infants.[2] The finding of this study is compared with that of the previous studies to find out the differences if any.

All new-born delivered in our hospital are sent for routine hearing assessment before discharge, this is done to assess and find out any hearing problems, so that early intervention can be given. The method of screening is OAE (Otoacoustic emission). Those babies who fail the1st test are retested within a period of one month by 2nd OAE. Those who fail in the 2nd screening undergoes BERA (Brain Stem Evoked Response Audiometry). The BERA test failed babies will be followed for development delay in all domains at 3, 6 and 9 months.

Otoacoustic emission (OAE) testing is a relatively new screening method suitable for neonatal and infant screening.[3,4] Otoacoustic emissions are sounds generated by normal cochlear hair cells, detectable with relatively simple instrumentation. Data concerning normative standards and reproducibility are now becoming available.[5] Using a cut off of 30 dB to designate hearing impairment, OAE testing has an overall agreement rate with ABR of 91%, with a sensitivity of 84% and specificity of 92%.[6-9]

Brainstem Evoked Response Audiometry-the screening BERA measures the summation of action potentials from the eighth cranial nerve (cochlear nerve) to the inferior colliculus of the midbrain in response to a click stimulus. Other names for this test include the screening (ABR) auditory brainstem response, brainstem auditory evoked response (BERA), and automated auditory brainstem response (AABR). Approximately 4% of infants screened with ABRs are referred for further audiologic evaluation.[10,11] ABR is the screening test needed to detect auditory neuropathy.

Diagnostic testing provides the necessary detail to determine whether hearing loss exists and, if it does, the type, degree, and configuration of the hearing loss. This information is the foundation on which medical and educational intervention decisions are made. The use of any single test to confirm hearing sensitivity is insufficient and not consistent with the recommended best practices.[12]

Parallel in importance to timely diagnostic, testing is the implementation of timely early intervention services. Research has shown that through early identification, appropriate use of hearing technology, and family-centred early intervention services with properly trained professionals, children with hearing loss experience better language, speech, cognitive, and social-emotional development than children who were identified later did not benefit from early intervention services.[13]

Results from a comprehensive longitudinal study in Colorado on the impact of early identification of hearing loss, showed that children who were identified early and received prompt intervention had significantly better vocabulary, language abilities, speech intelligibility, phoneme repertoires, syntax, social-emotional development, parental bonding, and parental grief resolution.[14]

Although efforts to identify and evaluate hearing loss in infants and young children have improved, there is yet any evidence to suggest that many children with hearing loss are not receiving the early intervention they need that ensure their normal development.[15] Neither universal screening nor a high risk screening exists in majority of the hospitals in our country. In such a situation, a centralized facility catering to all hospitals in a given city is a practical option. A two-stage screening protocol is projected, in which infants are first screened with otoacoustic emissions (OAE). Infants who failed are then screened with auditory brainstem response (BERA).

This two tier screening program (the second tier being BERA, which is more expensive) is required only for a selected few, making the program more practical, and affordable. It is the practicability of this program that makes it relevant for replication in other cities of the country, thus making it a model screening program for any developing country.

METHODS

A prospective cohort study was conducted in the Department of Pediatrics, Dr. SMCSI Medical College during period of 2 year with 1000 new-borns. All inborn and out born neonates admitted in NICU and Postnatal ward of Dr SMCSI Medical College.

Inclusion criteria

New-born of any gestational age (includes all preterm, term, post term and all risk factors) are selected for screening for hearing impairment.

Exclusion criteria

1. Parent refusal.
2. Those babies who are having hearing problem and not willing for follow up and treatment.
3. Babies developing seizures during infancy to be excluded from study.
4. Neonates with a craniofacial abnormality were excluded.
5. Babies less than 36 weeks of gestation age are excluded from developmental assessment.

Methodology

- All new-borns fulfilling the above criteria, born in Dr. SMCSI Medical College and Hospital, Karakonam and those new-borns referred from other hospitals for a period of 2 years will be taken for study.
- First they will be screened with OAE (Otoacoustic

Emission) for hearing assessment.

- Neonates who fail OAE first time will be called back again after 2 weeks for re-evaluation with OAE.
- Neonates who fail OAE test 2nd time will undergo BERA test (Brain Stem Evoked Response Audiometry) for a more definitive evaluation.
- Babies who fail BERA test are diagnosed as hearing impaired.
- Babies who are screened and found to have hearing impairment will be assessed for development at 3, 6 and 9 months of age.
- Term babies having 2 combined risk factors (hyperbilirubinemia and ototoxic drugs) for acquired hearing impairment are also screened for developmental delay.
- Serum bilirubin level according to the gestational age as per the AAP guideline is used for determining Hyperbilirubinemia is new-borns.
- The development of these babies will be screened using Denver Developmental Screening Tool (DDST).

RESULTS

Table 1: Gender distribution of new-borns with slightly female predominance.

Sex	Frequency	%
Females	538	53.8
Males	462	46.2
Total	1000	100.0

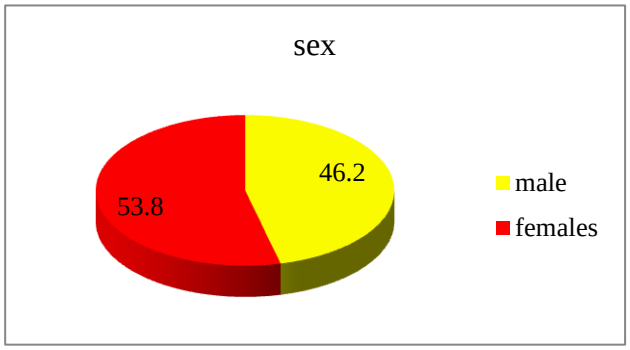

Figure 1: Pie graph showing distribution of males and females.

Figure 1 shows that among the new-born studied 53.8% were Females and 46.2% were Males.

Table 2: Birth weight distribution of new-born.

LBW	Frequency	%
Normal	890	89
LBW	110	11
Total	1000	100.0

The table 2 shows that only 11% of the new-borns were low birth weight (Weight<2.5kg).

Table 3: Mean birth weight of new-born babies.

	N	Minimum	Maximum	Mean	SD
Birth weight in Kg	1000	0.8	4.0	2.801	0.3

Table 3 shows that the mean birth weight of babies in this study is 2.8kg.

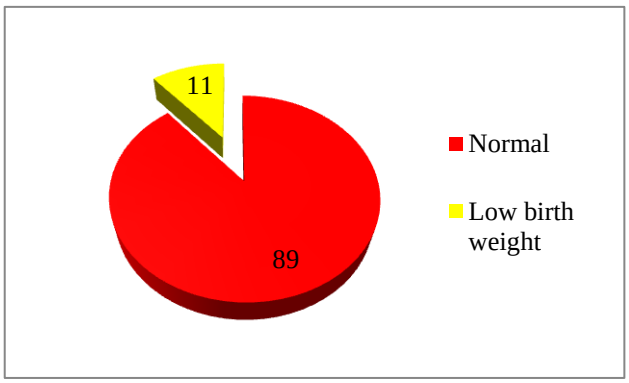

Figure 2: Pie graph showing distribution of low birth weight babies among total new-borns.

Figure 2 shows that among the total new-born studied only 11% were low birth weight, remaining 89% have a birth weight more than 2.5 kg.

Table 4: Distribution of babies born term and preterm.

Gestation	Frequency	Percent
Term	884	88.4
Preterm	116	11.6
Total	1000	100.0

Table 4 shows that preterm babies constitute 11.6% of the total new-born studied.

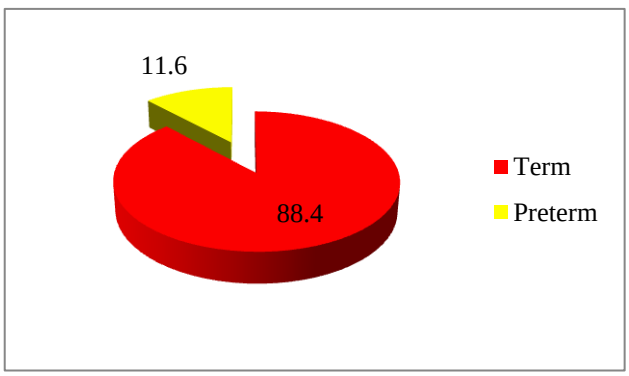

Figure 3: Pie graph showing distribution of term and preterm babies (gestation< 37 weeks).

Figure 3 shows that among the total new-born studied 11.6% constitutes preterm babies rest 88.4% were babies born with gestation age >37 wks.

Table 5: Hyperbilirubinemia and normal bilirubin level.

Hyperbilirubinemia	Frequency	%
Absent	863	86.3
Present	137	13.7
Total	1000	100.0

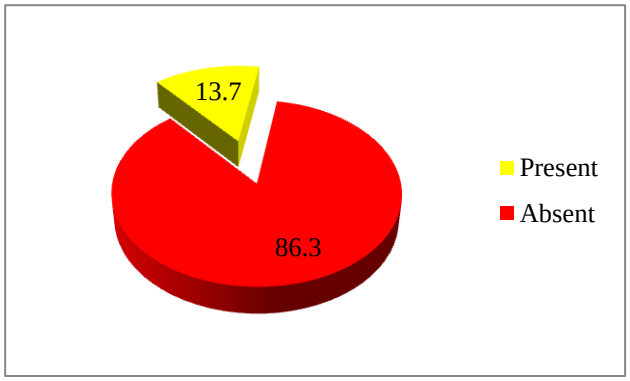

Figure 4: Pie diagram showing distribution of hyperbilirubinemia among total new-born.

Table 6: Distribution of new-borns treated with ototoxic drugs.

Ototoxic drugs	Frequency	%
Not given	939	93.9
Given	61	6.1
Total	1000	100.0

Table 6 shows that 6.1% of the total new-borns studied got treatment with ototoxic drugs.

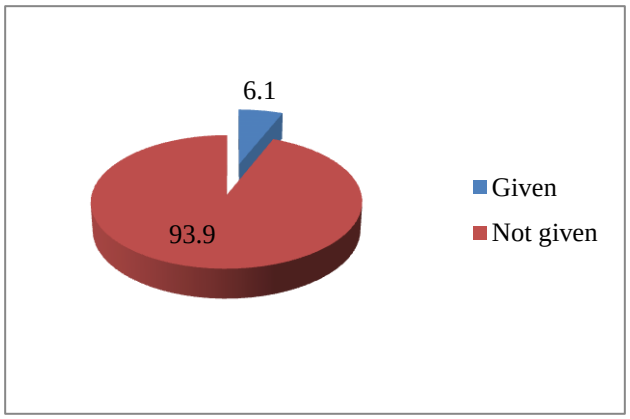

Figure 5: Pie diagram showing distribution on new-borns treated with ototoxic drugs.

Figure 5 shows that 6.1% of the total new-borns got treatment with ototoxic drugs.

Table 7: Hearing impaired children among the total new-born.

Hearing assessment	Frequency	%
Normal	995	99.5
Impaired	5	0.5
Total	1000	100.0

Table 7 shows that 0.5% of the new-borns studied had hearing impairment.

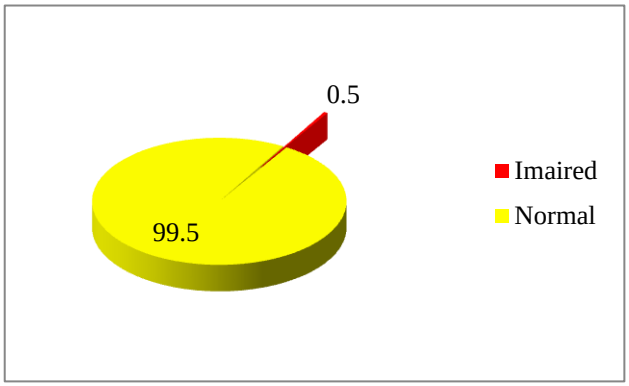

Figure 6: Pie diagram showing distribution of hearing impairment among new-borns.

Figure 6 shows that the prevalence of hearing impairment is 0.5%.

Table 8: Correlation of developmental delay in hearing impaired babies.

Gross motor	Hearing assessment		Total
	Normal	Impaired	
Not assessed	987	1	988
No delay	8	0	8
Delay	0	4	4
Total	995	5	1000

Table 8 shows that total 5 babies were hearing impaired. Development assessment was done for all term babies with hearing impairment and all of them had gross motor delay.

Table 9: Hearing assessment and fine motor delay.

Fine motor	Hearing assessment		Total
	Normal	Impaired	
Not assessed	987	1	988
No delay	8	0	8
Delay	0	4	4
Total	995	5	1000

Table 9 shows that total 5 babies were hearing impaired. Development assessment was done for all term babies with hearing impairment and all of them had Fine motor delay.

Table 10: Hearing assessment and language delay.

Language	Hearing assessment		Total
	Normal	Impaired	
Not assessed	987	1	988
No delay	4	0	4
Delay	4	4	8
Total	995	5	1000

Table 10 shows that total 5 babies were hearing impaired. Development assessment was done for all term babies with hearing impairment and all of them had language delay.

Table 11: Hearing assessment and personal social developmental delay.

Personal social	Hearing assessment		Total
	Normal	Impaired	
Not assessed	987	1	988
No delay	5	0	5
Delay	3	4	7
Total	995	5	1000

Table 11 shows that total 5 babies were hearing impaired. Development assessment was done for all term babies with hearing impairment and all of them showed personal social developmental delay.

Table 12: Result of developmental assessment of at risk babies for acquired hearing impairment.

Gestation			Jaundice + ototoxic drug		Total
			Absent	Present	
Term	Gross motor	Not assessed	872	0	872
		No delay	0	8	8
		Delay	3	1	4
	Total		875	9	884
Preterm	Gross motor	Not assessed	101	15	116
	Total		101	15	116

Table 12 shows that of the 1000 babies 884 babies were term babies, rest 116 babies were preterm babies. Among the 884 babies 9 babies had both hyperbilirubinemia and were treated with ototoxic drugs, so was having risk for developing acquired hearing impairment. Developmental assessment done in those 9 babies shows that only 1 baby had gross motor delay.

Table 13: shows that of the 1000 babies 884 babies were term babies, rest 116 babies were preterm babies. Among the 884 babies 9 babies had both hyperbilirubinemia and were treated with ototoxic drugs, so was having risk for developing acquired hearing impairment. Developmental assessment done in those 9 babies shows that only 1 baby had fine motor delay.

Table 13: Developmental assessment-fine motor delay in babies high risk babies.

Gestation			Jaundice+ ototoxic drug		Total
			Absent	Present	
Term	Fine motor	Not assessed	872	0	872
		No delay	0	8	8
		Delay	3	1	4
	Total		875	9	884
Preterm	Fine motor	Not assessed	101	15	116
	Total		101	15	116

Table 14: Development assessment-language delay in high risk babies.

Gestation			Jaundice+ ototoxic drug		Total
			Absent	Present	
Term	Language	Not assessed	872	0	872
		No delay	0	4	4
		Delay	3	5	8
	Total		875	9	884
Pre-term	Language	Not assessed	101	15	116
	Total		101	15	116

Table 15: Development assessment-personal social domain in high risk babes.

Gestation			Jaundice+ ototoxic drug		Total
			Absent	Present	
Term	Personal social	Not assessed	872	0	872
		No delay	0	5	5
		Delay	3	4	7
	Total		875	9	884
Pre-term	Personal social	Not assessed	101	15	116
	Total		101	15	116

Table 14 shows that of the 1000 babies 884 babies were term babies, rest 116 babies were preterm babies. Among the 884 babies 9 babies had both hyperbilirubinemia and were treated with ototoxic drugs, so was having risk for developing acquired hearing impairment. Developmental assessment done in those 9 babies shows that 5 baby had language delay.

Table 15 shows that of the 1000 babies 884 babies were term babies, rest 116 babies were preterm babies. Among the 884 babies 9 babies had both hyperbilirubinemia and were treated with ototoxic drugs, so was having risk for developing acquired hearing impairment. Developmental assessment done in those 9 babies shows that 4 baby had language delay.

DISCUSSION

The term congenital hearing loss means the hearing loss is present at birth. Congenital hearing loss can be caused by genetic or non-genetic factors. Non-genetic factors can account for about 25% of congenital hearing loss. Hearing-impaired children identified very lately are at risk of substantial delay in their acquisition of communication and language skills, with consequent longer-term risk to mental health, education achievement, and quality of life. The ramifications of childhood hearing impairment, a few of which include delayed language, learning, and school performance, are readily accepted worldwide. Upon investigation of the effects of new-born screening and subsequent early intervention on language outcomes for children, the results overwhelmingly indicate that early intervention for children with hearing loss is associated with later beneficial language outcomes.

This is a prospective cohort study starting from1st January 2013 to 1st November 2014. During this study period, 1000 new-borns including both inborn and out-born were screened for hearing, and those babies with hearing impairment were followed for their progress in development and found out the 'Clinical correlation between hearing impairment and developmental delay'. Of the 1000 babies screened, 5 were hearing impaired.

Comparison of gender distribution in study

Current Sex Ratio of India in 2014 is 940 Females/1000 Males. The states of South India have the best Sex Ratio of females per 1000 males. Kerala with 1084 females per 1000 males has the highest sex ratio according to 2011 Census of India. In this study the females constitute 53.8% while the males constitute 46.2%. That is Females >Males.

Comparison of low birth-weight in study

In this study the incidence of low birth weight is 11%, which is low when compared with other studies by Misra M et al which had a prevalence of low-birth weight of 23%. And by Bhat BV et al with an incidence of low birth weight of 19% in India.[16,17]

Comparison of gestational age

Preterm birth is defined as birth before 37 completed weeks gestation, and it is estimated that each day, across the world over 41,000 infants are born before this gestational age. Worldwide an estimated 10% of all births are preterm. India, were 13% of births are preterm, contributes 24% of the global total of preterm births, as suggested by Blencoweh et al.[18] In a study by Platt MJ et al the incidence of preterm delivery was 10%.[19] In this study the incidence of preterm babies are 11.4%, in corresponding to the other studies

Comparison of hyperbilirubinemia

Studied from different part of the world shows that hyperbilirubinemia is a common problem in the new-borns. A cord blood bilirubin as well as 48 hour serum bilirubin value is checked and hyperbilirubinemia is estimated using AAP guidelines. A study by Sarici SU et al shows that the incidence of hyperbilirubinemia is 10.5%.[20] Another study by Sciutoetal M shows that the incidence of jaundice in new-born is 19%.[21] A Pakistani study shows incidence 27%.[22] This study shows that the incidence of hyperbilirubinemia is 13.7%, which is low when compared to 2 studies worldwide.

Prevalence of hearing impairment

A study by US Preventive Services Task Force shows that the prevalence of hearing impairment is 1-2/ 1000 live birth. .Another study shows that the prevalence of hearing impairment 1 in 900-2500 live birth.[23] A study from Cochin by Abraham Paul shows that the incidence of 0.98 in low risk babies and 10.5% in high risk babies.[24] In this study the incidence of hearing impairment is 0.5%.

Comparison of Hearing Impairment and development

It is well recognized fact that hearing is critical to language development and, speech learning, communication and. Children with hearing loss or auditory processing problems continue to be an under identified and underserved population. The earlier hearing loss occurs in a child's life, more serious is the effects on the child's development. It has been also studied by Ho PT et al that language and communication deficits that are often mistakenly attributed to hearing loss.[25] Another study by Edwards LC et al, shows that significant developmental delay is predictive of poor outcomes, for cochlear implant. And so early identification of delay is a must for better outcome of treatment for hearing impairment, like cochlear implant.[26]The study conducted by Rajendran V et al shows that motor developmental delay can occur in hearing impaired children.[27]

CONCLUSION

From present study we concluded that, Hearing impairment is a significant problem in new-born. Hearing impairment can cause delayed development in all domains. So all new-borns should undergo hearing screening at birth, and should be kept under follow-up for developmental assessment.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. US Preventive Services Task Force. Universal screening for hearing loss in new-borns: US Preventive Services Task Force recommendation statement. Paediatrics 2008; 122:143.
2. Comparative study of brainstem evoked response audiometry in developmental delayed infants and normal healthy infants. Int J Biol Med Res. 2014;5(3):4261-4.
3. Morgan DE, Canalis RF. Auditory screening of infants. OtolaryngolClin North Am. 1991;24:277-84.
4. Kennedy CR, Kimm L, Cafarelli Dees D, et al. Otoacoustic emissions and auditory brainstem responses in the newborn. Arch Dis Child. 1991;66:1124-9.
5. Abdo MH, Feghali JG, Stapells DR. Transient evoked otoacoustic emissions: clinical applications and technical considerations. Int J Pediatr Otorhinolaryngol. 1993;25:61-71.
6. Bonfils P, Dumont A, Marie P. Evoked otoacoustic emissions in newborn hearing screening. Laryngoscope. 1990;100:186-9.
7. Lafreniere D, Jung MD, Smurzynski J. Distortion-product and click-evoked otoacoustic emissions in healthy newborns. Arch Otolaryngol. 1991;117:1382-9.
8. Chuang SW, Gerber SE, Thornton ARD. Evoked otoacoustic emissions in preterm infants. Int J Pediatr Otorhinolaryngol. 1993;26:39-45.
9. Probst R, Harris FP. Transiently evoked and distortion-product otoacoustic emissions: comparison of results from normally hearing and hearing-impaired human ears. Arch Otolaryngol. 1993;119:858-60.
10. Pickett BP, Ahlstrom K. Clinical evaluation of the hearing-impaired infant. Otolaryngol Clin North Am. 1999;32:1019.
11. VanStraaten HL. Automated auditory brainstem response in neonatal hearing screening. Acta Paediatr Suppl. 1999;88:76.
12. Buz Harlor AD, Bower C. Hearing Assessment in Infants and Children: Recommendations Beyond Neonatal Screening. Pediatrics. 2009;124(4):436.
13. Kennedy. Language Ability after Early Detection of Permanent Childhood Hearing Impairment. N Engl J Med. 2006;354:2131-41.
14. National Center for Hearing Assessment and Management. NCHAM, 2010.
15. Epidemiology of low birth weight in an industrial area in India. Misra M, Mishra S, Sharadamma . J Trop Pediatr. 1995;41(6):374-6.
16. Bhat BV, Adhisivam B. Trends and outcome of low birth weight (LBW) infants in India. Indian J Pediatr. 2013;80:60-2.
17. Blencowe H, Cousens S, Oestergaard MZ, Chou D, Moller A, Narwal R. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. Lancet. 2012;379:2162-72.

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