# Outcome of a Newborn Hearing Screening Program in a Tertiary Care Center, South India

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## Abstract

**Objective:** Using data from a four year period, the authors evaluated the Universal Newborn Hearing Screening (UNHS) Program in the Government Medical College Manjeri, South India. The prevalence of hearing loss (HL) among screened children, description of confirmed case characteristics, and documentation of speech and language development acquired by children at follow up are discussed.

**Design:** Hospital based retro-prospective study.

**Method:** Data were collected from all newborns who underwent UNHS from November 2014 to October 2018. Confirmed HL cases were studied by pre-structured questionnaire and telephone interview. Speech and language assessments of 10 confirmed cases were conducted after an intervention period.

**Results:** 16,625 of 17,260 babies were screened (96.3%). Thirteen infants had confirmed HL (prevalence rate = 0.08%) and 61.5% of those with HL did not have risk factors. Median confirmation age was 6 months with an Interquartile Range (IQR 4–12). Median age of speech therapy and hearing aids was 17.5 months (IQR 13–25) and the median duration of intervention before assessment was 30 months (IQR 17–43). Three children were lost to follow up. The remaining 10 children received speech therapy; five children used hearing aids, five required cochlear implants at a median age of 24 months (IQR 17.5–33). Eight children showed a lag in speech and language development after assessment, with a median delay of 19.3 months (IQR 2–34.5).

**Conclusions:** Program coverage was optimal, with most newborns successfully screened. More than half of the confirmed children did not exhibit risk factors for HL and might not have been identified early without UNHS. The observed median age of starting intervention for confirmed cases was higher than the age recommended by AAP guidelines and most of the children had language development below those of children with typical hearing after months of intervention.

**Key words**: Universal Newborn Hearing Screening, outcome, otoacoustic emission, hearing loss, neonates

**Acronyms**: ABR = auditory brainstem response; DPOAE = distortion product otoacoustic emissions; HL = hearing loss; ISD = Integrated Scale of Development; REELS = Receptive Expressive Emergent Language Scale; UNHS = universal newborn hearing screening

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Hearing loss is one of the most common congenital conditions seen in newborns. One to three per 1000 newborns and 2 to 4% in Newborn Intensive Care Unit (NICU) have hearing loss (Dedhia et al., 2018; Erenberg et al.,1999; Parving et al., 2003). According to the World Health Organization, it is estimated that about 7.5 million children around the world have a significant problem with hearing (Dedhia et al., 2018). Hearing loss can have a great impact on a child's development. Failure to identify newborn babies with hearing loss early in life may result in delayed development of speech and language, poor academic achievements, and deficient social and emotional development (Haddad et al., 2019; Stevenson et al., 2010, Yoshinaga-Itano et al.,1998).

The peripheral auditory organs are completely developed at birth, but proper development of the auditory cerebral cortex requires appropriate sound stimulation especially in the first 2 to 3 years after birth. After this period, regardless of hearing rehabilitation, the brain's plasticity starts decreasing and the development of spoken language is limited (Ruben & Rapin, 1980). It has been shown that children diagnosed with hearing loss at an earlier age of about 6 months followed by early interventions including speech therapy, hearing aid, and cochlear implantation, often achieve normal or near normal spoken language development (Yoshinaga-Itano, 2004). Without universal screening for hearing loss, hearing problems may not be detected early for many children and once hearing loss is detected, it may be too late for them to receive optimal benefit from intervention.

Universal Newborn Hearing Screening (UNHS) helps to ensure early detection of hearing loss and to execute effective interventions as early as possible (Yoshinaga-Itano, 2003). The American academy of Pediatrics (AAP) recommends screening for hearing loss be completed by 1 month of age, confirmation by 3 months of age, and early intervention by the age of 6 months (AAP, 2010; Joint Committee on Infant Hearing [JCIH], 2007, 2019; Mehl, & Thomson, 2002). According to the JCIH 2019 Position statement, it is recommended that those states who have achieved the benchmark of 1-3-6 months, should try to achieve the 1-2-3 months timeline (JCIH, 2019).

For the last two decades, UNHS has been initiated in many countries in the world as a cost effective practice for standard newborn care (Korver et al., 2017). The implementation of UNHS in developed countries is extensive. Approximately 98% of newborn babies are screened in United States (Centre for Disease Control and Prevention, 2019). A retrospective study in England analyzing the screening for nine years showed that 98.9% of infants are screened by 3 months of age (Wood et al., 2015). Many studies conducted around the world have shown that UNHS helps in improving the early detection of hearing loss (Dedhia et al., 2018).

According to the World Health Organization (WHO), the majority of children who suffer from hearing loss are from developing countries of South Asia, Sub Saharan Africa and Asia Pacific (World Health Organization, 2018). African countries lack mandatory screening strategies at present and there is only 24% reported coverage for hearing screening (Theunissen & Swanepoel, 2008). Thus, implementation of UNHS in resource-constrained and developing countries is very important, but at the same time challenging. A staged approach should be adopted for implementation of universal screening by initially targeting the coverage of high risk groups, followed by universal screening (Das et al., 2020).

Nationwide UNHS is not yet started in many developing countries. In India, at present, it is done at sub-national level or district wise only (Singh, 2015) and not implemented uniformly across the country (Galhotra & Sahu, 2019). Another study revealed that only 38% of medical colleges in India have a newborn screening program (Kumar & Mohapatro, 2011).

In 2006, the Government of India launched the National Program for Prevention and Control of Deafness (NPPCD). The main goal of this program was to prevent and control hearing loss and to rehabilitate people of all age groups with hearing problems. Institution-based and community-based screening programs are being implemented in several districts of the country under this program (Galhotra & Sahu, 2019). Community-based programs are mainly targeting those babies born at home. Rashtriya Bal Swasthya Karyakram (RBSK) is another program launched in 2013 which is an important initiative involving child health screening and early intervention services for children 0 to 18 years of age for birth defects including congenital hearing loss, developmental delays, and other disabilities (Galhotra & Sahu, 2019).

A centralized screening facility for universal hearing screening was established in Cochin, Ernakulam district of Kerala, South India in 2003, which included 20 major hospitals (Paul, 2011, 2016). UNHS started in the Government Medical College Manjeri, Kerala in November 2014 and has been continuing successfully until now. The current study was planned to look at the coverage and gaps in implementation of the program, and provide corrective measures for improvement.

**Objectives**

The objectives of this study were to determine the coverage and the outcome of the Universal Newborn Hearing Screening Program at Government Medical College, Manjeri, Kerala, South India and to determine the prevalence of hearing loss among those babies who were screened. Secondary objectives were to assess the characteristics of confirmed cases, the interventions carried out, and the status of speech and language development after intervention had been initiated.

**Materials & Method**

This was a hospital based retrospective study. Distortion product otoacoustic emissions (DPOAE) was used for screening in our hospital. In DPOAE, frequency specific pure tone stimuli is delivered to the ear through the instrument probe. The frequency range of 2kHz to 5kHz was used. The model of instrument used in our hospital was Interacoustics Titan. A signal to noise ratio (SNR) of > 6 dB in 3 out of 4 frequencies tested was labeled as *pass*. Those cases who failed the screening were labeled as *refer*. For confirmation, we used Intelligent Hearing Systems (IHS) Solo ABR (auditory brainstem response). The stimuli used were clicks and tone burst at a rate of 11.1 and at 500Hz, 30dB nHL was taken as threshold for HL, and a filter of 30 to 3000Hz was used.

A trained nurse conducted hearing screening. The protocol followed for newborn hearing screening in our institution was to complete DPOAE for all newborns admitted in the hospital (both inborn and outborn) 24 hours after birth, but before discharge from the hospital. Those who passed screening with no risk factors for hearing loss (JCIH, 2019) were discharged. If they had risk factors, they were advised to repeat DPOAE every 6 months until 3 years of age.

The refer cases were called back at 6 weeks of age and the screening test was repeated. To decrease the dropout rate, the screening test was completed at routine immunization so that an extra hospital visit for hearing screening was avoided.

Those babies who failed the second screening test (refer) were sent to the Audiology Department of our institution for confirmatory test by ABR and once the hearing loss was confirmed, babies were referred to other facilities for specific interventions like cochlear implantation, which was not available in our hospital. The details of all the

confirmed cases, including the interventions done, were maintained by a separate registry in our hospital, and the Audiology Department followed up with them.

During the 3 month study period of October 2019 to December 2019, the authors collected data from babies born during a 4 year span (November 2014 to October 2018). The follow-up of confirmed cases was completed during the month of December 2020. Permission to conduct the study was obtained from the hospital ethical committee (Ref No: IRC/GMCM/33(2)). Data included total number of deliveries, screened babies, missed cases, follow up cases, total number of pass or refer cases, total number of high-risk babies screened and number of babies who failed the screening among high-risk groups. Details of the confirmed cases were collected from the hospital follow up registry, including phone numbers of the parents. The parents were contacted by telephone. The questionnaire included patient's demographic details, time of confirmation of diagnosis, and time and type of interventions and risk factors for hearing loss as per the AAP guideline (JCIH, 2019).

The cases were reviewed during the month of December 2020. There was a delay in getting these families to the hospital because of the prevailing Covid-19 pandemic. Children were assessed using the Integrated Scale of Development (ISD; Cochlear, 2010) and the Receptive Expressive Emergent Language Scale (REELS; Bzoch & League,1971; Nair et al., 2013) with the help of an audiologist. These scales were used to assess the speech and language development of children in the Audiology Department. The speech and language development of each child at the time of follow-up was documented.

ISD incorporates different stages of development of listening, receptive and expressive language, speech, cognition, and social communication. Using this scale, children were assessed to discover the language development achieved at the time of follow up. REELS assesses different aspects of linguistic behavior which include receptive language and expressive language. Receptive Language Age , Expressive Language Age, and Combined Language Age of each child was calculated with REELS and compared with the chronological age of the child. As per our institutional policy, any delay of more than 6 months from chronological age was taken as a significant delay.

The data collected were statistically analyzed with the help of a statistician. Outcome was measured in terms of coverage of screening, prevalence of hearing loss, and percentage of cases identified as refer cases at each screening. The prevalence of hearing loss among the study group was calculated. For confirmed cases, median age of detection of hearing loss, median age of diagnosis confirmation, median age of starting interventions, median age of cochlear implantation, and median age of delay in speech and language development were determined. Qualitative variables were summarized as frequency and percentages and presented in Tables 1 through 3. Quantitative variables were summarized as Median and Inter quartile range (IQR).

**Results**

A total of 17,260 babies were born during the study period, out of which 16,625 babies were screened (96.3%) through the newborn hearing screening program in our hospital. Among 16,625 newborns, there were 1057 (6.4%) refer cases after the first screening. Out of these 1057 babies, 998 (94.4%) were followed up and 59 were lost in follow up. Out of 998 babies, the second screening yielded 16 (1.6%) refer cases. Three out of 16 refer cases subsequently tested normal by auditory brainstem response and 13 babies were confirmed to have hearing loss (0.08%). Eight out of 13 confirmed cases (61.5%) did not have any risk factors for hearing loss.

The main risk factors for hearing loss identified in this study are shown in Table 1 and included the following: family history of childhood hearing loss, NICU admission and use of aminoglycosides, and neonatal jaundice treated by exchange transfusion.

**Table 1**
*Risk Factors Identified in Confirmed Cases of Hearing Loss (n = 13)*

| Risk factor identified | Total no. | Percentage (%) |
|---|---|---|
| Family history of hearing loss | 2 | 15.4 |
| NICU admission | 2 | 15.4 |
| Newborn jaundice treated by exchange transfusion | 1 | 7.7 |
| No risk factors | 8 | 61.5 |

The clinical characteristics of the patients with confirmed hearing loss is shown in Table 2. The majority (84.6%) were full-term babies, with no gender preponderance. No risk factors for hearing loss were evident in 61.5% of cases.

**Table 2**
*Clinical Characteristics of Confirmed Cases (n = 13)*

| Characteristics | | Number (%) |
|---|---|---|
| Gender | Male | 6 (46.2) |
| | Female | 7 (53.8) |
| Birth weight | ≥ 2.5kg | 7 (53.8) |
| | < 2.5kg | 6 (46.2) |
| Gestational Age | Term (≥ 37wks) | 11(84.6) |
| | Preterm (< 37wk) | 2 (15.4) |
| High risk group | Yes | 5 (38.5) |
| | No | 8 (61.5) |

Median age of confirmation by ABR was 6 months (IQR 4–12). The lower age limit of confirmation was 2 months, and the upper age limit was 14 months. The median age of starting interventions like speech therapy and hearing aids was 17.5 months (IQR 13–25). The lower and upper age limit of starting interventions were 12 months and 26 months respectively. Median age for cochlear implants among confirmed cases was 25 months (IQR 17.5–33). The lower age limit was 17 months and upper age limit was 41 months. Median duration of intervention at the time of assessment was 30 months (IQR 17–43).

Five out of 13 children (38.5%) were managed by cochlear implant and speech therapy, free of cost using Government funds. Five children (38.5%) were managed by hearing aids and speech therapy only. Two children (15.3%) with mild hearing loss were managed by speech therapy alone. One child with global developmental delay, was bedridden

and managed conservatively by physiotherapy alone, without any intervention for hearing loss.

Out of the 13 children with hearing loss, only 10 (76.9%) children turned up for review and language assessment. Those included four cases with cochlear implant, three cases with hearing aid and speech therapy, and two cases who received speech therapy alone. The remaining one child had global developmental delay along with hearing loss, and did not receive any type of intervention. Three were lost to follow up (23.1%). After assessing the speech and language, it was noted that eight children showed a lag in speech and language development as evidenced by a delayed combined language age. The language assessment using REELS and the ISD scale is given below (Table 3). The results of ISD were similar to REELS. There was a median delay of 19.3 months in language development (IQR 2–34.5).

**Table 3**
*Speech and Language Assessment in Confirmed Cases (n = 10)*

| Age | Sex | Diagnosis | Interventions Done | Assessment by REELS (months) | | | ISD (months) |
|-----|-----|-----------|-------------------|------|------|------|------|
| | | | | RLA | ELA | CLA | |
| 5 years 4 months | M | B/L profound HL | Cochlear Implant | 33–36 | 33–36 | 33–36 | 31–36 |
| 3 years 5 months | F | B/L profound HL | Nil | 0–3 | 0–3 | 0–3 | 0–3 |
| 5 years 6 months | M | B/L profound HL | Cochlear Implant + Speech Therapy | 42–48 | 42–48 | 42–48 | 31–36 |
| 3 years 7 months | M | B/L severe-profound HL | Hearing Aid + Speech Therapy | 24–27 | 24–27 | 24–27 | 16–18 |
| 5 years 1 month | M | B/L mild HL | Speech Therapy | 54–60 | 54–60 | 54–60 | --- |
| 3 years 10 months | F | B/L profound HL | Cochlear Implant + Speech Therapy | 30–33 | 30–33 | 30–33 | 31–36 |
| 3 years 9 months | M | B/L severe-profound HL | Hearing Aid + Speech Therapy | 20–22 | 20–22 | 20–22 | 16–18 |
| 4 years 8 months | F | B/L severe HL | Hearing Aid + Speech Therapy | 18–20 | 18–20 | 18–20 | 16–18 |
| 6 years | M | B/L profound HL | Cochlear Implant + Speech Therapy | 42–48 | 42–48 | 42–48 | 31–36 |
| 1 year 9 months | F | (R) mild HL | Speech Therapy | 22–24 | 22–24 | 22–24 | 19–24 |

*Note.* HL = hearing loss; B/L = bilateral; REELS = Receptive Expressive Emergent Language Scale; RLA = receptive language age; ELA = expressive language age; CLA = combined language age; ISD = Integrated Scale of Development.

## Discussion

Coverage of the UNHS program in this study is 96.3% which is optimal per AAP guidelines. It is comparable to a study from Malaysia in which the coverage was around 98% (Ahmad et al., 2011). Like our study, Ahmad et al. (2011) was a hospital-based study and screening was done by DPOAE. But our coverage is higher compared to a study from China which was a population-based study in the rural areas of China where the coverage of screening was 89.2%. The screening method used in that study was transient evoked OAE (TEOAE; Guanming et al., 2012).

There was a high refer rate after the first screening in our study. This may be due to the fluid in the middle ear cavity (middle ear effusion) or residual debris which is normally seen in ears of newborns as observed in many other studies (Boone et al., 2005, Boudewyns et al., 2011). Referred cases were less in our study compared to the study from China (Guanming et al., 2012).

The prevalence of hearing loss in this study was low compared to the study from Germany which was a population-based study in which the prevalence was 2.32 per 1000 newborns (Rissmann et al., 2018) and also

compared to another hospital-based study from Benin city, where the prevalence was 6.5% (Amina et al., 2010). It was less when compared to the Hearing Screening and Follow-up Survey (HSFS) in United States, in which the prevalence rate was 1.7 per 1,000 babies screened (CDC, 2019). In our study we had 59 (5.6%) refer cases who were lost after the first screening. They might have done the repeat OAE at 6 weeks from their nearby hospital and been diagnosed as HL elsewhere. This could be a reason for low prevalence in our study.

The percentage of confirmed cases with no risk factors for hearing loss was 61.5%. In a similar study from the Ernakulum district, Kerala, India, only 29.6% cases did not exhibit risk factors (Paul, 2011). This was low compared to our study and shows the importance of universal screening of all babies early in their life for detection of hearing loss since hearing loss can be present without risk factors.

In our study there was a delay in the age of confirmation by ABR and age of starting intervention of confirmed cases when compared to the recommended AAP guidelines (JCIH, 2019). Similar findings were obtained in a study done from Saudi Arabia in which mean age of confirmation was 20 months and mean age of intervention was 25 months (Alshawi et al., 2019). But in a study from Germany, median age of confirmation was 3 months of age and median age of starting intervention was 4 months of age (Rissmann et al., 2018).

This delay in age of confirmation and age of starting intervention may be due to the inadequate human resources available for newborn hearing screening and follow up in the public sector and limited availability of screening equipment. More orientation programs for health workers and social workers are needed to educate stakeholders about the importance of proper follow up of confirmed cases. The success of any screening program depends mainly on the early intervention and management of diagnosed cases. Also, procurement of more equipment and timely maintenance of the same is very crucial. More detailed studies should be conducted to find out the exact reason for this delay.

The treatment and rehabilitation of all the confirmed cases were free of cost, under Government plans. Five children received cochlear implants, 5 received hearing aids and all these 10 were enrolled in speech therapy. Three children among the total 13 were lost to follow up. Of the remaining 10 children, eight had not achieved age-appropriate speech and language after a median duration of intervention of 30 months. There was a gross delay when compared to the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study which included 470 deaf Australian children whose hearing loss was diagnosed by newborn hearing screening. In the LOCHI study, 72% of the screened group who received early intervention in the form of hearing aids before 6 months of age had better language outcome at the age 5 years (Ching & Leigh, 2020). Finally, in our study two children, who had mild hearing loss, received speech therapy alone

and had normal speech. The remaining one child had global developmental delay; parents were not that keen and motivated to go for any treatment.

**Limitations of the Study**

Data was gathered from a single Centre; hence, the prevalence may not be a true representation of the population. Availability of single machine and single personnel for the screening was a major technical limiting factor for timely completion of the hearing screening.

**Conclusion**

The coverage of the newborn hearing screening program in our hospital was optimal. The prevalence of hearing loss in our study was 0.08%. The study highlights the importance of universal screening for hearing loss, because the majority of the confirmed cases in this study did not have the risk indicators associated with hearing loss. Children with hearing loss usually appear normal at birth without any complaints. They could be identified only because of the universal screening of all newborns. The study also emphasizes the importance of proper follow up of the confirmed cases as there was a time delay of about 12 months from the time of confirmation to the time of intervention. Also, eight children who had undergone interventions, did not achieve age-appropriate speech and language development. Thus, this study also emphasizes the importance of timely intervention following confirmation of the cases. We have to ensure adequate human resources and proper infrastructure. A multidisciplinary team of Neonatology, Pediatrics, Otorhinolaryngology, Audiology, Auditory verbal, and speech therapy should be available for different stages in the screening process and management to insure the timely identification, diagnosis, and management of children with hearing loss. Regular follow up of these children, including regular assessment of speech and language development, is also important.

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### NEWBORN HEARING SCREENING PROGRAM

Hearing loss is more common than any other condition screened for at birth. As many as 3 to 4 out of every 1,000 babies in the United States are born with some level of hearing loss. Based on that estimate, 33 to 44 babies are born with hearing loss in South Dakota each year.

The Department of Health Newborn Hearing Screening Program recommends that:

- All babies be screened by **1 month** of age, preferably before leaving the hospital,

- If after 2 screenings the baby does not pass, a medical and hearing evaluation is needed before **3 months**, and

- Once hearing loss is detected, services and intervention should be started by **6 months** of age.

*The following videos were produced by the South Dakota Early Hearing Detection and Intervention Collaborative*

EHDI
Early Hearing Detection & Intervention
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Early Hearing Detection Intervention - English
**EARLY HEARING DETECTION INTERVENTION**
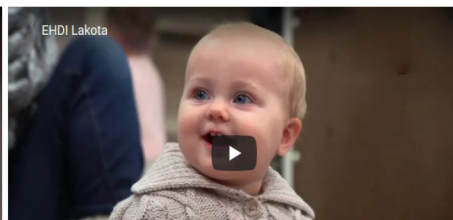
EHDI Lakota
**O'THOKAHE NAGHUN WOIYTHE PASIYAKEL WIČ'OS'KUN**

Early Hearing Detection Intervention - Spanish
**INTERVENCIÓN TEMPRANA DETECCIÓN AUDITIVA**