

# Auditory Screening in Infants for Early Detection of Permanent Hearing Loss in Northern Iran

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## Abstract

**Background:** Undiagnosed hearing loss can cause disorders in speech and language and delay in social and emotional development. **Aim:** This study aimed to screen for hearing loss in all newborns born in Babol city during 2009-2011. **Subjects and Methods:** Fifteen thousand one hundred and sixty-five newborns (49% [7430/15165] male and 51% [7735/15165] female) born during a 30-month period in Babol, underwent hearing screening by the otoacoustic emission (OAE) test at the age of 15 days. In infants referred at this stage, an auditory brainstem response (ABR) test was the next investigation. Data analyzed using Statistical Package for the Social Sciences software Version 16 (Chicago, IL, USA, 16) through descriptive statistic method. **Results:** In the first screening stage, 10.8% (1648/15165) cases were referred to the second stage for further investigation. 9.4% (154/1648) were lost to follow-up from among the referred cases despite continuous contact and education about the importance of the problem. Among the participants in the second stage, 6.2% (92/1494) were referred to the third stage and underwent ABR and OAE testing. 14.1% (13/92) were lost at this stage. Of the remaining participants, 34.2% (27/79) were diagnosed with a hearing loss. Therefore, the incidence of hearing loss in this study was 1.8/1,000 newborns. **Conclusion:** Given the prevalence of hearing loss in this study, implementation of a universal newborn hearing screening program is recommended.

**Keywords:** Africa, Hearing screening, Neonate

## Introduction

Hearing plays a significant role in language and intellectual development. The impact of early diagnosis and rehabilitation of newborns with hearing loss cannot be overstated.<sup>[1]</sup> Since the disease develop gradually over years while first signs can be detected early; therefore early screening is the best way of prevention of advanced hearing disorders.<sup>[2]</sup> Congenital and acquired hearing loss in newborns and children can lead to deficiencies and defects in the evolution of speech, poor educational function, and lifelong social non-concurrence and emotional distress. Pediatricians are required to identify at-risk

children, intervene in a timely and effective manner, and refer patients as necessary.<sup>[3,4]</sup> The importance of early diagnosis is clear, but diagnosis and treatment in the 1<sup>st</sup> months of life is a recent concept.<sup>[5]</sup>

The incidence of sensorineural hearing loss is approximately 1-3/1,000 newborns.<sup>[6]</sup> This is 1/1,000 about severe to deep deafness (70 db or greater). Therefore, only 2-5% of newborns has deafness or hearing loss and the remaining (95-98%) are normal.<sup>[7]</sup> 50% of children with a severe to profound congenital hearing loss have no risk factors for deafness. This means that screening of at-risk children only misses 50% of congenital hearing loss. For this reason, screening of all newborns has been recommended.<sup>[8]</sup>

Both the auditory brainstem response (ABR) and the otoacoustic emission (OAE) test are used to screen hearing in newborns.<sup>[9,10]</sup> The OAE test measures the response of the cochlea to noise emitted by a microphone in the external ear canal and reflects the status of the peripheral auditory system

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and the outer hair cells.<sup>[11]</sup> The ABR test uses a surface electrode to measure neural activity in the cochlea, auditory nerve and brainstem in response to acoustic stimuli, reflecting the status of the peripheral auditory system, the eighth nerve and the auditory brainstem.<sup>[12]</sup> This study aimed to screen for hearing loss in all newborns born in Babol city (northern Iran) during 2009-2011 and to determine the most appropriate treatment and follow-up actions.

## Subjects and Methods

This cross-sectional study evaluated all newborns born at Yahya Nejad, r Ayatollah Rohani Hospital and the Babol neonatal clinic from August 8, 2009 to March 19, 2011 in northern Iran. The proposal of this study was approved by the Research Ethics Committee of Babol University of Medical Sciences. The parents of newborns who included in this study signed a consent form. Exclusion criteria were admission to a neonatal intensive care unit, pre-maturity and birth weight less than 1,500 g. In all cases, the parents gave consent and received information about hearing loss and the benefits of screening.

During screening, an OAE test was performed initially on 15,165 newborns in the first stage, followed by an OAE test in the second stage for newborns who presented with hearing loss in the first stage. Newborns failing the follow-up screen tested by OAE and ABR in the third stage were diagnosed as hearing loss in this stage and also referred for full audio logical diagnostic testing and treatment program after the third stage of screening [Table 1].

Both ears of new born aged 15 days were examined by an audiologist. The method for the OAE test, entails a miniature earphone and microphone are placed in the ear, sounds are played and a response is measured. If a newborn hears normally, an echo is reflected back into the ear canal and is measured by the microphone. When a baby has a hearing loss, no echo can be measured on the OAE test. The cases are then categorized as normal or hearing impaired and are referred to the second stage and tested by Automated Auditory Brainstem Response (AABR), sounds are played to the baby's ears. Band-aid like

electrodes are placed on the baby's head to detect responses. In those found to have hearing loss, the severity of the problem was determined and the hearing loss categorized as: Mild (threshold of hearing 15-30 db); middle (30-50 db); or deep (70 db or greater). The newborns diagnosed with hearing loss at this stage underwent rehabilitation and were prescribed hearing aids.

## Tools

Equipment for OAE testing was supplied by MAICO Ltd., Germany. Equipment for OAE testing was supplied by Hortman Ltd, Germany and EP25, Interacoustic Ltd, Denmark. ASSR: Interacoustic Ltd, Denmark.

Equipment for OAE testing was supplied by Otodynamics Ltd., UK, Hatfield, Hertfordshire and for the ABR test by Beyerdynamic, Germany. The study was approved by the Babol Medical Science Universities Ethical Committee.

## Otoacoustic emission

In the healthy cochlea, vibration of the hair cells in response to noise generates acoustic energy, known as OAE's. OAE testing therefore measures the integrity of the inner ear. A lightweight probe is placed in the ear canal and generates wide-band 'clicks'. Acoustic energy produced in response to the clicks is detected by a microphone within the probe. Automated OAE screeners display the results of the test as either "pass" or "refer," requiring no test interpretation by screening personnel.

The test takes between 1 and 5 min in ideal conditions, with optimal test techniques. In practice, the average total time for testing, including discussion of the procedure with the parents, settling the baby, performing the test and recording the results, may be between 15 and 20 min.<sup>[13]</sup>

## Automated auditory brainstem response

This measures not only the integrity of the inner ear, but also the auditory pathway. It can therefore detect the rare condition of auditory neuropathy, in children who are deaf but have normal OAE's (because the cochlea is normal). The stimulus (either clicks or tones) is presented using either earphones or an ear canal probe, and the electrophysiological response from the brainstem is detected by scalp electrodes. Automated devices allow screening to be performed by non-specialists. Responses from a large number of stimulus presentations are averaged and the automated screener uses a response algorithm to produce a 'pass' or 'refer' result. The "pass" level is set at about 35 decibels. This test takes 15-20 min, but once again this time may be longer if a child is restless, and does not include time for discussion and preparation before the test.

## Sensitivity and specificity

Most of the infants who screen positive for hearing loss are found to have normal hearing on further diagnostic testing.

**Table 1: Summary of screening stages**

Stage	Status	Incidence (%)
1. OAE	Normal	13,518 (89.1)
	Referred to the next stage	1648 (10.9)
	Total	15,165 (100)
2. OAE	Normal	1402 (93.8)
	Referred to the next stage	92 (6.2)
	Total	1494 (100)
	Lost to second stage*	154 (9.3)
3. OAE+ABR	Normal	52 (65/8)
	Hearing disorder	27 (34.2)
	Total	79 (100)
	Lost to third stage**	13 (14.1)

\*Includes one death, \*\*Includes three deaths. OAE: Otoacoustic emission, ABR: Auditory brainstem response

Estimates of sensitivity for OAE range from 80% to 98% and for AABR from 84% to 90%.<sup>[14]</sup>

### Statistical analysis

Data obtained was analyzed using the Statistical Package for the Social Sciences, Version 16 (Chicago, IL, USA,) and with descriptive method.

## Results

The participants in this study were 15,165 newborns in the nursery ward; 49% (7430/15,156) were male and 51% (7735/15,165) were female. As shown in Table 1, at the first screening stage, 10.8% (1648/15,165) cases were referred to the second stage for further investigation. 9.4% (154/1648) were lost from among the referred cases despite continuous contact and education about the importance of the problem. Among the participants in the second stage, 6.2% (92/1494) were referred to the third stage and underwent ABR and OAE testing. 14.1% (13/92) were lost at this stage. Of remained participated, 34.2% (27/79) were diagnosed with a hearing loss [Table 1]. Therefore, the incidence of hearing loss in this study was 1.8/1000 newborns (95% CI: 1.1-2.5). In other words, the number needed to screen (NNS), or the population screened, to find one case was at least 562.

Of the 27 cases of hearing loss, seven had unilateral impairment and 20 had difficulty with both ears. Of those with bilateral sensori-neural hearing loss, six had severe to profound impairment, two were moderate and 12 were mild to moderate. The average age of diagnosis of hearing loss was 4 months and 3 days, with a minimum age of 48 days and a maximum of 8 months. Recommended treatments include cochlear implants, hearing aids, and referral to a speech and hearing rehabilitation center.

## Discussion

This study aimed to screen and detects the percentage of hearing loss in northern Iran. The result showed a high rate of responses in both first and second stage. In our study cases lost to follow-up were about 9.4% in the first stage and 14.1% were lost at the second stage.

Out of 15,165 cases 27 were diagnosed as having hearing loss in the last stage and referred to the advanced test and rehabilitation programs. The total incidence of hearing loss was 1.8/1000 newborn, which meant the NNS or the population screened to find one case was at least 562. The size of the population covered by this study was 15,165 and the duration of the study were 30 months which is comparable to the study of Farhadi *et al.*, of 8490 newborns born in Tehran, Iran during 2003-2004.<sup>[14]</sup> In Taghdiri *et al.*'s study, the incidence of bilateral hearing loss was about 1-4/1000 newborns in the nursery ward; including both unilateral and bilateral hearing loss, the incidence was 7-13/1000 newborns, but in our study,

which conducted in the nursery ward and the total incidence of hearing loss was 1.8/1000 newborns, it implies the low incidence of hearing loss in northern Iran in compare of Tehran, especially considering our larger sample size. Although in another study done by in Mashhad city, the incidence was 2 out of per 1000 neonates<sup>[15]</sup> which it is similar to our finding. In a recently conducted a study in Tehran by Yousefi *et al.* it was shown that the rate of hearing disorders was 9 out of 1000 neonates and the rate of deep deafness was 2 out of 1000 neonates who had profound hearing loss and received a cochlear implant surgery.<sup>[16]</sup> Another study conducted in Brazil on 11,466 newborns, (representing 90.52% of the living newborns) showed that the prevalence of sensori-neural hearing loss was 0.96 out of 1000. Of the 11 children with sensori-neural hearing loss, eight children received hearing aids and five started the therapeutic process before the age of 1 year.<sup>[17]</sup> Cumming estimated that sensori-neural hearing loss occurs in approximately one to three cases out of each 1000 live birth and about one case in every 1000 births suffers from bilateral or severe hearing loss (7 decibel [db] or more). It was indicated that three children out of each 1000 suffer from hearing loss of 30 db or more,<sup>[18]</sup> which is similar to the findings of our study.

In the present study, 10.8% of the newborns who underwent OAE were referred to the second stage. In the study of Farhadi *et al.*, this figure was 10.3%.<sup>[14]</sup> In another study conducted in South Africa by Swanepoel *et al.*, it was 11.1%.<sup>[19]</sup> As it is obvious the percentages are approximately similar with studies which conducted in Tehran and South Africa in the first stage by OAE.

In Nigeria Olusanya *et al.* performed hearing screening of newborns by non-specialist staff without prior audiological experience and found that it was feasible in an inner-city environment in Lagos after a training period of 2-weeks. The screening coverage was 98.7% of all eligible newborns and the mean age of screening was 2.6 days. Forty-four babies out of the 1274 who completed the two-stage screening were referred yielding a referral rate of 3.5%.<sup>[20]</sup> In the study done in the same city (Babol) in northern Iran on 330 newborns by Zahedpasha *et al.* in Amirkela Hospital in Babol, acoustic emission testing found hearing loss in 2.1% of newborns in the intensive care unit.<sup>[21]</sup> In our study, it was 10.2% in the first stage and 6.4% in the second stage. This difference in percentage of referral is explained by significant differences of sample sizes in the two studies.

Finally, limitation and advantages of used tools also affect the results. Both the OAE and the AABR screen require a quiet baby and a quiet testing environment. OAE relies on a functional outer, middle and inner ear, and AABR a functional outer, middle and inner ear, and lower auditory pathway. These screening tests are not designed to detect central hearing impairment (where there is hearing loss secondary to the dysfunction of the pathways from brainstem to the auditory

cortex). As the stimuli for both tests are introduced via the external ear canal, debris in the canal or middle ear fluid can affect the accuracy of the test. In particular, OAE testing may be affected by amniotic fluid in the ear canal when testing is conducted in the first 48 h following birth. This may account for some false positive results. In the study by Yousefi *et al.* in Tehran out of 1000 neonates, 18 (1.8%) had hearing loss during two test performed by transitory evoked otoacoustic emissions (TEOAE), six neonates who had hearing loss by OAE, were confirmed by AABR. Therefore, 12 responses of TEOAE were false positive. At the age of 3 months, out of 1000 neonates, nine had hearing loss by AABR that out of nine neonates, six were identified by TEOAE. Therefore, three responses of TEOAE was false negative.<sup>[16]</sup> This suggests that the choice of screening test influencing the percentage of patients referred. In the present study, the NNS was 562. In the studies of, Finitzo<sup>[22]</sup> and Prieve *et al.*,<sup>[23]</sup> using ABR and TEOAE, the NNS was greater than this (666 and 1422, respectively).

The authors suggest future studies by an experienced audiologist. As some studies show that an inexperienced tester can cause false negatives. Therefore, an audiologist familiar with OAE technology should be involved in decision making regarding screening technology and in tracking program outcomes and performing tympanometry in conjunction with OAE screening with subsequent referral for audiological evaluation also recommended in guide lines for children failing OAE only and rescreening for children failing both OAE and tympanometry may reduce the need for multi-stage screening and improve loss to follow-up. Our suggestion is running screening in several centers simultaneously. Overall our results demonstrate the need for a hearing loss prevention program in Iran, to achieve the global standard for newborn screening and prevention of hearing disorders in the future.

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## References

- Mukari SZ, Tan KY, Abdullah A. A pilot project on hospital-based universal newborn hearing screening: Lessons learned. *Int J Pediatr Otorhinolaryngol* 2006;70:843-51.
- Cunningham M, Cox EO, Committee on Practice and Ambulatory Medicine and the Section on Otolaryngology and Bronchoesophagology. Hearing assessment in infants and children: Recommendations beyond neonatal screening. *Pediatrics* 2003;111:436-40.
- Olusanya BO, Wirz SL, Luxon LM. Community-based infant hearing screening for early detection of permanent hearing loss in Lagos, Nigeria: A cross-sectional study. *Bull World Health Organ* 2008;86:956-63.
- White KR, Forsman I, Eichwald J, Munoz K. The evolution of early hearing detection and intervention programs in the United States. *Semin Perinatol* 2010;34:170-9.
- Norton SJ, Gorga MP, Widen JE, Folsom RC, Slinger Y, Cone-Wesson B, *et al.* Identification of neonatal hearing impairment: A multicenter investigation. *Ear Hear* 2000;21:348-56.
- Lima GM, Marba ST, Santos MF. Hearing screening in neonatal intensive care unit I. *Pediatric (Rio J)* 2006;82:110-4.
- Mauk GW, White KR, Mortensen LB, Behrens TR. The effectiveness of screening programs based on high-risk characteristics in early identification of hearing impairment. *Ear Hear* 1991;12:312-9.
- Atas B, Altunhan H, Eryilmaz MA, Atas E. Frequency of congenital hearing loss in 43,503 healthy newborn infants in Konya, Turkey. *J Pak Med Assoc* 2011;61:727-8.
- 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.
- Guidelines for the Organization and Administration of Universal Newborn Hearing Screening Programs in the Well-Baby Nursery Newborn Screening Program. 2013L/(800) 664-7772. [www.health.state.mn.us/newbornscreening](http://www.health.state.mn.us/newbornscreening).
- American Academy of Pediatrics, Joint Committee on Infant Hearing. Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. *Pediatrics* 2007;120:898-921.
- Coates H. Diagnostic tests, newborn hearing screening *Aust Prescr* 2003;26:82-4.
- Meier S, Narabayashi O, Probst R, Schmuziger N. Comparison of currently available devices designed for newborn hearing screening using automated auditory brainstem and/or otoacoustic emission measurements. *Int J Pediatr Otorhinolaryngol* 2004;68:927-34.
- Farhadi M, Mahmoudian S, Mohammad K, Daneshi A. The pilot study of a nationwide neonatal hearing screening in Iran: Akbarabadi and Mirzakouchak Khan hospitals in Tehran (June 2003-October 2004). *Hakim Res J* 2006;3:6575.
- Taghdiri MM, Eghbalian F, Emami F, Abbasi B, Zandevakili H, Ghale'iha A, Razavi Z. Auditory evaluation of high risk newborns by automated auditory brain stem response. *Iran J Pediatr* 2008;18:330-4.
- Yousefi J, Ajalloueyan M, Amirsalari S, Hassanali Fard M. The specificity and sensitivity of transient otoacoustic emission in neonatal hearing screening compared with diagnostic test of auditory brain stem response in Tehran hospitals. *Iran J Pediatr* 2013;23:199-204. Published by Tehran University of Medical science. Available from: <http://www.ijp.tums.ac.ir/index.php/ijp/article/downloadSuppFile/1780/660.2013/5/21>. [Last accessed on 2013 May 21].
- Bevilacqua MC, Alvarenga Kde F, Costa OA, Moret AL. The universal newborn hearing screening in Brazil: From identification to intervention. *Int J Pediatr Otorhinolaryngol* 2010;74:510-5.
- Cummings CW. *Otolaryngology Head and Neck Surgery*. 2<sup>nd</sup> ed. Philadelphia: Saunders; 2005.
- Swanepoel D, Ebrahim S, Joseph A. Newborn hearing screening in a South African private health care hospital. *Int J Pediatr Otorhinolaryngol* 2007;71:881-7.
- Olusanya BO, Ezeaka CV, Ajayi-Obe EK, Mukhtar-Yola M,

- Ofovwé GE. Paediatricians' perspectives on global health priorities for newborn care in a developing country: A national survey from Nigeria. *BMC Int Health Hum Rights* 2012;12:9.
21. Zahedpasha Y, Ahmadpoor M, Aghajani R. Hearing screening following treatment of neonates in NICU. *Iran J Pediatr* 2007;1:1420.
22. Finitzo T, Albright K, O'Neal J. The newborn with hearing loss: Detection in the nursery. *Pediatrics* 1998;102:1452-60.
23. Prieve BA, Gorga MP, Neely ST. Otoacoustic emissions in an adult with severe hearing loss. *J Speech Hear Res* 1991;34:703.

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