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## Results of Newborn Hearing Screening in Tepecik Education and Research Hospital

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### ABSTRACT

**Objectives:** This study aimed to emphasize the significance of newborn hearing screening for detecting congenital hearing loss within the first 6 months of birth.

**Methods:** The data of 5399 infants born in the İzmir University of Health Science Tepecik Training and Research Hospital, İzmir, Turkey, and screened for hearing between January 2018 and December 2018 was presented in this study. All term, preterm, and asphyctic newborn deliveries in the aforementioned hospital were included. The hearing screening was conducted using the auditory brainstem response (ABR) method. The first step involves the evaluation of the results of all infants before being discharged from the hospital and, the second step involves infants with problems in the results of their first step and subjected to advance testing.

**Results:** This study included 5399 infants in the first and second steps. Of these infants, 5231 (96.9%) passed the first step. Consequently, 136 (2.5%) of the 168 infants evaluated in the second step passed it, while 32 (0.6%) of the infants were evaluated again in more detail in the third step. Six (0.2%) of the infants were not called for further evaluation, and 5 (0.2%) were diagnosed with advanced/very advanced bilateral sensorineural hearing loss.

**Conclusion:** Congenital hearing loss negatively affects the child's language, speaking, communication, and cognitive skills. Newborn hearing screening has an important place in the early diagnosis of congenital hearing loss. The number of diagnosed and treated babies suffering from hearing loss is increasing as the number of hearing screening tests becomes widespread in Turkey.

**Keywords:** Child, deafness, hearing impairment



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### INTRODUCTION

Hearing screening is used in all newborns to ensure that infants who have problems in hearing are diagnosed at the earliest time in the most definite and appropriate way. The rate of congenital hearing loss is between 0.1% and 0.6% in all healthy newborns.<sup>[1]</sup> A simple newborn hearing screening will provide an early diagnosis of hearing loss, which can influence the infant's future life and success.<sup>[2]</sup> It is most ideal for all newborns to be screened within 12–24 h after birth, 30 minutes after feeding, in their natural sleep. The babies who failed the test and were rescreened and passed the test with both ears before their discharge were considered to be normal. The method used in screening should be able to detect hearing losses of  $\geq 30$  dB in the frequency region required for the speech of children and normal development.<sup>[3]</sup>

Evoked otoacoustic emissions and auditory brainstem response (ABR) measurements are tools used alone or together in newborn hearing screening. Two types of evoked otoacoustic emissions are made use in most hearing screening. These are transient otoacoustic emissions (TEOAE) and distortion product otoacoustic emissions (DPOAE) tests. The most frequently used of these two tests is the TEOAE because it is simpler, has a shorter test time, and reveal seven very light hearing loss compared with the other method.<sup>[4,5]</sup> If the patient fails the test, referring the patient to third-level centers for further examination and treatment is appropriate. Moreover, babies with a history of neonatal intensive care hospitalization or risk factors should be screened with ABR.<sup>[2,5]</sup>

The American Academy of Pediatrics recommends that all newborn babies should be screened for hearing within 1 month after birth, the hearing loss should be confirmed within 3 months, and the necessary medical intervention should be made within 6 months. Hearing screening has become widespread since the 2000s and detecting hearing loss has become possible in the early newborn period through the "National Newborn Screening Campaign."<sup>[6,7]</sup> Moreover, primary screening centers are located in all hospitals in each province. The screening team consists of a physician trained in the screening program and the implementation of tests and an audiometrist or a nurse. These teams are spread all over Turkey within the framework of a nationwide neonatal newborn hearing screening program. The Public Health Institution data in 2015 supported this idea. According to these data, 93% of all babies born in the hospital in the country were screened.<sup>[6,7]</sup>

Family physicians working in primary care should ensure that the hearing test was performed during the follow-up of each baby during the neonatal period. Successful application of neonatal hearing screening tests and earlier recognition of babies with hearing loss can be achieved with this follow-up. Moreover, family physicians should inform the families about the diagnosis, devices used for treatment, and training commencement.<sup>[8,9]</sup>

This study aims to evaluate the neonatal hearing screening results performed at the Health Sciences University, Tepecik Training and Research Hospital, Izmir, Turkey, in light of the literature and to determine the incidence of hearing loss in newborns.

## METHOD

This study included 5339 infants born in Tepecik Training and Research Hospital between January 2018 and December 2018. Moreover, all term, preterm, and asphyctic newborn deliveries in the aforementioned hospital were

included in this study. In the first step, all babies delivered were tested for hearing before discharge. Screenings were conducted everyday between 09:00 a.m. and 04:00 p.m. hours, including holidays and working days before the infant was discharged from the hospital. Furthermore, the mothers of all infants screened for hearing were given documents including information and the results.

The hearing screening was conducted in the birth clinic by a certified and experienced audiometry technician and delivery nurse. The screening tests were applied when the infant was in the mother's lap and in deep sleep, lying as still and silent as possible. The ear anatomy and the size of the external auditory canal were taken into consideration while the probe of the device used in screening was placed in the ear of infant. The sizes of the ends of the probe were chosen according to the external auditory canal anatomy of the infant. The infant passed the screening when passing criteria were obtained from both ears. The infants who did not meet the passing criterion in one or both ears were called again 15 days later to repeat the test. The hearing screening was conducted in a silent room with 35 dB sound pressure level (SPL) environmental noise designed only for the hearing screening. The hearing screening of infants was made by using Madsen Accuscreen (GN Otometrics A/S, Taastrup, Denmark) device with automatic ABR (O-ABR) method. Three single-use electrodes were used by placing an earth electrode to the cheek, a positive electrode to the forehead, and a negative electrode behind the ear. The test was started when the impedance value between the skin and electrode was smaller than 4 k $\Omega$ . The shape of the ABR wave form response changes with age because the response-sensing algorithm in the device filters and optimizes the signals recorded according to criteria for infants until 1 year. The response "passed" shows that the ABR to 35 dBnHL broadband stimulants is detected. This method primarily tests frequencies between 2 and 4 kHz, which is the most important acoustic information for speech development. The sensitivity and the specificity of the device are reported to be 99.7% and between 98.3% and 99.5%, respectively.<sup>[2,5]</sup> Thus, obtaining a passed response from the O-ABR device is the criterion to pass the screening test. The result passed excludes a significant hearing loss in these frequencies with a reliability of 99.7%.<sup>[2,5]</sup>

The infants who failed in both tests in one or two ears were referred to a tertiary reference center for advanced testing. Following otorhinolaryngologic and audiologic examinations conducted here, the infants were taken under follow-up and treatment suitable for their detected hearing thresholds. Computer-based patient data records were re-

viewed in detail for this study. Babies who expired 1 month after delivery were excluded.

### Statistical Analysis

The Statistical Package for the Social Sciences, version 21.0 (IBM, Armonk, NY, USA) was used for statistical analysis. Numerical variables were presented as mean, standard deviation, median, minimum and maximum values. Moreover, categorical variables were presented as frequency and percentage. The Kolmogorov–Smirnov normality test was first performed to confirm the distribution of variables.

## RESULTS

The mean age of the 5399 cases included in this study was  $27.5 \pm 8.1$  years. Descriptive and obstetric features of participants are summarized Table 1.

In the hearing screening conducted in 5399 infants, 5231 (96.9%) infants passed the first step. Consequently, 136 (2.5%) of the 168 infants evaluated in the second step passed it, while 32 (0.6%) of the infants were evaluated again in more detail in the third step. In this step, 6 (0.2%) of the infants were not called for further evaluation, and 5 (0.2%) were diagnosed with advanced/very advanced bilateral sensorineural hearing loss. Screening process of newborns in the study is shown in Table 2.

## DISCUSSION

The screening protocol used in newborn hearing screening is of great importance. Although protocols and measurement parameters used in newborn hearing screenings are different, these different protocols are not significantly different from each other and have been used in different studies in the literature.<sup>[10]</sup>

ARB, TEOAE test, and three-step screening protocols are

Age of mother (years)	27.5±8.1
Gravida	3.0 (1.0-6.0)
Parity	1.0 (0.0-4.0)
Gestational age (weeks)	37.5±4.3
Type of delivery	
NSVD	2379 (44.1)
C/S	3020 (55.9)
Gender of newborn	
Female	2691 (49.8)
Male	2701 (50.2)
Birth weight (g)	3005.1±1207.9

C/S :Cesarean delivery; NSVD: Normal spontaneous vaginal delivery.  
Data is presented as mean±SD, median (min-max) and n(%).

**Table 2.** Screening process of newborns in the study

	Evaluated	Passed	Called for control	Not brought to control
First step	5399	5231 (96.9)	168 (3.1)	-
Second step	168 (3.1)	136 (2.5)	32 (0.6)	-
Third step	32 (0.6)	21 (0.4)	5 (0.2)	6 (0.2)
Hearing loss	5 (0.2)	-	-	-

Data is presented as n (%).  
Percentage among the 5399 newborns included in the study.

frequently applied in newborn hearing screenings. In addition to protocols that include using TEOAE and two-step or TEOAE and ABR tests together, studies that include the protocol of using together the DPOAE and ABR tests have also been found. However, it is remarkable that the ABR test is recently used alone in hearing screenings. Furthermore, the ABR test is applied to all infants born in Tepecik Training and Research Hospital. In addition to the protocols based on the measurements applied in the clinic, studies also exist in which newborn hearing screening is made in a questionnaire form or through volunteering people in a house environment.<sup>[6,7]</sup> The protocol of using the ABR test alone, which was used in this study, is popular worldwide and is being used alone in many other countries as well. Furthermore, the ABR test gives valuable information in recognizing problems of the central hearing processes. However, the obligation of placing electrodes, the requirement of a longer time, and the necessity of making measurements while the infant is asleep are among the disadvantages of the ABR test.<sup>[11]</sup>

Factors such as being simple, easy, and short as well as the calmness of the infant for measurement are enough to increase the value of the TEOAE test in newborn hearing screenings. However, the ABR test, which gives more effective results and information on different areas, is used alone when an earlier diagnosis of patients who have problems especially in the central hearing process is made to patients coming from different parts of the country. Thus, only a few numbers of cases not coming to follow-up or not followed up with the ARB test alone were noted.<sup>[12,13]</sup>

Studies on newborn hearing screening included infants in different groups. Moreover, studies including healthy-born infants only and infants in the intensive care unit are also available. While bilateral hearing loss is seen in one to three per 1000 healthy newborns, this rate increases to two to four per 100 in newborns who have been hospitalized in the intensive care units. Thus, the early detection of congenital hearing loss is very important in this respect.<sup>[12,13]</sup>

Hearing losses can occur in three different periods of life (i.e., prenatal, perinatal, and postnatal). The prenatal period covers the risk factors of hearing loss that may occur during the mother's pregnancy. These include genetic causes, ototoxic drug use, radiation exposure, congenital infections (TORCH), trauma, and some systemic diseases. Moreover, in the perinatal period, babies with low birth weight (<1500 g), blood mismatch in intensive care, asphyxia, head trauma during birth (vacuum, forceps, etc.), blood exchanges, and infections can be possible risk factors. In the postnatal period, infections, convulsions, ototoxic drugs, head injuries, genetic disorders, craniofacial anomalies, and idiopathic causes can be possible risk factors. Following the children whose family history possesses risk in terms of hearing loss in certain periods is very important even if they passed the newborn hearing screening program.<sup>[14,15]</sup> This study included all newborn infants although defects in hearing tests exist mostly in infants who are hospitalized in newborn intensive care centers due to preterm birth and asphyxiated births.

Some studies compared the hearing screening results of infants in the newborn intensive care unit and those of healthy newborns or the results of infants with hearing loss risk and those who do not have a risk.<sup>[16]</sup> However, the current study gave the results of all newborns because all of the newborns underwent hearing screening regardless of whether they had a risk factor or not. The hearing screening of the infants in the newborn intensive care unit is still conducted with the same protocols. Thus, the results related to these are not mentioned in the present study. While getting a bilateral response for the infant to pass the test is a commonly supported approach in hearing screenings, several studies take unilateral response as a criterion to pass.<sup>[16,17]</sup> The study proposes that when a unilateral response is taken and the other ear is not evaluated the detection of a possible unilateral hearing loss becomes difficult. Although in the current study there was no infant with unilateral hearing loss, due to having a bilateral response as a criterion, the study advocates that the newborn hearing screenings should be conducted bilaterally.

The common approach in newborn hearing screenings is conducting the screening before the infant is discharged. However, although rare, screenings are also conducted after the infant is discharged. Since response can be taken in hearing screening even when the baby is 24-h old, evaluating the infant before discharge is time-consuming and will eliminate the risk of infants not being brought to the hospital again.<sup>[18,19]</sup> With the introduction of the national neonatal hearing screening program in all maternity hospitals, the number of babies having newborn hearing screening

has rapidly increased. Accordingly, the number of babies whose hearing loss has been confirmed within the first year of life has significantly increased compared with previous years. Moreover, studies in different health centers, which had audiology units, supported this view.<sup>[20-22]</sup> Values related to congenital hearing loss following newborn hearing screening vary between 0.1% and 0.6% for bilateral hearing loss and between 0.2% and 0.4% for unilateral hearing loss.<sup>[20-22]</sup> In the data obtained in this study, the rate of bilateral hearing loss is 0.2%. This result shows that the hearing loss rate in Turkey is in parallel with the world literature.

It has been long emphasized that people who conduct newborn hearing screening should be trained on using the devices for screening. Studies report that hearing screening is conducted by audiologists, health technicians, and nurses.<sup>[23]</sup> In this study, the screenings were conducted by certified and experienced audiologists and audiometry technicians. Moreover, in Turkey, hearing screening is conducted by audiometry technicians and nurses after receiving training in state hospitals where hearing screening programs were started. Thus, the practice of having intern nurses, students, and volunteers conducting hearing screening in some other countries is not a common practice in Turkey.

In this study, 0.2% newborns failed the follow-up controls. However, the study by Eryilmaz et al. reported that most of the babies who failed the first screening test did not come to the second-line control appointments. This study observed that only 24 of the 189 babies came to second-line control appointments.<sup>[24]</sup> Similar findings were presented in the study by Özcebe et al. where in 2% of the babies who failed at the screening did not come to control appointments. Therefore, the diagnosis of a hearing loss is delayed if these babies had hearing loss.<sup>[25]</sup> In addition to these studies, studies investigating the causes of delays in diagnosis and instrumentation in different centers in Turkey are needed. Identifying the causes of delay will support the development of interventions to prevent these causes, thereby minimizing auditory deprivation by earlier instrumentation. Furthermore, determining the screening protocol to be used in newborn hearing screenings is important. When other studies in the literature were examined, similar protocols based on electrophysiological studies were used although minor differences were observed.<sup>[20-22]</sup>

In the case of too much environmental noise where hearing screening is conducted, TEOAE responses will be masked. Thus, the noise level in the test room in which screening is conducted is important in terms of measurement reliability. It is emphasized that hearing screening

should be conducted in silent places and the measurement is recommended in environments that have an environmental noise level <60 dB SPL. In this study, the hearing screening measurements of all the infants were conducted in a room that was specially chosen and organized for hearing screening with a silent atmosphere suitable for ARB measurement. As in many countries in the world, the hospital newborn hearing screening has been increasing in Turkey as well.<sup>[9,19]</sup> Hearing loss, which is an important public health problem, must be detected early and screening should be widespread throughout the country. This can only be achieved by the efforts of family physicians, experts, and families.<sup>[20,21]</sup>

When the device is given before 6 months old to infants who have mild to advanced hearing loss, "expressive" language tests at 3 years old are within normal limits. Without newborn hearing screening, the diagnosis age of hearing loss extends to 30–36 months on average. In case of hearing loss not being diagnosed in the early period of life, attaining basic language, social, and cognitive skills, adapting to school, and having social integration in advanced periods are difficult. The service provided by installing a hearing device is appropriate for the goal when five of the infants who were diagnosed with hearing loss were evaluated in terms of installing a hearing device and starting training. In addition to diagnosing all infants with hearing loss before they were 6 months old, all families were also given consultancy service within this period. The socioeconomic conditions in Turkey sometimes make it difficult for newborn hearing screening to reach its goal in some aspects. In addition, the early installation of the device in these children because the families are informed of their state in early periods results in families isolating these children from other children. Moreover, the families' behaviors and complaints on why this happened to their children cause them sadness and distress. Thus, experts, families, and everyone involved in this issue should do their part to make newborn hearing screenings reach the national goal in Turkey.<sup>[26,27]</sup>

## CONCLUSION

This study reports the results of the newborn hearing screening Tepecik Training and Research Hospital. The hearing screening tests should be expanded throughout the country as soon as possible, and the babies with hearing loss should be identified before permanent damages occur. Using the screening tests mentioned in the study approximately %97 of the babies are expected to pass the first test while 0.2% of those are expected to have advanced/very advanced bilateral sensorineural hearing loss.

## Disclosures

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

**Ethics Committee Approval:** This study was performed with the approval of the Non-Interventional Clinical Research Ethical Committee of the University of Health Sciences Tepecik Training and Research Hospital (Approval date: January 10, 2018 and Approval number:2018/01/48). This study was retrospective and voluntary consent form could not be obtained.

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