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Evaluation of newborn hearing screening test results at Zonguldak Bülent Ecevit University Hospital

Zonguldak Bülent Ecevit Üniversitesi Hastanesi yenidoğan işitme tarama testi sonuçlarının değerlendirilmesi

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ABSTRACT

Aim: To evaluate the outcomes of newborn hearing screening tests (NHS) conducted between January 2021 and July 2025 at Zonguldak Bülent Ecevit University Hospital, the regional reference center for the national newborn hearing screening program in Türkiye, and to compare them with national and international data.

Material and Methods: This retrospective study included 1,844 healthy term newborns screened using the Automated Auditory Brainstem Response (A-ABR) method. Screenings were performed before discharge by an audiometrist and an otorhinolaryngologist using the Accu-screen Pro device. Infants who failed the initial test were retested after 10 days, and persistent failures underwent diagnostic Auditory Brainstem Response (ABR) at three months of age. Risk factors such as consanguinity, family history of hearing loss, TORCH infections, neonatal hyperbilirubinemia, and intensive care unit (ICU) stay were documented. Infants with risk factors were followed up with clinical ABR testing at six months. Data was recorded in both hospital and national databases.

Results: Of the 1,844 newborns screened, 1,067 (57.9%) passed, 757 (41.1%) were referred due to risk factors, and 20 (1.1%) failed the screening test. There was no statistically significant difference in the rate of hearing loss between genders ($\chi^2 = 2.06$, $p = 0.151$). Five infants (0.28%) were diagnosed with bilateral hearing loss—two with total hearing loss requiring cochlear implantation and three who became hearing aid users. Of the infants in whom hearing loss was confirmed at our referral center, two had a positive family history of hearing loss, while three had a documented history of neonatal intensive care unit (NICU) stay. In our study, the rate of newborns who successfully passed the screening was determined to be 99.72%. Loss to follow-up was observed in one case despite notification through official channels.

Conclusion: The prevalence of neonatal hearing loss in this study (0.28%) aligns with national and international reports, supporting the effectiveness of Türkiye's universal screening program. However, challenges such as post-screening follow-up loss remain. Continuous education of healthcare professionals and families, early intervention, and systematic monitoring of at-risk infants are essential to improve outcomes and ensure timely rehabilitation for affected children.

Keywords: Newborn, hearing screening, hearing loss, automated ABR

ÖZ

Amaç: Bu çalışmada, Türkiye Ulusal Yenidoğan İşitme Taraması Programı kapsamında referans merkez olarak görev yapan Zonguldak Bülent Ecevit Üniversitesi Hastanesi'nde Ocak 2021 – Temmuz 2025 tarihleri arasında gerçekleştirilen yenidoğan işitme tarama sonuçlarının değerlendirilmesi ve ulusal ile uluslararası verilerle karşılaştırılması amaçlanmıştır.

Gereç ve Yöntemler: Retrospektif olarak planlanan çalışmaya, işitme taraması yapılan 1.844 sağlıklı term yenidoğan dâhil edilmiştir. Taramalar, taburculuk öncesi odyometrist ve kulak burun boğaz uzmanı tarafından Accu-screen Pro (Madsen, Danimarka) cihazı ile Otomatik Beyinsapı İşitsel Cevap (A-ABR) yöntemi kullanılarak yapılmıştır. İlk testte geçemeyen bebekler 10 gün sonra yeniden değerlendirilmiş, üçüncü testte de başarısız olanlar üç aylıkken tanısal ABR testine alınmıştır. Akraba evliliği, ailede işitme kaybı öyküsü, TORCH enfeksiyonları, yenidoğan sarılığı, fototerapi ve yoğun bakım öyküsü gibi risk faktörleri sorgulanmış ve riskli bebekler altı aylıkken klinik ABR ile takip edilmiştir. Veriler hastane ve Sağlık Bakanlığı ulusal veri tabanına kaydedilmiştir.

Bulgular: Toplam 1.844 yenidoğanın 1.067'i (%57,9) testi geçti, 757'si (%41,1) risk faktörü nedeniyle yönlendirildi ve 20'si (%1,1) testi geçemedi. Cinsiyetler arasında işitme kaybı oranında istatistiksel olarak anlamlı bir fark bulunmadı ($\chi^2 = 2,06$, $p = 0,151$). Beş bebekte (%0,28) bilateral işitme kaybı saptandı; bunlardan ikisinde total işitme kaybı olup koklear implant merkezine yönlendirildi, üçü işitme cihazı kullanıcısı olarak özel eğitim desteği almaktadır. Referans merkezimizde işitme kaybı tespit edilen bebeklerden ikisinin ailesinde işitme kaybı öyküsü, üçünün ise yoğun bakım öyküsü mevcuttu. Çalışmamızda taramadan başarıyla geçen bebeklerin oranı %99,72 olarak saptanmıştır. Bir bebek takip dışı kalmıştır.

Sonuç: Bu çalışmada saptanan yenidoğan işitme kaybı oranı (%0,28), literatürde bildirilen oranlarla uyumludur ve Türkiye'deki ulusal tarama programının etkinliğini desteklemektedir. Ancak tarama sonrası takip kayıpları hâlâ önemli bir sorundur. Programın başarısını artırmak için ailelerin ve sağlık çalışanlarının bilgilendirilmesi, riskli bebeklerin düzenli izlenmesi ve erken rehabilitasyon hizmetlerinin güçlendirilmesi büyük önem taşımaktadır.

Anahtar Kelimeler: Yenidoğan, işitme taraması, işitme kaybı, otomatik ABR

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Highlights

- The prevalence of bilateral permanent hearing loss among 1,844 term newborns screened at Zonguldak Bülent Ecevit University Hospital between 2021–2025 was 0.28%, consistent with national and international reports.
- The three-step Automated ABR–based screening protocol demonstrated a high overall success rate, with 99.72% of newborns passing the screening process.
- The history of neonatal intensive care unit (NICU) stay emerged as the most prominent shared risk factor among infants diagnosed with permanent hearing loss.
- Loss to follow-up remained a significant challenge, limiting early diagnosis and timely intervention within the screening program.
- Findings support the effectiveness of the national newborn hearing screening program and highlight the need to strengthen parent education, healthcare provider awareness, and long-term monitoring of at-risk infants.

INTRODUCTION

Hearing loss in newborns is a significant health issue that can result in permanent impairments in speech and language development if not identified and treated early. It is estimated that hearing loss occurs in approximately 1 to 3 out of every 1,000 live births (1). This rate is notably higher than that of conditions such as congenital hypothyroidism (25 out of 100,000) and phenylketonuria (8 out of 100,000), which are metabolic disorders for which newborn screening is routinely conducted (1,2).

The first year of life is a crucial time for children's speech and language development. Speech is a learned behavior, and hearing plays a key role in this process (3). Research shows that infants with hearing impairments exhibit differences compared to their typically developing peers during the babbling stage, which occurs between four and eight months of age. Studies indicate that infants with hearing loss produce fewer consonants during this developmental stage, and their creativity in sound production gradually decreases between four and eighteen months (4).

Hearing screening programs are essential for early diagnosis and prompt treatment of hearing loss. Both parents and physicians may struggle to accurately identify infants with severe hearing loss during the first year of life. When hearing loss goes undetected during this critical period, it can adversely affect cognitive abilities, social skills, and language development (5). Research has demonstrated that children diagnosed with hearing loss who receive hearing aid within six months tend to perform within normal limits on expressive language tests by age 3 (6,7).

The first newborn hearing screenings in Türkiye took place in 1994 and 1998 at Marmara University Hospital and Hacettepe University Hospital. In 2003, a national program was launched, implementing screenings at several pilot hospitals, including Gazi, Hacettepe, Marmara, and Dokuz Eylül Universities. This program was later expanded to encompass all 81 provinces nationwide (8). Before 2019, hearing screening was performed using transient otoacoustic emissions (TEOAE) or ABR, or both. Currently, hearing screening in Türkiye has been performed using ABR since 2019 (9).

The aim of this study is to present the findings obtained from newborn hearing screenings conducted between January 2021 and July 2025 at Zonguldak Bülent Ecevit University Hospital, which was designated as the reference hospital for the hearing screening program, and to analyze these findings and compare the prevalence of hearing loss, screening success, and reference rates with similar studies in the literature.

MATERIAL and METHODS

This study was designed as a retrospective, observational, and descriptive investigation based on the review of newborn hearing screening records of 1,844 healthy term newborns obtained between January 2021 and July 2025 at Zonguldak Bülent Ecevit University Hospital. Ethical approval was obtained prior to the study in accordance with the Helsinki Declaration (01/10/2025, decision number: 2025/17-17).

The inclusion criteria for the study were: being born in term (≥37 weeks' gestation), undergoing a hearing screening in the hospital near postpartum discharge, and obtaining family consent. Excluded from the study were infants born prematurely (<37 weeks), those who remained in the neonatal intensive care unit for extended periods and were unable to complete the routine screening protocol, and those who were unable to complete the screening process due to reasons such as death, loss to follow-up, or failure to return for follow-up.

The parameters examined in the study were evaluated in three main groups. Demographic and birth-related parameters included gestational age and gender. Hearing

screening parameters included the newborn's initial screening result (pass, fail, or risk referral), final screening result (screened or referred for clinical ABR), ear side (right, left, or bilateral involvement), tympanometry findings (presence of middle ear fluid, eardrum status, middle ear pressure), acoustic reflex measurements, otoacoustic emissions (TEOAE) results, and clinical ABR threshold and waveform findings. Outcome parameters were classified as normal hearing or varying degrees of hearing loss based on the clinical ABR result.

According to the screening ABR protocol in the NHS program of the Ministry of Health, all newborns/ without risk factors should be screened by ABR. The neonate should not be discharged without ABR testing. Newborns who fail the third screening ABR test should be referred to the reference center. Even if newborns with risk factors passed the test, they were referred to the reference center for follow-up. The newborn screening protocol should be completed within 30 days of birth. If the protocol is not completed within 30 days, it should be referred to the reference center without waiting for the completion of the screening protocol after the first test.

To minimize the potential impact of fluid and cerumen in the external auditory canal on test results, the screenings were conducted close to the time of the infants' discharge.

An audiometrist and an ear, nose, and throat specialist conducted hearing screenings using a three-stage protocol. For initial screening of infants, the Accu-screen Pro (Madsen, Denmark) A-ABR device was used. The screenings took place with the infant either on their mother's lap or on a flat surface and ensuring the infant had a full stomach. All tests were carried out in a soundproof room with a noise value not exceeding 35 dB. Appropriate probes were chosen based on the size of the infant's external auditory canal. An automatic "pass" result was considered a successful outcome for the screening test. Infants who passed the A-ABR test in both ears were classified as "passed." Families of infants who did not pass the unilateral or bilateral A-ABR test were informed and invited to return for a repeat test after 10 days. Infants who failed the test underwent an otoscopic examination. If any issues with the external auditory canal that could influence the A-ABR response were discovered during the examination, appropriate treatment and recommendations were provided. After ruling out any external auditory canal problems, the infants were retested. Babies who did not pass the first screening were scheduled for a second checkup, during which another A-ABR test was performed. For those who failed the third screening, a clinical ABR appointment was arranged for three months of age, conducted during spontaneous sleep in a sound-attenuated room.

Newborns who passed the screening were questioned about risk factors, including febrile illness, toxoplasmosis-rubella-cytomegalovirus-herpes simplex (TORCH) infections, consanguineous marriage, family history of hearing loss, neonatal hyperbilirubinemia, phototherapy, and intensive care unit (ICU) stay. For babies with risk factors, an appointment was scheduled for a clinical ABR at 6 months of age. The newborns' gender, mode of delivery, birth weight, and gestational age were recorded. Risk factors within the family were discussed and recorded at the first visit and entered into the Ministry of Health's national hearing screening program. Screening results were recorded in our hospital's follow-up logbook.

After ear examinations for infants who failed screened or who had risk factors, tympanometry assessment (1,000 Hz) and acoustic reflex measurements were performed using an Interacoustic AT235 impedance meter (Interacoustics A/S, Assens, Denmark) to assess the presence of middle ear fluid, the condition of the eardrum, middle ear pressure, and acoustic reflex arc. TEOAE testing was performed using a Clinical Oto Acoustic Emission device (Echoport 292 I) to obtain information about the cochlea.

Clinical auditory brainstem response (ABR) testing was performed using the Eclipse EP20 device with TDH-39 headphones. Vertex–mastoid electrodes were used, with impedances maintained between 3,000 and 5,000 ohms. A 0.5 ms variable-polarity click stimulus was presented at a rate of 31.1 clicks/s, and responses were averaged over 2,000 stimuli. The lowest intensity at which wave V was identified was recorded as the threshold.

Newborns who did not pass the clinical ABR were enrolled in a rehabilitation program following radiological examinations. Plans were made for either amplification or implantation, and these individuals were subsequently included in the national hearing screening program administered by the Ministry of Health.

In this study, the data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics for categorical variables were expressed as frequency (n) and percentage (%). Differences in hearing loss rates between genders were evaluated using the Chi-square (χ^2) test when the expected cell frequencies were low. Risk factors, and possible etiologies of infants who failed the screening test (n = 20) were analyzed using the same methods. A p-value of < 0.05 was considered statistically significant.

RESULTS

The distribution of newborn hearing screening tests performed at Zonguldak Bülent Ecevit University Hospital over five years is given in Table 1, and the percentage values are given in Figure 1. The distribution of screened newborns by gender and the number of cases with detected hearing loss by gender and year are presented together in Figure 2.

An examination of the screening test results (Table 2) reveals that of the 1,844 newborns, 1,067 (57.9%) passed the screening test, 757 (41.1%) were referred to our reference center due to risk factors, and 20 (1.1%) failed the test.

A total of 985 (53.4%) male and 859 (46.6%) female newborns were screened in the study. Hearing loss was detected in 7 males (0.7%) and 13 females (1.5%) (Figure 2). There was no statistically significant difference in the rate of hearing loss between genders ($\chi^2 = 2.06$, $p = 0.151$).

Table 1. The distribution of newborn hearing screening tests

Year	Screening	Passed	Referral Due to Risk Status	Failed
2021	622	426 (68.5)	191 (30.7)	5 (0.8)
2022	571	328 (57.4)	238 (41.7)	5 (0.9)
2023	301	143 (47.5)	154 (51.2)	4 (1.3)
2024	200	99 (49.5)	99 (49.5)	2 (1)
2025	150	71 (47.3)	75 (50)	4 (2.7)

Values are given as number (n) and percentage (%).

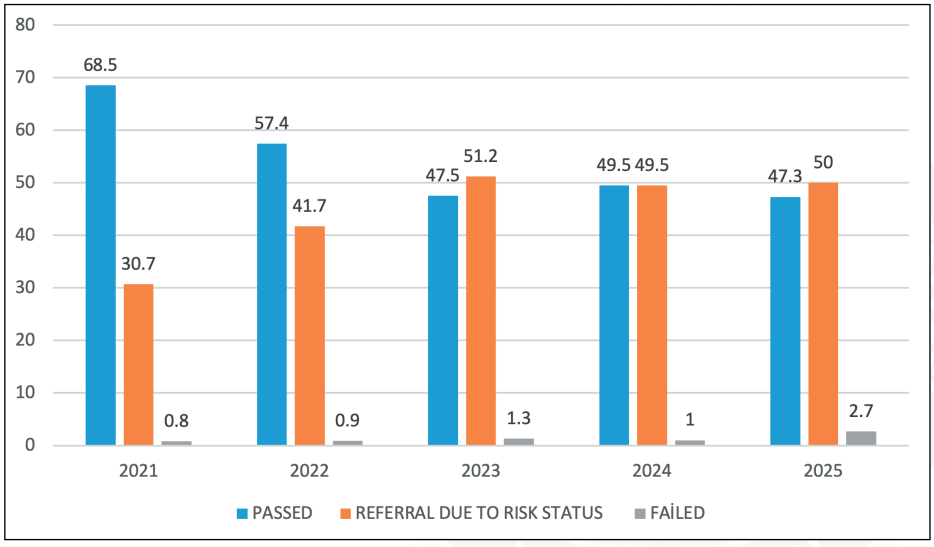

Figure 1: Percentage values by year

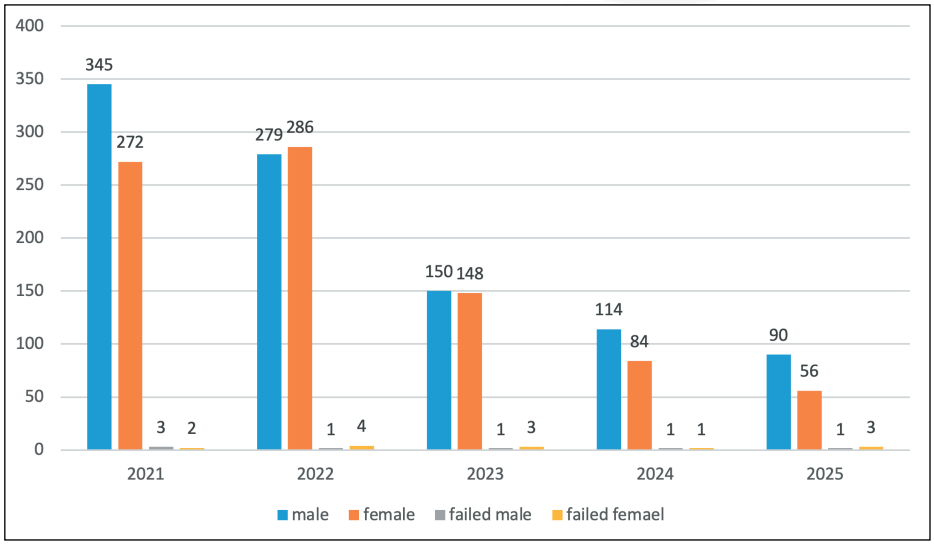

Figure 2: Gender-specific hearing loss detection by year

Table 2. Screening test results

Total Screening	Passed	Referral Due to Risk Status	Failed
1,844	1,067 (57.9%)	757 (41.1%)	20 (1.1%)

Note: Percentages may not sum to 100% because of rounding.

Upon examination of the risk factors of the 20 infants who failed the newborn hearing screening (NHS), it was determined that 15 had a history of neonatal intensive care unit (NICU) stay, 2 had a family history of hearing loss, and 3 had mothers who reported medication use during pregnancy.

Clinical ABR testing performed at our reference center on 20 infants who failed the newborn hearing screening revealed hearing loss in 3 cases, while 17 infants exhibited normal hearing findings. Conversely, hearing loss was identified in 2 of the 757 infants who passed the screening but were referred due to risk factors. All 5 infants diagnosed with hearing loss had a history of intensive care. Additionally, one infant who failed the screening was not brought to our reference center by the family, and this case was reported to the Provincial Health Directorate.

A comprehensive analysis of the five-year hearing screening results reveals that of the 1,844 newborns, 1,839 (99.72%) had normal hearing, and five (0.28%) had bilateral hearing loss. Two of the five babies had total hearing loss and were referred to hospitals that perform cochlear implants to be evaluated for cochlear implants; three babies are hearing aid users and receive special education support.

DISCUSSION

Neonatal hearing loss is one of the most common congenital disorders in childhood, with a global prevalence of 1–3 per 1,000 live births (1). This rate places hearing loss among the most common congenital anomalies. The World Health Organization (WHO) and the American Academy of Pediatrics (AAP) recommend that hearing loss in newborns be diagnosed within the first three months of birth and that treatment begin no later than six months (10). This approach is based on the fact that the first years of life are a critical period for speech and language development. Hearing loss can lead to permanent developmental problems if not intervened upon early.

The Auditory Brainstem Response (ABR), one of the primary electrophysiological methods used in the diagnosis of hearing loss, measures the electrical response of the auditory nerve and brainstem pathways to click stimuli. The ABR test is also known in literature as Screening ABR, Automated ABR (AABR), or Brainstem Auditory Evoked Response (BAER) (11). This test is an objective method that increases the reliability of screening programs. It is recommended as a first-line test in international protocols because it enables the early detection of hearing loss, particularly in at-risk infants (12).

In addition to these electrophysiological methods, imaging techniques are also an important complementary tool in determining the etiology of hearing loss. The literature reports that structural abnormalities are detected in 27.4% to 39% of cases. The most common radiological finding is an enlarged vestibular aqueduct, frequently associated with Pendred syndrome. In unilateral sensorineural hearing loss, the most common radiological abnormality has been identified as a hypoplastic cochlear nerve (13,14).

Internationally, newborn hearing screening was first introduced in the United States in 1993 and has subsequently been implemented in many countries, including the United Kingdom, Canada, Germany, India, and Australia (12). However, there are some differences in screening protocols between countries. These differences are mainly due to factors such as the timing of the test, the type of device used, and the frequency of repeat tests. Generally, all protocols are electrophysiological and aim for early diagnosis (11,15).

Similarly, in Turkey, newborn hearing screening was initiated at Marmara University in 1994 and was quickly expanded nationwide by the Ministry of Health (16). The program, which became mandatory in 2008, aimed to ensure that all newborns receive hearing screening. This national program has enabled the widespread adoption of screening not only in university hospitals but also in state hospitals and other healthcare institutions where births occur.

Studies conducted in our country have shown that hearing loss rates are similar to those reported in the literature. For example, a study conducted in the Aegean Region reported a bilateral hearing loss rate of 0.3% (17). Screenings conducted in different cities across Turkey have reported rates ranging from 0.09% (Denizli) to 0.52% (Van). The 0.28% rate found in our study is consistent with the literature and supports the effectiveness of the national program (18). Additionally, there was no statistically significant difference in the rate of hearing loss between genders ($\chi^2 = 2.06$, $p = 0.151$).

When evaluated in terms of risk factors, the most commonly reported causes are premature birth, low birth weight, prolonged neonatal intensive care unit stay (>7 days), use of ototoxic medications, and intrauterine infections (19). Furthermore, it has been reported that ear deformities occur in one in every 6,000 births, and inner ear anomalies are

found in approximately 10-15% of cases (20). In our study, two of the infants who were found to have hearing loss had a family history, and three had been admitted to the neonatal intensive care unit. This finding is consistent with the risk factors reported in the literature. Families of all infants who underwent neonatal hearing screening were informed about the possibility of progressive hearing loss and advised to re-refer if their children exhibited language developmental delays.

It has been emphasized that infants with a family history of hearing loss should be re-examined at 12 and 24 months of age. While the rate of hearing loss in healthy newborns is 0.1%, this rate increases to 10% in at-risk groups (21-25). Therefore, infants at risk should undergo at least one audiological evaluation between 24 and 30 months of age, even if they pass the screening test (23, 25).

One of the most significant problems limiting the success of screening programs is post-screening loss. The literature reports that families, both in our country and worldwide, often fail to follow testing protocols, resulting in delayed follow-up appointments (22, 26). Similarly, some infants were lost during the follow-up period at our center. This situation disrupts early diagnosis and treatment. To prevent follow-up loss, it is crucial that families are informed accurately and in detail about the process, that the reasons for the tests are clearly explained, that risk factors are meticulously assessed, and that records are maintained by experienced personnel (19,23-25). The risk status of infants is determined through verbal anamnesis obtained from families. The use of artificial intelligence (AI) will help prevent loss to follow-up and will enable the system to automatically refer to high-risk cases. The integration of AI with human expertise is expected to significantly enhance the quality of healthcare services while reducing the potential risks associated with these technologies (27). Additionally, family physicians, pediatricians, and ear, nose, and throat specialists have important responsibilities in this regard.

"This study has several limitations. First, due to its retrospective design and single-center setting (Zonguldak Bülent Ecevit University Hospital), the findings may have limited generalizability. Second, the data were obtained from hospital records, and follow-up data from external centers could not be included. Third, the screening procedures were performed by different personnel, which may have introduced inter-operator variability.

An additional limitation of this study is the exclusion of premature infants and newborns who were lost to follow-up. Although these groups constitute clinically important and high-risk populations within newborn hearing screening programs, their inclusion could have introduced heterogeneity related to gestational age, comorbid conditions, and incomplete diagnostic follow-up. Therefore, these cases were intentionally excluded to maintain methodological consistency and internal validity. Future prospective and multicenter studies focusing specifically on premature infants and follow-up–incomplete cases may provide further insight into screening outcomes in these vulnerable populations.

A considerable limitation concerns the statistical analysis of risk factors. In the hospital database, risk factors for infants who passed the screening were recorded as binary entries (presence/absence) rather than specific categorical data (e.g., duration of NICU stay), preventing detailed comparisons. Furthermore, despite the large screening cohort, the total number of cases diagnosed with permanent hearing loss (n=5) was insufficient to provide the statistical power required for advanced multivariate analyses. Consequently, causal relationships between specific risk factors and hearing loss could not be established statistically.

Conclusion

This study, along with other findings in the literature, indicates that newborn hearing screening programs implemented in Turkey yield results consistent with international data. However, cases that cannot be followed up after screening remain a serious problem. To increase program effectiveness, special attention should be paid to informing families, continuing the training of healthcare personnel, and long-term monitoring of at-risk infants. Strengthening access to early diagnosis and treatment will positively impact not only children's individual development but also society's overall health and quality of life.

Author Contributions

Study conception and design: **Duygu Erdem,** data collection: **Duygu Erdem, Furkan Sucu,** analysis and interpretation of results: **Duygu Erdem, Furkan Sucu,** draft manuscript preparation: **Duygu Erdem, Furkan Sucu.** The author(s) reviewed the results and approved the final version of the article.

Conflicts of Interest

The authors have no conflict of interest to declare.

Ethical Approval

Approved by the Ethics Committee of Zonguldak Bülent Ecevit University (01/10/2025, decision number: 2025/17-17)

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