Universal newborn hearing screening in southwestern Iran

Nader Saki [a], Arash Bayat [a, *], Reza Hoseinabadi [b], Soheila Nikakhlagh [a], Majid Karimi [c], Rezvan Dashti [d]

[a] Hearing Research Center, Imam Khomeini Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[b] Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran
[c] Department of Audiology, School of Rehabilitation, Iran University of Medical Sciences, Tehran, Iran
[d] Musculoskeletal Research Center, School of Rehabilitation, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

A B S T R A C T

Objectives: The implementation of Neonatal Hearing Screening (NHS) program is still at the preliminary stage particularly in developing countries despite the burden of permanent congenital and early-onset hearing impairment. The purpose of this study was to report results for universal newborn NHS in a cohort of children born in the southwestern region of Iran, as part of a national screening program set up by the Iranian National Health System.
Methods: During this cross-sectional study, which took place between March 2013 and April 2016, healthy newborns were screened using transient evoked otoacoustic emissions (TEOAEs) and automated auditory brainstem responses (AABRs) methods at several points in time as early as possible after birth. Screening followed a two-stage strategy and newborns referred after the second-stage screening were scheduled for diagnostic evaluation.
Results: A total of 92,521 newborns were screened in the urban (n = 67,780) and rural (n = 24,741) regions. Hearing impairment was confirmed in 223 (2.41 per 1000) newborns. One hundred forty-one (1.52 per 1000) of these newborns were affected bilaterally. More than 87% of these infants (195/223) showed a sensorineural hearing loss, while the defect was found to be conductive in 12 cases (P < 0.001). Of the 223 cases with hearing loss, 28 (12.5%) infants had auditory neuropathy. The majority of the infants, in both urban and rural regions, showed severe hearing impairment. We did not observe any significant difference among the incidences associated with gender (p = 0.29).
Conclusion: Our results demonstrated that universal newborn hearing screening program is an adequate program for southwestern of Iran with high coverage, low referral rate, and good follow-up rate.

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1. Introduction

The sense of hearing is important during the early years of life for the development of speech, language, and cognition [1]. Hearing impairment is the most common congenital disease and its prevalence is estimated more than twice the total of other disorders which are detectable in infants by screening [2]. There is shown in different projects that the prevalence of hearing loss is 1—3 infants per thousand live births [3—6].

Screening refers to the use of fast and simple tests and procedures to identify in a large population those who have the disorder from those who do not have it [7]. The main objective of newborn hearing screening at an early age is to reduce the impact of hearing loss on linguistic, intellectual, social and emotional developments and fulfilling the needs for health, rehabilitation and education [8—11]. Another factor that makes screening essential is the economic burden of hearing loss and the increase in costs of treatment and rehabilitation in case of delay in the diagnosis and early intervention [12].

Due to the fact that about half of children with hearing loss show no symptoms at birth and during infancy they suffer from hearing loss [13], the importance of public hearing screening program of newborns as a method of increasing the number of identified hearing loss for early intervention is evident.

The purpose of this study was to report results for universal newborn hearing screening in a cohort of children born in

* Corresponding author.
E-mail addresses: ahvaz.ent@gmail.com (N. Saki), bayat-a@ajums.ac.ir (A. Bayat), reza1hoseinabadi@yahoo.com (R. Hoseinabadi), saki-n@ajums.ac.ir (S. Nikakhlagh), morvaridclinic@yahoo.com (M. Karimi), rezvan.dashti@gmail.com (R. Dashti).

southwestern of Iran, as part of a national screening program set up by the Iranian National Health System.

2. Materials and methods

2.1. Participants

This prospective cross-sectional study took place over a three-year period, between March 2013 and April 2016. A community-based UNHS program was performed in the Khuzestan Province (southeastern Iran). This area is the sixth largest metropolitan area in the Iran, with an estimated population of 4,530,000 people. In Khuzestan region, rural areas are closely linked to the urban region through geographical, social, and cultural ties. This study was carried out at the eight referral units based on the number of births (approximately 35,000 annual live births) and postnatal follow-up visits.

The study protocol was approved by the local Ethical Committee. Before the screening, the parents received a full explanation about the testing process and gave their consent.

According to the screening protocol, healthy newborns were screened using transient evoked otoacoustic emissions (TEOAEs) and automated auditory brainstem responses (AABRs) methods at several points in time as early as possible after birth. Screening tests were performed by audiologists experienced in neonatal screening. We excluded newborns with risk factor for hearing loss: risk factors considered in the program were based on the list from the Joint Committee on Infant Hearing [14]. Risk factors were reported by professionals performing the screening tests, Pediatricians, or Otolaryngologists.

2.2. Screening procedure

During this study a two-stage screening protocol was implemented:

Stage I: Newborns were screened using TEOAE and AABR tests within the first 48 h of life. The screening instrument used was the AccuScreen (MADSEN-GN Otometrics, Denmark) and he ears were screened separately. 'Pass' means, ear tested passed the test and 'refer' means ear tested failed the test. "Refer" criterion for subjects was a unilateral or bilateral refer for either screening device. Those neonates with persistent "refer" outcome were transferred to the further screening (Stage II).

Stage II: The second screen was performed on newborns who yielded a "refer" result during the initial screen. In this stage, within 1 month after birth, TEOAE and AABR tests were also conducted in the same manner. TEOAE screening was carried out first 77.4% of time, while AABR was conducted first 22.6% of the time. Those neonates who did not pass the retest were referred for complete audiological evaluations (Diagnostic ABR and OAE assessments).

All subjects referred from the hearing screening were recommended to undergo diagnostic testing within 3 months after discharge, as well as to undergo a physical examination by otolaryngologists in one of the regional specialized centers. These centers specialize in pediatric hearing impairment diagnosis and rehabilitation.

2.3. Instrumentation

TEOAE screening was conducted using the Accuscreen (GN Resound, Denmark). The probe of this handheld device was placed in the external ear canal of the newborn with a rubber tip. TEOAEs were elicited by click stimulus delivered by a probe transducer in the external ear canal. The emissions or "echos" from outer hair cells of the inner ear were recorded by a microphone in an external ear probe assembly.

AABR test was accomplished by a one-channel equipment with non-inverted electrode on the upper forehead, inverted electrode on the nape of the neck and ground electrode on the shoulder/forearm. An ear probe tip was used in one ear at a time according to the position of the neonate in the cradle or with the mother in natural sleep. The stimulus consisted of auditory click sounds of 100 ms duration at a presentation rate of 37.1 clicks/sec, band pass filter of 100–1501 Hz, and an intensity of 35 dB nHL.

2.4. Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0. Descriptive statistics were used to summarize quantitative variables while categorical variables were summarized by percentages. The chi-squared test was utilized to investigate the associations between two categorical variables such as degree of hearing loss and region. A significance level of 0.05 was applied.

3. Results

The study included 92,521 neonates screened for hearing impairment in the urban (n = 67,780) and rural (n = 24,741) regions. There were 46,147 boys and 46,374 girls (Table 1). The gestational age was 37.4 ± 2.5 weeks and the birth weight was 2.93 kg ± 0.68.

During the period of the study, total of 92,521 newborns were examined.

At the first screening stage, 11.68% (10,804/92,521) cases failed to pass the screening examinations and were recalled for outpatient screening one month later. However, 4.23% (457/10,804) were lost from among the referred cases despite continuous contact and education about the importance of the problem. The test results of the screening are shown in Table 1.

Among the participants in the second step, 89.25% (9643/10,804) newborns showed normal test results, but 1161/10,804 (10.75%) newborns remained "refer" cases and recalled for diagnostic assessment. Therefore, 98.75% newborns passed the screening phases (first screen and second screen combined) and only 1.25% newborns were referred for diagnostic hearing examinations.

Urban areas revealed a significantly lower refer rate compared to rural areas in the initial screening stage (p < 0.05; Chi-Square). Rescreen refer rates were also higher in the rural areas than urban areas (p < 0.05; Chi-Square). We did not observe any significant

Table 1
The total number of infants screened, referred, and referred to diagnostic stage during the screening program.

Screening stage	Urban		Rural		Total
	Boys	Girls	Boys	Girls	
No. of screened newborns (Stage I)	33201	34579	12946	11795	92521
No. of screened newborns (Stage II)	3640	3963	1524	1677	10804
No. of referred newborns to diagnostic stage	419	379	178	185	1161