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# Feasibility of establishing a neonatal hearing screening program and measuring hearing loss among neonates in Dakahlia Governorate

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ORIGINAL STUDY

# Feasibility of Establishing a Neonatal Hearing Screening Program and Measuring Hearing Loss Among Neonates in Dakahlia Governorate

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**Abstract**

*Objectives*: **The aim was to evaluate the incidence of hearing impairment among neonates in a rural setup and detect permanent hearing impairment of moderate to severe degree in the frequency range important for speech recognition in neonates, at earliest possible time and help to provide appropriate intervention (medical/surgical/rehabilitation) following the detection of a permanent hearing impairment.**

*Background*: **Deafness is the most common curable childhood handicap. It is a well-recognized fact that unidentified hearing impairment can adversely affect optimal speech and language development and therefore academic, social, and emotional development. Universal neonatal hearing screening programs have been implemented in many developed countries.**

*Patients and methods*: **Our screening was done on neonates being taking care in a primary healthcare unit of the Ministry of Health and Population. This was a nonrandomized observational study done for a duration of 2 years on 1475 neonates. All neonates were screened using a two-stage protocol, with otoacoustic emission (OAE) test and final confirmation with auditory brainstem response (ABR).**

*Result*: **A total of 1475 neonates were screened, of whom 374 failed and 1101 passed in the first OAE test and 124 failed and 211 passed in the second OAE. Then, ABR was done for 28 babies, and finally, about six babies with complete hearing loss (HL) were confirmed by ABR. Our screening was done to determine the incidence of permanent HL of moderate to severe variety. The incidence of hearing impairment was 4 per 1000 newborns screened.**

*Conclusion*: **This study helped in early detection of HL and early intervention of cases.**

*Keywords:* Auditory brainstem response, Otitis media with effusion, Otoacoustic emissions

## 1. Introduction

Hearing is the most vital of all senses in newborns. Almost all information from surroundings is received through sound perception by newborns [1].

The incidence of hearing impairment is one to three per 1000 newborns screened. It is well recognized that unidentified hearing impairment could adversely affect optimal speech and language development and consequently the acquisition of literacy skill, as well as academic, social, and emotional development [2,3].

There is evidence showing that neonates with hearing impairment whose identification and remediation took place before 6 months of age were able to perform significantly better on vocabulary, communication, intelligence, social skills, and behavior, which was necessary for success in their later lives. The ultimate goal is to improve access to education and vocational rehabilitation services and to generate awareness among the masses [4].

More than 5% of the world's population has disabling HL, of whom 10% (32 million) are children. The majority of these children live in middle-income and low-income countries. Congenital

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causes lead to HL, being present at or acquired soon after birth. These could be caused by hereditary or nonhereditary genetic factors or by certain complications that occurred during pregnancy and childbirth. Early detection and intervention remained the key factor in minimizing the effect of HL on a child's development and educational achievements [5].

The WHO had quoted that in infants and children with HL, early identification and management through infant hearing screening programs could improve the linguistic and educational outcomes for each child. Children with hearing impairment would benefit through use of hearing aids, assistive listening devices, and cochlear implants. However, the production of hearing aid devices does not meet the need that is generated. Most developed countries have successfully finalized universal neonatal hearing screening programs [6,7].

The Joint Committee on Infant Hearing had set three goals: screening should be completed by 1 month of age, diagnosis should be made by 3 months, and intervention and treatment should commence by 6 months [8].

Upon this consideration, the aim of the study was to assess HL in newborns as a part of hearing screening program. Screening obstacles were also addressed to be resolved appropriately with provision of purposeful family counseling.

## 2. Patients and methods

This was a prospective nonrandomized observational study done over 2 years (during the period between January 2020 and December 2021) in primary healthcare units of the Ministry of Health and Population in Dakahlia Governorate. The study was approved by the Ethical Committee of Menoufia University (191219PEDI73).

### 2.1. Inclusion criteria

Our study included all neonates (1475 preterm or fullterm) who visited the primary healthcare unit of Ministry of Health and Population (1475 neonates), especially those admitted to the neonatal ICU (NICU) due to congenital infection, hyperbilirubinemia, hypoxia, respiratory distress syndrome, or any other causes and who had some risk factors such as consanguinity and a family history of HL. Tests used for screening newborns for HL included otoacoustic emission (OAE) (Interacoustics A/S Audiometer Alle 1, Middelfart, Denmark, SN 1A3003231) and automated auditory brainstem response (ABR) audiometry (manufactured by Interacoustics, Denmark − Assens Denmark SN 30262000).

The first OAE was done for all 1475 neonates with age ranged from 3 to 28 day and was performed in a purposefully designed room for scanning tests because OAE is masked in presence of excessive environmental noise. Periods in which newborns were calm or sleeping were preferred. The result was 'PASS' or 'REFER.' The result 'PASS' suggested that the neonate had no hearing impairment in the specific frequency tested. Neonates who failed the first screening were subjected to a second level of hearing screening after 15 days by performing the second OAE test. This was done in the Department of Otorhinolaryngology by a trained health worker, which was a completely automated analysis system that gave a 'PASS' or 'REFER' result. 'PASS' suggested that the neonate had no hearing impairment in the specific frequency tested, and 'REFER' indicated that the neonate had hearing impairment. Neonates who could not pass the second OAE test underwent confirmatory ABR at the age of 6 months, which was done by an audiologist. Newborns who failed ABR were taken to the rehabilitation program, and amplification or implantation was planned.

N.F.B: tympanometry (ZODIAC, 901 Otometrics A/S, Taastrup, Denmark) was done for all neonates who did not pass the second OAE test before doing ABR to exclude otitis media with effusion (OME) (conductive cause of HL).

Some obstacles observed during the screening process and their suggested interventions are mentioned in Table 1.

### 2.2. Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) program for Windows (standard version 26). The normality of data was first tested with one-sample Kolmogorov−Smirnov test. Descriptive analyses were used, with results presented as proportions.

IBM SPSS Statistics for windows, version 26 (SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis.

## 3. Results

As shown in the flow chart of our study (Fig. 1 and Table 2), 1475 neonates were screened, of whom 1101 (74.6%) passed the first OAE and 374 (25.4%) failed to pass the first OAE. Those who failed were referred to undergo second OAE, of whom 211 passed the second OAE and 124 failed to pass the second OAE and 39 were lost to follow-up. The 124 neonates who did not pass the second OAE were referred to undergo tympanometry to exclude

*Table 1. Obstacles during screening process and the suggested interventions.*

| Obstacles | Intervention |
|---|---|
| Parent causes | |
| Refusal of the parents to do the test | Describe to them the importance of the test in detecting any hearing problems early and its positive reflection on taking precautions and early treatment |
| Difficulty attending for families who live in areas do not close to the place of screening | Describe to them the nearest place for screening and the easiest way to reach the place of examination |
| COVID-19 pandemic, some parents refused to take the test due to the outbreak of the Corona virus | Taking all precautions to prevent the spread of infection, including sterilization and comprehensive disinfection measures. The necessity of wearing masks and sterilizing with alcohol. Reassure parents and search for the nearest center to them |
| Missed follow-up time | Set another date and emphasize the importance of follow-up |
| Some parents fail to know the test result | Notify the parents of the test results as soon as they are available, with the need to provide all means of communication |
| Baby causes | |
| A crying and irritable baby | Give the baby to his mother, wait for him to calm down, and then try again |
| Feverish or diseased baby | Postpone the test, examine the baby to find out the cause, prescribe the appropriate treatment, and set another time for the test |
| Screening place causes | |
| Excessive environmental noise interferes with the test | Maintain a calm environment in the vicinity of the examination |
| Overcrowding and sometimes not all cases can be tested | Set scheduled appointments for cases to reduce overcrowding while working to provide more examination devices and well-prepared examination |
| Testing causes | |
| The OAE probe does not fit well in some cases | Try to fit smoothly or change it |
| First OAE test failed due to ear wax or ear fluid | Repeat the test after 2 weeks |
| False positive OAE test results due to transient ear problems as ear wax and ear fluids | Work to provide the ABR test as an early screening method to avoid these false results |
| Few of the centers that do the ABR examination and the presence of the ABR waiting list | Directing parents to the nearest available places and participating in facilitating communication and scheduling appointments. Moreover, try to increase the number of ABR devices |

ABR, automated brainstem response; OAE, otoacoustic emission.

conductive caused of hearing impairment such as OME. Of them, 70 did not pass, 19 were lost to follow-up, and 35 passed tympanometry. Those who passed tympanometry were referred to undergo ABR; 22 of them had normal ABR, seven of them were lost to follow-up, and six had abnormal ABR. These six neonates had sensory neural HL, with a prevalence rate of 0.4%. The risk factors of these infants are given in Table 3.

Tympanometry was done for 124 cases, and the results showed that 28.2% were normal, 56.5% were OME, and 15.3% were lost to follow-up. A total of 35 cases were referred to undergo ABR, and the results showed that 62.9% were normal, 17.1% were abnormal, and 20% were lost to follow-up.

As shown in Table 4, the first OAE had six patients who were true + ve, 1101 patients were true −ve, 361 patients were false + ve, and 0 were false −ve. This result had 100% sensitivity, 75% specificity, and 75.4% accuracy. The second OAE showed that six patients were true + ve, 211 patients were true −ve, 111 patients were false + ve, and 0 were false −ve. This result had 100% sensitivity, 65% specificity, and 66.2% accuracy.

Some obstacles observed during the screening process are mentioned in Table 1.

## 4. Discussion

Significant HL is one of the most frequent congenital diseases present at birth, occurring in about one to three of every 1000 healthy neonates [2,3].

In our study, hearing defect was seen in four per 1000 neonates. The initial signs of HL were very subtle, and systematic neonatal hearing screening was the most effective means of early detection. The early identification of congenital HL was necessary to minimize the consequences of hearing impairment on the future communication skills of a baby [9].

In our study, the diagnosis of HL was confirmed in 6 months, and intervention and treatment were started.

The techniques most often employed and successfully used in the universal neonatal hearing screens are (i) automated auditory brainstem responses (AABRs) and (ii) OAEs. Both OAE and

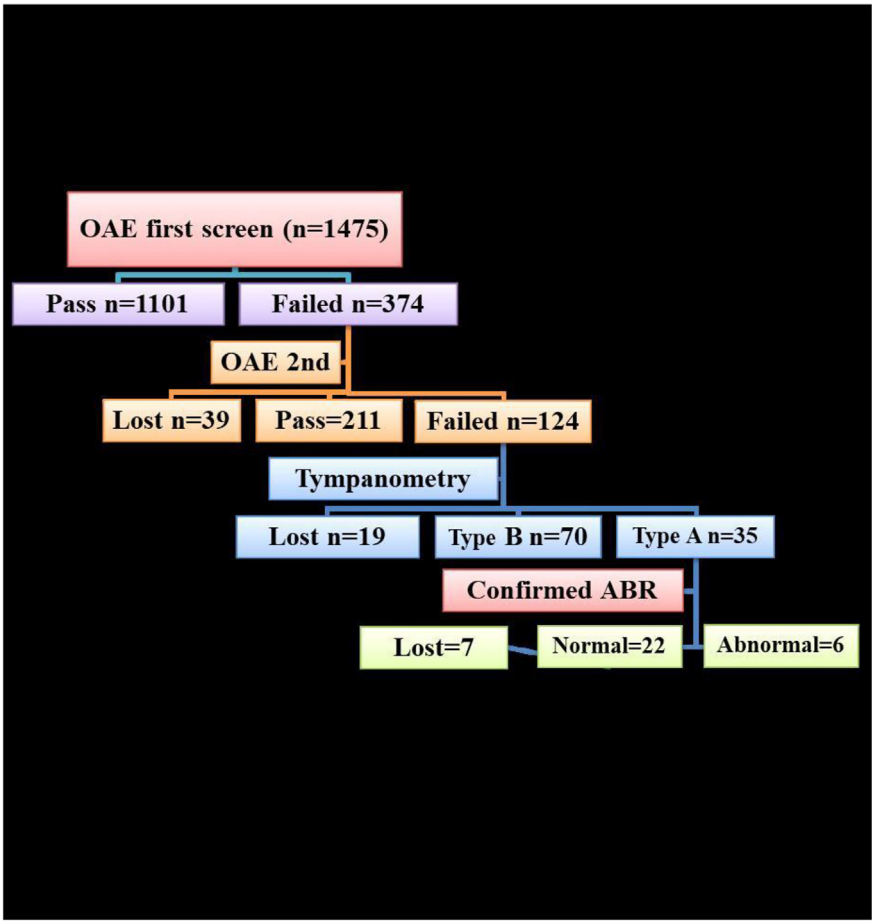


*Fig. 1. Flow chart of the studied group.*

AABR technologies provide noninvasive recordings of physiologic activity underlying normal auditory function, and both are easily performed in neonates and infants [6].

This study was aimed to screen and identify causes for HL in newborn infants in Dakahlia Governorate, which subsequently helped in updating the information on HL prevalence in our governorate as

*Table 2. Results of neonatal hearing screening.*

| Tests | The study group ($N = 1475$) [$n$ (%)] |
|---|---|
| First OAE | |
| Pass | 1101 (74.6) |
| Failed | 374 (25.4) |
| Second OAE | |
| Pass | 211 (56.4) |
| Failed | 124 (33.2) |
| Lost | 39 (10.4) |
| Tympanometry | |
| Type A (normal) | 35 (28.2) |
| Type B (OME) | 70 (56.5) |
| Lost | 19 (15.3) |
| ABR | |
| Normal | 22 (62.9) |
| Abnormal | 6 (17.1) |
| Lost | 7 (20.0) |

ABR, auditory brainstem response; first OAE, first otoacoustic emission screening; second OAE, second otoacoustic emission screening; OME, otitis media with effusion.

*Table 3. Relationship between hearing loss and risk factors.*

| Risk factor | Newborns without hearing loss [$n$ (%)] | Newborns with hearing loss [$n$ (%)] | $P$ value |
|---|---|---|---|
| Duration of pregnancy | | | |
| Full term | 1379 (99.8) | 3 (0.2) | 0.003 |
| Preterm | 1383 (96.5) | 3 (3.5) | |
| Delivery method | | | |
| Normal | 201 (99.0) | 2 (1.0) | 0.165 |
| Cesarean | 1261 (99.7) | 4 (0.3) | |
| Consanguinity | | | |
| Positive | 267 (98.2) | 5 (1.8) | 0.001 |
| Negative | 1195 (99.9) | 1 (0.1) | |
| Congenital hearing loss in the family | | | |
| Yes | 39 (92.9) | 3 (7.1) | ≤0.001 |
| No | 1423 (99.8) | 3 (0.2) | |
| Jaundice | | | |
| No | 1198 (99.6) | 5 (0.4) | 1.0 |
| Yes | 264 (99.6) | 1 (0.4) | |
| Stay in ICU | – | | |
| No | 1228 (99.8) | 2 (0.2) | 0.008 |
| Yes | 234 (98.3) | 4 (1.7) | |

*Table 4. Validity of otoacoustic emission as standard screening test in diagnosis of neonatal hearing loss in comparison with automated brainstem response.*

| Test | True + ve | True −ve | False + ve | False −ve | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|---|---|---|---|---|---|---|---|
| OAE first | 6 | 1101 | 361 | 0 | 100 | 75 | 75.4 |
| OAE second | 6 | 211 | 111 | 0 | 100 | 65 | 66.2 |

OAE, otoacoustic emission.

well as in detecting obstacles and providing proper management counseling to the affected families. This study was carried out on 1475 neonates in different centers at Dakahlia Governorate, Egypt.

As is commonly accepted in most North African, Middle East, and West Asian cultures, intrafamily unions collectively account for 20–50% of all marriages. This difference may be owing to more awareness of risks of consanguineous marriages in our society, as about 18.6% of parents had a history of consanguineous marriages. This was lower than the percent found by Hamamy [10], who stated that consanguineous marriages were more common, and the author also reported on the different dangers of consanguineous marriage and effect of higher education levels. In the study by Augustine et al. [11], 20.7% of the screened neonates had + ve consanguineous marriage.

In our study, 86.1% of neonates were delivered by cesarean section and only 13.9% were delivered via vaginal delivery. In the study by Gouri et al. [12], 95.5% of neonates were delivered by cesarean section and only 4.5% were delivered by vaginal delivery. In our study, about 2.9% of screened neonates had + ve family history of HL. In the study by Augustine et al. [11], 8.6% of screened neonates had a +ve family history of HL.

In our study, 1475 neonates were screened, of whom 1101 (74.6%) passed the first OAE and 374 (25.4%) did not pass the first OAE. The babies who did not pass the first OAE were referred to second OAE, of whom 211 (56.4%) passed the second OAE, 124 (33.2%) did not pass the second OAE, and 39 (10.4%) were lost to follow-up.

Babies who did not pass the second OAE were referred to undergo tympanometry to exclude conductive causes of HL. Of 124 babies who did not pass the second OAE, about 35 (28.2%) of them had type A (normal) tympanometry, 70 (56.5%) had type B tympanometry (OME), and 19 (15.3%) were lost to follow-up.

The 35 babies who had normal tympanometry were referred to undergo ABR and 22 (62.9%) of them had normal ABR, 7 (20%) were lost to follow-up, and 6 (17.1%) had abnormal ABR.

Vishwakarma et al. [13] found that 81.1% of neonates passed the first OAE, and also Augustine et al. [11] stated that 90.9% of screened neonates passed the first OAE test.

Pagnossim et al. [14] found that the conductive causes of HL include ear wax and ear fluid, which were detected in 3.33% of the screened neonates.

In our study, the prevalence of HL in our screened neonates was about 0.4%. Erode [15] stated that the prevalence of neonatal HL was 0.7% in Istanbul.

Moreover, Sathyabhama and Karat [16] found that prevalence of HL in neonates was 0.8%, which was lower than Wenjin et al. [17], who found that the prevalence of HL was 1.8%.

Although OAE was cheap, quick, simple, and reliable, with a sensitivity of 100% and specificity of 99% [18], AABR had the additional advantage of identifying neonates with auditory neuropathy unlike the testing by OAE. The other advantages of AABR included rapidity, easy-to-use, and high sensitivity (0.99) and specificity (0.87) [19]. In our study, OAE had sensitivity of 100% and specificity of 75.3% in the first OAE and 65.5% in the second OAE (Table 4).

In the study by Augustine et al. [11], three (5.2%) of 58 neonates with HL had hyperbilirubinemia. In our study, one (0.4%) of six neonates who had HL had hyperbilirubinemia. Different studies have shown significant correlations between different risk factors and HL. The most common risk factors were ototoxic treatments, prematurity, low birth weight, and ICU stay of more than 7 days [20]. In our study, four (1.7%) of six neonates with HL were admitted to ICU and three of six neonates with HL were premature.

Genetic counseling must be offered to the families and should be provided with information about HL as a public health problem, stressing on the importance of monitoring speech and language. Moreover, families should be informed about the importance of regular follow-up and premarital screening testing, especially for at-risk families with a prevalence of similar conditions.

In addition, awareness should be raised about the importance of hearing aid devices and early introduction of language and provision of education and rehabilitation programs.

### 4.1. Conclusion

Hearing impairment is a serious disability that affects a child's language development and communication skills.

Early identification and intervention programs for a child with hearing impairment helps to prevent and minimize language and communication delays identified and to enhance the child's language development and communication skills for learning.

Egyptian National Hearing Screening program in newborns could be used to detect hearing impairment in the first days after birth, where the prevalence of HL among newborns in this study reached 0.4%. Parental counselling and placement in appropriate schools with hearing impaired educators were also important aspects in the total rehabilitation program for the young hearing impaired.

## Consent statement

The study protocol was approved by the Medical Ethical Committee of the Faculty of Medicine, Menoufia University. Informed consent was taken from each participant before being enrolled in the study.

## Conflicts of interest

There are no conflicts of interest.

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