A practical screening model for hearing loss in Iranian school-aged children

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Background: **Hearing loss is a common and considerable disability that harms educational performance of school children in developing countries like Iran. Lack of a simple and practical screening protocol often deters routine and systematic hearing screening at school entry.**

Methods: **This study was to establish a practical screening model for hearing loss in school-aged children based on a community-based, retrospective case-control study in Ilam, the capital of Ilam province in Iran. Results from the audiologic and non-audiologic examination of 785 children in primary schools were selected and examined. The non-audiologic evaluation consisted of medical history, general physical examination, while the audiologic assessment consisted of otoscopy, audiometry and tympanometry.**

Results: **Univariate analysis of non-audiologic variables showed an association between hearing loss and male gender (P<0.05) and the grade of study (P<0.05). The frequency of impaired hearing in the first grade of primary schools was significantly higher than the children in the second grade (P<0.05). In audiologic factors related to impaired hearing, otitis media with effusion (OME) was diagnosed significantly (P<0.05).**

Conclusion: **Routine screening based on the identification of OME will facilitate the detection of a major amount of hearing impaired school-aged children.**

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Key words: **hearing loss;**
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Introduction

Hearing loss among school children in the developing countries has been widely reported as a considerable health problem.[1-6] Since majority of the schools in such countries are based on auditory-verbal methods, hearing impairment will have negative outcomes on educational performance. Therefore, hearing screening at school entry has been proposed for the early detection and rehabilitation of hearing impaired school children in the developing countries.[7,8] Unfortunately, school-aged children are rarely screened for hearing loss during routine clinical examination, and health authorities pay little attention to audiometric evaluation particularly in primary schools. This is usually attributable to the inadequate knowledge of parents, school authorities and healthcare providers on the outcomes of light or mild hearing loss.

Regarding the mentioned issues, it is favorable to set up a routine school audiometry for detection of hearing impaired children based on the World Health Organization (WHO) definition of "disabling hearing impairment" in children under the age of 15 years described as "a permanent unaided hearing threshold level in the better ear of 31 dB or greater".[9] This criterion, however, has some inherent limitations. For example, it excludes children with conductive hearing loss, which is common in this age group as a result of recurrent, chronic or acute otitis media.[1-5] It also does not recognize children with unilateral hearing loss of any degree or those with permanent (sensorineural or mixed) hearing loss less than 31 dB. These children face difficulties in communication caused by adverse listening conditions such as noisy classrooms. Such conditions will have negative effect on their educational state.[10-12] Therefore, a significant number of school children with "disabling" hearing loss are unlikely to be detected by hearing screening based on the WHO criterion alone. While children with moderate-to-profound permanent and bilateral hearing loss (>40 dB) may be detected through primary parental suspicion, those with light/mild hearing loss (16-40 dB) are unlikely to be so detected because the handicap is associated more with receptive rather

than expressive linguistic skills.[13,14] As a result, we examined the audiologic and non-audiologic profile of hearing impaired school children to determine predictors of hearing loss as a basis for a hearing loss screening program. The parameters were derived from conventional school health and child surveillance programs.[15,16]

Methods

Sampling

This cross sectional study was conducted in Ilam province, Islamic Republic of Iran, with a population of 785 school children in the first and second grades of primary schools. The sample was selected from 10% of primary schools by simple randomization sampling. The first child was randomly selected from the class register and every third child thereafter. Altogether 785 children were selected by this process. They comprised 343 (43.4%) girls and 442 (56.6%) boys, aged 6-7 years (mean 6.7 years). The majority (96.3%) of them belonged to the least affluent social classes III-V based on mothers' education and fathers' occupation and monthly income.[17,18] The study was approved by the Ethics Committee of Ilam University of Medical Sciences and informed consent was obtained from the parents of the participating children before enrollment. The data were collected over a period of four months within the same school year.

Non-audiologic examination

A structured questionnaire was distributed to the parents to ascertain the medical, social and family status of the children. Height, weight, birth weight and head circumference (occipitofrontal circumference, OFC) were measured. A plastic measuring tape 183 cm with a range of 0-183 cm and an accuracy of 1 mm was used for the measurement of height. Weight was measured with a self-calibrating scale with a range of 0-130 kg and an accuracy of 200 g. Each child was weighed wearing the school uniform, which was light, and without shoes and socks. The measurement was recorded to the nearest 100 g. OFC was measured with a plastic tape, which has a range of 0-2 m and an accuracy of 1 mm. The measurement was recorded to the nearest millimeter, taken from the midway between the eyebrows and the hairline at the front of the head and from the occipital prominence at the back of the head. The anthropometric results were interpreted using normalized international growth reference curves.[19] General medical examination was undertaken to document any other routine clinical information.

Audiological examination

Otoscopy and audiometry

The ear canals were examined with an otoscope. Foreign bodies, debris and impacted cerumen were removed before audiometric tests that were performed in the quietest section in each school using a duly calibrated pure-tone audiometer with TDH-39 earphones and audiocups for extra attenuation. The tests were carried out only when the noise level meter reading was <45 dB. A modified two-stage audiometric examination was conducted following a daily biological check of the pure-tone audiometer. At the first stage of the audiometric test, a pass or fail criterion of 20 dB HL was applied to each ear at frequencies 0.5, 1.0, 2.0, and 4.0 kHz. A pass represented correct responses to signals at all frequencies in both ears. A fail was recorded if there was no response at one or more frequencies in either ear. The children who failed were referred to the teaching hospital for threshold testing and bone conduction. A pure tone average >15 dB HL at frequencies 0.5-4.0 kHz was considered as failure. Pure tone averages were classified into one of the following hearing loss categories: light (16-25 dB HL), mild (26-40 dB HL), moderate (41-70 dB HL), severe (71-90 dB HL), and profound (>90 dB HL). Hearing loss was classified as sensorineural if the air-bone gap was <15 dB and conductive if it was >15 dB. Hearing loss was regarded as mixed if the air-bone gap was >15 dB and the bone conduction thresholds were also elevated (>15 dB).

Tympanometry

Similarly, tympanometric assessment was conducted in two stages at an interval of 6 weeks to allow for the resolution of any transient middle ear conditions. In the first stage, children with non-type A tympanograms were referred for a repeat assessment. Those with persistent non-type A tympanograms at the end of the second stage were considered as having the failed tympanometric test. Those with type B tympanograms among this group were classified as having otitis media with effusion (OME).

Selection of subjects and controls

Seventy-seven children had pure tone average >15 dB HL in frequencies 0.5-4.0 kHz at the end of the second stage audiometry and were enlisted as subjects. They included 44 boys (57.1%) and 33 girls (42.9%), with an age range of 6-7 years (mean: 6.6 years). From the remaining 708 children, 150 were selected as controls, matched for age and sex.

Data analysis

Discrete variables were expressed as percentages and

compared with the Chi-square test or Fisher's exact test as appropriate. Continuous variables were compared by means of the unpaired, two-sided *t* test. All statistical analyses were performed using SPSS software Ver.13. $P<0.05$ was considered statistically significant.

Results

Altogether 785 children were examined. They comprised 343 (43.4%) girls and 442 (56.6%) boys, ranging in age from 6 to 7 years (mean 6.7 years). From the 77 hearing impaired children, 65 (84.4%) had light/mild hearing loss, while 12 (15.6%) experienced moderate/moderately severe hearing loss. Gender played a significant role in impaired hearing. Of the children with impaired hearing, 44 (57.1%) were male and 33 (42.9%) were female ($P<0.05$). Furthermore, significant difference was observed between children's grade of study and frequency of haring loss. Forty-five (58.8%) of these children studied at the first grade of primary schools, whereas 32 (41.2%) studied at the second grade ($P<0.05$). The results of our study are shown in Table.

In audiologic factors related to impaired hearing, a positive history of otitis media was known as a risk factor ($P=0.001$). In 51 children (66.2%) OME was diagnosed at the time of examination, but the remaining 26 (33.8%) did not show any signs of otitis media. Forty-six children (59.7%) had conductive hearing loss, 31 children (40.3%) had sensorineural type of hearing loss, and none had mixed type. In other words, hearing loss was transient in 46 (59.7%) children and permanent in 31 (40.3%) ($P>0.05$). Moreover, 57 children (74.0%) had unilateral type of hearing loss, while the remaining 20 (26.0%) had bilateral type ($P>0.05$). Tympanometry examination revealed the following results in children: tympanograms type A in 479 children (61.0%) and non type A tympanograms in 306 (39.0%). Abnormal tympanograms of 77 children with different levels of hearing loss were divided into three types: type An in 47 (61.0%), type B in 27 (35.1%), and type C1, C2 and C3 in 3 (3.9%). The degree and patterns of hearing loss are presented in Table. Investigations of the school children with impaired hearing showed that 51 children (66.2%) had a birth weight above 1500 g, whereas 16 children (20.8%) had low birth weight. We were not able to determine the birth weight of the other 10 children ($P>0.05$). Only 33.3% of parents were aware of hearing loss in their children, the other 66.7% had no acknowledgement about hearing loss in their children at the time of diagnosis ($P>0.05$).

Discussion

Hearing loss of children was mainly light to mild and unilateral in our study. Of the three factors that were found to be significant in our analysis (gender, the grade of study and history of otitis media), one was audiologic. This may justify the reason for the inclusion of routine and systematic hearing screening in well-established child health surveillance protocols.[15,16]

Screening is justifiable only where the required treatment is accessible and inexpensive. It may be claimed that hearing aid is an expensive treatment in poor communities; however, hearing impairment would be alleviated by basic intervention such as preferential seating in classroom even without using hearing devices. With proper education, children are also less likely to be misunderstood by people with whom they interact in difficult listening situations. Moreover, selective screening based on risk factors has been supported as a cost-effective alternative to universal screening in developing countries.[20]

Otitis media is considered in some reports as the commonest cause of childhood hearing loss in developing countries.[21,22] Studies in such countries reported prevalence rates of 13.8%-36.2% for OME among comparable school-aged populations.[2,4,23,24] The main risk factors for OME are usually lack of standard hygienic and nutritional status, poor housing conditions, and presence of viral or bacterial infection and upper respiratory allergy.[22] A diagnostic marker for the accurate identification of OME during routine

Table. The characteristics of children with impaired hearing

Variables				*P* value
Gender	Male 57.1% (*n*=44)	Female 42.9% (*n*=33)		*P*<0.05
Severity of hearing loss	Light to mild 84.4% (*n*=65)	Moderate to severe 15.6% (*n*=12)		NS
Type of hearing loss	Conductive 59.7% (*n*=46)	Sensorineural 40.3% (*n*=31)		NS
Tympanometry type	Type An, 61.0% (*n*=47)	Type B, 35.1% (*n*=27)	Types C1/C2/C3, 3.9% (*n*=3)	NS
Birth weight	<1500 g 66.2% (*n*=51)	>1500 g 20.8% (*n*=16)	Unknown 13.0% (*n*=10)	NS
Parental awareness	Yes 33.3% (*n*=25)	No 66.7% (*n*=52)		NS
Grade of study	First grade 58.8% (*n*=45)	Second grade 41.2% (*n*=32)		*P*<0.05
History of otitis media	Yes 66.2% (*n*=51)	No 33.8% (*n*=26)		*P*=0.001

NS: not significant.

clinical examination remains elusive. Pneumatic otoscopy is a unique tool for primary diagnostic method with tympanometry as a gold standard.[25] In spite of the fact that pneumatic otoscopy is cheaper and subjective, it requires considerable skills and involves extensive training. Tympanometry is highly sensitive and quite expensive to use as a screening tool routinely. The accurate diagnosis of OME is still a challenge to many clinicians even in the developed world.[26,27] This may often result in over-diagnosis of acute otitis media (AOM) and its over-treatment with broad-spectrum antibiotics.[28,29] AOM is a common but self-limiting childhood disease and only in few cases does it progress to OME. Thus, a more practical option for a developing country presently seems to be the prevention of OME as suggested by the WHO.[24]

The lack of correlation between hearing loss, history of hearing difficulties and ear discharge is corroborated by a study which found parents' prediction of hearing loss associated with OME unreliable.[30] However, it may be of interest to mention that parents in the USA for instance are being trained for simple home otoscopy in order to reduce reliance on physicians for uncomplicated middle ear infections.[31] The aim is to teach parents to recognize normal tympanic membranes and this allows parents to detect any occlusion in the external auditory canal due to excessive or impacted cerumen.

The view that childhood hearing impairment is commonest in low socio-economic classes has become conventional wisdom because of the impact of poor hygienic conditions, low immunization rate, and unnecessary use of ototoxic medications.[32,33] However, some surveys suggest the controversy over the association between socio-economic status, otitis media and hearing loss. For instance, in a cross-sectional study among 5-6 years old pre-school children in Malaysia, it was found that the higher the working status and income of the parents, the higher the risk of having a child with OME.[26] The authors suggested that early enrollment of children into day-care centers by these working parents increased the risk of cross-infection. In contrast, some other studies reported a higher prevalence of otitis media in the lower socio-economic classes, while others found no association between otitis media and socio-economic status.[34-37] Regarding this variability, parental literacy by itself is unlikely to be a universal predictor of hearing loss in school-aged children. Furthermore, a screening model that only consists of impacted cerumen and OME is perhaps more expedient for a developing country because of its significantly better specificity. When the detection of OME is impossible, screening for impacted cerumen should be regarded.

This study suggests that hearing loss in school-going children cannot be readily detected during routine clinical examination without a systematic audiologic screening. OME is one of the most important predictors of hearing loss in this population. When general audiometric screening cannot be implemented, selective screening or referral based on these factors would facilitate the detection of a significant proportion of hearing impaired children for proper and suitable intervention.

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