Prevalence and risk factors for hearing disorders in secondary school students in Ismailia, Egypt

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انتشار اضطرابات السمع وعوامل اختطارها بين طلاب المدارس الثانوية في الإسماعيلية، بمصر

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الخلاصة: أُجري من خلال هذه الدراسة تقدير لمدى انتشار اضطرابات السمع وعوامل اختطارها في عيِّنة تمثِّل 10% من جميع طلاب المدارس الثانوية في مدينة الإسماعيلية، بمصر. وأعطي استبيان لجميع المشاركين، كما خضعوا لاختبارات «ويبر» و«ريني» لقياس العجز السمعي. وأوضحت الدراسة انتشار الصَّمَم بنسبة 22.2% بين الطلاب الـ 2633 الذين أُجري عليهم البحث، كان أغلبُه صمَّما حسياً عصبياً. وتبيَّن وجود مزيج من الصمم الحسي العصبي والصمم التوصيلي بنسبة أكبر لدى طلاب المدارس التقنية (46.2%) منها لدى طلاب المدارس العامة (28.6%) أو التجارية (25.3%). وتَمَّ بتحليل التحوُّف اللوجستي العديد المتغيِّرات، تحديد عدد نوبات التهاب الأذن الوسطى، وسوابق معالجة أمراض الأذن، وسوابق الإدخال إلى مستشفى الحميات، وسوابق جراحات الأذن، كعوامل اختطار مستقلة للإصابة بالصمم الحسي العصبي.

ABSTRACT This study estimated the prevalence of hearing disorders and associated risk factors in a 10% sample of all secondary-school students in Ismailia city, Egypt. All participants were given a questionnaire and Weber and Rinne tests for hearing disabilities. Among 2633 students, the prevalence of hearing loss was 22.2%, mostly sensorineural hearing loss. More students at technical schools had mixed sensorineural and conductive hearing loss (46.2%) than students at general (28.6%) or commercial (25.3%) schools. Multivariate logistic regression analysis identified the number of attacks of otitis media, history of ear disease treatment, history of admission to fever hospital and history of ear surgery as independent risk factors for sensorineural hearing loss.

Prévalence et facteurs de risque des troubles auditifs chez les élèves du secondaire à Ismaïlia en Égypte

RÉSUMÉ Cette étude a évalué la prévalence des troubles auditifs et des facteurs de risque associés dans un échantillon représentant 10 % de la population des élèves du secondaire de la ville d'Ismaïlia (Égypte). Tous les participants se sont vu remettre un questionnaire et ont subi les tests d'acuité auditive de Weber et de Rinne. Dans cet échantillon de 2633 élèves, la prévalence de la perte d'audition s'élevait à 22,2 %, consistant majoritairement en une surdité neurosensorielle. Les élèves des collèges et lycées d'enseignement technique étaient plus nombreux à présenter une surdité mixte de transmission et neurosensorielle (46,2 %) que les élèves des collèges et lycées d'enseignement général (28,6 %) ou commercial (25,3 %). L'analyse de régression logistique multivariée a permis d'identifier comme facteurs de risque indépendants de surdité neurosensorielle le nombre d'épisodes d'otite moyenne, d'antécédents de traitement d'une pathologie auriculaire, d'hospitalisations pour épisodes fébriles et d'otochirurgie.

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Introduction

Hearing loss in infants and children may be sensorineural, conductive, or mixed unilateral or bilateral and symmetric or asymmetric. It can also be syndromic (involving other identifiable features) or nonsyndromic (isolated hearing loss); congenital or postnatal; prelingual, perilingual or postlingual (i.e. onset before, during, or after speech or language acquisition); and genetic or nongenetic [*1*]. Sensorineural hearing loss is an extremely common disorder, with a spectrum of effect ranging from an almost undetectable degree of disability to a profound alteration in the ability to function in the society. Because its onset is frequently insidious and accompanied by subtle compensatory strategies, hearing loss is usually overlooked by physicians and patients [*2*].

The prevalence of hearing loss in several countries has been estimated as 4%, 7.9% 15% and 10.8% in Saudi Arabia, Pakistan, Kenya and the United States of America respectively [*3–6*]. It was estimated that 3.9 million children in Africa had mild hearing loss and 1.2 million had moderate to severe hearing loss [*7*]. In Egypt, there is a scarcity of studies estimating the prevalence of hearing loss.

The risk factors for conductive and sensorineural hearing loss are mutually exclusive. Risk factors for the former include middle ear infection, trauma to the tympanic membrane, foreign body impaction in the external canal and consanguineous marriages, while those for sensorineural include viral neuritis, fracture base, ototoxic drugs, noise exposure and tumours of the cerebello–pontine angle [*3,8*]. In Europe, as in sub-Saharan Africa, the most prevalent causes of hearing impairment are chronic and suppurative otitis media [*7,9,10*].

There is a paucity of data regarding the risk factors of hearing loss in Egyptian adolescents. Thus, epidemiologic studies are needed to assess hearing loss in this important age category for setting priorities and designing efficient interventions.

The main objective of this study was to estimate the prevalence of hearing loss among secondary-school students in an Egyptian city, and to identify the risk factors associated with it, in order to enable specific preventive measures to be targeted at students with these risk factors.

Methods

There are around 1.5 million inhabitants of Ismailia city. All secondary schools in the city (19 schools) were included in the study: 10 general schools, 5 commercial schools and 4 technical schools. From 2 classes per school year, 10% of the students in each school year were randomly selected. Over the period September 2003 to July 2004, 2750 students were invited to participate in this study, of whom 2633 accepted (response rate 95.7%). No significant difference was found between participants and non-participants regarding their age or sex.

Students were asked to complete a standardized interview questionnaire, whom included demographic data (age, sex, school type, number of siblings and order of birth), clinical symptoms and the main risk factors for hearing loss. These factors included family history of consanguinity between parents or hearing problems, and history of ear surgery, infections, trauma, admission to fever hospital and intramuscular injection of antibiotics.

All participants were subjected to Weber and Rinne tests for assessment of hearing disabilities. According to the findings of these tests, a student was considered to have normal hearing, conductive hearing loss, sensorineural hearing loss or mixed

conductive and sensorineural hearing loss. Only 44 (1.7%) students had an ambiguous diagnosis and were excluded from our analysis. Comparative analysis between students with coherent and incoherent diagnoses showed no statistically significant differences regarding their demographic data or medical and family past history.

Analysis

Initial comparisons between students with different hearing loss and those with normal hearing tests were done using the Pearson chi-squared test for categorical variables. Risk factors for conductive hearing loss are completely different from those for sensorineural hearing loss. Thus, conductive and sensorineural hearing loss were considered as 2 distinct pathologies and we conducted a separate multivariate model for each of them.

The multivariable models to describe the risk factors for conductive and sensorineural hearing loss were obtained using stepwise logistic regression analysis initially with a conservative significance level of 0.25. Our dependent variable for this analysis was the state of hearing (whether normal or abnormal) according to Weber and Rinne tests findings. Subsequently, the resulting model was reduced using a likelihood ratio test with a significance level of 0.05. The calibration of the final model was assessed using the Pearson chi-squared goodness-of-fit test, and its discrimination was assessed by the area under the receiver-operating curve. All statistical analyses were performed using *SPSS*, version 11.0.

Results

Demographic data

A total of 2589 secondary-school students were included in our study; 1713 (66.2%) were from the 1st grade school year, 430 (16.6%) from the 2nd grade and 446 (17.2%) from the 3rd grade. Nearly half of the students (49.8%) were from general secondary school and the rest were from commercial (24.8%) or technical school (25.4%). The mean (standard deviation) age of the students was 15.4 (SD 1.2) years (range 13 to 21 years) with a female to male ratio of 1.3:1. The mean number of siblings of the students was 3.2 (SD 1.6) and only 632 students (24.4%) reported consanguinity between parents.

Prevalence of types of hearing loss

A total of 576 students out of 2589 (22.2%) had hearing loss. Of these, 403 (70.0%) had sensorineural hearing loss, 82 (14.2%) bilateral conductive hearing loss, 91 (15.8%) mixed sensorineural and conductive hearing loss.

Tinnitus, vertigo and hearing difficulty while talking to friends were the 3 commonest symptoms related to the different diagnoses of hearing loss. The percentage of students diagnosed as sensorineural, conductive, and mixed sensorineural and conductive hearing loss and complaining of tinnitus were 71.7%, 58.5% and 71.5% respectively. Meanwhile, vertigo and hearing difficulties while talking to friends were reported in 51.9% and 50.1% of students diagnosed as sensorineural, 53.6% and 48.7% of conductive and 64.9% and 57.2% of mixed hearing loss respectively.

Risk factors for hearing loss

Table 1 shows the association between the sociodemographic characteristics of the studied groups and different types of hearing loss. Mixed sensorineural and conductive hearing loss was higher in females (82.4%) than males (17.6%) compared with those with normal hearing and this difference was highly statistically significant ($P < 0.001$). Otherwise, no sex differences were

Table 1 **Association between different diagnoses of hearing loss and sociodemographic characteristics**

Variable	Normal hearing (*n* = 2013)		Sensorineural hearing loss (*n* = 403)		Bilateral conductive hearing loss (*n* = 82)		Mixed sensorineural and conductive hearing loss (*n* = 91)	
	No.	%	No.	%	No.	%	No.	%
Female sex	1111	55.2	225	55.8	40	48.8	75	82.4[b]
School type								
General	1027	51.0	183	45.4	54	65.9[a]	26	28.6
Commercial	490	24.3	109	27.0	20	24.4	23	25.3
Technical	496	24.6	111	27.5	8	9.8	42	46.2[b]
Consanguinity between parents	481	23.9	102	25.3	21	25.6	28	30.8
Family history of hearing problems	450	22.4	106	26.3	19	23.2	22	24.2

n = *total number of students.*
[a]P < *0.01 versus normal hearing;* [b]P < *0.05 versus normal hearing (Pearson chi-squared test was used for categorical variables).*

noticed in both sensorineural and bilateral conductive hearing loss. The percentage of students at general school diagnosed with bilateral conductive hearing loss (65.9%) was higher than that of students at commercial (24.4%) and technical schools (9.8%) compared to those with normal hearing. Moreover, the percentage of students at technical school diagnosed as mixed sensorineural and conductive hearing loss (46.2%) was higher than that of students at other school types (28.6% at general schools and 25.3% at commercial schools). The mean number of siblings was only significantly higher in mixed sensorineural and conductive hearing loss compared to those with normal hearing. No association between order of birth and any type of hearing loss was found (data not shown).

Past history of ear surgery, otitis media, admission to fever hospital, intramuscular injection of antibiotics and ear disease treatment were statistically associated with the presence of sensorineural hearing loss (Table 2). Similarly, history of ear surgery, ear disease treatment, postnasal discharge and trauma were statistically associated with the presence of bilateral conductive hearing loss. Mixed sensorineural and bilateral conductive hearing loss was significantly associated with a history of postnasal discharge, otitis media, measles and mumps, intramuscular injection of antibiotics and ear disease treatment. No association of consanguinity was found between family history of hearing problems and the presence of hearing loss.

Multivariate analysis

The multivariate logistic regression model identified the number of attacks of otitis media, history of ear disease treatment, history of admission to fever hospital and history of ear surgery as the independent risk factors for sensorineural hearing loss (Table 3).

The risk factors possibly associated with conductive hearing loss in the final mul-

Table 2 **Association between different diagnoses of hearing loss and history of different risk factors**

History of:	Normal hearing (*n* = 2013)		Sensorineural hearing loss (*n* = 403)		Bilateral conductive hearing loss (*n* = 82)		Mixed sensorineural and conductive hearing loss (*n* = 91)	
	No.	%	No.	%	No.	%	No.	%
Postnasal discharge	601	29.9	135	33.5	36	43.9[a]	38	41.8[c]
Ear surgery	17	0.8	10	2.5[a]	4	4.9[b]	1	1.1
Otitis media	132	6.6	50	12.4[b]	9	11.0	16	17.6[b]
Measles or mumps	572	28.4	109	27.0	25	30.5	43	47.3[b]
Trauma	69	3.4	14	3.5	8	9.8[a]	5	5.5
Admission to fever hospital	253	12.6	70	17.4[c]	13	15.9	16	17.6
Intramuscular antibiotics	236	11.7	64	15.9[c]	9	11.0	18	19.8[c]
Ear disease treatment	157	7.8	67	16.6[b]	20	24.4[b]	13	14.3[c]

n = *total number of students.*
[a]P < *0.01 versus normal hearing;* [b]P < *0.001 versus normal hearing;* [c]P < *0.05 versus normal hearing (Pearson chi-squared test was used for categorical variables).*

tivariate analysis model are presented in Table 4. A history of ear surgery carried the highest risk for conductive hearing loss (odds ratio = 4.06).

Discussion

The importance of early detection of hearing loss that may interfere with the process of learning has been repeatedly reported [*11–13*].

Our study aimed to estimate the prevalence of hearing loss among secondary-school students, and to identify the risk factors associated with it. Before reaching conclusions based on the present results, it is necessary to consider a number of potential objections to our procedures. Simple tools such as questionnaires and tuning fork tests were used (Rinne and Weber test). These tools are characterized by high specificity and low sensitivity. For instance,

Table 3 **Factors associated with sensorineural hearing loss in the multivariate analysis**

Variable	Odds ratio	95% confidence interval	*P*-value
Number of attacks of otitis media	1.21	1.04–1.42	0.014
History of ear disease treatment	1.98	1.27–3.09	0.003
History of admission to fever hospital	1.55	1.04–2.29	0.029
History of ear surgery	2.79	1.07–7.28	0.035

Hosmer–Lemeshow goodness-of-fit test: P = *0.672.*
Discrimination (area under the receiver operating characteristics curve): 0.590.

Table 4 **Factors associated with conductive hearing loss in the multivariate analysis**

Variable	Odds ratio	95% confidence interval	*P*-value
History of postnasal discharge	1.52	1.18–1.96	0.001
History of ear disease treatment	3.25	1.88–5.61	0.000
History of ear surgery	4.06	1.28–12.84	0.017
General school (reference category)	–	–	–
Commercial school	3.62	1.70–7.73	0.001
Technical school	2.81	1.21–6.49	0.016

Hosmer–Lemeshow goodness-of-fit test: P = *0.831.*
Discrimination (area under the receiver operating characteristics curve): 0.711.

the specificity of a questionnaire to detect hearing loss is 94%, compared with 62.4% for otoscopy and 84% for tympanometry. However, its sensitivity is 5 times less than the 2 previously mentioned methods [*14*]. Tuning fork tests are the traditional methods of differentiating conductive from sensorineural hearing impairments prior to the advent of pure tone audiometry. However, they cannot substitute for a correctly done pure tone audiometry with a full masking. The Rinne tuning fork tests have high specificity and low sensitivity to detect conductive hearing loss. Thus, when a Rinne test becomes negative it should be a reliable indicator [*15–17*]. Also, in about 25% of cases, the results of the Weber test do not agree with the results of pure tone audiometry. Its interpretation is sometimes difficult in the presence of bilaterally affected ears and it should be applied to unilateral hearing loss [*15,16*]. The results arising from these tools must be treated as provisional diagnoses that need confirmation by a more sophisticated battery of tests including pure tone audiometry and tympanometry, otoacoustic emissions and augmented brainstem response. Of course, from the history and tuning fork examination we could suspect that a student may have conductive or sensorineural hearing loss, and they will be referred to audiological evaluation.

The present study revealed a prevalence of all types of hearing loss of 22.2%. This prevalence is higher than the prevalences reported in other developing countries such as Kenya (15%) and Pakistan (8%) [*3,6*]. This could reflect different environmental exposures as there is a greater exposure to portable music devices, cell-phone use and high-powered output music speakers among young people in our environment. Segal and his coworkers [*18,19*] reported that up to 70% of hearing loss was sensorineural. This high proportion agrees with the results of the present study, where sensorineural hearing loss was the most prevalent loss, constituting 70% of the cases.

A previous English study has shown that there is no effect of sex on hearing loss until age 31 to 40 years [*20*]. Similarly, our study showed that sex has no effect on either sensorineural or conductive hearing loss. However, it did have an effect on mixed sensorineural and conductive deafness especially in females. There is no clear explanation for this and it could be due to a subgroup anomaly.

Regarding the risk factors associated with hearing loss, we found that positive

consanguinity and presence of family history of hearing problems among parents of the children were not significantly associated with suspected sensorineural hearing loss. Similarly, O'Hara et al. reported that consanguineous marriages were not associated with hearing impairment [*21*]. However, consanguinity was the major factor in other studies [*22,23*]. In our study, family history was not associated with the presence of sensorineural or conductive hearing loss. Billings and Kenna found a family history of sensorineural hearing loss or prematurity and/or complicated perinatal course in 28.6% of their patients [*24*].

Otitis media seems to have an impact on the development of hearing loss in schoolchildren. In the present study a highly significant association was found between history of otitis media and the presence of sensorineural or mixed sensorineural and conductive hearing loss. These findings agree with the results of a recent survey conducted in schoolchildren in Greenland [*25*]. Similarly, previous studies in other developing countries, such as Brazil and Nigeria, have shown that a history of chronic otitis media in schoolchildren carried a higher risk for hearing loss [*26,27*]. Sensorineural hearing loss is found to be significantly associated with episodes of otitis media. These findings are in accordance with reports from Alaska, Canada, Greenland and Pakistan [*3,25*].

In our study, as in the study of Elahi et al. [*3*], no cases of hearing loss were attributable to viral infections such as measles and mumps. A retrospective study carried out in Turkey has shown that febrile illness was the major cause of hearing loss [*28*]. Similarly, the present study has demonstrated that previous admission to fever hospital was significantly associated with sensorineural hearing loss.

In the univariate analysis, trauma was significantly associated with conductive hearing loss. In accordance with this finding, Cummings considered head trauma as one of the important risk factors for hearing loss [*29*].

The univariate and the multivariate analyses have shown that a history of otolaryngologic surgery carried a higher risk for sensorineural and conductive hearing loss. Previous studies have also showen a high risk of otolaryngologic surgery for different types of hearing loss [*26,30*].

The multivariate model in the present study showed that commercial school type was highly associated with conductive hearing loss. This might be due to the activities related to this school type, which include noise levels that may exceed the permissible values [*31*]. If students are being exposed, for example, to hazardous noise levels there is a need to obtain measurements of noise levels and supply students with ear protection in the classrooms.

The prevalence of the mixed type of hearing loss was almost the same as the conductive type. In the univariate analysis, in the group with mixed hearing loss, females represented 82% of the sample, although sex differences were not noticed in either of the other 2 types of hearing loss (conductive or sensorineural). Again, almost half of the students with mixed type of hearing loss were from technical schools. A factor that affects exclusively girls in technical schools should be explored. A history of measles or mumps was associated with the mixed type of hearing loss; an association that was not evident in the other groups with hearing loss.

In conclusion, audiometric screening is highly recommended to detect hearing loss among secondary-school students. Notwithstanding the limitations of the tools

used in our study, the administration of a well-structured questionnaire at school entry, complemented by tuning fork tests may be a practical option for an early detection programme in any developing country.

References

1. Brookhouser PE. *Incidence and prevalence.* Paper presented at National Institutes of Health Consensus Development Conference on early identification of hearing impairment in infant and young children, Bethesda, Maryland, March 1–3, 1993.
2. Cummings CW et al. Differential diagnosis of sensorineural hearing loss. In: *Otolaryngology head and neck surgery, Volume 4*, 3rd ed. St Louis, Mosby, 1998:2908–9.
3. Elahi MM et al. Paediatric hearing loss in rural Pakistan. *Journal of otolaryngology*, 1998, 27(6):348–53.
4. Niskar AS et al. Prevalence of hearing loss among children 6 to 19 years of age: the Third National Health and Nutrition Examination Survey. *Journal of the American Medical Association*, 1998, 279(14):1071–5.
5. Abolfotouh MA, Ghieth MM, Badawi IA. Hearing loss and other ear problems among schoolboys in Abha, Saudi Arabia. *Annals of Saudi medicine*, 1995, 15(4):323–6.
6. Kirkpatrick M, Costello ADL, Palmer HM. Is the prevalence of childhood hearing impairment overestimated in developing countries? *Journal of tropical pediatrics*, 1992, 38:92.
7. Smith A, Hatcher J. Preventing deafness in Africa's children. *Africa health*, 1992, 15(1):33–5.
8. Lee KJ, ed. *Essential otolaryngology head and neck surgery, Volume 1*, 8th ed. Columbus, Ohio, McGraw–Hill, 2003:29–31.
9. De Beer BA et al. Hearing deficits in young adults who had a history of otitis media in childhood: use of personal stereos had no effect on hearing. *Pediatrics*, 2003, 111(4 Pt 1):E304–8.
10. Papp Z et al. Sensorineural hearing loss in chronic otitis media. *Otology & neurotology*, 2003, 24(2):141–4.
11. Allonen-Allie N, Florentine M. Hearing conservation programs in Massachusetts' vocational/technical schools. *Ear and hearing*, 1990, 11(3):237–40.
12. Blake P, Busby S. Noise levels in New Zealand junior classrooms: their impact on hearing and teaching. *New Zealand medical journal*, 1994, 107(985):357–8.
13. Ptok M. Frühdiagnostik kindlicher Hörstorungen. [Early diagnosis of hearing impairment in children.] *Zeitschrift für ärztliche Fortbildung und Qualitätssicherung*, 2004, 98(4):265–70.
14. Olusanya B. Early detection of hearing impairment in developing countries. *Audiology*, 2001, 40(3):141–7.
15. Stankiewicz JA, Mowry HJ. Clinical accuracy in tuning fork tests. *Laryngoscope*, 1979, 89(12):1956–63.
16. Capper JW, Slack RW, Maw AR. Tuning fork test in children (an evaluation of their usefulness). *Journal of laryngology and otology*, 1987, 101:780–3.
17. Browning GG, Swan IR. Sensitivity and specificity of the Rinne tuning fork test. *British medical journal*, 1988, 297:1381–2.
18. Segal S et al. Hearing loss after direct blunt neck trauma. *Otology & neurotology*, 2003, 24(5):734–7.
19. Segal S et al. Inner ear damage in children due to noise exposure from toy cap pistols and firecrackers: a retrospective

review of 53 cases. *Noise health*, 2003, 5(18):13–8.

20. Davis AC. Epidemiology of hearing loss. In: Stephens D, ed. *Scott-Brown's otolaryngology*. *Volume 2, Adult audiology*, 5th ed. London, Butterworths, 1987:90–126.

21. O'Hara J et al. Prevalence of hearing impairment in siblings of deaf children. *Journal of the Pakistan Medical Association*, 2002, 52(2):73–7.

22. Morton R et al. Disability in children from different ethnic populations. *Child: care, health and development*, 2002, 28(1):87–93.

23. Turan O, Apaydin F. [Genetic sensorineural hearing loss in childhood.] *Kulak burun boğaz ihtisas dergisi*, 2002, 9(2):99–105 [In Turkish].

24. Billings KR, Kenna MA. Causes of pediatric sensorineural hearing loss: yesterday and today. *Archives of otolaryngology—head & neck surgery*, 1999, 125(5):517–21.

25. Homoe P. Otitis media in Greenland. Studies on historical, epidemiological, microbiological, and immunological aspects. *International journal of circumpolar health*, 2001, 60(suppl. 2):1–54.

26. Godinho EN et al. Prevalence of impact of otitis media in schools in Brazil. *International journal of pediatric otorhinolaryngology*, 2001, 61(3):223–32.

27. Olusanya BO, Okolo AA, Aderemi AA. Predictors of hearing loss in school entrants in a developing country. *Journal of postgraduate medicine*, 2004, 50(3):173–9.

28. Derekoy FS. Etiology of deafness in Afyon school for the deaf in Turkey. *International journal of pediatric otorhinolaryngology*, 2000, 55(2):125–31.

29. Trauma to the middle ear and temporal bone. In: Cummings CW et al., eds. *Otolaryngology head and neck surgery, Volume 4,* 3rd ed. St Louis, Mosby, 1998:3076–9.

30. Sculerati N. Analysis of a cohort of children with sensory hearing loss using the SCALE systematic nomenclature. *Laryngoscope*, 2000, 110(5 Pt 1):787–98.

31. Roeser RJ, Coleman T, Adams RM. Implementing an industrial hearing conservation program in the schools. *Journal of school health*, 1983, 53(7):408–11.