

Original article

Population Based Study and Global Estimates of Hearing Impairment in Schoolchildren

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Abstract: Hearing impairments in schoolchildren affects learning and communication. Reliable data on hearing loss prevalence in this group are necessary for planning the audiological care.

Aim. To compare data from a population based study of the hearing loss prevalence in schoolchildren and estimates from the Global Burden of Disease (GBD) study in the Republic of Yemen.

Materials and methods. Data extraction was performed from the GBD database on the prevalence of bilateral hearing loss >20 dB among children aged 5–9 years in the Republic of Yemen. A two stage study of hearing loss prevalence among primary school students aged 6–9 years in Sana'a, Republic of Yemen, in a sample of 2200 children using screening audiometry at 20 dB at 0.5, 1, 2, and 4 kHz in school settings, followed by tonal threshold audiometry and tympanometry in a specialized clinic. Hearing loss was assessed as unilateral or bilateral when hearing thresholds were higher than 25 dB.

Results. According to GBD estimates, bilateral hearing impairment in this population is 2.2%, including 1.4% of mild degree. According to the results of a Yemenian population study, mild and moderate hearing impairment was detected in 10.6%, of which 6.8% – unilateral, 3.8% – bilateral hearing loss. There were no cases of severe or profound hearing loss. The prevalence of otitis media with effusion was 6%, chronic suppurative otitis media – 1.8%, sensorineural hearing loss – 1.6%.

Conclusion. Bilateral hearing impairments occur in 2.2–3.8% of primary school students, with unilateral impairments the prevalence is up to 10.6%. Of these, at least 65% have conductive hearing loss due to pathology of the middle ear. The data obtained will improve the efficiency of ear and hearing care for schoolchildren.

Keywords: hearing impairment, hearing loss, prevalence, schoolchildren, epidemiology, global burden of disease.

1. Introduction

The problem of timely detection of hearing disorders in children has not only medical, but also social significance. Hearing loss hinders speech development, has a significant impact on the psychosocial adaptation of the child, significantly limiting the possibility of education, communication, which is important for full development [1-3].

To plan care for ear diseases and hearing disorders, it is necessary to know their prevalence among the entire population or in certain groups. There are various methods for studying the prevalence of diseases, while each has its own advantages and limitations. The registration of cases of the disease by appeal identifies persons with active complaints, which may not be effective enough in detecting mild and moderate hearing disorders, as well as non-purulent ear diseases, not accompanied by painful or uncomfortable sensations [4, 5]. In this regard, medical examinations or medical examinations, as well as screening for hearing disorders, are more appropriate. More accurate data on the prevalence of diseases can be obtained on the basis of population studies of sufficiently large representative samples of the population. In different countries, depending on the threshold of audibility, taken as clinically significant, and taking into account cases of unilateral or bilateral hearing loss, the prevalence of hearing loss among school-age children is 1.6-22.6% [6-11]. In Russia, hearing disorders and ear diseases among schoolchildren were detected in 15-19% in different



regions [12, 13]. According to estimates of meta-analysis, 88 population studies, the prevalence of hearing loss in children is 13.1% with an average hearing threshold at frequencies of 0.5, 1, 2 and 4 kHz on a better hearing ear of more than 15 dB, 2.2% – more than 25 dB, 0.9% – more than 40 dB [14]. The World Health Organization, within the framework of the program for the prevention of deafness and hearing loss, has developed a methodology for a population-based epidemiological study of the prevalence of ear diseases and hearing disorders Ear and Hearing Survey5. The algorithm includes, at the first stage, registration of otoacoustic emissions for children aged 0-4 years or automatic audiometry for children over 5 years and adults, otoscopy (when detecting sulfur plugs, foreign bodies, their removal), tympanometry. At the second stage, the audibility thresholds are evaluated by the tonal threshold audiometry method. The application of the proposed algorithm in different countries will allow comparing the prevalence of hearing loss in individual populations based on uniform criteria [15]. In case of insufficient epidemiological data, it is possible to determine the prevalence of various diseases and conditions by calculating estimates based on the use of Bayesian statistics methods. To this end, they are publicly available on the Internet and are regularly updated, the last revision was made in 2019. As part of the GBD study, an international expert group calculates estimates of the prevalence of hearing disorders globally and by individual regions, subregions, gender, age and severity. To calculate, data from population studies and articles included in systematic reviews are analyzed, and detailed data is requested from researchers if necessary [16-18].

Despite the fact that the GBD study is based on the results of previously conducted population studies, comparison with more up-to-date data will help improve the methodology of subsequent assessments. The aim of the study is to compare the data of a population epidemiological study of the prevalence of hearing disorders in schoolchildren and the estimates of the Global Burden of Disease study on the example of the Republic of Yemen.

2. Patients and Methods

The data was extracted from the GBD open database on the prevalence of hearing disorders among children aged 5-9 years in the Republic of Yemen in 2009. The data obtained were compared with the results of a population study of the prevalence of hearing disorders among primary school students aged 6-9 years in the city of Sanaa of the Republic of Yemen in a sample of 2,200 children conducted in 2009-2010. At the first stage, a hearing test was performed using an AD 229b audiometer in a screening mode in school conditions. Each ear was presented with a tone intensity of 20 dB with a frequency of 500, 1000, 2000, 4000 Hz. The absence of a reaction at least at one frequency on one or both sides was assessed as a "failed" result. At the second stage, these children underwent a complete audiological diagnosis (tonal threshold audiometry for air and bone conduction at frequencies 125-8000 Hz, tympanometry, otoscopy) in a specialized center. The criteria for determining hearing loss in both studies are given in Table 1.

3. Results

According to the GBD study, the prevalence of bilateral hearing impairment among children aged 5-9 years in the Republic of Yemen in 2009 It was estimated at 2.2%, or 2,228 cases per 100,000 of the corresponding population (95% uncertainty interval (IN) 1,828-2,626) with a predominance of mild hearing loss – 1.4%, or 1,415 cases per 100,000 of the corresponding population (95% IN 1,167-1699) (Table 2). According to a population study, the prevalence of all hearing disorders with an audibility threshold of more than 25 dB among children aged 6-9 years in the Republic of Yemen was 10.6%, of which 6.8% were unilateral, 3.8% were bilateral (Table 3). In the study sample, all identified cases of hearing loss corresponded to mild and moderate degrees. Among the identified hearing disorders, unilateral conductive hearing loss accounted for 54% (126 cases), unilateral sensorineural hearing loss – 10% (24 cases), bilateral conductive hearing loss – 31% (72 cases), bilateral sensorineural hearing loss – 2% (5 cases). Bilateral conductive hearing loss on the one hand and sensorineural hearing loss on the other was detected in 7 children (3% of cases). In accordance with the GBD hierarchy, otitis media, age-related and other hearing disorders (including sensorineural hearing loss), congenital ear abnormalities and meningitis are distinguished among the causes of hearing disorders. Thus, according to GBD estimates, among children aged 5-9 years in the Republic of Yemen, the prevalence of hearing impairment due to otitis media is 1.4% (1,416 per 100,000 children), sensorineural hearing loss is 0.7% (720 per 100,000). Congenital anomalies of the ear are the cause of hearing loss in 54 children per 100,000 in this age group. The prevalence of hearing loss due to meningitis is estimated at 8 per 100,000. In the structure of the causes, 2/3 are hearing disorders due to otitis media, 1/3 are sensorineural hearing loss (Table 4). Table 1 Criteria for determining hearing loss and classification by severity in the GBD study and population study.



Table 1. Hearing loss identification criteria and severity classification in the GBD study and population based study.

Criteria	Global Burden of Disease	Population-based research
Two - sided /one - sided	two - sided	two - sided ,one - sided
Hearing impairment (average threshold at 0.5, 1, 2, 4 Hz)	>20 дБ	> 25 дБ
Severity		
mild	20-34 дБ	25-40 дБ
moderate	35-49 дБ	41-55 дБ
moderate-severe	50-64 дБ	56-70 дБ
severe	65-79 дБ	71-90 дБ
deep	80-94 дБ	
deafness	>95 дБ	>90 дБ

Table 2. Distribution of abnormalities of hearing by severity among children aged 5 to 9 years in the Republic of Yemen, estimated by the Global Burden of Disease study.

Degree of hearing loss	Number of cases per 100 000 population	95% IN	Fraction, %
Mild	1415	1167-1699	63
Moderate	440	281-613	20
Moderate-severe	131	75-203	6
Severe	70	39-115	3
Deep	106	63-164	5
Deafness	64	36-101	3
All cases	2228	1828-2626	100

Table 3. Prevalence of hearing loss among children aged 6 to 9 years in the Republic of Yemen according to the population based study.

	Number of cases	Fraction, %	Share in the sample (n=2200), %
One - sided	150	64	6,8
Two - sided	84	36	3,8
All cases	234	100	10,6

Table 4. Cause of hearing loss profiles among children aged 5–9 years in the Republic of Yemen as estimated by the Global Burden of Disease study.

Reason	Number of cases per 100 000 population	95% IN	Fraction, %
Otitis media	1446	1194-1721	65
Sensorineural hearing loss	720	473-1039	32
Congenital anomalies of the ear	54	16-123	2,5
Meningitis	8	2-12	0,5



All cases	2228	1828-2626	100
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Table 5. Cause of hearing loss profiles among children aged 5 to 9 years in the Republic of Yemen as estimated by the population based study.

Reason	Number of cases	Fraction (n=234)	Prevalence (n=2200)
Exudative otitis media	131	56%	6%
Perforation of the eardrum	40	17%	1,8%
Chronic otitis media with suppuration	39	17%	1,8%
Eustachian tube dysfunction	28	12%	1,3%
Sensorineural hearing loss	36	15%	1,6%

In a population study, the prevalence of middle ear pathology was revealed in the etiological structure of hearing disorders among schoolchildren with confirmed hearing impairment: in 56% of cases, exudative otitis media was diagnosed, in 17% – perforation of the eardrum, in 17% – chronic otitis media with suppuration. Auditory tube dysfunction was detected in 12% of cases, sensorineural hearing loss – in 15%. It is worth noting that one child could have different pathology of the hearing organ. Thus, the prevalence of exudative otitis media in the study population was 6%, perforated otitis media and chronic otitis media with suppuration – 1.8%, auditory tube dysfunction – 1.3%. Unilateral and bilateral sensorineural hearing loss occurs in this population with frequency 1.6% (Table 5). In the study sample, 1% of children (21/2200) had sulfur plugs, after removal of which the auditory function was restored, so these cases were not included in the general analysis. Congenital anomalies of the ear and cases of hearing impairment due to meningitis were not detected in the population study, which is in accordance with the sample size.

4. Discussion

The problem of timely detection of hearing loss is due to its non-obviousness both for persons with hearing impairment themselves and for their environment, especially in the children's population. In the present paper, the prevalence of hearing impairment is compared based on a population study of schoolchildren in the Republic of Yemen and global estimates in a similar population. Similar comparative publications on this pathology were not found by the authors. According to the GBD study in the Republic of Yemen, bilateral hearing impairments among children aged 5-9 years occur with a frequency of 2.2%. According to the results of a study of a population of children similar in age and year of study, the prevalence of bilateral hearing loss is higher and is 3.8%. The data obtained are consistent with a number of other population studies in developing countries, according to the results of which the prevalence of bilateral hearing loss was detected with a frequency of 1.8–5.7% [19-23]. In Zimbabwe, C. Pedersen et al. Data were obtained on the prevalence of all unilateral and bilateral hearing disorders in children at the level of 10.6%, which fully corresponds to the presented results from Yemen [24]. Based on the data obtained in the GBD study, 2/3 of all cases of hearing impairment account for mild hearing loss. In a population study in the Republic of Yemen, only mild and moderate hearing impairments were detected. According to the GBD results, it was possible to expect the detection of 2,200 children up to 4 cases of severe hearing loss and deafness in the study sample. Their absence can be explain the design of the study, which was conducted in mass schools where children with profound hearing loss do not study. The generally recognized problem of comparing different studies of the prevalence of hearing disorders is recognized by different criteria of hearing loss. The most relevant works evaluate the frequency of hearing loss in the study sample based on several criteria. Thus, C. Pedersen et al. In 2022, data on the prevalence of hearing disorders in children were published at the level of 4.2% with hearing thresholds of more than 25 dB and at the level of 0.4% with hearing thresholds of more than 30 dB in a better hearing ear [24]. A meta-analysis of population studies from countries with different socio-economic levels showed the prevalence of childhood hearing loss of 2.2% with hearing thresholds in the better-hearing ear of more than 25 dB, 0.9% - more than 40 dB [14]. According to the results of a similar meta-analysis of 21 studies in central and South Africa, data were obtained on the frequency of childhood hearing loss of 17% with hearing thresholds of 20 dB, 2% - more 30 dB [25]. Among school-age children, especially in elementary grades, the leading cause of hearing disorders is the pathology of the middle ear. Both according to the results of population studies and GBD estimates, purulent and non-purulent otitis media cause at least 2/3 of all hearing disorders in early school age, accounting for up to 85-95% in the etiological structure of hearing loss [19-22]. At the same time, the prevalence of exudative otitis media in the population of schoolchildren according to the presented study is 6% in Yemen, according to F. Mahomed Asmail et al. in South Africa – 7.5% [20]. Sensorineural disorders in the population of children of early school



age are less common, their prevalence in the Republic of Yemen is estimated at 0.7% according to GBD data, 1.6% – according to the results of a population study. A possible limitation of the presented population study is the insufficient representativeness of the sample represented by primary school students of the capital of the Republic of Yemen, the city of Sanaa. As a rule, residents of metropolitan regions are in more favorable socio-economic conditions, which contributes to a lower incidence, including ear diseases.

5. Conclusions

The comparison of the GBD study data and the population study of the prevalence of hearing disorders among schoolchildren of the Republic of Yemen showed the comparability of the results of both studies. Bilateral hearing disorders occur in 2.2–3.8% of primary school students, taking into account unilateral disorders, the prevalence increases to 10.6%. Of these, at least 65% have conductive hearing loss due to the pathology of the middle ear. The data obtained will improve the effectiveness of providing assistance to children with ear diseases and hearing disorders.

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The use of artificial intelligence: the article is written without the use of artificial intelligence technologies.

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