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HEARING IMPAIRMENT AMONG PRIMARY SCHOOL CHILDREN IN YEMEN

3.1.3. Otorhinolaryngology

THESIS

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На правах рукописи

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НАРУШЕНИЯ СЛУХА СРЕДИ УЧАЩИХСЯ НАЧАЛЬНЫХ ШКОЛ РЕСПУБЛИКИ ЙЕМЕН

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INTRODUCTION

Relevance of the topic. The early detection of hearing loss in children and timely intervention has long been one of the main health priorities in the vast majority of developed countries [Luxon L.M., 2000; Fonseca S., 2005; Mehra S., 2009; Akinpelu O.V., 2014; Mackey A.R., 2021; Neumann K., 2022]. The following areas of modern audiology improves constantly: the screening techniques, the diagnostic and audiological equipment, the strategies and methods for early intervention [Kemper A.R., 2004; Korres, S., 2005; Espeso A., 2006; Halloran D.R., 2009; Larry Y., 2009]. According to the World Health Organization (WHO), two out of three people with hearing loss live in developing countries [WHO, 2021]. Moreover, rural population in developing countries has a greater risk than urban residents [Katbamna B., 2001; Matthiassen C.N., 2007].

The reasons for the differences between developed and developing countries are the lack of regular examinations of children by an otorhinolaryngologist, hearing tests, poverty, malnutrition, ignorance, ignorance of the causes of hearing loss and inaccessible to the majority of the population of developing countries [Jafari Z., 2007; Swanepoel D.W., 2009]. In developing countries, the main budget funds are used to combat life-threatening diseases, such as diphtheria, tetanus, and infectious meningitis [Jamison D.T., 2006]. Pathologies that do not pose an immediate threat to human life are considered not dangerous; therefore, the budget line for the treatment and prevention of hearing loss and deafness is traditionally small [Olusanya B.O., 2005; 2007; WHO, 2021].

In many developing countries, the obstetric system is poorly developed or inaccessible to the population. Most women give birth at home or in midwives,

and babies are born outside medical facilities, so the development of hearing screening programs for newborns in these countries is problematic in terms of logistics [WHO, 2015].

In the world, 466 million people live with moderate or severe hearing loss in their best ears and even more with mild hearing loss and / or ear diseases, 34 million of children included [WHO, 2018]. WHO estimates that 60% of cases of deafness and hearing loss can be avoided. In more than 25% of cases, hearing problems begin in childhood. Unfortunately, 80% of all deaf and hard of hearing people live in low- and middle-income countries. Persistent hearing impairment turns into a lifelong problem that negatively affects communication with others, education, employment, and personal relationships. As a result, the state loses a part of the able-bodied population, which places a heavy burden on the country's economy [Olusanya B.O., 2007, 2014; WHO, 2016].

Ear diseases in childhood are a significant problem. Even mild hearing impairment or one-sided hearing loss have a negative impact on the child's academic performance, on communication with friends, complicates adaptation in the speech environment, and limits the possibility of receiving highly paid work in the future [Davis J., 1986; Tireri L., 1988; Hartvig J., 1989; Judith E., 2004; Shrestha R., 2001; Wake M., 2006; Md Daud M.K., 2010; Stevenson J., 2010; Jensen R.G., 2011]. Regular audiological screening of schoolchildren will prevent the reduced hearing from adversely affecting children's performance and communication with friends [Fortnum H.M., 2001; Bamford J., 2007; Bristow K., 2008; Sarafraz M., 2009; Sininger Y.S., 2010; Skarzynski H., 2012; Chadha S.K., 2013; Deltenre P., 2013; WHO, 2021].

Some forms of hearing loss and ear diseases could be prevented, and in other cases, minimize their consequences through early diagnosis, subsequent treatment and rehabilitation [Olusanya B.O. 2000; Matthiassen C. N., 2007;

Samelli A.G., 2011; WHO, 2016]. However, without accurate data on the prevalence of hearing loss and ear diseases, it is difficult to plan the necessary medical care.

In the Republic of Yemen, the poorest state in the Arab region with a population of 24.4 million people in 2013, studies on the prevalence of hearing loss and ear diseases, including among children, have never been conducted. However, studies conducted in neighboring countries of the Republic of Yemen and some other developing countries have revealed a significant prevalence of ear diseases and hearing loss among students in secondary schools. Thus, the prevalence of hearing loss among schoolchildren in Nigeria is 13.6%, and in Egypt reaches 20.9% [Abdel-Hamid O., 2007; Olusesi A.D., 2008].

The negative consequences of hearing loss in children, as well as the lack of data on the epidemiology of ear diseases in the difficult socio-economic conditions of the Republic of Yemen, necessitate a study of the prevalence of hearing loss in the country, which will subsequently create an audiological screening system, prevention of the development of hearing loss and an algorithm for providing medical care to children with ear diseases.

Degree of investigation of the problem

An analysis of the literature showed that so far, no studies have been conducted to assess the hearing of primary school students in the Republic of Yemen, no studies have been conducted to assess the prevalence of hearing impairment among children, and no socio-economic conditions affecting the prevalence of hearing loss have been studied, a single algorithm for school hearing screening approved by WHO has not been used in the Republic of Yemen.

Objective: to assess the prevalence, etiology and risk factors of hearing loss among primary school students in Sana'a city in Yemen.

Study tasks:

1. To investigate the prevalence of hearing loss among primary school children in Yemen;

2. To assess the type and severity of hearing impairment in primary school children;

3. To investigate the causes of hearing impairment among primary school children;

4. To investigate the presence of various risk factors and their possible impact on the development of hearing loss and ear pathology in primary school children in Yemen;

5. To propose an acceptable algorithm for the country to detect hearing loss among children and consider possible ways to prevent hearing loss among children.

Scientific novelty of the study

The prevalence and nature of hearing impairments among primary school children was studied for the first time in the Republic of Yemen. The results are comparable with studies conducted in other countries [Abdel-Hamid O., 2007; Olusesi A.D., 2008]. The structure of the hearing loss incidence among children due to the socio-economic situation of the population in the Republic of Yemen have been revealed.

The effectiveness of school hearing screening has been proven for the timely provision of the necessary medical care to prevent the development of permanent hearing impairment.

The contribution of various risk factors to the development of hearing loss in children of primary school age in the Republic of Yemen was established as a result of a complete audiological examination and anamnesis study in a group of children identified by screening.

Theoretical and practical significance of the study

The theoretical significance is determined by the prospects of the study, since the obtained results substantiate the need for further study of the problem and the formation of a concept for combating hearing loss.

The predominance of conductive hearing loss was revealed in the structure of hearing impairment in primary school children due to otitis media with effusion and chronic suppurative otitis media, that requires activities for prevention, including vaccination, early detection and treatment.

An algorithm for school hearing screening contributing to the timely diagnosis of hearing impairment and the prevention of permanent hearing loss has been developed. The use of this algorithm will improve the efficiency of childhood hearing loss detection in developing countries.

The significance of various risk factors was determined, which made it possible to develop a system of preventive measures to reduce ear diseases and permanent hearing loss in the Republic of Yemen, including educational work among teachers and parents of primary school children.

Theoretical and methodological basis of the study

The theoretical basis of the study is determined by the known data on the negative impact of hearing impairment on the cognitive and mental development of children, less academical and social success in cases of untimely detection, treatment and rehabilitation [Stevenson J., 2010; Sininger Y.S., 2010; Jensen R.G., 2011; Skarzynski H., 2012; Chadha S.K., 2013; Deltenre P., 2013; Olusanya B.O., 2008; 2014]. The study of the prevalence of this pathology is necessary for planning the provision of medical care.

The subject of the study is the prevalence of hearing impairment among primary school students in the city of Sana'a. The object of the study were 2200

schoolchildren aged 6-9 years, examined at the screening stage in a school setting. 255 children identified with suspected hearing loss and 255 children not identified by screening underwent full audiological examination in a specialized clinic.

The methodological basis of the study consists in the use of the clinical and anamnestic methods, audiological diagnostic for hearing impairment and the analytical method for determining the prognostic significance of risk factors for hearing loss. Statistical analysis is based on the methods of descriptive statistics (determination of mean values and standard deviation); χ^2 test was used to compare relative indicators. Statistical data processing was performed using the Statistica 10 and SAS JMP 10 software.

The main positions to be defended

1. It has been proven that the prevalence of hearing loss among primary school children in the Republic of Yemen is 10.6%. The main causes of hearing impairment among primary school children in the Republic of Yemen are otitis media with effusion and chronic suppurative otitis media due to unfavorable social conditions, which requires the organization of the activities for the prevention, early detection and treatment of these diseases.

2. It has been established that, given the high prevalence of hearing impairment in primary school children in the Republic of Yemen, the widespread implementation of the audiological screening algorithm is of particular importance. The algorithm includes the examination of the hearing of children at school setting at the first stage (examination by an otorhinolaryngologist, otoscopy and pure tone audiometry in screening mode), and a full audiological examination of children identified with suspected hearing impairment at the second stage (history taking, otoscopy, ear canal toilet, if necessary, impedance

audiometry, pure tone audiometry). The proposed algorithm will reduce the frequency of ear inflammatory diseases and hearing impairment among the child population, reduce the frequency of complications of otitis media with effusion and chronic suppurative otitis media, prevent the socially significant hearing impairments, and provide the educational and communicational ability restoration.

Compliance of the thesis with the Passport of a scientific specialty

The thesis «Hearing impairment among primary school children in Yemen» corresponds to the passport of the specialty 3.1.3. Otorhinolaryngology (medical sciences) and research areas: p.1 «Researches on the etiology, pathogenesis and prevalence of ENT diseases», p.2 «Development and improvement of methods for the diagnosis and prevention of ENT diseases».

Personal contribution of the author

The personal contribution of the applicant consists in direct participation in all stages of the dissertation research: analysis of the state of the issue according to modern literature, formulation of goals, research objectives, methodological approaches to solve the goals and objectives, in the development of research protocols, in the implementation of the study, in obtaining results. The author independently conducted a clinical and audiological study of all patients. The discussion and interpretation of the results was carried out jointly with the supervisor and co-authors of publications. The main provisions to be defended and the conclusions of the thesis are formulated independently by the author.

Reliability and approbation of the thesis

The work was performed on sufficient clinical material (2200 children) with main and control groups. Statistical analysis is based on descriptive statistics methods (determination of mean values and standard deviation), χ^2 test was used to compare relative indicators. Data processing was performed using the Statistica 10 and SAS JMP 10 software.

The reliability of the data is confirmed by the act of verification of the primary material (September 30, 2022). The thesis research was approved by the Research Ethics Committee of the People Friendship University of Russia of the Ministry of Science and Higher Education of the Russian Federation (September 22, 2022, protocol No.10).

The topic of the thesis was approved by the Academic Council of the People Friendship University of Russia (September 22, 2022, Protocol No.1).

The thesis approbation was held at the meeting of the Department of Otorhinolaryngology of the Medical Institute of the People Friendship University of Russia of the Ministry of Science and Higher Education of the Russian Federation (September 30, 2022, protocol No.2).

Implementation in practice

The results of the study have been implemented in the educational process of the Department of Otorhinolaryngology of the Medical Institute of the FSAEI HE «People Friendship University of Russia» of the Ministry of Science and Higher Education of the Russian Federation (Certificate of implementation, September 30, 2022) and Department of Audiology of the FSBEI FPE «Russian Medical Academy of Continuous Professional Education» of the Ministry of Healthcare of the Russian Federation (Certificate of implementation, October 10, 2022). The results of the study are used in teaching students, as well as at

postgraduate training of medical specialists - clinical residents and graduate students.

The results of the study were implemented in the practical work in the Specialized medical center in the city of Sana'a, the Republic of Yemen (Certificate of implementation from September 05, 2022).

Publications

On the topic of the thesis 7 scientific papers were published, of which 3 - in the international citation databases Web of Science and SCOPUS and 2 - in the peer-reviewed scientific journals recommended by the Higher Attestation Commission of the Ministry of Education and Science of the Russian Federation.

The main positions of the thesis were presented in the form of scientific reports and discussed at the XXXI World Congress of Audiologists (Moscow, 2012), 7th, 8th, 9th National Congresses and 11th, 12th 13th International Symposia «Modern Problems of Physiology and Pathology of Hearing» (Suzdal, 2017, 2019, 2021).

Volume and structure of the thesis

The thesis is set out on 120 pages of typewritten text and consists of an introduction, a chapter «Review of Literature», a chapter «Materials and Methods», a chapter «Results», a chapter «Discussion», conclusion, findings, practical recommendations, a bibliography of 185 references, 12 tables and 10 figures.

CHAPTER 1. REVIEW OF LITERATURE

1.1. Epidemiology of hearing loss among primary school children

Hearing impairment in children is one of the most common diseases. Congenital hearing loss makes it difficult to acquire speech skills. The hearing loss of early childhood has a significant impact on the psychosocial adaptation of the child, significantly limiting the ability to get an education, work, communication with others, which is important to ensure a satisfactory standard of living [Russ S., 2003; Abdel-Hamid O., 2007].

In different parts of the world, numerous studies have been conducted to assess the prevalence of hearing loss in children. In developed countries, for example, in England, in children aged five years, the prevalence of persistent hearing loss in the general population is 3.65 per 1000 children, while mild and one-sided forms of hearing loss are found at a frequency of 2.13 per 1000. In Finland, various hearing impairments among schoolchildren were detected in 2.5% of children, in Denmark - in 3.6%, in Canada – 7.7%, in Poland – 9.4%, in Greenland – 10% depending on hearing threshold level [Haapaniemi J., 1995; Fortnum H. M., 2001; Davis A., 2002; Feder K.P., 2017; Skarżyński H., 2020; Jensen J.S., 2021]. In the United States, the prevalence of any hearing loss (uni- or bilateral with hearing threasholds above 25 dB) has risen in 2010 up to 14,5% [Su B.M., 2017]. If take into account the cases of minimal hearing loss, the prevalence of hearing loss increases significantly [Saral M., 2009; Mehra S., 2009; le Clercq C.M.P., 2017, 2020].

Studies in several developing countries have revealed a significant prevalence of hearing loss among children. In Kenya, hearing is reduced in

5.6% of children, and in India, the prevalence of child hearing loss varies from 5.5% in Punjab to 21.6% in Lucknow [Rao R.S., 2002]. Research by Olusanya B.O. et al., in a rural elementary school in southern India in 2004, showed that the total prevalence of hearing pathology (including ear wax) was 21.5% [Olusanya B.O., 2004].

Epidemiological studies conducted on the African continent showed a large scatter of data. In various studies, hearing loss was diagnosed among children with different frequencies from 1 to 13.5% of cases. Moreover, hearing loss with hearing thresholds >30 dB in a better hearing ear was detected in 2.1–3.4 per 1000 children, and severe hearing loss or complete deafness was found in 2.4–4.0 per 1000 children [Westerberg B.D., 2005; Ologe F.E., 2004; Olusanya B.O., 2005a]. In Tanzania, according to Olusanya B.O. et al. in 2004, ear diseases were detected in 27.7% of elementary school students [Olusanya B.O., 2004]. In rural areas of Nigeria and South India, studies have shown hearing loss in 13.9% of school-age children, with an average age of 6.7 years. In Uganda, the prevalence of hearing loss with thresholds among primary school children is 3.3%, in urban South African school children – 2.2% [Basañez I., 2015; Mahomed-Asmail F., 2016]. This variation in research results largely depends on the studied population and is largely due to the chosen definition of what is considered a hearing impairment [Olusanya B.O., 2000].

Studies conducted in Arab countries, for example, in Saudi Arabia, revealed hearing loss in 13% of children examined, with sensorineural hearing loss (SNLH) in 1.5% and mixed hearing loss in 1.1%. Most children had conductive hearing loss (10.4%). The causes of conductive hearing loss were acute suppurative otitis media (1.1%), chronic suppurative otitis media

(CSOM) (1.3%) and otitis media with effusion (OME) (8%). A survey conducted in Oman in 1996-1997 showed that bilateral hearing loss was diagnosed in 55 out of 1000 children [Al Khabori M., 2004; Al-Abduljawad K.A., 2003]. A study in Egypt revealed hearing loss in 5.3% of school-age children in Alexandria and in 13.7% in the province of Ismailia [Mourad M.I., 1993; Abdel-Hamid O., 2007].

Thus, the significant prevalence of ear diseases in developing countries, compared with developed countries, is demonstrated by the results of numerous studies, and the rural population is at greater risk than urban residents [Matthiassen C.N., 2007].

A well-known problem in comparing different studies on the prevalence of hearing loss is the different criteria for hearing loss. The most relevant works estimate the frequency of hearing loss in the study sample based on several criteria. So, C. Pedersen et al. in 2022, data were published on the prevalence of hearing impairment in children at the level of 4.2% at hearing thresholds of more than 25 dB and at the level of 0.4% at hearing thresholds of more than 30 dB in the better ear [Pedersen C., 2022]. A meta-analysis of population studies from countries with different socioeconomic levels showed a prevalence of childhood hearing loss of 2.2% with hearing thresholds in the better ear of more than 25 dB, 0.9% - more than 40 dB [Wang J., 2019]. According to the results of a similar meta-analysis of 21 studies in central and southern Africa, data were obtained on the frequency of childhood hearing loss of 17% at hearing thresholds of 20 dB, 2% - more than 30 dB [Desalew A., 2020].

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 epidemiological study of the prevalence of ear diseases and hearing impairment Ear and Hearing Survey. The algorithm includes, at the first stage, the registration of otoacoustic emission in children aged 0-4 years or automatic audiometry in children over 5 years of age and adults, otoscopy (with manipulations for ear wax or foreign bodies if detected), tympanometry. At the second stage, the hearing thresholds are evaluated by the method of tone threshold audiometry. The application of the proposed algorithm in different countries will make it possible to compare the prevalence of hearing loss in individual populations based on common criteria [WHO, 2020].

In case of insufficient epidemiological data, it is possible to determine the prevalence of various diseases and conditions by calculating estimates based on the application of Bayesian statistics methods. For this purpose, the Global Burden of Disease (GBD) project was created. The results of GBD research 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 impairment globally around the world and by individual regions and subregions, gender, age and severity. For the calculation, data from population studies, articles included in systematic reviews are analyzed; if necessary, detailed data are requested from researchers [Monasta L., 2012; Stevens G., 2013; GBD 2019 Hearing Loss Collaborators, 2019]

By the time of onset, it distinguishes between congenital and acquired hearing loss. The term «congenital hearing loss» means that hearing is already impaired in the newborn [Korver A.M., 2017]. This group includes hereditary hearing loss and acquired in the process of prenatal development

or during childbirth. Genetic factors are considered responsible for more than 50% of all cases of congenital hearing loss [Toriello H.V., 2004; Morton C.C., 2006]. Genetically induced hearing loss can be nonsyndromic (autosomal dominant, autosomal recessive, associated with the X chromosome) or syndromic [Cremers C.W.R.J., 2002; Schrijver I., 2004; Smith R.J., 2005; Morton C.C., 2006].

Other cases of congenital hearing loss that are not hereditary in type include intrauterine infections, drugs used by the mother during pregnancy, and diseases carried by the child at birth or shortly after birth and causing varying degrees of SNHL [1merican speech and hearing association, 1991]. Risk factors include:

• Intrauterine infections, including rubella, cytomegalovirus, syphilis and herpes simplex;

• Complications related to the Rhesus conflict;

• Prematurity;

• Diabetes in the mother;

• Toxicosis during pregnancy;

• Oxygen starvation (anoxia).

According to Joint Committee of Infant Hearing recommendations [Joint Committee on Infant Hearing, 2007, 2019], the risk factors for delayed-onset childhood hearing loss are:

1. Caregiver concern regarding hearing, speech, language, or developmental delay.

2. Family history of permanent childhood hearing loss.

3. Neonatal intensive care of more than 5 days or any of the following regardless of length of stay: extracorporeal membrane oxygenation, assisted

ventilation, exposure to ototoxic medications (gentamycin and tobramycin) or loop diuretics (furosemide/Lasix), and hyperbilirubinemia that requires exchange transfusion.

4. In utero infections, such as cytomegalovirus, herpes, rubella, syphilis, and toxoplasmosis.

5. Craniofacial anomalies, including those that involve the pinna, ear canal, ear tags, ear pits, and temporal bone anomalies.

6. Physical findings, such as white forelock, that are associated with a syndrome known to include a sensorineural or permanent conductive hearing loss.

7. Syndromes associated with hearing loss or progressive or late-onset hearing loss, such as neurofibromatosis, osteopetrosis, and Usher syndrome; other frequently identified syndromes include Waardenburg, Alport, Pendred, and Jervell and Lange-Nielson.

8. Neurodegenerative disorders, such as Hunter syndrome, or sensory motor neuropathies, such as Friedreich ataxia and Charcot-Marie-Tooth syndrome.131

9. Culture-positive postnatal infections associated with sensorineural hearing loss, including confirmed bacterial and viral (especially herpes viruses and varicella) meningitis.

10. Head trauma, especially basal skull/temporal bone fracture§ that requires hospitalization.

11. Chemotherapy.

Concerning the capacity of national public health systems to provide audiological diagnostics the list of risk factors for permanent hearing loss in

different countries varies widely [Núñez-Batalla F., 2012; Wood S.A., 2013; Wróbel M.J., 2014; Vos B., 2015].

Acquired hearing loss is a hearing loss that develops after birth at any stage of life as a result of a disease or injury. The following diseases at any part of temporal bone or hearing passway can lead to acquired hearing loss in children: ear wax or foreign bodies, middle ear inflammation, perforation of the eardrum, meningitis, measles, encephalitis, influenza, mumps, head trauma, ototoxic drugs, too loud sounds from toys, fireworks or music players [Zakzouk S. M, 1996; Kalpana R., 1997; Niskar A.S., 2001; Jensen R.G., 2013; Khandaker G., 2014]. About 60% of the cases of childhood hearing loss are curable with medical treatment or surgery or can be prevented with vaccination [WHO, 2016].

1.2. The impact of hearing loss on primary school children

Hearing impairment negatively affects a child's educational performance and development of appropriate language and social skills.

Even a minimal, unilateral sensorineural hearing impairment can impede a child's educational performance. According to Fitzpatrick E.M. et al., at least half of the children with permanent hearing loss has mild or unilateral hearing impairment [Fitzpatrick E.M., 2014]. A significant bilateral hearing impairment can result in severe educational limitations and result in social and psychological problems for both the affected child and his/her family. Early identification, prompt therapy and supportive services can attenuate or prevent the burden of hearing loss [Bess F.M., 1986; Briscoe J., 2001; Kiese-Himmel C., 2002].

For all ages and for both sexes, hearing loss causes difficulties with interpersonal communication and leads to significant individual social problems, especially isolation and stigmatization. All these difficulties are more magnified in developing countries, where there are generally limited services, few trained staff members, and little awareness about how to deal with these difficulties [Seely D.R., 1995; Smith A.W. 2001; Olusanya B.O., 2014].

Yoshinaga-Itano C. and Moeller M.P. analyzed the results of the linguistic development of children with early intervention (when children with impaired hearing started visiting specialists in a timely manner) and showed the benefits of early diagnosis even for children with moderate hearing impairment. An unfavorable prognosis is more likely associated with the age of diagnosis than with the degree of hearing loss [Yoshinaga-Itano C., 1999; Moeller M.P., 2000]. The most recent study presented the better vocabulary outcomes in children who met early hearing detection and intervention criteria, especially in cases of mild and moderate severity [Yoshinaga-Itano C., 2017; le Clercq C.M.P., 2020].

According to Davis J. et al, the passive vocabulary, speech capabilities, and logical reasoning ability in children with moderate hearing loss exceeded tolerance abnormalities in a population of a similar age (<40 dB HL when assessing hearing thresholds at frequencies of 0.5, 1 and 2 kHz) [Davis J., 1986]. In children with mild to moderate hearing loss there was no lagging behind peers in tests for language development, literacy, understanding and memorizing sentences, numbers, but they lagged behind similarly for children with specific speech impairments in repetition meaningful words (a set of sounds), in understanding phonological differences (of the same sound,

pronounced differently in different languages) and in distinguishing hearing similar words [Briscoe J., 2001; Wake M., 2006]. It was shown that students with mild bilateral and unilateral mild hearing loss perform significantly lower attention and communication questionary-based scores [Elbeltagy R., 2020].

Unilateral hearing loss (UHL) is often detected for the first time in school-age, even if it has been present since birth. With normal hearing in the second ear, it is often ignored, but unilateral deafness can cause problems at school and beyond. A child with UHL cannot determine the source of the sound and hear the voice with an increased noise background is more difficult for him. Most children will not want to wear a hearing aid if they normally hear with the other ear, but they should be seated in the classroom taking into account their characteristics, and teachers should know and take into account their problem [Kiese-Himmel C., 2002; Fleisch B., 2008; Martınez-Cruz C.F., 2009].

The prevalence of UHL in schoolchildren, according to various researchers, ranges from 0.1% to more than 5%. The prevalence of unilateral SNHL >45 dB in school-age children is 3 cases per 1000 people. If take into account children with a mild degree of hearing loss (25-40 dB), this coefficient will increase to 13 cases per 1000 people [Niskar A.S., 1998].

Although several studies have documented that for a child with UHL it is more difficult to distinguish speech in noise background than for normal hearing peers, there is still little data on the effect of UHL on the development of speech and language skills in a child. Kiese-Himmel C. reported about a middle-aged delay in which a child with UHL pronounces a two-word phrase for an average of 5 months compared with normally hearing

one-and-a-half-year-old children [Kiese-Himmel C., 2002]. Borga E. et al. from Sweden evaluated the development of language in children with hearing loss at the age of 4-6 years, and concluded that children with unilateral deafness have a lag in speech development, and the degree of lag is proportional to the severity of hearing loss [Borga E., 2002]. Tireri L. et al. observed children with UHL and reported the problems with speech or language development [Tireri L., 1988]. However, all authors note that in most cases, parents say that their child faces difficulties in learning at school. In one study, 30 children aged 10–16 years with UHL were compared with a control group of 30 healthy children. The researchers concluded that children who did not hear in the right ear performed some oral tests worse, while children who did not hear in the left ear showed results almost like in children with normal hearing. Hartvig J. et al. object the increased number of students at Tokyo University with UHL suggests that learning disabilities cannot be attributed only to unilateral deafness of a child [Hartvig J., 1989].

The fitting of a hearing aid for children with UHL is not as straight forward as with children with bilateral hearing loss. There is no evidence about whether babies with UHL benefit from being fit with a hearing aid early [Briscoe J., 2001; Wake M., 2006; McKay S., 2008]. The use of a hearing aid in school-aged children with moderately severe or better hearing in the impaired ear has met with considerable success as indicated by subjective rating scales [Bess F.H., 1998].

The American Academy of Audiology Pediatric Amplification Protocol addressed the fitting of amplification on children with UHL and minimal to mild hearing loss in its special consideration section. The following statement is relevant to the discussion: «The decision to fit a child

with UHL should be made on an individual basis, taking into consideration the child's or family's preference as well as audiological, developmental, communication and educational factors [American Academy of Audiology, 1997, 2011]. This issue is still discussed in more resent sources: «current clinical practice guidelines and protocols for pediatric hearing aid fitting recommend managing these conditions on a case-by-case basis» [Bagatto M., 2020].

1.3. Ethiology of hearing loss in school children

Impacted wax may be the cause of the conductive hearing loss complete occlusion of the external ear canal by wax can cause a 30–40 dB loss. Foreign bodies in the external ear canal should also be considered when a sudden onset of a conductive hearing loss has been complaint of. They are especially common in schoolchildren with prevalence up to 35% [Maharjan M., 2021].

In developing countries otitis media (OM) is the most frequent cause of children visits the physician for illness. It is one of the most common childhood infections, which is second to common cold as a cause of infection in childhood and a leading reason for antibiotic prescriptions in the developed world. For children less than 15 years old, the major cause for hearing impairment and the most frequent diagnosis made in clinical practice is OM [Berman S., 1995; Smith A.W., 1996; Bento R.F., 2003; Anggraeni R., 2019].

The most common morbidity of OM is conductive hearing loss due to otitis media with effusion (OME). Children with severe and recurrent OM and persistent middle ear effusion are at risk for problems in behavior and

development of speech, language and cognitive abilities. Despite advances in public health and medical care in developed countries OME still continues to be significant health problem all around the world. [Klein J.O., 2001; Okur E., 2004; Cai T., 2017].

The burden of otitis media is particularly heavy for children in areas of the world in which access to medical care is limited. If left, acute otitis media may lead to persistent perforation of the tympanic membrane and disarticulation of the middle ear ossicles leading to permanent conductive hearing loss. Berman S. reviewed reports from several developing countries, and emphasized high rates of tympanic membrane perforation, persistent otorrhea (consistent with CSOM) and mastoiditis [Berman S., 1995]. Mild impairment of hearing is the most common complication of acute otitis media and OME. This deficit is equivalent of putting plugs in the ear of the patient. With such deficits, the softer speech sounds and voiceless consonants may be missed. The hearing loss is not influenced by the quality of the fluid but rather by the extent that the middle ear is filled with fluid. SNHL may complicate the matter even more due to spread of infection or products of inflammatory process through the round window membrane or as a suppurative complication of labyrinthitis [Bluestone C.D., 1998].

Children from developing countries are having unfavorable environments, which associated with extraordinarily high incidence of severe episodes of otitis media with frequent perforation of tympanic membrane and persistent suppurative discharge and necrotizing process in the middle ear, including destruction of ossicles [Bidadi S., 2008].

In the Nepalese context, approximately 16% of the population above the age of 5 years suffers from otitis media. More than 55% of these cases

occur in school going children, most of them belonging to the lower socio-economic class [Shrestha R., 2001; Mishra S.C., 2002; Acuin J., 2004]. A study in a village in Southern India by Abraham V.J. et al identified prevalence of hearing loss among school children to be 11.9%, with the most common cause of hearing loss being otitis media [Abraham V.J., 2003]. Olusanya B.O. et al screened school children in Lagos, Nigeria, and found prevalence of hearing loss to be 13.9%. otitis media was observed in 20.9% of these children [Olusanya B.O., 2000]. Similarly, Okur E. et al from Turkey carried out a study in primary school children and found prevalence rate of OME was 7.4 %, with maximum prevalence of 10.4% at age between 6 and 8 years. By increasing age, the prevalence of OME decreased [Okur E., 2004].

Chronic otitis media (COM) is a major global cause of hearing impairment, which is an important public health problem with substantial economic and social costs, especially in developing countries. It is vanishing in developed Western countries since operations for COM seem to have decreased markedly over the past few decades [Alho O.P., 1997].

The term “chronic otitis media” includes chronic suppurative inflammation of the middle ear and OM with the presence of exudate. These two forms of OM together with other pathologies of the middle ear - perforation of the eardrum, cholesteatoma and otosclerosis - are the most common causes of conductive hearing loss. Most WHO reports on the prevalence of OM do not provide separate data on acute and chronic OM, although hearing loss is considered a chronic and often lifelong disorder, depending on the severity and frequency range in which hearing thresholds are increased [WHO, 2004; 2006].

The global burden of illness from CSOM involves 65–330 million individuals with draining ears, 60% of whom (39–200 million) suffer from significant hearing impairment [WHO, 2004]. Several studies showed that hearing loss caused by COM leads to hearing/speech difficulties, as well as attention deficit, language learning problems, reading problems, cognitive and behavioral disorders [Davis J., 1986; Bidadi S., 2008].

CSOM is the commonest cause of childhood hearing impairment in developing countries. The disorder is associated with adverse socioeconomic conditions, follows poorly treated acute OM. It is defined as a tympanic membrane perforation with suppurative otorrhoea present continuously for at least 2 weeks. CSOM continues for months or years with increasing hearing impairment; it can lead to life-threatening infective complications [Smith A.W., 1996; 2001].

CSOM is often ignored by parents, although high prevalence of this condition has frequently been reported among populations in developing countries. Children with COM may either be unable to express the type of the problem or be unaware of the associated mild to moderate hearing impairment. Consequently, the condition often goes unnoticed by both health care professionals and parents. Children who have bilateral COM may suffer 1-2 years' educational retardation with significant delays in speech and language acquisition, even though their hearing impairments are rarely <45 dB [Gell F.M., 1992].

Chronic middle ear infection was considered the main cause of mild to moderate hearing impairment among children and young people in developing countries. This results from disruption of the eardrum and ossicles assembly (conductive hearing loss) or from hair cell damage by

bacterial infection that has penetrated the inner ear (SNHL), or both (mixed hearing loss). Inadequate antibiotic treatment, frequent upper respiratory tract infections, nasal disease, and poor living conditions with poor access to medical care are related to the development of CSOM [WHO, 2004; 2006].

Despite the wide and sometimes indiscrimination use of antibiotics, and improvements in public health and medical care, CSOM is still frequently seen in developing countries. According to WHO reports, the prevalence of COM around the world ranges from 1 to 46 percent in disadvantaged groups in developing and developed countries. A prevalence of more than 1 percent of COM in children in a community indicates that an avoidable burden of the disease exists but can be dealt with in the general health care [WHO, 2004].

CSOM is varies between socio-economic strata within a community and less prevalent at the higher socio-economic levels and in urban areas compared with rural areas. This is put down to better medical services [Ologe F.E., 2004].

Bluestone C.D. stressed various risk factors contributing to the occurrence of the disease, as overcrowding, poor hygiene and nutrition, inadequate or unavailable health care, high rate of nasopharyngeal colonization with pathogenic bacteria and passive smoking and addition factors such as impaired immunologic status, environmental and social factors. Based upon the prevalence of CSOM, the author suggested a classification of populations into four categories; the highest prevalence rate (12–46%) was found in Alaska, Australian aborigines and native Americans, high (4–8%) as in New Zealand, Malaysia, low (1.4–2%) in Korea, India,

Saudi Arabia and lowest, (less than 1%) in USA, UK, Denmark, Finland [Bluestone C.D., 1998].

Several serious attempts have been done in Saudi Arabia to figure out the prevalence of CSOM, and its effect on the hearing. In 1982, a study was carried out by Zakzouk and Sengupta in rural areas of Al- Qassim area in the Central region of Saudi Arabia. They studied 293 school children between the age 6–18 years and found that the prevalence was 5.5%. The prevalence was higher in the areas with less health care services and less public awareness. Therefore their recommendation has been directed to the health authority to pay more attention to those highly affected areas [Zakzouk S.M., 1996]. In 2002 the prevalence rate of CSOM was decreased to 1.31%, the prevalence was found to be slightly higher in male children than female [Zakzouk S.M., 2002].

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 [Sarafraz M., 2009]. Also in the United States Mehra S. et al. reported the low-income households demonstrate a higher prevalence of hearing loss compared to households with higher income levels [Mehra S., 2009].

Rao R.S. et al. reported a statistically significant inverse relationship between the incidence of hearing impairment and socio-economic status of the community [Rao R.S., 2002]. The prevalence was higher among children with a positive family history of hearing impairment when compared with those with no family history. Similarly, the prevalence was higher among children born to consanguineous marriages. However, these differences were

not found to be statistically significant. Such diseases are an important cause in communities where consanguinity is common**.** The prevalence of consanguinity varies by culture and is highest in Arab countries, followed by India, Japan, Brazil, and Israel [Khlat M., 1991].

1.4. Early detection and prevention of childhood hearing loss

Hearing loss is one of the main causes of disability, unfortunately, in comparison with other diseases, hearing impairment is not taken seriously and is often neglected [Zakzouk S.M., 2002]. This is because this pathology can go unnoticed for a long time. The most important thing in treating a child with hearing loss is early diagnosis, which, unfortunately, is not always possible, although it could minimize the consequences and ensure timely treatment.

The prevention of hearing loss can be organized at all levels. Primary preventative measures include vaccination to minimize the burden of ear-related infections, avoiding exposure to hearing hazards through rising the awareness. Hearing screening is a secondary preventive level, as early detection of unnoticed hearing impairment can help to avoid or mitigate the problems. Providing the intervention services like hearing aid fitting or cochlear implantation, assistive technologies, speech training, family and community work is a tertiary prevention [WHO, 2021].

Neonatal hearing screening aims to detect babies with congenital hearing loss, especially those with no risk factors, and provide timely treatment before reaching the age of six months [Tognola G., 2007; Joint Committee on Infant hearing, 2007, 2019]. Universal newborn hearing screening programs were implemented widely in many developed countries

in contrary to developed countries [WHO, 2009; Bussé A.M.L., 2021]. The screening testing is usually performed in birth facilities before discharge or in outpatient clinics, for example during scheduled health check or vaccination visits. The introduction of newborn hearing screening programs in developing countries with limited resources can be supported by international or non-government organizations and professional associations [Olusanya B.O., 2004; Swanepoel D.W., 2006; Olusanya B.O., 2014].

Progressive or acquired hearing loss may develop later in early childhood or school-age. The prevalence of persistent hearing impairment among 9-year-old children almost three-times higher compared to congenital forms [Fortnum H., 2001]. Therefore, screening for hearing impairment in school-age children is included in the concept of identifying hearing loss across the lifespan [WHO, 2021]. All children should be screened for hearing loss at least once during the preschool years. In addition, hearing screening should always occur when hearing loss is suspected by parents or care-takers. Manual pure tone screening with an audiometer is currently the preferred method of screening for hearing loss in typically developing preschool and school-age children [Yong M., 2020; WHO, 2021].

The 2007 review by J. Bamford et al. is considered the first study to evaluate the medical technology of school hearing screening, furher their results were used in the American Academy of Audiology recommendations. [Bamford J., 2007; American Academy of Audiology, 2011]. At the same period the European consensus statement on hearing screening of pre-school and school-age children was approved [Skarzynski H., 2012].

The most commonly used method for school hearing screening pure-tone air conduction audiometry. The acoustic stimulus are pure tones 500,

1000, 2000, and 4000 Hz at a screening level of 20 dB HL for individuals between approximately 3 years through third grade and any high-risk children in other grade levels. A screening positive is failure to respond to test signals at any frequency in either ear. Children unable to hear at one or more frequencies at a 20-dB level in either ear did not pass the screening. All screening positives are to be rescreened within 2 weeks. If ambient noise levels are too high, hearing screening at 500 Hz may be omitted [American speech and hearing association, 1997; Halloran D.R., 2009; Prieve B.A., 2015; WHO, 2021].

For hearing screening in children over 9 years of age, the digit triplet test can be used. It is a fairly effective alternative to pure tone audiometry in countries with limited health resources or in remote areas, since it can be performed using applications specially developed for smartphones. It is not recommended to screen with whispered speech due to low sensitivity. [Denys S., 2018; Manus M. 2021].

Hearing screening programs requires ease access to audiology service to diagnose and manage the hearing problems. Audiology, with its high-tech equipment, hearing aids and experienced, qualified personnel of various specializations, remains a luxury for developing countries with their limited resources in the field of healthcare, social development and education [Jauhiainen T., 2001]. According to Olusanya B.O. et al. in developed countries, there are 320 otorhinolaryngologists for every 1 million children under 15 years old, while in the third world in some regions there is not even one otorhinolaryngologist for a million children [Olusanya B.O., 2004]. The WHO emphasizes that good, university-trained audiologists are urgently needed in developing countries; they should know how to approach the

treatment of hearing loss at any age, how to select hearing aids, how to conduct and evaluate appropriate programs and train technical staff [WHO, 2004].

Without accurate data on the prevalence of hearing loss, it is difficult to plan the necessary medical care; therefore, identifying children with hearing loss increases public awareness of the problem and ultimately leads to new opportunities for medical care and timely treatment [Berg A.L., 2006].

Some forms of hearing loss and ear diseases can be prevented and, in other cases, minimized by early diagnosis and subsequent treatment [Matthiassen C.N., 2007; WHO, 2016].

Hearing screening is now considered an essential public health care for the early detection of disabling life-long childhood hearing impairment globally. However, like any health interventions in childhood, parental support and participation is essential for achieving satisfactory uptake of services [Olusanya B., 2009].

Prevention of congenital hearing loss. Most nationalities, along with their religion, economy, cultural traditions and geography, have decisive factors that influence the choice of spouse. At the same time, these factors contribute to the spread of incest, and the resulting genetic homogeneity leads to the manifestation of rare autosomal recessive diseases [Schrijver I. 2004; Petersen M.B., 2006; Morton C.C., 2006].

The prevalence of closely related marriages depends on cultural traditions and is very high in Arab countries; they are followed by India, Japan, Brazil and Israel. The most common union is the marriage of a cousin. Genetic consultation should, firstly, be made taking into account the cultural

characteristics of the people, and secondly, should inform parents about the etiology of their child's hearing loss and the proposed inheritance pattern of any genetic pathology [Khlat M., 1991; Arab S.B., 2004].

A complete medical history should include maternal pregnancy information, a history of childbirth, and a family history. It is especially important to know about hearing loss in cousins and second cousins, especially if the hearing began to deteriorate before the age of 30; you need to ask about inherited features that may be associated with syndromic hereditary hearing loss. If there are relatives with hearing loss in the family, it is necessary to compose a family tree. Targeted genetic counseling and public health education will help reduce the incidence of autosomal recessive deafness in these populations [Cremers C.W.R.J., 2002; Smith R. J. H. 2003]. Genetic screening as an adjunct to universal newborn hearing screening is also discussed [D'Aguillo C., 2019]

Prevention of acquired hearing loss. In developing countries where there is no vaccination program against rubella, congenital rubella syndrome remains the most important cause of acquired SNHL. The severe consequences of this pathology are decisive in the implementation of any vaccination program. The WHO 's global vaccine and immunization program contains recommendations for the prevention of congenital rubella, and preliminary studies support vaccination with Haemophilus influenzae (H. Influenzae) and pneumococcus (S. Pneumoniae). In more developed countries, where cases of congenital cytomegalovirus infection have suppressed congenital rubella syndrome as the most common cause of congenital acquired SNHL in children, the creation of an effective vaccine

remains among the main priorities [Luxon L. M., 2000; Dewan P., 2012; Mongua-Rodriguez N., 2013; Goderis J. 2014].

The program for the prevention of deafness and hearing loss should be carried out in close collaboration with the appropriate vaccination unit of the WHO to emphasize and clearly calculate the benefits of immunization for the prevention of congenital hearing loss (measles-mumps-rubella vaccine) and hearing loss due to meningitis (hemophilic wand).

Vaccination. Vaccination against bacterial infections of Haemophilus and Pneumococcus, meningitis, measles, mumps and rubella helps prevent ear-related infections in children. According to the recommendations of the vaccination program carried out by the local health authority, all children in the community should be vaccinated against these diseases, after which they should apply for the community to participate in the expanded immunization program [Smith AW, 2001; WHO, 2002].

Prevention of infectious diseases of the ear. Ear infections are widespread among young children, especially with overcrowding, the presence of smokers in the family, unsanitary conditions and constant contact of children with colds and sick family members. Early treatment of ear infections will help to avoid complications, such as hearing loss [Downs M.P., 1999].

Ototoxic drugs. Ototoxic drugs are drugs that can have a negative effect on the organ of hearing. These medicines should only be prescribed by doctors. Known ototoxicity is possessed by aminoglycoside antibiotics, for example, gentamicin and streptomycin, and antimalarial drugs - quinine and chloroquine [Espeso A., 2006; Núñez-Batalla F., 2022]. Recently the

ototoxicity of as cisplatin in childhood cancer treatment is widely discussed [van As JW, 2016; Strebel S., 2022].

Hearing protection from noise. Under the influence of loud sounds, and noise the stereocilia of the outer hair cells of the cochlea is damaged and not restored. In children the excessive use of personal audio systems with headphones can lead to irreversible hearing loss [le Clercq, 2018; WHO, 2018].

Development and management of a screening program. The development of audiological screening programs requires careful planning, implementation and monitoring. Important factors in creating a program are individual and professional responsibility of a specialist, risk management, quality improvement and evaluation of program effectiveness [Sabo M.P., 2000; Piotrowska A., 2012].

Individual and professional responsibility is the responsibility of the audiologist who develops, conducts and monitors the screening program in order to provide the patient with appropriate care at all levels. It is the responsibility of the audiologist to create mechanisms to ensure (a) patient confidentiality; (b) the proper application of the screening protocol, including the training and management of support staff, and (c) the proper counseling and referral of the patient to specialists [American speech and hearing association, 1997; Joint Committee on Infant Hearing, 2019; WHO, 2021].

Risk management and quality assurance: the audiologist must evaluate the risk factors associated with the screening program and develop procedures to minimize or eliminate these factors. Risk factors in hearing screening include potential infection, inaccurate screening results from

equipment malfunctioning or calibration errors, erroneous patient referral, or errors in subsequent patient management. The audiologist is responsible for establishing mechanisms (a) for the control of infectious diseases through general preventive measures, (b) equipment setup (calibration), electrical safety and daily signal verification, (c) accurate patient identification and recording. To guarantee the quality of screening, written documentation should be regularly maintained [Davis A., 1997; Korres, S., 2005; Cutler J. 2012; Elloy M.D. 2012; WHO, 2021].

Evaluation of a program means evaluating the effectiveness of screening and involves developing a mechanism for (a) quantifying the "passed / failed and referred to specialist" ratio, (b) evaluating the ratio of false positive and false negative conclusions and (c) ensuring the effectiveness of follow-up protocols, especially for patients which, according to the results of the screening, were referred to a specialist. Evaluation of the program should be carried out continuously in order to identify and adjust the factors that impede optimal screening and patient care [Alberti W., 1999].

Methods for evaluating a screening program should be developed prior to its implementation so that the audiologist can guarantee the quality and effectiveness of the screening [Augustsson I., 1990; WHO, 2010, 2021; Neumann K., 2019, 2022].

The efforts of the WHO to prevent and control hearing impairment in children in developing countries help countries minimize the number of preventable hearing impairment and subsequent disability [WHO, 2010]. A 2010 WHO report says that 60% of cases of childhood hearing loss can be avoided through prevention, early diagnosis, and treatment. The estimates

differ significantly in low- and middle-income countries (75%) and in high-income countries (49%) [WHO, 2016].

World Health Assembly resolution 70.13 on prevention of deafness and hearing loss [WHA, 2017] urges for following measures:

- Developing a global database on deafness and hearing impairment to demonstrate the size and costs of the problem and help compare cost-effectiveness of interventions;
- Developing a training resource on Primary Ear and Hearing Care for primary health care workers;
- Developing and disseminating guidelines against major preventable causes of hearing impairment;
- Building partnerships to provide affordable hearing aids and services to people in need;
- Raising awareness about the level and costs of hearing impairment and the opportunities for prevention;
- Encouraging countries to establish national programmes for prevention.

1.5. Republic of Yemen: economics and health

The Republic of Yemen is an Arab state located in the south of the Arabian Peninsula, bordering Oman and Saudi Arabia. It is washed by the Red and Arabian Seas (Fig. 1A). The area of the territory is 527 970 km^2.

According to the 2013 census, the country's population was 24.4 million. Almost 70% of the population lives in rural areas (Fig. 1B).

The Republic of Yemen is one of the poorest Arab countries. Gross domestic product per capita in 2009 amounted to 2.5 thousand dollars (less from the Arab countries is only in Sudan and Mauritania, but in general it is

173rd in the world). For comparison, in Russia in the same year, this figure amounted to 8.6 thousand, and in the United States 47 thousand dollars.

A

B

Fig. 1 Geographical location (A) and physical map (B) of the Republic of Yemen

The capital of the country since 1990 is the city of Sana'a (Fig. 2). Sana'a is the largest city of the republic with a population of 2.5 million people (2013 data).

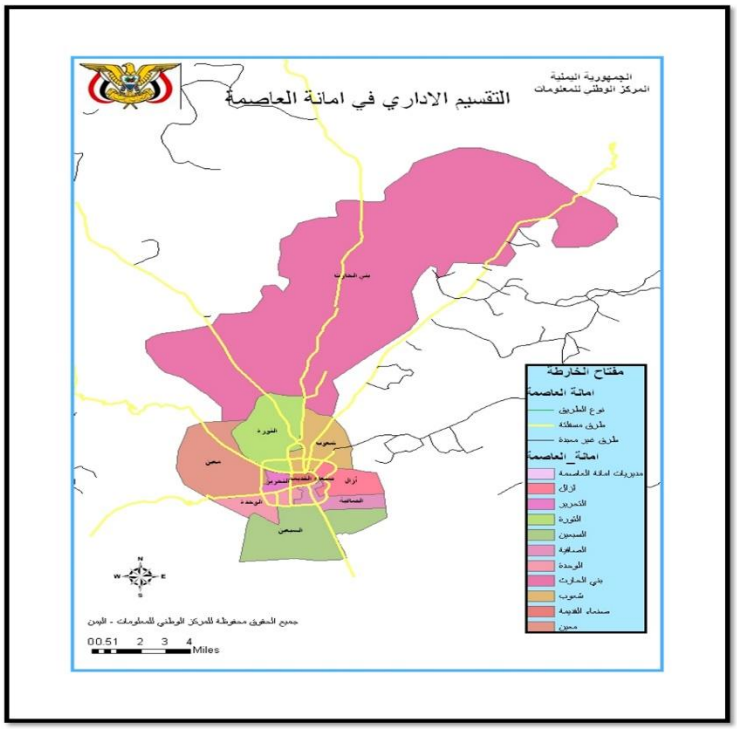

Fig. 2. Map of the city of Sana'a

The cost of healthcare per capita is $200; for comparison, in Russia this figure is $1,587 in 2013. For the majority of the population, medical care is practically not available. According to estimates, for every 10 thousand people there are only 3 doctors and 6 beds in a hospital. Most births occur at home. There is no organized unified system of obstetric care in the country, and few people have the help of doctors. Throughout the country there are only two audiologist doctors, one of whom is the author of this work. The country lacks services such as ambulance and blood banks. Only 25% of rural areas are covered by the medical service, while in cities this indicator is 80%.

In the Republic of Yemen, as in other states of this region, a rather high fertility rate is 4.8 births per woman. The birth rate is 43.4 per 1000 people. In 2013, 425165 newborns were registered. An increase in the number of newborns was noted, compared with 2011 and 2012, by more than 150 thousand children. However, to date, childbirth takes place most often

at home, without medical care and subsequent medical examination. Hence the high maternal mortality rate - 210 deaths per 100,000 births in 2010, that is, every 500 pregnant women die in childbirth. Infant mortality is often caused by infectious diseases from which vaccines exist or other treatable diseases. Therefore, the main efforts of the healthcare system are aimed at the prevention and treatment of life-threatening diseases, to which diseases of the ENT organs, in particular the ear, in most cases do not apply.

In the Republic of Yemen, there is not a single system of audiological screening; moreover, no work has been carried out in the country to study the prevalence of ear diseases, hearing loss, and there is no data on risk factors for hearing loss. The country does not have a system for registering deaf children, as well as a unified education system for deaf children. According to rough estimates, there are about 3,000 thousand deaf children in the country. Given all of the above about the socio-economic situation in the country, the situation with diseases of the hearing organ among children can be as dramatic as in other developing countries. All this, of course, indicates the relevance of the study of the prevalence of hearing loss, assessing the type of hearing impairment and risk factors for the development of hearing pathology in children in the Republic of Yemen.

CHAPTER 2. MATERIALS AND METHODS

2.1. General characteristics of the examined children

The selection of children for examination was carried out from November 2009 to April 2010 in the capital of the Republic of Yemen, Sana'a. The study included 2200 students of the first, second and third grades of primary schools in the city. Children were 6–9 years old; the study involved both boys and girls in a 1:1 ratio. A representative sample was taken from 12 elementary schools in four districts of the city with different socio-economic levels. 573 children lived in an area with a high socio-economic standard of living (26%), 871 children were from an area with an average level (40%), 756 children lived in an area with a low level (34%) (Fig. 3). Data on the socio-economic status of the region were obtained from the Central Statistical Department of Sana'a.

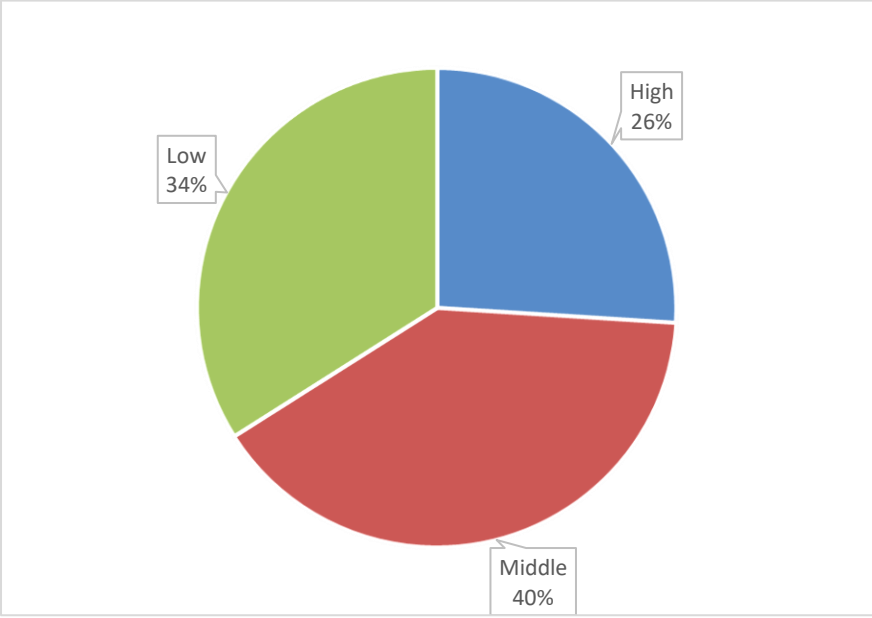

Fig. 3. The distribution of the examined children by the socio-economic level of the district of residence of schoolchildren in the city of Sana'a.

Schools were selected randomly. The sample size was calculated with a 95% confidence interval in proportion to the target population based on available data on the presence of diseases in 5% with a maximum error of 1%.

The first study participant in each class was randomly selected from a classroom journal, after which every third one following him was selected.

The examined group was dominated by children from large families. More than 3 brothers and sisters had 75.5% of children (Fig. 4). Two thirds of families have parents with a low level of education (Fig. 5).

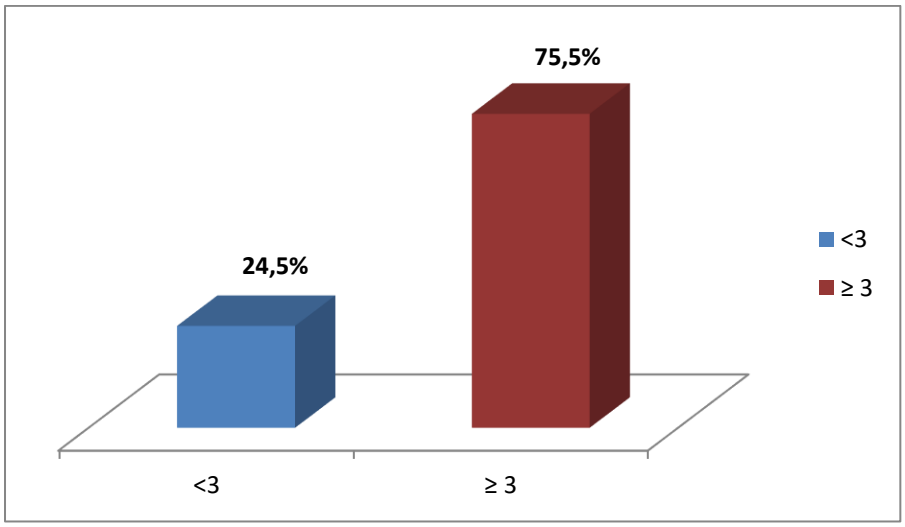

Fig. 4. Distribution of the number of brothers and sisters in the families of children of the surveyed group.

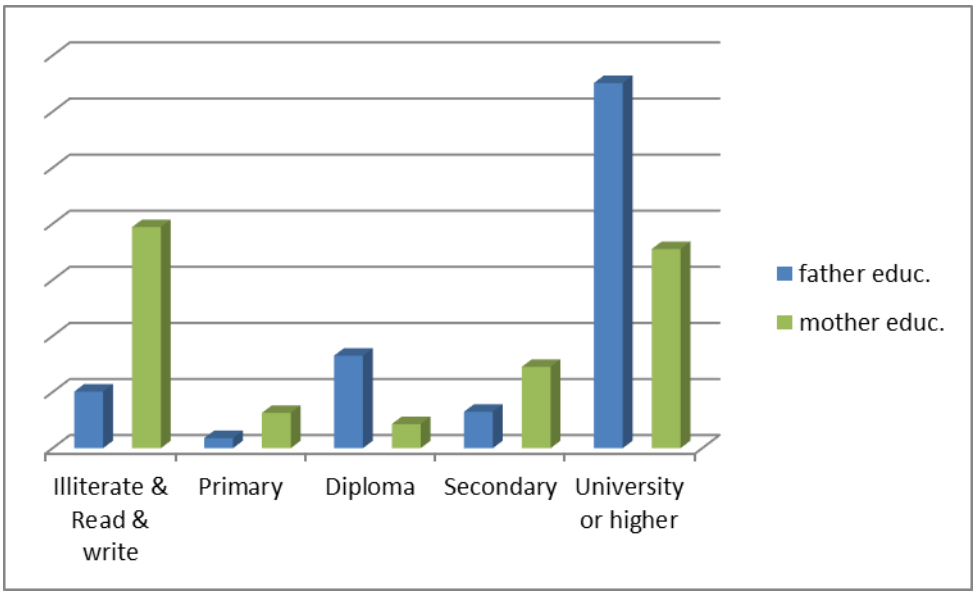

Fig. 5. The distribution of children in the surveyed group by the level of education of father and mother.

2.2. Research methods

The study was conducted in 2 stages. At the first stage, all children underwent a screening examination at school. The study included screening by an otorhinolaryngologist, otoscopy and tonal audiometry in a screening mode using an AD229b audiometer (Interacoustics, Denmark) [Sabo M.P., 2000; Driscoll C. 2008; Gell F.M. 1992]. At the second stage, children who did not pass the screening and the children of the control group were sent to the university clinic, where a full audiological examination was carried out, including taking an anamnesis, otoscopy, an ear toilet if necessary, performing impedancemetry on an AZ26 impedancemeter (Interacoustics, Denmark), tonal threshold audiometry at using a clinical audiometer AC40 (Interacoustics, Denmark) in a soundproofed cabin. The medical history and

family history were specified for each child, in addition, they used a specially designed questionnaire.

At the first stage in the school, the following procedures were mandatory for each student:

1) Filling out the screening form (Appendix 1) at the school, indicating the age, gender, class, living conditions and the result of the screening audiometry (“passed / failed”).

2) Otoscopic examination made it possible to exclude the presence of suppurative discharge from the ear and perforation of the tympanic membrane.

3) All the children were examined and underwent screening audiometry in the quietest room of each school.

For pure tone audiometry, the choice of the screening environment is very important. The area must be reasonably quiet. The screening site should be selected during school hours so that noise problems can be identified. The site should be away from stairs, windows, street noise, hall traffic, cafeterias, heating/cooling vents and equipment, bathrooms, play areas and machine rooms, etc. Sound treated areas sometimes are available in school libraries or music rooms.

Noise levels in the test environment must be checked prior to any hearing screening procedure. The person performing the check should have normal hearing sensitivity. The noise level check is accomplished easily with the audiometer. Wearing the audiometer earphones, the screening frequency pure tones (1000 Hz, 2000 Hz and 4000 Hz) should be heard at a level of 10 dB (screening level for children is 20 dB). If the tones cannot be heard at 10 dB at each screening frequency, do not screen in that environment.

Preparation of the child for his hearing screening is extremely important. An instruction for hearing screening may be given to children individually or in groups. Individual instruction should be given to the child face-to-face and prior to placing the earphones on him. Stress the importance of responding quickly to the tone even if it is very faint. The child should be asked to respond to the tone by raising his hand or by saying "yes". Instructions for screening should be simple, standard instructions can be as follows:

“You are going to hear some tones (beeps, whistles, bells, etc.).”

“Every time you hear one, raise your hand.”

“Raise your hand as soon as you hear the tone, even if it is very soft.”

Seat the child being screened so that his face is visible to the examiner the screening, but so that he faces away from the tester and the audiometer. It is important that the child not see the tester's hands or the screening record form.

Then each child was introduced to pure-tone at 1000 Hz with a comfortable hearing level of 60 dB HL. The test tones were then presented to the child at an intensity level of 20 dB HL. Each ear was tested at frequencies 0.5, 1.0, 2.0 and 4.0 kHz.

Following completion of the screening, results must be evaluated on a “pass” or does not pass “fail” basis. If a subject responded positively to all frequencies for each ear the pure tone screening result was recorded as a pass. If a subject did not respond to any either ear, the subject was re-instructed after the earphones were removed. The earphones were appropriately replaced and the subject was re-screened. Failure to respond to a test frequency in either ear was recorded as a “fail”.

The results were entered in an individual screening form. If the child did not pass the screening, he was necessarily sent to a university clinic for the extended audiological examination.

Together with the non-screened child, a healthy child was referred to a specialist as a control group for a similar examination. For the control group, each child was selected, "passed" screening, following the child who screened "failed." Thus, the control group was formed from children in the same amount as the main one, and consisted of children of the same age and the corresponding schools.

Children who did not pass the screening, as well as children of the control group were sent to the university clinic. An audiological examination in the clinic was carried out no later than 3 months after the screening date. Parents were notified in writing of screening results and related recommendations.

At the second stage, the clinic carefully collected anamnesis data, parents filled out a questionnaire (Appendix 2). Peculiarities of the course of pregnancy and childbirth, past illnesses, including the ear, throat, and nose, were noted. In the questionnaire, special attention was paid to issues of family history: parenting, bad habits, number of brothers and sisters, burden of family history of hearing loss, consanguinity of parents. A number of questions dealt in detail with social status and family income.

An audiological examination included an acoustic impedance measurement (tympanometry and acoustic reflex recording with a type A tympanogram) and pure tone audiometry at frequencies from 250 to 8000 Hz for air conduction and at frequencies of 500 - 4000 Hz for bone conduction.

The results were recorded on an registration form (Appendix 3). Before an audiological examination, if necessary, some children had an ear toilet.

Tympanograms were classified according to the international classification [Driscoll C., 2008; Palmu A.I., 2005].

Tympanogram Type A curve: Normal middle ear function. Normally, the maximum compliance peak in children is from -150 to +100 daPa with an immitance of 0.2-2.5 millimhos (mmhos).

Type As curve: low peak height (low compliance), compliance peak is -150 to +100 daPa and immittance is less than 0.2 mmhos. This suggests:

- middle ear effusion
- ossicular fixation decreasing tympanic membrane mobility.

Type Ad curve: High peak height (high compliance) compliance peak is -150 to +100 daPa and immittance is more than 2.5 mmhos. This suggests:

- tympanic membrane thinning (healed post-rupture)
- ossicular disarticulation.

Type B curve: Flat curve (low compliance or no immittance peak)

See decreased compliance below (based on volume)

- normal volume, average ear canal volumes for children are 0.42-0.97, suggest a middle ear effusion or sclerosis
- low volume suggests a cerumen impaction or probe is against the side of the ear canal.
- high volume suggests a tympanic membrane Perforation or patent tube.

Type C curve (high negative pressure), the compliance peak is less than -150daPa, it suggests:

- developing or resolving OM.

- eustachian tube dysfunction.
- retracted TM.

Pass/fail criteria:

Pass: Compliance peak is considered within normal value in children if it’s type A curve.

Fail: Any type of tympanometry other than type A and ear canal abnormality such obstruction or wax impaction or presence of secretion and perforation of tympanic membrane.

Children with non-type A tympanograms were referred for a repeat evaluation after 6 weeks. Those with persistent non type A tympanograms at the second stage were considered as having failed the tympanometric test they need medical or surgical interference (Fig.6).

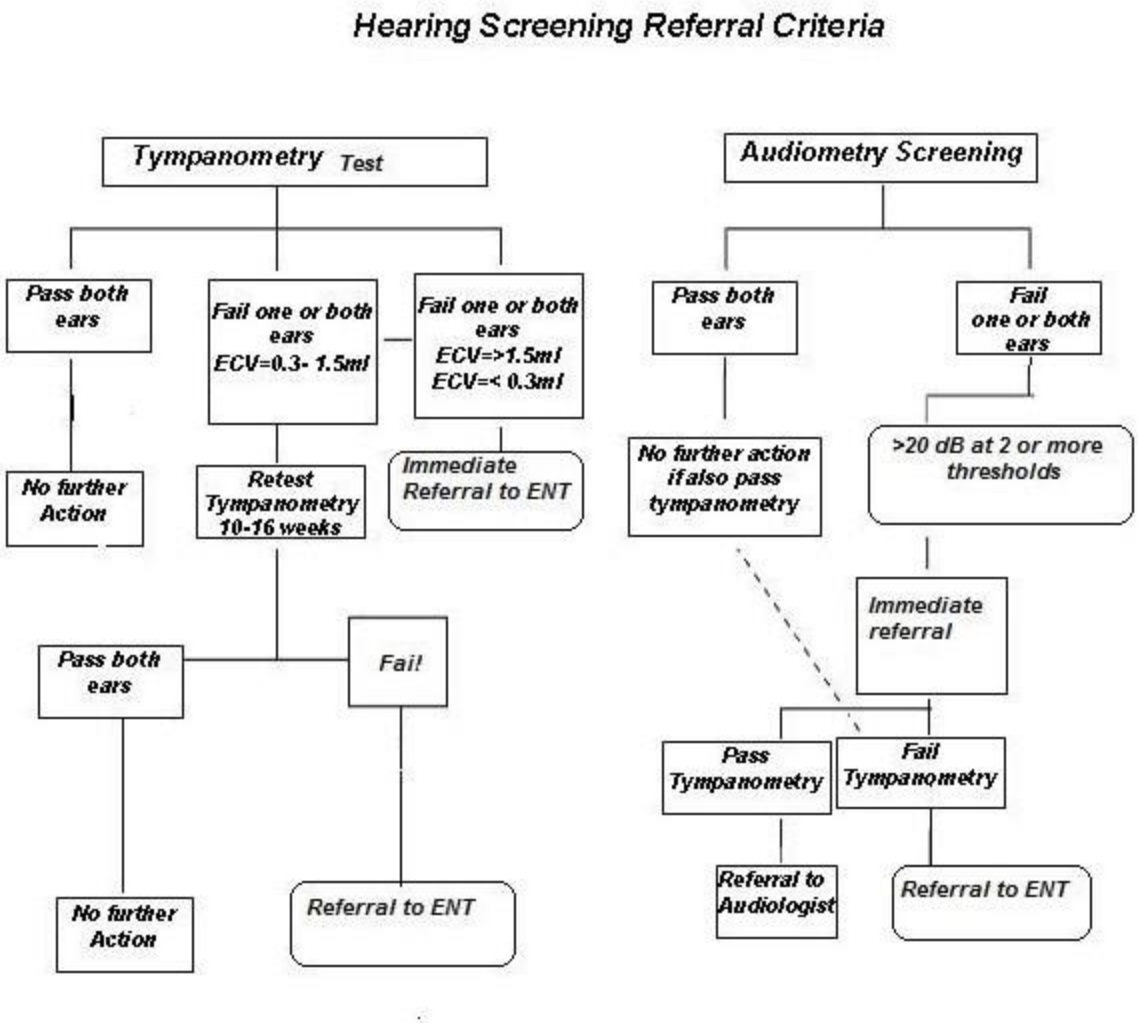

Fig.6 Hearing screening referral criteria (Tognola G. et al. 2002)

The degree of hearing loss. According to the results of tonal threshold audiometry, the degree of hearing loss was established by the mean hearing threshold level at 500, 1000, 2000 and 4000 Hz.

1) Mild hearing loss: - 26-40 dB;

2) Moderate - from 41 to 55 dB;

3) Moderately-to-severe - from 56 to 70 dB;

4) Severe – from 71 to 90 dB;

5) Profound - over 90 dB.

Clinical forms of hearing loss. Hearing loss was classified as sensorineural if the bone-air interval was <15 dB above hearing thresholds (aHT), and conductive if it was> 15 dB aHT. Hearing loss was considered as a mixed if the bone-air interval was> 15 dB and the thresholds of bone conduction were also increased (> 15 dB aHT). The frequencies at which hearing is impaired were designated as low (<500 Hz), medium (500–2000 Hz) and high (> 2000 Hz). Hearing loss at high frequencies was defined as an air conduction threshold> 15 dB at two or more frequencies of 4.0, 6.0 or 8.0 kHz per one or both ears [American speech and hearing association, 1995; Smith R. J. H., 2005].

2.3. Statistical analysis

The statistical analysis is based on the methods of descriptive statistics (determination of mean values and standard deviation); $\chi 2$ test was used to compare relative indicators. Statistical data processing was performed using the Statistica 10 and SAS JMP 10 software.

CHAPTER 3. RESULTS

3.1. The results of hearing screening of primary school children

This study was conducted on 2200 students (1100 males and 1100 females) age from 6-9 years old in 12 school in 4 different socio-economic status areas. 255 students failed the screening (main group), accounting for 11.6% of primary school children. 255 children from the same classes who successfully passed the screening were included in the control group and sent to the university clinic for an audiological examination.

Table 1

Distribution by age, gender and socio-economic status of children examined in the second stage

		Failed group		Control group	
		(n=255)	%	(n=255)	%
Socio-economic status area	High	66	25.8	76	29.8
	Middle	94	36.8	98	38.4
	Low	95	37.2	81	31.7
Grade	1st	88	34.5	88	34.5
	2nd	83	32.5	83	32.5
	3rd	84	33	84	33
Gender	Boys	145	56.9	139	54.5
	Girls	110	43.1	116	45.5
Age	< 8 years	120	47.1	131	51.4
	≥8 years	135	52.9	124	48.6

The children of the failed group and the control group are comparable by age and gender (Table 1). In the study group, a slight predominance of students with low and medium socio-economic status of the family was noted.

During the examination at the university clinic at the second stage, 21 children out of 255 children who did not pass screening were found to have ear wax. After removing, the children successfully underwent an audiological examination, which confirmed normal hearing thresholds. As a result of the examination, the diagnosis of hearing loss among children who did not undergo audiological screening at school was confirmed in 234 children, i.e. in 10.6% of primary school children (Table 2).

Table 2

Results of hearing screening and diagnostic assessment in the children

Procedure	Positive cases		Negative cases	
	No	%	No	%
Hearing screening (n=2200)	255	11,6	1945	88,4
Diagnostic hearing assessment of positive of failed cases (n=255)	234	10,6	21	1%
Diagnostic hearing assessment of control group (n=255)	-	-	255	100

At the first stage, referral rate was in 11.6% of primary school children. A further examination found that 1% of children failed the screening due to the ear wax. Hearing impairment was confirmed in 91.8% (234/255) of children failed the screening at school and examined at the second stage. All 255 children in the control group as a result of examination in the clinic

showed normal hearing thresholds in both ears, that is, hearing impairment and occluded wax in children in the control group were not detected.

3.2. The prevalence and type of hearing loss in children of the examined group

An analysis of the results of an audiological examination of 234 hearing impaired children showed a predominance of unilateral hearing impairment. 150 children had unilateral hearing loss, which accounted for 64% of the cases detected. Bilateral hearing loss was diagnosed in 84 children (36%) of the examined group (Fig. 7).

Among the unilateral disorders, conductive hearing loss prevailed, which was established in 126 children (126/150, 84%) and amounted to 57 cases per 1000 children of the same age. Unilateral SNHL was observed in only 24 children (24/150, 16%) and amounted to 9 cases per 1000 children aged 6-9 years.

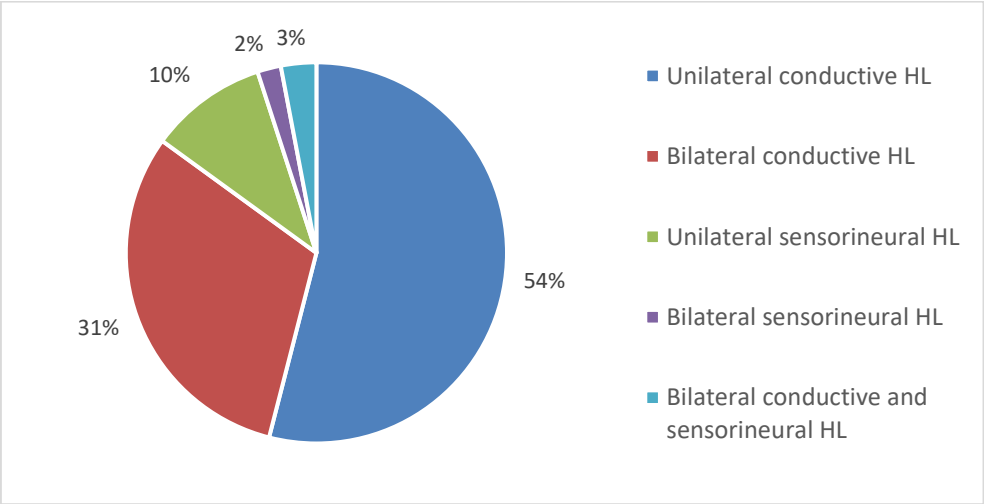

Fig. 7. Distribution of unilateral and bilateral hearing impairment in the examined group of children (n = 234)

Among bilateral hearing impairment, conductive hearing loss, which was diagnosed in 72 children, was also more common. Bilateral SNHL was found in 5 children, which amounted to 2 cases per 1000 elementary school children.

In the group as a whole, unilateral conductive hearing loss was 54%, unilateral SNHL - 10%, bilateral conductive hearing loss - 31%, bilateral SNHL - 2%. Bilateral conductive hearing loss in one ear and SNHL in the other were detected in 7 children (3% of cases).

The results of the study showed that among elementary school students, unilateral hearing impairment is almost twice as common as bilateral. The prevalence of unilateral hearing impairment among elementary school students aged 6–9 years was 68 cases per 1000 children of this age. The prevalence of bilateral hearing impairment among elementary school students aged 6–9 years was 38 cases per 1000 children of this age.

As a result of the study it was shown that the conductive type of hearing loss occurs almost 7 times more often than SNHL, 87.1% and 12.9% of cases, respectively (Table 3). The right and left ear are affected with the same frequency, 50.9% and 49.1% of cases, respectively. The prevalence of single and bilateral conductive hearing loss in the examined group was 93 per 1000 children aged 6-9 years. The prevalence of unilateral and bilateral SNHL was 16 per 1000 children 6-9 years old.

Table 3

Distribution of cases of hearing loss by side and type

(n = 318, number of ears with hearing impairment)

	Side of impairment				Total	
	Right	%	Left	%		%
Conductive	139	43,7	138	43,4	277	87,1
Sensorineural	23	7,2	18	5,7	41	12,9
Total	162	50,9	156	49,1	318	100

Analysis of the data showed a mild hearing loss with threshold increase from 25 to 40 dB in most cases, which amounted to 83% (263/318) of the number of ears with hearing loss (Table 4). The prevalence of mild hearing loss in the conductive type was also noted. A moderate degree of loss with an increase in hearing thresholds from 41 to 55 dB was diagnosed in 17% of cases (55/318), with the prevalence of conductive hearing loss predominated. Severe hearing damage and deafness in the examined group were not identified.

Table 4

Type and severity of hearing loss

(n=318, number of ears with hearing impairment)

Type of hearing loss	Severity of hearing loss				
	Mild	Moderate	Severe	Profound	Total
Conductive	233	44	-	-	277
Sensorineural	30	11	-	-	41
Total	263	55	-	-	318

Thus, among 255 children failed the screening at the first stage in school, 21 children showed occluded wax, after removal of which, hearing was normal, and no other ear pathology was detected. Examination of the remaining 234 children revealed unilateral hearing impairment in 64% of children. The conductive type of hearing impairment was diagnosed almost 7 times more often than sensorineural (87% and 13%). Most of the examined children showed mild hearing loss, much less often moderate hearing loss. There were no cases of severe and profound hearing loss in the examined group.

3.3. The structure of ear diseases with hearing impairment in children of the examined group

As a result of examination and examination in a clinic, it was found that the following pathological conditions on the one hand or on both ears were the cause of the detected cases of hearing loss in primary school children.

OME was diagnosed in 138 children, chronic perforated otitis media without exacerbation in 40 children, CSOM in the exacerbation stage in 39 children. Eustachian tube dysfunction occurred in 28 children, SNHL was detected in 36 cases (5 children with bilateral hearing impairment). Note that the same child could have one pathological condition (for example, OME) on one ear and the second - an exacerbation of CSOM - on the second ear.

The most common cause of hearing loss in the examined group of primary school children is OME with a frequency of 43% (138 of 318 ears). The prevalence of all identified pathological conditions was calculated by us for 2200 children who participated in the examination (Table 5). The prevalence of OME among primary school children was 15 cases per 1000. The prevalence of chronic perforated otitis media was 4.5 cases per 1000

children. The prevalence of chronic suppurative otitis media with effusion was 4 cases per 1000 children. The prevalence of SNHL was 4.5 cases per 1000 children.

Tympanometry is the leading method in the diagnosis of OME. The main diagnostic feature is registration of type B tympanograms. With pure tone audiometry mild conductive hearing loss was diagnosed in most cases.

Table 5

Prevalence of clinical findings among primary school children (n=2200)

Clinical findings	Number of impaired ears	%	Prevalence by 1000 children aged 6-9
Otitis media with effusion	138	43%	15
Chronic perforative otitis media	40	12,5%	4,5
Chronic suppurative otitis media with effusion	39	12,5%	4
Eustachian tube dysfunction	28	8,8%	3
Sensorineural hearing loss	41	12,9%	4,5
Ear wax	32	10,0%	3,5
Total	318	100%	36

The next significant cause of hearing loss after OME was CSOM. In the examined group of children, CSOM met with a frequency of 25% (79 out of 318 ears). This disease requires a separate consideration, since it not only causes the development of hearing loss, but can lead to life-threatening complications such as mastoiditis, meningitis, brain abscess, and others.

3.4. Chronic suppurative otitis media in primary school children

In the diagnosis of CSOM in the acute period or without exacerbation, otoscopy and the collection of anamnesis data were of major importance. In the case of suppurative discharge, tympanometry was not possible. In children with persistent perforation of the tympanic membrane, a type B tympanogram was recorded with a significantly increased value of the volume of the external auditory canal, or, in the case of normal functioning of the auditory tube, it was impossible to achieve tightness. Children of the examined group with CSOM were divided into two subgroups: cases of COM in the acute stage with discharge at the time of examination were 12.5%, and cases of COM with persistent dry perforation were 12.5% (Table 5).

According to the obtained data, CSOM was almost twice as likely to be detected in boys - 50 children (63.3%) than in girls - 29 (36.7%) (Table 6). In this case, a uniform age distribution of children with CSOM was revealed - 41 children under the age of 8 years, 38 children aged 8 years and older.

Table 6

Distribution of the children with chronic suppurative otitis media by gender and age

	Gender		Age	
Chronic suppurative otitis media	Boys	Girls	<8 years	≥8 years
	50 (63.3%)	29 (36.7%)	41 (52%)	38 (48%)

A detailed examination revealed that for patients with CSOM unilateral impairment is more typical (Table 7).

Table 7

Uni- and bilateral impairment in chronic suppurative otitis media

	Unilateral impairment	Bilateral impairment	Total
Chronic suppurative otitis media with effusion	31	8	39
Chronic perforative otitis media	38	2	40
Total	69 (87.3%)	10 (12.7%)	79 (100%)

According to the data obtained, the examined children came from families with different socio-economic status.

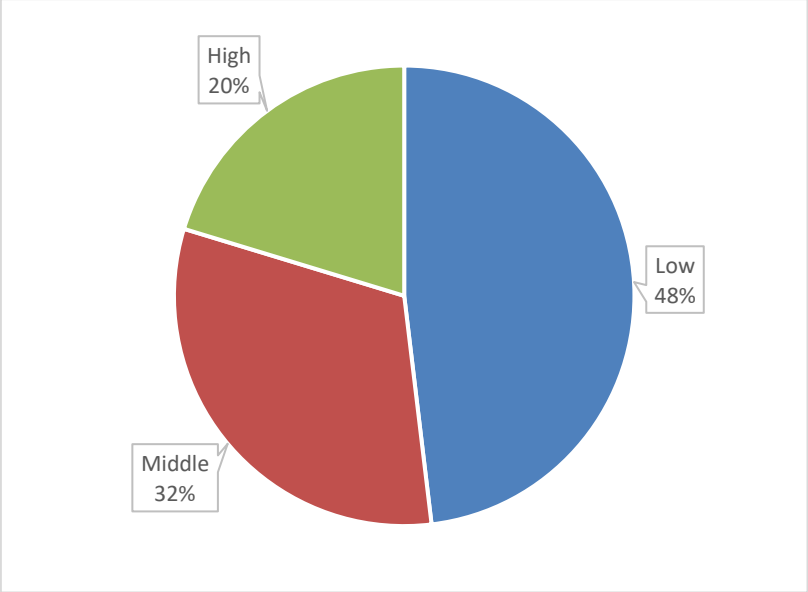

Fig. 8. The distribution of cases of chronic suppurative otitis media according to the socio-economic status of the family.

Chronic suppurative otitis media was more common in children from families with a low socio-economic status or with a low standard of living

(Fig. 8). So, 38 children out of 79 (48%) with CSOM media lived in families with low socio-economic status. 25 children (32%) came from families with middle socio-economic status, and only 16 children (20%) lived in families with high socio-economic status. A statistically significant relationship was noted between CSOM and difficult socio-economic conditions of life ($\chi 2=26.92$, $p<0.0005$).

The results of the study made it possible to show the dependence of the prevalence of CSOM among children on the socio-economic status of the family (Table 8).

Most children with CSOM, 54.5% came from families with three or more children.

Table 8

Prevalence of chronic suppurative otitis media
by socio-economic status of family

	Socio-economic status			Total
	Low	Middle	High	
All children (n=2200)	756	871	573	2200
Chronic suppurative otitis media	38	25	16	79
%	5,0%	2,9%	2,8%	3,6%

Analysis of family history data showed that passive smoking contributes to the development of CSOM. Thus, second-hand smoke was noted, in connection with the presence of smokers in the family, in 51 children (64.6%).

The educational level of the mothers of the examined children varied from lack of education to higher education. CSOM was noted in 57% of cases (45 children) in children whose mothers have no education (Fig. 9). However,

a statistically significant relationship between the prevalence of CSOM and the level of education of the mother was not obtained (p=0.17).

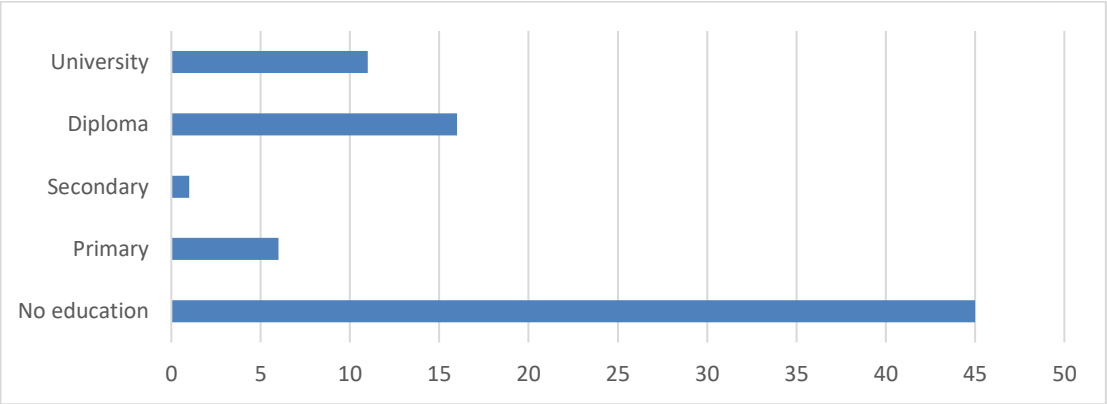

Fig. 9. Distribution of children with a diagnosis of chronic suppurative otitis media depending on the level of education of the mother.

The results of a study of family history and the presence of closely related marriages, an analysis of the degree of consanguinity of parents of children with a diagnosis of CSOM are presented in Fig. 10. In most children with CSOM, the parents were in a close relationship, and in 52 students (65.8%), their parents were cousins (siblings) to each other. Statistically significantly less often, children with CSOM were in the families of parents not related by consanguinity ($p<0.001$).

Thus, CSOM among primary school children occurs with a frequency of 3.6%. This disease, according to the results obtained, is more common in boys than in girls, and in most cases only one ear is affected. Such social conditions as a low socio-economic status, passive smoking, a large number of children in the family, as well as a low level of mother education or its absence contribute to the development of this disease.

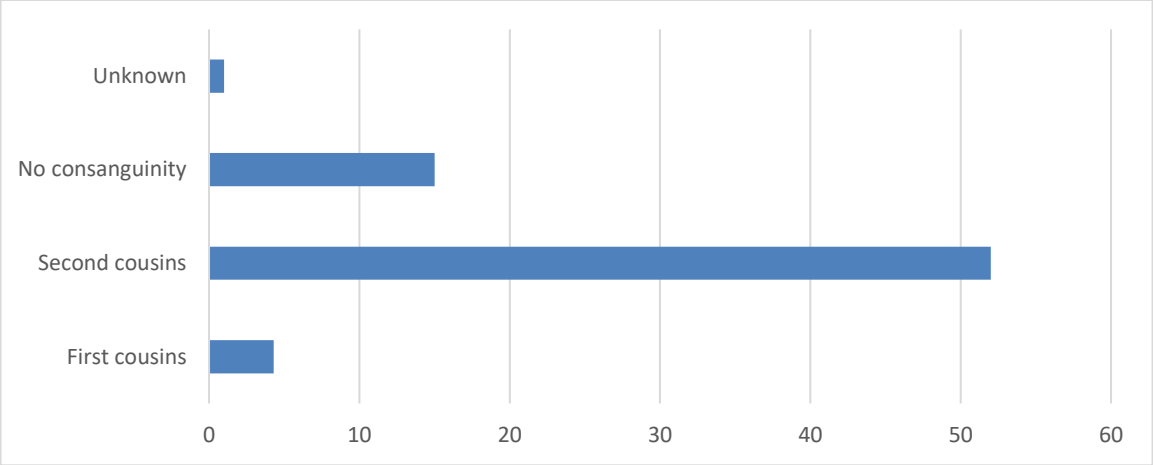

Fig. 10. Distribution of children with chronic suppurative otitis media, depending on the degree of consanguinity of the parents.

Eustachian tube dysfunction detected in 28 cases according to tympanometry (tympanogram type C) led to mild hearing loss or was not accompanied by hearing impairment. In most cases, unilateral auditory tube dysfunction was detected in children with CSOM or OME on the other ear.

SNHL was detected in 36 children (on 41 ears). Bilateral SNHL was diagnosed in 5 children, and unilateral SNHL in 31 children. It should be noted that all 5 children with bilateral SNHL were from parents who were closely related (three were cousin siblings, two were second cousins). Thus, the prevalence of bilateral SNHL in the Republic of Yemen according to the results of the data was 2.2 per 1000 children of primary school age (5 out of 2200). The prevalence of unilateral SNHL in the Republic of Yemen according to the results of the data was 14 per 1000 children of primary school age (31 out of 2200).

3.5. Risk factors of hearing loss in primary school children

The connection of some history data as well as social factors with the risk of hearing impairment in children of the examined group was evaluated

due to the results of a first stage survey and a survey of parents of children who underwent the second stage of the examination in the clinic.

Table 9

The relationship of the socio-economic status of the area of residence and hearing impairment in children

	Socio-economic status			Total
	Low	Middle	High	
All examined children	756	871	573	2200
Children failed the screening	88	96	71	255
Referral rate	11,6%	11,0%	12,3%	11,6%

The total study referral rate is 11.6%, and the difference in the socio-economic status of families of children in the city of Sana'a did not affect the risk of hearing impairment (Table 9), except for the risk of developing CSOM (Table 8). Thus, CSOM in children from areas with a low socio-economic status is almost twice as common as in children from areas with a high socio-economic status (2.8% and 5.0%, respectively).

To assess the relationship of family factors, parents collected data on such harmful habits of parents as tobacco smoking and chewing kata. Qat is a plant whose chewing, causing a similar effect to alcohol consumption, is common on the Arabian Peninsula, including in the Republic of Yemen. When collecting a family history, the degree of consanguinity of the parents, cases of hearing loss in the family, and the number of children in the family were clarified (Table 10).

Table 10

The relationship of family factors with hearing impairment in children

	Failed group (n=255)		Control group (n=255)		Odds ratio	95% confidence interval	χ^2	*p*
	n	%	n	%				
Smoking								
Yes	150	58,8	165	64,7	0,779	0,55-1,12	1,87	0,172
No	105	41,2	90	35,3				
Qat chewing								
Yes	241	94,5	216	84,7	3,108	1,64-5,88	13,16	0,007
No	14	5,5	39	15,3				
Consanguinity								
No	99	38,8	106	41,6	1,121	0,79-1,60	0,40	0,527
Yes	156	61,2	149	58,4				
Family history								
No	210	82,4	242	94,9	3,989	2,10-7,60	19,92	0,001
Yes	45	17,6	13	5,1				
Number of children in a family								
<3	44	17,3	81	31,8	1,221	0,89-1,70	1,70	0,132
≥3	211	82,7	174	68,2				

According to the data obtained, in the group of children with hearing impairment, a greater number of children from families where parents chew qat. However, there were no statistically significant differences compared with the control group ($p > 0.05$).

It should be noted that in general, the group of respondents was distinguished by the predominance of parents who smoke and / or chew qat. So, in the group of parents of children with hearing impairment, 58% smoke and 94.5% of parents chew qat, in the control group 64.7% and 84.7%, respectively.

In the failed group and in the control group a large number of families were noted where parents are in consanguinity - 61.2% and 58.4%, respectively. A positive family history, that is the presence of relatives with hearing impairment had 17.6% of the children in the examined group and 5.1% of the children in the control group.

Differences in family composition are noted. There were more families (31.8%) in the control group of families with no more than 3 children than in the group of children with hearing impairment (17.3%). In contrast, a high proportion of large families was observed in the group of children with hearing impairment 82.7%, against 68.2% of families in the control group.

Nevertheless, according to the results of the study, statistically significant differences are observed only in the case of a positive family history of hearing impairment.

Table 11

The relationship of perinatal risk factors with hearing impairment

	Failed group		Control group	
	n=255	%	n=255	%
Disease during pregnancy				
Yes	2	0,8	1	0,4
No	253	99,2	254	99,6
Drug use during pregnancy				
Yes	3	1,2	1	0,4
No	252	98,8	254	99,6
Labor				
Pre-term	-	-	-	-
Cesarean section	55	21,6	20	7,8
Low birth weight	7	2,7	-	-
Unknown	193	75,6	235	92,2

Analysis of the history data regarding perinatal risk factors showed that all children of the examined and control groups were born on time. Isolated cases of diseases or drug use by the expectant mother during pregnancy were noted. In the group of children with hearing impairment, children born with cesarean section and with a weight lower than normal than in the control group are more common, however, the difference is not statistically significant ($p > 0.05$).

According to the data obtained during the questionnaire, a relationship was found between hearing loss and some postnatal risk factors: neonatal

jaundice, fever, as well as head trauma in the postnatal period, measles and mumps (table 12). In failed group parents more often had a history of ear discharge than in the control group.

Table 12

The relationship of postnatal risk factors with hearing impairment

Risk factors	Failed group		Control group	
	n=255	%	n=255	%
Jaundice	15	5,9	0	0
Fever	18	7,1	0.0	0,0
Head trauma	18	7,1	1	0,4
Infections				
Mumps	22	8,6	3	1,2
Measls	8	3,1	0	0
Ear discharge	53	20,8	6	2,4

Analyzing the results, it should be noted that a total of 134 children (57%) had one or more risk factors. In the history of the disease and in the family history, the studied risk factors were absent in 100 children (42%).

CHAPTER 4. Discussion

Regular hearing screening in school-age children is now everywhere carried out in developed countries - the UK, Australia, USA, Germany, Austria, Italy and others. In addition, equipment for audiological assessment of hearing thresholds appears in schools. Hearing screening before entering school, introduced in many developed countries, is very important because it allows early detection of hearing loss and timely treatment [Bento R.F., 2003; Neumann K., 2006; Beers A.N., 2010]. If hearing loss remains unrecognized, the child is faced with various problems. In developing countries, where governments are primarily tasked with controlling deadly contagious infectious diseases, the lack of material resources further distracts attention from the concept of regular hearing tests in children. Therefore, ear diseases are an even greater public health problem in developing countries [Krueger W.W., 2002]. The Republic of Yemen is one of the poor countries in the Arab region, ranked 153rd on the Human Development Index (HDI), which places among low human development countries. Ever since reunification of the country in 1990 its relative position on the HDI index has remained steady, with very slow progress towards attaining the Millennium Development Goals (MDG) goals.

The Republic of Yemen is a developing state, occupying the 153rd place in the list of the human development index, that is, the country's social development remains low. After reunification in 1990, the country's serial number in the list of the human development index has not changed, and the movement towards the Millennium Development Goals is very slow.

The country has a high poverty level - about 45% of the population lives on less than $2 a day. Indicators of social development — child malnutrition, maternal mortality during childbirth, and educational attainment — remain depressing. In addition, the Republic of Yemen is one of the poorest countries in the Arab region, and studies have never been done to determine the prevalence of hearing loss among children and adults.

In the course of this study, 2,200 children aged 6–9 years were examined. The sex ratio in the study population was 1: 1. Most of the study participants - 1945 children - successfully passed audiological screening (88.4%). Those who did not pass the screening were sent to the clinic for further audiological examination.

Hearing impairment was detected in 255 children (11.6%). After removing ear wax in 21 children, the number of children with hearing loss decreased to 234 (10.6%), while in the USA this indicator among primary school students is 3.0%, and in Denmark - 3.6%. The results on the prevalence of hearing loss among children in the capital of the Republic of Yemen, Sana'a, are consistent with similar studies in other developing countries. For example, in Egypt, studies revealed hearing loss in 5.3% of school-age children in Alexandria and 13.7% in the province of Ismailia [Mourad M.I., 1993]. Research results in India range from 5.5% in Punjab to 21.6% in Lucknow [Rao R.S., 2002]. The percentage sent for further examination (11.6%) was similar to the results of studies in Nigeria and South India, where 13.9% and 11.9% of children with hearing loss were identified among schoolchildren, respectively. The data obtained differ from the results of a study in Swaziland, where only 3.3% of children with hearing loss were found among school students [Matthiassen C.N, 2007; Olusanya B.O., 2005b].

The results of the study indicate that the prevalence of hearing loss among primary school students in Sana'a (10.6%) is lower than in Egypt (20.9%). According to Abdel-Hamid O. et al., A community survey to assess the prevalence of hearing loss among school-age children in Egypt revealed hearing loss in 16.0% of children [Abdel-Hamid, 2007]. Mourad M.I. et al. in 1993 reported 24.5% of cases of hearing loss among primary school children [Mourad M.I., 1993]. Al-Abduljawad K.A. and Zakzouk S.M. in 2003, they published the results of a study that showed hearing loss in 13% of examined children, with 1.27% hearing loss in the left ear, 2.26% in the right ear, and bilateral hearing loss in 9.47% . Sensoneural hearing loss was found in 1.5% of the examined children [Al-Abduljawad K.A., 2003].

In Saudi Arabia, where cultural and ethnic traditions are close, the prevalence of hearing loss among children is estimated at 13% [Daghistani K.J., 2002]. Thus, in our study, the prevalence of hearing loss was higher than in developed countries, and corresponds to the prevalence of hearing impairment in developing countries, including neighboring Saudi Arabia.

Among boys, hearing loss was noted more often than among girls: 145 (56.9%) compared with 110 (43.1%), which shows a slight dependence of hearing loss on gender - in boys it is slightly more often than in girls. Such results are consistent with data from studies conducted in South India and Kenya, where specialists also revealed a minimal difference in the prevalence of hearing loss in boys and girls and emphasized that children, regardless of gender, should have equal opportunities to receive medical care [Matthiassen C.N, 2007].

According to the data obtained, no statistically significant differences were found between the year of study of the study participants and the

prevalence of hearing loss (among students of the first class of children with hearing loss were 34.5%, the second - 32.5%, the third - 32.9%).

The prevalence of hearing impairment in four districts of the capital of the Republic of Yemen was as follows: Alsabaen (27.8%) Maeen (21.6%), Shoaob (16.1%) and Banialhareth (34.5%).

Unilateral hearing impairment was found in 64.1% of children. In our study, there was no statistically significant difference between the side of the lesion - the right or left ear. A predominantly unilateral lesion was identified in a number of similar studies [Al Khabori M., 2007; Matthiassen C.N., 2007].

Most of the children examined had mild hearing loss, much less often a moderate degree of hearing loss. There were no cases of more severe hearing impairment in the examined group. Bess et al. in 1998, reported a slight hearing loss in 11.3% of school children [Bess F.H., 1998]. The results showed the effectiveness of the chosen screening methodology, because in the absence of audiological screening, mild and even moderate hearing loss, despite its negative impact on learning and communication, went unnoticed by both parents and teachers for a long time.

Among 255 children failed audiological screening, in 21 children ear wax were the cause of hearing loss. That is, the prevalence of ear wax is 1.0% among primary school children, which contrasts with the data of some other studies. Ear wax caused screening failure in 8% of cases. Sulfuric obstruction of the ear canals remains one of the most common complaints that general practitioners apply to residents of developing countries. Ear wax were observed in 38.4% of blacks and 49.9% of pre-school Indians in South Africa [Fleisch B., 2008]. Olusanya B.O et al. showed that ear wax were found in 52.6% of 359 school-age children from the surveyed population in Lagos,

Nigeria. Over 80% of the small ethnic Polynesians surveyed in East Samoa had ear wax. Many authors point out that this can turn into a real problem, as it is often associated with hearing loss [Ezeanolue B.C., 2003; Al Khabori M., 2004; Olusanya B.O., 2004]. Olusanya B.O. et al. noted not only hearing loss as a general consequence of ear wax, but also found that blockage of the auditory canals leads to poor school performance [Tharpe A.M., 1991; Davis J., 1986; Olusanya B.O., 2008].

In the course of this study, it was shown that the cause of most cases of hearing loss among primary school students in Sana'a is conductive hearing loss - 87.1%, SNHL was detected in only 12.9% of cases. The prevalence of SNHL among primary school children was 1.6%. Similar data were obtained in Saudi Arabia - SNHL was found in 1.5% of the examined children [Al-Abduljawad K.A., 2003].

The incidence of SNHL among primary school children (1.6%) in the Republic of Yemen does not significantly exceed these indicators in developed countries [Fonseca S., 2005; Neumann K., 2006; Bristow K., 2008; Mehra S., 2009;].

In most of the populations studied, heredity plays a leading role in the development of SNHL. Perinatal risk factors, such as prematurity up to 32 weeks, prolonged mechanical ventilation, hyperbilirubinemia, birth asphyxia and others, also make a certain contribution to the structure of SNHL in developed countries [Smith R.J.H., 2003; 2005].

In the Republic of Yemen, medical care for deeply premature babies or those born with complications requiring a long and expensive treatment is not available in most cases, and such children do not survive. According to the results of a survey of parents in both groups of children, both with hearing

loss and in the control group, according to the anamnesis, indications of any of the above factors are rare. As a result, perinatal factors are of minimal importance in the etiology of SNHL. On the other hand, closely related parents' marriages (cousins or second cousins) of all children with bilateral SNHL are indirect evidence of the leading role of hereditary factors in the development of sensorineural and other forms of hearing loss in children in the Republic of Yemen.

The prevalence of conductive hearing loss in children with hearing loss (87.1%) is consistent with the results of many studies in India, Nigeria, Pakistan and China. However, a study by Bess F.H. et al. somewhat contradicts our data, because during the screening, 5.4% of the 1200 children examined by these authors revealed SNHL and only 3.4% had conductive hearing loss. This disagreement can be explained by the fact that after the introduction of mandatory hearing screening for children in elementary schools, ear diseases that cause conductive hearing loss are most likely treated in time [Tharpe A.M., 1991; Bess F.H., 1998].

Among the causes of conductive hearing loss, OME was the most common diagnosis in the studied population (5.9%), then CSOM followed in frequency: chronic perforated otitis media without exacerbation (1.8%) and CSOM in the acute stage (1.8%), Eustachian tube dysfunction (1.2%).

OME is one of the most common causes of hearing loss in children. The results of the study showed that the prevalence of OME in the studied sample of school children is 6.2% of cases in the examined group. This result is consistent with a study by Olusanya B.O. et al. They revealed OME in 18.7% of cases in the study population [Olusanya B.O., 2000]. Epidemiological studies in Malaysia, India, Nigeria and Egypt show a significant prevalence

of OME, which was found in 13.8–36.2% of school students [Mourad M.I., 1993; Abdel-Hamid O., 2007; Chadha S.K., 2013]. Zakzouk S. M. et al. In a study in Saudi Arabia, hearing loss was detected in 13% of children aged 5 to 15, with OME being the most common cause of pathology [Zakzouk S. M., 2002]. In contrast, Adhikari P. found in 2009 that CSOM is more common among schoolchildren of Nepal than OME [Adhikari P., 2009].

The main risk factors for the development of OME are unsanitary conditions, poor nutrition, poor living conditions, the presence of a viral or bacterial infection and allergic diseases of the upper respiratory tract [Zakzouk S.M., 1996].

According to the results of our study, the prevalence of CSOM in the Republic of Yemen was 3.6% and was higher than in Spain, Malaysia and Jamaica, where chronic purulent otitis media is rare 0.7%, 0.17%, 0, 16%, respectively. In the central region of Saudi Arabia, the prevalence of CSOM was 5.5% [Zakzouk S.M., 2002]. CSOM was detected in 3% of the study sample in Nepal and 3.5% in Kenya; a high prevalence of CSOM was noted in India (7.8%).

According to the WHO, COM is one of the main causes of hearing loss [American speech and hearing association, 1990]. Children and adolescents with this disease develop persistent hearing loss of mild or moderate severity, mainly conductive in type [Alberti W., 1999], which is confirmed by our results.

Some studies have shown that hearing loss due to CSOM in the acute stage leads to speech impairment, attention deficit, difficulty learning languages and reading, as well as cognitive and behavioral disorders

[Bluestone C.B., 2001; Olusanya B.O., 2006]. All this indicates the importance of the study.

The prevalence of CSOM in developing countries varies from 1.3% to 17.0% in various socio-economic sectors of the society, while in developed countries such as the USA and Great Britain this indicator is less than 1% [Berman S., 1995]. CSOM disappears in developed countries, and the number of relevant surgical interventions has significantly decreased over the past decades [Al-Abduljawad K.A., 2003; Lasisi A.O., 2007]. At the same time, in many developing countries, CSOM remains one of the most common chronic diseases in children.

The main diagnostic sign of CSOM is the presence of persistent perforation of the tympanic membrane with constant or periodic purulent discharge. From the middle ear, the infection can spread to neighboring tissues with the development of facial paresis, deafness, and life-threatening complications such as mastoiditis, lateral sinus thrombosis, meningitis, and intracranial abscesses [Olusesi A.D., 2008; American speech and hearing association, 1995]. The frequency of deaths resulting from such complications is 1 in 100,000 in developed countries and 1 in 100 in developing countries [Berman S., 1995]. To prevent the development of hearing loss and serious complications resulting from COM, care for patients with this disease should be organized at the level of primary care. It was possible to avoid all the above complications in the children examined by us due to the treatment carried out after detection during the study.

CSOM is a common cause of persistent mild to moderate hearing loss in children and adolescents. In our study, cases of mild hearing loss were mainly detected in children. The high prevalence of CSOM is explained by

household crowding and crowding in the house. Poverty is considered as the main risk factor for this disease in developing countries and for some nationalities in developed countries.

We have not revealed statistically significant differences in the incidence of hearing loss in different areas of the city of Sana'a (11.0-12.3%). Apparently, this is because the high socio-economic status of the capital region for the Republic of Yemen is significantly lower than the standard of living in developed countries. The exception is the prevalence of CSOM found in every 20 children of primary school age in areas with a low socio-economic status (5.0%), that is, almost twice as often as in areas with a high socio-economic status (2.8%). However, the prevalence of CSOM, even in areas with high socio-economic status, significantly exceeds this value in developed countries, amounting to less than 1.0%.

The high incidence of CSOM in the country is associated with overpopulation, poor housing, lack of hygiene and nutrition, impaired immunological status, passive smoking, frequent upper respiratory tract infections, inadequate medical care and low population education. The inaccessibility of the necessary medical care is the main reason for the wide spread of CSOM. All these factors accompany the lives of children throughout the country, but they are especially pronounced in areas with low socio-economic status. So, Bidadi S. and Lasisi A.O. et al. emphasize the close connection of CSOM with difficult social conditions of life [Bidadi S., 2008; Lasisi A.O., 2007].

According to our data, in the family history of hearing impaired children, compared with the control group, abuse of tobacco by parents of the child was noted. Most often these were children from families with three or

more children. A study in Saudi Arabia showed that the problem of hearing loss is more common in large middle-class families [Daghistani K.J., 2002]. The negative impact of family size on hearing loss in a child can be explained by the fact that parents always have more time for children and maintaining order in the house while the family is small. When there are more children, less time and resources are devoted to each child. Large families, especially those with low incomes, often live in cramped conditions, and this becomes a problem, as crowding is associated with constant noise, an increased likelihood of frequent infectious diseases, which is exacerbated by secondhand smoke [Egeli E., 2004].

As a result of our study, it was shown that hearing loss was statistically significantly associated with a family history, with a high level of closely related marriages. And this applies to both cases of conductive and sensorineural hearing loss. In the case of SNHL, hereditary causes can be assumed. In the case of conductive hearing loss, the presence of other family members with hearing impairment is probably due to the fact that adverse social conditions lead to ear diseases not only in the examined child, but also in other family members.

According to our data, children with hearing loss, especially as a result of COM, often came from families of parents who did not have an education, who were in a close relationship. The close kinship between parents in the studied population turned out to be very common, especially many marriages between cousins (67.2%). In the Middle East, where closely related marriages are also often made, this indicator varies from 25.9% among groups of Israeli Arabs to 57.7% among residents of Saudi Arabia. According to the results of the study, due to a small number of cases, it is difficult to trace the relationship

of bilateral SNHL with closely related parents' marriage. Given the existing tradition of closely related marriages in the Republic of Yemen, whatever the consequences, such marriages will be extremely difficult to avoid. However, it is possible to conduct educational work among the population and, if a close marriage cannot be avoided, it is possible to increase the family's alertness regarding hereditary diseases, including hearing loss.

Thus, the risk of developing hearing impairment is, above all, higher in children with a family history of hearing loss, as well as in children from families where parents smoke and / or chew cat, are in blood relationship and the family has more than three children.

It should be noted that in the Republic of Yemen, women often give birth not at the clinic, but at home or in midwives, and are rarely seen by a doctor during pregnancy. In this regard, early infant mortality and mortality of women in childbirth are high, mothers of the examined children rarely indicated any diseases during pregnancy, pathology in childbirth. As a result of the study, it is noteworthy that in the group of children with hearing impairment more often than in the control group there are cases of cesarean section and birth weight below normal, but the difference is not statistically significant. There are some other works that showed a similar trend - in the group of children with OME, a greater number of children born as a result of cesarean section were noted than naturally [Gultekin E., 2010]. Thus, the pathology of pregnancy and childbirth in the anamnesis of school-age children in Sana'a is so rare that, apparently, they do not contribute to the etiology of hearing loss.

According to the data obtained, there was a connection between hearing loss and risk factors such as neonatal jaundice, fever, as well as head trauma in the postnatal period, measles and mumps. The latter emphasizes the

importance of widespread measles and mumps vaccination. The vaccination scheme for children in the Republic of Yemen includes vaccines against the following infections: poliomyelitis, pneumococcal infection, diphtheria, tetanus, whooping cough, hemophilus influenzae, hepatitis B, rubella, and measles. Mumps is not one of the infections against which immunization is being carried out, which is probably why 8.6% (22 of 255) of hearing-impaired children suffered mumps. Immunization, unfortunately, does not cover fully and not all children in the country, and therefore measles was recorded in the history of 3.1% (8 out of 255) of children who did not pass screening.

Of greater importance in the development of hearing impairment by school age are diseases and injuries in the postnatal period.

Among children with hearing impairment, parents noted a history of episodes of discharge from the ears much more often than in the control group. We believe that the lack of parental awareness of the significance and possible consequences of discharge from the ear, combined with the low availability of medical care, led to the neglect of these symptoms and, as a result, to a significant spread of CSOM and hearing loss [Low W.K., 2005; Maharjan M., 2006].

An analysis of the data indicates insufficient attention to risk factors for the development of hearing loss and emphasizes the importance of monitoring hearing acuity for a systematic assessment of ongoing changes. The problem of hearing loss in childhood deserves further study and increased attention from both doctors and the general population. Our epidemiological study has shown the importance of various aspects of this problem and of particular relevance for the population living in developing countries.

CONCLUSION

Normal hearing is a basic condition for learning to speak and master a language. If hearing loss remains undetected at the very beginning of life, delayed speech development and difficulties in language acquisition may appear later, therefore, early diagnosis of hearing loss is very important [Tognola G., 2007; Theunissen S.C., 2014].

After arthritis and hypertension, hearing loss is the third of the main chronic diseases leading to disability. In developed countries, hearing loss has spread as a result of a combination of several factors - increased noise background, aging and heredity. Infectious diseases are another factor leading to hearing loss in the population of developed countries. In other words, the problem of hearing loss can be called global [Luxon L.M., 2000; Abdel-Hamid O. 2007].

Due to the fact that serious infectious diseases are common in developing countries, the health priorities in most of these countries are often divided into priority and others. The main attention of those responsible for the distribution of funds is focused on life-threatening diseases, such as diphtheria, tetanus, infectious meningitis [Jamison D.T., 2006], while pathologies that do not pose a direct threat to human life are considered not dangerous; therefore, the budget line for the treatment and prevention of hearing loss and deafness is not traditionally provided for [Olusanya B.O., 2014].

This attitude is often justified by the limited resources of low-income national governments in developing countries. Typically, such countries receive grants and donations from international charitable agencies, but

statistics show a general decrease in financial assistance from wealthy world powers to developing countries [UNICEF, 1999].

WHO estimates that in 25% of cases, hearing problems begin in childhood. Unfortunately, 80% of all deaf and hard of hearing people live in low and middle income countries. Hearing impairment negatively affects communication with others, the ability to get an education, employment, and personal relationships. Thus, the state loses part of the working population, which negatively affects the economy of the country as a whole [Yoshinaga-Itano C., 1999; WHO, 2004].

Poverty, poor nutrition, ignorance and limited medical care, the absence of regular examinations by an otolaryngologist are an important component of predisposition to frequent hearing diseases. In many developing countries, primary health care now boils down to the simplest prevention - immunization, prenatal and natal surveillance, and public education on sanitation and hygiene. This includes the training of obstetricians, the provision of emergency obstetric care and the prevention of home birth without the presence of a qualified specialist; this helps to minimize the risk of hearing loss [Olusanya B.O., 2009]

The WHO pays much attention to projects to control and prevent hearing loss and deafness. It helps its Member States reduce the causes of hearing loss leading to disability, which can be avoided through prevention and rehabilitation. A 2006 report by the WHO said that the most effective basic measures to combat ear diseases and hearing loss should include training specialists for the primary treatment of ear diseases and hearing loss, first aid specialists or large-scale involvement of similar specialists; this will have a huge impact on the prevalence of ear diseases and hearing loss. However, in

most developing countries there are no first-aid specialists for ear diseases [Jamison D.T., 2006].

The first study in the Republic of Yemen on the prevalence and etiology of hearing loss among children aged 6-9 years confirmed the urgency of this problem. Even without taking into account ear wax one in ten children aged 6–9 years in Sana'a suffers from hearing loss, which is comparable with data from other developing countries. Moreover, in 87.1% of cases, conductive hearing loss was detected due to diseases that are treated with timely detection and restoration of hearing. That is, most cases of hearing loss in children could be avoided by conducting a systematic audiological screening and creating a system of care for children with ear pathology.

It is shown that the high prevalence of hearing loss in children is associated primarily with a low social standard of living, overcrowding, low level of education of parents, inadequate medical care and the prevalence of closely related marriages. Despite the fact that such global problems as poverty, malnutrition, crowded living, the tradition of close marriages, most likely, will not be resolved in the near future, educational work can increase the attention of parents and teachers to children with discharge from the ears, with a burdened family history hearing loss, etc. Widespread vaccination will also help reduce the risk of developing ear diseases and hearing loss, which will eliminate the risk factors for hearing loss such as measles and mumps.

This study covered 2200 children of primary school age in the city of Sana'a, the capital of the Republic of Yemen, one of the most prosperous cities in the country. In this regard, it can be assumed that the prevalence of hearing impairment in other cities and regions of the country is even higher. The research algorithm used has been shown to be highly effective in detecting

hearing impairment in children, including those that seriously threaten the health of the child. The algorithm of this study does not require significant material costs and the separation of parents from work when performing the first stage. Therefore, the use of this algorithm will allow to detect such diseases of the organ of hearing, as OME, CSOM, to treat in a timely manner and prevent complications. Inspections of schoolchildren as an organized population are common practice in most countries of the world [Sarafraz M., 2009; Piotrowska A., 2012]

Note that children with severe hearing impairment are not enrolled in secondary schools in the Republic of Yemen. The latter, due to the lack of a centralized medical care system and specialized education system in the country, are at home and most of them are deaf and dumb because they cannot speak. In this regard, the study of the prevalence of severe congenital hearing impairment and the provision of assistance to such children is one of the problems of public health in the country, the solution of which requires significant material costs and new personnel, audiologists and sound educators. According to rough estimates, 3 thousand deaf and dumb children live in the country. If we take into account the birth rate statistics in the country, an average of 307 thousand newborns per year (according to data for the period 2009-2013), then according to world statistics, an average of 300 more children are added to the number of children with severe hearing impairment (1 per thousand newborns) World practice has shown that the early detection of congenital hearing impairment is possible only through the introduction of a universal audiological screening program for newborns, conducted in many countries since 2006 [Swanepoel D.W., 2008].

Unfortunately, at present, there are no conditions in the country for such screening and timely assistance to children with severe hearing loss.

One of the five priorities of UNICEF (the United Nations agency whose task is to monitor the well-being of children around the world) is to create conditions for the optimal development of the child. According to UNICEF, it is very important to give the child a good start in life, to lay the necessary foundation for successful learning. In 2005, UNICEF expressed concern about the needs of children who are “excluded (from life) and seem to have become invisible” as a result of hearing loss and other diseases, and should receive support at the national level in order to encourage their development in early childhood through early childhood diagnosis of hearing loss and proper treatment (UNICEF, 2005). As the study showed, this statement by UNICEF is extremely relevant for the Republic of Yemen.

FINDINGS

1. The prevalence of hearing loss among primary school children in Sana'a, Republic of Yemen, is 10.6%, which necessitates the development of organizational measures for the early detection and prevention of hearing loss in children.

2. Among primary school children, hearing impairment is conductive in 87.1% of cases, unilateral - in 64.1% of cases. The prevalence of unilateral hearing impairment was 68 cases per 1000 children of this age, the prevalence of bilateral hearing impairment was 38 cases per 1000 children of this age. Hearing impairments among primary school children are characterized by mild and moderate severity.

3. The most common cause of hearing loss in the capital of the Republic of Yemen, the Sana'a city among primary school students is otitis media with effusion with a frequency of 5.9%, the prevalence of chronic suppurative otitis media is 3.6%, sensorineural hearing loss is 1.6%, which requires therapeutic and rehabilitation measures and the follow-up of these patients.

4. Low socio-economic community level, low educational level of parents, a large number of children in the family, consanguinity of parents increases the risk of hearing loss in a child as a result of various ear diseases. The possibility of hearing impairment is significantly higher in children with a family history of hearing loss, episodes of suppuration from ears, measles or mumps in the anamnesis.

5. The proposed two-stage algorithm for hearing screening among primary school children is an effective means of early detection of ear diseases

and permanent hearing impairments in developing countries, which makes it possible to recommend its inclusion in the examination standards in medical organizations in the country.

PRACTICAL RECOMMENDATIONS

It is necessary to organize hearing screening including otoscopy and screening audiometry for the purpose of early detection of hearing impairment in children before school entry and in primary school children.

It is necessary to include otoscopy, pure tone audiometry and tympanometry in the audiological examination to confirm hearing loss and investigate the nature of hearing impairment.

The cases of conductive hearing loss due to otitis media with effusion or chronic suppurative otitis media must be managed with sanitation of the upper respiratory tract, anti-inflammatory and antibiotic therapy, if necessary.

Children with mild sensorineural hearing loss must be placed in the first rows in the classroom in front of the teacher, with unilateral hearing loss - with a better hearing ear to the teacher. Children with moderate and severe sensorineural hearing loss need hearing aids fitting and application of assistive technologies.

In order to prevent hearing loss due to infectious diseases, vaccination against measles, rubella, mumps, Haemophilus influenzae type B and meningococcus should be included in the national vaccination plan, and ototoxic drugs should be avoided or used with caution.

Ear and hearing care can be provided through availability of maternal and child health care, improvement of social conditions, especially for children from large families.

Primary prevention of hereditary hearing loss can be provided through consultations in consanguineous couples and premarital risk assessment.

Implementing educational programs for parents (at courses for pregnant women, recently delivered mothers, immunization centers) and teachers is important to raise the awareness of normal hearing for the child's learning and communication, risk factors and signs of hearing loss in children.

LIST OF ABBREVIATIONS

aHT – above hearing threshold

ASHA – American Speech-Language-Hearing Association

COM – chronic otitis media

CSOM – chronic suppurative otitis media

ENT – ear, nose and throat

OM – otitis media

OME – otitis media with effusion

SNHL – sensorineural hearing loss

UNICEF - United Nations International Children's Emergency Fund

UHL – unilateral hearing loss

WHO – World Health Organization

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Appendix 1

Audiometry Screening Form

Date of the Interview:.....
dd/mm/yy

Identification Section:

Serial No. :

School Name:.....

School code number:.....

Area surrounding School:.....

1. High SES
2. Middle SES
3. Low SES

Q1. Child's Name: .....

Q2. Grade: : 1. primary 1st 2. primary 2nd 3. primary 3rd

Q3. Date of birth: day/ month/year

dd/mm/yy
__/__/__
Don't Know 99/99/99

Q4. Age in Years.....

Q5. Gender: 1. Male 2. Female.....

Q6. Screening Audiometry: Level (dB)	20dB	20 dB	20 dB	20 dB
Frequency (Hz)	500Hz	1000 Hz	2000 Hz	4000 Hz
Right Ear				
Left Ear				

Q7: 1. Pass .....2. Fail:.....

		Answer	Quest.	م
		.....	Father name	س1
		|__|__|	Father Age	س2
		Cigg.1..... shesha2..... Habl-bubl3.....	smoking	س3
		Hour/day	Smoking / day	س4
		yes 1..... no2.....	Qat chewing	س5
		daily1..... weekly2..... sometime3..... stopped4.....	If answer Yes	س6
		illiterate1..... Read/write2..... primary3..... middle 4..... diploma5..... secondary6..... university7.....	Father education	س7
		No work1 ..... worke2..... empolye3..... Empolye in preivet4..... Own work5.....	Job	س8
		<20.0001..... 20-40.0002..... 40-80,0003..... >80,0004.....	Income	س9
		|__|__|	NO. of wifes	س10
		illiterate..... .....1..... Read/write..... .....2..... primary.....3..... middle..... ...4..... diploma..... .....5..... secondary..... .....6..... university..... .....7.....	Mother education	س11

		No work.....1..... **employee.....2.....** **Private work.....3.....**	**Mother Job**	**س12**
		|__|__|	**Brother No.**	**س13**
		Yes.....1..... **No.....2.....**	**Had fever during pregnancy**	**س14**

			م
	yes.....1..... **no.....2.....**	**Mother used medicine**	**15**
	normal.....1..... **c/s.....2.....**	**delivery**	**16**
	9 months.....1..... **<9 months.....2.....**	**Pregnancy period**	**17**
	normal.....1..... **less.....2.....**	**Baby weight**	**س18**
	yes1..... **no.....2 .....**	**incubation**	**س19**
	yes.....1..... **no.....2.....**	**Jaundice**	**س20**
	yes1..... **no2.....**	**cyanosis**	**س21**
	yes1..... **no2.....**	**Had fever**	**س22**
	yes1..... **no2.....**	**vaccination**	**س23**
	yes1..... **no2.....**	**measles**	**س24**
	yes1..... **no2.....** **I don't know99.....**	**mumps**	**س25**
	yes1..... **no2.....**	**Admission in hospital**	**س26**
	yes1..... **no2.....**	**earache**	**س27**

	I don't know99.....		
	yes1..... **no2.....** **I don't know99.....**	**Ear discharge**	**س28**
	yes1..... **no2.....**	**adenotonsillectomy**	**س29**
	yes1..... **no2.....**	**Insertion of grommet**	**س30**
	1.....نعم **2.....لا**	**Head trauma**	**س31**
	yes1..... **no2.....**	**consanguinity**	**س32**
	1st 1…….....…… **2nd 2.....** **others3.....**	**Degree of consanguinity**	**س33**
	yes1..... **no2.....**	**There is any one in family with HL**	**س34**
	1st1…….....…… **2nd2.....** **others3.....**	**Degree of relative**	**س35**
	congenital1..... **post natal2.....** **post febrile3.....** **in old age4.....**	**His age when he had HL**	**س36**

Examination:

General exam. ***signes of syndrome***

Otoscopic examination:
Rt. Ear:
Lt. Ear:

Tympanometry:
Rt. Ear:
Lt. Ear:

Acoustic Reflexe Thresholds :

Frequency KHz	**0.5**	**1**	**2**	**4**
Rt. Ear				
Lt. Ear				

PURE TONE:

Frequency (Hz)	**500**	**1000**	**2000**	**4000**	**8000**
Right Ear					
Left Ear					