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ORIGINAL ARTICLE

Hearing Screening Program in School-Age Children in Western Poland

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Objective: Many countries have implemented newborn hearing screening programs, resulting in early intervention and therapy. In spite of that, there is a significant number of schoolchildren with hearing problems. In 2008, the Institute of Physiology and Pathology of Hearing in collaboration with KRUS (Polish Agricultural Social Insurance Fund) developed and implemented the program of hearing screening in schoolchildren, starting with the eastern regions of Poland. This paper presents the results of the second stage of the program, implemented in western Poland in 2010.

Materials and Methods: Program was implemented in western Poland during four months of 2010; 95,411 children, in 4,041 schools, have been examined. Screening was performed using the Platform of Sensory Organs Examinations™, developed by the Institute of Sensory Organs in collaboration with the Institute of Physiology and Pathology of Hearing. The Platform comprises central computer and a number of portable computers, communicating with the central database via Internet, equipped for performing: pure tone audiometry, hearing test 'I can hear'™, speech test 'I can speak'™, sight test 'I can see'™, audiological questionnaire, dichotic digits test and gap detection test.

Results: Seven-year olds represented 77% of results. Rate of positive results (i.e. audiometry in at least one frequency <20 dB HL and/or positive result of central test) among first graders was 13,9%. The occurrence of tinnitus in this age group was 15,1%, in the group with positive screening result - 51,7%.

Questionnaire results demonstrated low awareness of parents/carers of their child's hearing problems: 58,8% did not notice the problem. Among children with positive results, 41% were not under specialist care, 27% never had hearing examination except neonatal hearing screening.

Conclusions: This program demonstrated that the large number of primary school students have hearing problems, which is not only health, but also an education problem. Authors recommend training a group of school nurses, or other school personnel, to perform screening tests on a regular basis.

The program of sensory organs screening is going to be a priority in the area of healthcare during Polish Presidency in European Union (second half of 2011), helping to raise the awareness of this problem's importance.

Keywords: Hearing screening, schoolchildren, hearing loss, tinnitus, central disorders, audiometry, digital dichotic test, audiological questionnaire

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Introduction

Sensory organs play an important role in everyday life, particularly as the means of communication between people. During the last hundred years the methods of communication have changed a lot. Today, it is normal to see in the street people, wearing MP3 earphones or Bluetooth earphone from their mobile telephone, walking and talking seemingly to themselves. People's attitude towards their hearing has changed. Good functional hearing is necessary if you want to attend mainstream school and achieve regular, possibly higher, education. Of course, there are many solutions available for deaf people enabling them attending school and universities, but it is not as easy for them as for the hearing people.

Studies performed in many countries indicate the incidence of hearing disorders in newborns ranging from 1 to 7 in 1000 [1], [2], [3], [4], [5]. Newborn hearing

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screening programs are being implemented in more and more countries, allowing the early intervention and specialist therapy. Many people benefited from the early intervention in childhood, which may have included measures such as cochlear implant surgery [6], fitting of the suitable hearing aid, or appropriate rehabilitation management. However, even though the newborn hearing screening programs have become routine in many countries [7], [8], [9], [10], still a large number of patients with different hearing disorders may be observed at school age.

In Poland, first studies on hearing screening examinations in newborns have been performed by Prof. Maria Goralowna (presented in 1993 during congress in Augustow/Poland). In years 1995-1998 Prof. Henryk Skarzynski and co-workers have done several studies on this subject [11]. All those studies were dedicated to the newborn screening and resulted in development of the universal newborn hearing screening program that has been implemented in general health care system in Poland.

From 2001 the Institute of Physiology and Pathology of Hearing has performed several epidemiological and screening studies focusing on another age group – children beginning their school education. The pilot study has been designed for Warsaw, Poland's capital. First pilot studies took place in 2006, focusing on children 12-13 years old, which means the first grade of the middle school (gimnazjum) in Polish school system. During this study, in Warsaw, 12,026 children from 221 schools have been examined in 4 weeks.

The results of those studies allowed us to assess tests and systems that have been used [11] to determine if they are appropriate tools to organize screening program which would be time-efficient, inexpensive and easy to implement. To guarantee the best benefit for children it was decided that the wide screening program should focus on children in the first grade of primary school. It is the youngest possible age group where the researchers could reach almost all children in one place, which is an important, time- and cost-saving factor.

In 2008, the Institute of Physiology and Pathology of Hearing, in collaboration with KRUS (Polish Agricultural Social Insurance Fund), have performed the hearing screening in school children in eastern Poland, during which 92,876 children have been examined [12]. Later, in the same partnership, the hearing screening program in schoolchildren has been performed in the western part of Poland. This study presents the results of that second stage of the program.

Materials and Methods

After analysis of the results of previous programs and tools and systems applied in them, the Platform of Sensory Organs Examinations™, developed by the Institute of Sensory Organs in collaboration with the Institute of Physiology and Pathology of Hearing, has been selected as the best system in terms of flexibility, availability of many tests in one unit, simplicity of operation and the possibility to communicate test results to the central database in real time.

The Platform is a system built on the basis of a powerful, central computer system and a number of portable computers equipped with audiometric headphones and a button for a tested person. Portable computers communicate with the central database via Internet.

Each portable device is provided with the software allowing performing following examinations and tests:

- Audiometric test: 'Audiogram'
- Hearing screening test: 'I can hear'™
- Speech screening test: 'I can speak' ™
- Sight screening test: 'I can see' ™
- Audiological questionnaire
- DDT' – dichotic digits test
- GDT'- gap detection test

Figure 1. Platform of Sensory Organs Examinations

During the screening program the results thereof are presented in this article following tests, from those available in the Platform, have been used: 'Audiogram', 'I can hear'™, audiological questionnaire, 'DDT' test and 'GDT' test [13].

'Audiogram' – this test enables performing air conduction pure tone audiometry test, for each ear separately, in frequency ranges from 250 to 8000 Hz, for losses not exceeding 80 dB HL and with a skip of 5 dB. Audiogram test results are displayed on the device's screen. The test has been designed in accordance with the norm EN 60645-1 IVcat. and Polish legal regulations [14].

Hearing screening test 'I can hear'™ [15] is a quick preliminary test allowing fast identification of any serious problem that may be found during examination. This program enables performing pure tone audiometry test for three frequencies: 1000, 2000 and 4000 Hz and the test of speech understanding in noise.

Gap Detection Test (GDT) allows assessing the ability to perceive the gaps between stimuli (in this instance – noise). During this test, the noise, interrupted by random periods of silence of varying length, is presented. There are earlier, different studies presenting use of similar versions of this test [16].

Dichotic Digits Test (DDT) is a test of dichotic listening, during which, pairs of digits are presented simultaneously, to each ear different pair. The testee is asked to repeat what s/he has heard in left, in right and then in both ears. Very important issue is that duration of all presented stimuli must be equal. There are studies in which authors use as the stimulus syllables [17], but in our experience using pairs of numbers provides more reliable and repeatable results.

DDT and GDT tests are applied in the screening program to detect central auditory disorders.

Audiological questionnaire included in the Platform allows conducting a survey of testes' hearing, sight and speech. Questionnaires (audiological and tinnitus) have been developed by specialists based on their long experience in relevant areas [18] and provide reliable information on the tested person. This feature is flexible – questionnaires can be updated, new questions added and their schema changed. This solution allows continual improvements of the form of an interview with the patient. Questionnaire comprises two parts, first is completed by parents or carers, and second incorporates questions asked of a tested child. Questions concern behavior in different social environments, e.g. school, school marks, attention during lessons, incidents that can be related to hearing or other senses' dysfunctions.

An important question put to both parties (parents/carers and children) is their observations of syndromes that could be recognized as tinnitus. If the answer was positive, further questions were asked in order to specify whether tinnitus lasted longer or shorter than 15 minutes and what was its character. Till now there have been some studies about how to measure and characterize tinnitus [19] [20], but without final widespread statement.

The results of each screening examination have been sent to the central database directly after conclusion of the examination, in accordance the data safety European laws and rules. That part of the program was developed with the support the grant from European Union Funds – program 2.3. under title "Integrated informatics' program for support of research on physiology and pathology of hearing". All connections between portable computers and the database, and all rules of data storage and processing have been designed in accordance with the data safety regulations.

Screening examinations have been scheduled only during months when risk of infection is reduced; they began in the first week of March 2010 and finished on July 23, 2010.

The device itself, as well as the solutions used during that screening program, received many awards during different Innovation and Trade Exhibitions:

- Gold Medal with Mention, 58th International Exhibition of Innovation, Research and New Technologies 'Brussels Innova 2009', Brussels 2009
- Award of the Minister of Science and Higher Education, 17th Exchange of Polish Inventions Awarded at World Exhibitions in 2009, Warsaw 2009
- Gold Medal, 38th International Exhibition 'Inventions Geneva', Geneva 2010
- Special award granted by the Isfahan University of Technology Robotic Center at the 38th International

Inventions Exhibition 'Inventions Geneva', Geneva 2010.

- Title of the 2010 Innovation Leader for the solution 'Platform of Sensory Organs Examination' at the 9th edition of the 'Innovation Leader' competition during the 5th All-Poland INTARG – Katowice 2010 Economic and Scientific Innovation Fair, Katowice 2010
- Silver Medal at 'Concours Lépine', Paris 2010
- Gold Medal at the 21th International Invention, Innovation & Technology Exhibition ITEX 2010, Kuala Lumpur 2010
- Special Prize of the Korea Invention Promotion Association at the 21th International Invention, Innovation & Technology Exhibition ITEX 2010, Kuala Lumpur 2010
- Special Prize of the Association 'Russian House for International Scientific and Technological Cooperation' at the 21th International Invention, Innovation & Technology Exhibition ITEX 2010, Kuala Lumpur 2010
- Silver Medal at the 2010 Taipei International lnvention Show & Technomart, Taipei 2010
- Special Prize at the 2010 Taipei International lnvention Show & Technomart, Taipei 2010
- Golden Medal at the 6th International Salon of Inventions and New Technologies 'New Times', Sevastopol 2010
- Golden Medal at the International Trade Fair 'Ideas-Inventions-New Products' IENA, Nuremberg 2010
- Gold Medal at the 4th International Warsaw Invention Show IWIS 2010

Materials

According to the agreement with KRUS, during four months of 2010, screening has been performed in 9 regions of western Poland (voivoships: Dolnośląskie, Kujawsko-Pomorskie, Lubuskie, Łódzkie, Opolskie, Pomorskie, Śląskie, Wielkopolskie, Zachodniopomorskie). Number of schools included in the program was 4,041, number of children – 95,411. A significant part of the program constituted a homogenous group of 7-years old children (grades 0 and 1 of primary school); they represented 77% of all results. There were more girls (51,4%) than boys (48,6%).

Table 1. Age distribution of children participating in the program

Grade of primary school	Number of children screened	Percent in program
0	2,167	2,3%
1	71,454	74,9%
2	8,762	9,2%
3	6,728	7,1%
4	2,642	2,8%
5	2,106	2,2%
6	1,552	1,6%
Total	**95,411**	

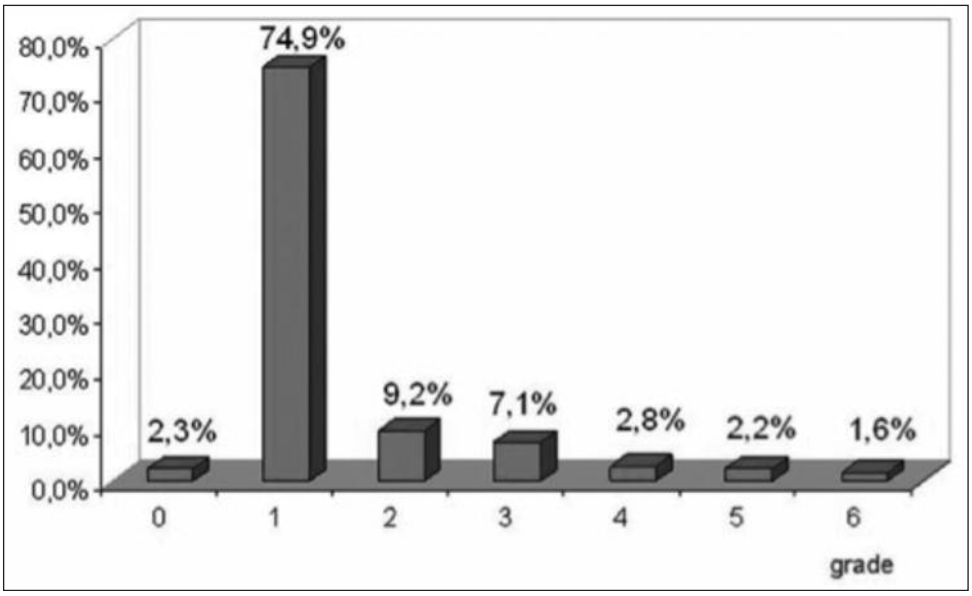

Figure 2. Distribution of children included in the program – school grades.

Program was dedicated to pupils in the first grade, but if there were some vacancies, e.g. some first graders did not want to undergo test or were absent from school due to illness, then older children were screened. What is important, however - this study presents the results, in majority homogenous, for the 6-7 years old children (first grade), who constituted the majority of testes', as the aim of this program was to collect data for that homogenous group.

Table 2. Participation of first graders and older children in the program

Region (voivodship)	First graders screened	Older children screened	Total number of children screened
dolnośląskie	8,138	2,660	10,798
kujawsko-pomorskie	8,007	2,251	10,258
lubuskie	3,908	1,324	5,232
łódzkie	7,025	2,449	9,474
opolskie	4,639	1,103	5,742
pomorskie	8,418	2,034	10,452
śląskie	7,973	2,115	10,088
wielkopolskie	17,452	7,073	24,515
zachodniopomorskie	6,131	2,721	8,852
Total	**71,454**	**21,790**	**95,411**

There were two major causes why children did not participate in screening examinations. First was lack of consent from parents or legal carers. Second was normal absence from school because of, for example, illness. Generally, in smaller villages the rate of positive consent was verging on 100%. In bigger cities included in the program the rate of consent was lower. For comparison in Warsaw during the pilot study (12-13 years old children) rate of positive consent to the screening was 65,4%. The age of children, which was chosen for cutting-edge period for future research, is 6-7 years old. The choice in each country is dependent on the school system organization. In Poland the school age starts at 7; however, there is tendency to lower it: the grade 0, when children are 6 years old, is presently voluntary, but will be obligatory in future years. That is why we in this study we included also the statistics about that group.

Results

We regarded the result of hearing screening examination as positive the result of the air conduction pure tone audiometry test ('Audiogram') in at least one frequency was <20 dB HL in one, or both, ears, and/or the result of central tests was positive. Among first graders, where material is largest (71,454 children), 13,9% results were positive.

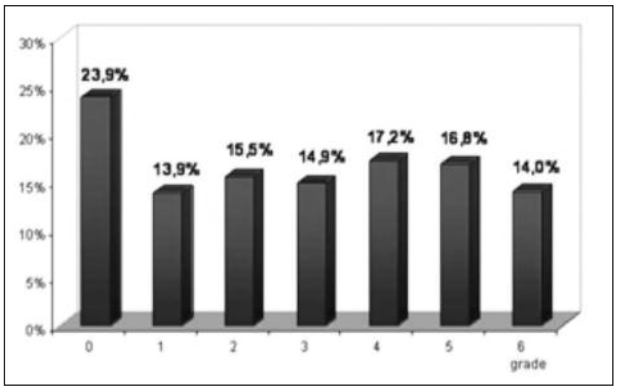

Figure 3. Number of positive results from grades 0-6 of primary school.

As presented in Fig. 3 the highest rate of positive results is in grade 0 - 23,9% , and the lowest, excluding first graders, in grade 6 – 14%. Regions with the lowest rate of positive hearing screening results are Lubuskie (12,7%) and Lodzkie (12,4%), the highest rate was in Zachodniopomorskie (17,2%).

The questionnaire included questions about tinnitus. Level of positive responses among children from the first grade was 15,1%. The positive result means that the child either has had at least one episode of periodical tinnitus lasting longer than 15, or has a constant problem. The percentage is higher in older

children and those from larger cities, amounting, in some groups, to 32%. The number of positive responses was also higher in the group of children with positive results of hearing screening – 51,7%.

The awareness of parents or carers of their child's hearing problems is very low. As many as 58,8% of them didn't realize that any problem existed (in group which was sent to control diagnostic – 27%). Among children with positive results, 41% were not under specialist medical care and 27% of them have never had their hearing examined except during the universal neonatal hearing screening.

All screening results were send to the central database in the Institute of Physiology and Pathology of Hearing, here they were anonymously analyzed by the team of specialists, and the feedback was sent back to school. If the screening results were positive, the child was referred for specialist diagnostics. The safety of personal data was assured by means of coding all personal information about each patient – specialists did not know whose results they were analyzing. Analysis of the group with the positive results of screening shows that 3,5% of those children have serious hearing problems, including severe hearing loss, and 22% moderate hearing loss. 45,9 % children from that group with positive results were recommended to have detailed diagnostic. The group has been also been categorized into single sided and bilateral hearing loss. Bilateral hearing loss was diagnosed in 48,1 % and unilateral in 52,1 %.

Discussion

The results of this program have shown that a large number of children from the primary schools have problems with hearing. Similar results have been obtained in the previous screening program in this age group, conducted in the rural areas of eastern Poland in 2008-2009.

Analysis of the results of questionnaires shows that tinnitus is a significant problem, particularly in larger cities. The proportion of positive responses to tinnitus questions grows with children's age.

Children, who have been referred for diagnostics, could choose any specialist clinic in Poland, therefore we do not have the complete after screening follow-up information. However, in the group has been consulted in the Institute of Physiology and Pathology of Hearing units and cooperative centers, we observed many children with problems that have been developing and aggravating for many years and have not been diagnosed earlier, including serious ones, like for example congenital cholesteatoma.

Hearing problems in schoolchildren are not only a health problem, but also a serious education problem. There were twice as many children with bad marks and behavior problems (like ADHD) in the group with positive screening results as in the whole primary school population.

Conclusion

The authors of this study recommend, based on the experiences collected in the run of two subsequent screening programs and their results, that in the follow up of this program a group of school nurses, or other school personnel, should be trained to perform screening tests on a regular basis in their schools. Another solution has been implemented in Poland, where 654 psychology-pedagogic centers have been equipped with specialist units for sensory organs (hearing, speech and vision) screening. Still authors provide works to evaluate, standardized and to have program polished. [21]

The program of sensory organs screening is going to be one of the priorities in the area of healthcare during Polish Presidency in European Union (second half of 2011), which will help to raise the awareness of the importance of this problem among the decision makers.

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