

# HEARING SCREENING OF SCHOOL CHILDREN IN THE WARMIAN-MASURIAN VOIVODESHIP

## Contributions:

A Study design/planning  
B Data collection/entry  
C Data analysis/statistics  
D Data interpretation  
E Preparation of manuscript  
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## Abstract

**Background:** Hearing screening is an important part of prevention. It allows early detection of hearing disorders, allowing treatment to begin early and eliminating or minimizing negative consequences. Children with hearing impairment often experience delayed speech development and cognitive abilities, which can result in learning disabilities and reduce school progress. Since 1999, the Institute of Physiology and Pathology of Hearing in Poland has provided a hearing screening program for school-aged children in the country. The main aim of the program is the early detection of hearing disorders, especially in children starting school, and to increase the awareness of parents and the school more generally about hearing problems.

**Material and Methods:** There were 6,297 children from the Warmian – Masurian Voivodeship enrolled in the program (3,050 girls; 3,247 boys) from grades 1 to 6 and aged between 6 and 13 years. Hearing screening was conducted over two time-frames: from September 2014 to June 2015, and from September 2015 to June 2016. Most of the children were from the first group: 81.1% of all pupils examined. Each child was assessed by pure tone audiometry and a questionnaire addressed to parents.

**Results:** Based on the result of the audiogram, screening showed that hearing impairment was found in 1169 (18.6%) of the examined pupils. Of these, 64.5% (750 children) had single-sided hearing loss.

**Conclusion:** The results confirm that awareness of hearing disorders in Poland is low. Many school-age children have hearing loss, but it is often not detected by caregivers and teachers. Even small hearing losses may cause difficulties in communication, emotional reactions, or learning. Early detection of hearing disorders is therefore crucial. A screening program can quickly identify patients with hearing loss and implement appropriate treatment and rehabilitation as soon as possible, actions that can improve the quality of life of the children and their families.

**Key words:** hearing screening • rural area • pure-tone audiometry • school-age children

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## RESULTADOS DEL CRIBAJE AUDITIVO EN NIÑOS EN EDAD ESCOLAR EN LA PROVINCIA DE VARMIA Y MASURIA

### Resumen

**Introducción:** El cribaje auditivo juega un papel extremadamente importante en la profiláctica. Permite la detección temprana de los trastornos de la audición, lo que permite un inicio rápido del tratamiento y elimina o minimiza las consecuencias negativas asociadas a este tipo de disfunción. Los niños con discapacidades auditivas a menudo experimentan un retraso en el desarrollo del habla y habilidades cognitivas, lo que puede resultar en problemas de aprendizaje y reducir el progreso escolar. Desde 1999, el Instituto de Fisiología y Patología de la Audición ha tomado una serie de iniciativas relacionadas con los cribajes auditivos. El objetivo principal del programa es la detección temprana de discapacidades auditivas, especialmente en los niños que comienzan la escuela y el aumento de la concienciación de los padres y el entorno escolar sobre los problemas de audición.

**Materiales y Métodos:** La investigación cubrió un total de 6,297 niños (3,050 niñas; 3,247 niños) de la provincia de Varmia y Masuria. Se incluyeron en el estudio personas de 6 a 13 años de primero a sexto de la escuela primaria. La investigación se realizó en dos etapas: desde septiembre de 2014 hasta junio de 2015 y desde septiembre de 2015 hasta junio de 2016. El grupo más grande estudiado fueron estudiantes de las clases de primero, constituyeron el 81.1% de la población estudiada. Se realizó a todos los participantes una audiometría tonal y una evaluación subjetiva basada en las encuestas de los padres.

**Resultados:** El análisis de los resultados obtenidos del examen de audición mostró que el resultado positivo del audiograma se encontró en 1169 alumnos examinados (casi el 18,6% de la población encuestada). Se observó que, entre todos los niños examinados, el 64,5% de la pérdida de audición detectada (750 niños) era la pérdida de audición unilateral.

**Conclusión:** Los resultados confirman que el conocimiento de las deficiencias auditivas en Polonia es bajo. Muchos niños en edad escolar tienen una pérdida auditiva, pero a menudo no es detectada por cuidadores y los profesores. Un daño auditivo incluso en pequeño grado puede causar dificultades en la comunicación, en la esfera emocional o en el aprendizaje. Por lo tanto, la detección temprana de la pérdida auditiva es crucial. Gracias a los programas de cribaje, podemos identificar a los pacientes con pérdida auditiva, implementar el tratamiento adecuado y la rehabilitación lo antes posible. Tales acciones pueden mejorar la calidad de vida de los niños y sus familias.

**Palabras clave:** • cribaje • zonas rurales • audiometría tonal • niños en edad escolar.

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## РЕЗУЛЬТАТЫ СКРИНИНГОВЫХ ОБСЛЕДОВАНИЙ СЛУХА У ДЕТЕЙ ШКОЛЬНОГО ВОЗРАСТА В ВАРМИНСКО-МАЗУРСКОМ ВОЕВОДСТВЕ

### Аннотация

**Введение:** Скрининговые обследования слуха имеют большое значение в профилактике. Они позволяют выявить нарушения слуха на раннем этапе, что обеспечивает возможность проведения лечения и устранения или уменьшения негативных последствий, связанных с данным видом нарушением. У детей с проблемами слуха часто наблюдаются задержка речевого развития и нарушение когнитивных способности, что может привести к отставанию в обучении и снижению успеваемости в школе. С 1999 года Институт Физиологии и Патологии Слуха проводит большое количество работы и программ, связанных со скрининговыми обследованиями слуха. Основной целью программы является раннее выявление нарушений слуха, особенно у детей, которые начинают обучение в школе, и повышение осведомленности родителей и школьной среды о проблемах слуха.

**Материалы и методы:** В исследовании приняли участие 6 297 детей (3050 девочек, 3247 мальчиков) из Варминско-Мазурского воеводства. Возраст исследуемых варьировался от 6 до 13 лет с 1 по 6 классы. Исследования проводились в двух этапах: с сентября 2014 г. до июня 2015 г. и с сентября 2015 г. до июня 2016 г. Наибольшую группу исследуемых составили ученики 1 класса, они составили 81,1% исследуемой популяции. Всем ученикам была проведена тональная аудиометрия и субъективная оценка на основе анкет для родителей.

**Результаты:** Позитивный результат скрининга слуха был обнаружен у 1169 человек, то есть у 18,6% обследованных детей. Среди детей с положительным результатом односторонняя потеря слуха была обнаружена у 64,5% (то есть у 750 учащихся).

**Выводы:** Результаты исследования подтверждают, что в Польше низкая осведомленность населения о нарушениях слуха. Многие дети школьного возраста имеют нарушение слуха, но часто родители и учителя не подозревают о проблеме. Нарушение слуха может вызвать в небольшой степени проблемы в коммуникации, в эмоциональной сфере или в обучении. Поэтому раннее выявление потери слуха имеет решающее значение. Благодаря программам скрининга мы можем выявлять пациентов с нарушением слуха и своевременно проводить соответствующее лечение и реабилитацию. Такие действия могут улучшить качество жизни детей и их семей.

**Ключевые слова:** скрининг • сельская местность • тональная аудиометрия • дети школьного возраста

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## WYNIKI BADAŃ PRZESIEWOWYCH SŁUCHU U DZIECI W WIEKU SZKOLNYM W WOJEWÓDZTWIE WARMIŃSKO-MAZURSKIM

### Streszczenie

**Wstęp:** Badanie przesiewowe słuchu pełni niezwykle ważną rolę w profilaktyce. Pozwalają one na wczesne wykrycie zaburzeń słuchu, umożliwiając w ten sposób szybkie rozpoczęcie leczenia oraz eliminują lub minimalizują negatywne konsekwencje związane z tego rodzaju dysfunkcją. Dzieci z zaburzeniami słuchu często doświadczają opóźnionego rozwoju mowy i zdolności poznawczych, co może skutkować trudnościami w uczeniu się oraz ograniczać postępy szkolne. Od 1999 roku Instytut Fizjologii i Patologii Słuchu podejmuje szereg inicjatyw związanych z badaniami przesiewowymi słuchu. Głównym celem programu jest wczesne wykrycie wad słuchu, szczególnie u dzieci, które rozpoczynają naukę w szkole oraz zwiększanie świadomości rodziców i środowiska szkolnego na temat problemów ze słuchem.

**Materiały and Metody:** Badaniem objęto łącznie 6,297 dzieci (3.050 dziewczynek; 3.247 chłopców) z województwa warmińsko-mazurskiego. Do badań włączono osoby w wieku od 6 do 13 lat z klas od 1 do 6. Badania zostały przeprowadzone w dwóch etapach: od września 2014r. do czerwca 2015r. oraz od września 2015r. do czerwca 2016r. Najliczniejszą grupę badanych stanowili uczniowie z klas I, stanowili oni 81.1% badanej populacji. Wszyscy uczniowie mieli wykonaną audiometrię tonalną oraz przeprowadzono subiektywną ocenę na podstawie ankiet dla rodziców.

**Wyniki:** Nieprawidłowy wynik badania przesiewowego słuchu stwierdzono u 1169 osób tj. 18.6% badanych dzieci. Wśród dzieci z dodatnim wynikiem, jednostronne uszkodzenie słuchu wykryto u 64.5% (tj. 750 uczniów).

**Wnioski:** Wyniki potwierdzają, że świadomość na temat zaburzeń słuchu w Polsce jest niska. Wiele dzieci w wieku szkolnym ma ubytek słuchu, ale często nie jest wykrywany przez opiekunów i nauczycieli. Uszkodzenie słuchu nawet w niewielkim stopniu mogą powodować trudności w komunikacji, w sferze emocjonalnej lub w uczeniu się. Dlatego kluczowe znaczenie ma wczesne wykrycie ubytku słuchu. Dzięki programom badań przesiewowych możemy zidentyfikować pacjentów z uszkodzeniem słuchu, wdrożyć odpowiednie leczenie i rehabilitację tak szybko, jak to możliwe. Takie działania mogą poprawić jakość życia dzieci i ich rodzin.

**Słowa kluczowe:** badania przesiewowe • tereny wiejskie • audiometria tonalna • dzieci w wieku szkolnym

## Introduction

The proper functioning of the organs of hearing, sight, and speech form the basis of social communication and the development of modern society. For pre-school and school children, disorders of the sensory organs are a major reason for delays in development. In the case of children starting school, it may make it difficult for them to adapt to the school environment. It may also cause concentration disorders, making it difficult to understand complex commands, poor communication, or slower learning. Due to the large variety of communication disorders in school-age children, actions are needed that will allow dysfunctions to be detected early and respond with appropriate therapy and rehabilitation [1,2].

Timely intervention is an important component of Early Hearing Detection and Intervention (EHDI) screening programs. In Poland, a neonatal hearing screening program (NHS) is carried out, the first projects of which were performed over 25 years ago [3]. The official database of the National Health & Nutrition Evaluation Studies (NHANES) indicates that permanent hearing loss in infants has a prevalence of about 2 to 4 per 1000 [4]. In school-age children, the number with hearing disorders is about 9 to 10 per 1000 [5].

Screening tests play an important preventive role, being the basic tool for prevention. They allow hearing disorders to be diagnosed early, thus enabling rapid treatment and eliminating or minimizing the negative consequences. Hearing screening is a simple and fast procedure that identifies whether a tested person is likely to have problems with their hearing [6]. If there is a positive hearing screening result, the individual should be referred for more detailed diagnostic procedures. In essence, screening has the goal of identifying individuals at risk of hearing disorders and refer them for otorhinolaryngological and audiological assessment.

The preventive aspect of screening consists of taking actions to create a healthy environment. Setting goals related to the priority area of public health, the Institute of Physiology and Pathology of Hearing (IPPH), Warsaw, has attempted to unify European audiologists, otolaryngologists, and speech therapists – experts representing national environments and international associations – around the idea of equalizing the chances of children with communication disorders. The results of international cooperation of an expert group chaired by Prof. Henryk Skarżyński of IPPH are two European Scientific Consensus statements implemented in Warsaw on 22 June 2011 during the 10th Congress of the European Federation of Audiological Societies [7–9]. The first, a “European Scientific Consensus on hearing screening in pre-school and school children” was signed by representatives of 27 countries. The second document, “EU Council Conclusions on early detection and treatment of communication disorders in children, including the use of e-health tools and innovative solutions”, aimed at drawing public attention to the problem of communication disorders and their consequences for the intellectual and emotional development of children, consequences which go on to affect their social and economic situation in adulthood.

The major aim of hearing screening programs is to detect a disorder at a stage when treatment can be effective in reducing long-term complications [10]. According to estimates provided by the World Health Organization (WHO), nearly 7.5 million children live in low to middle income countries [11].

School screening programs may be pivotal for identifying hearing loss in young children. The classroom is an acoustic environment in which precise transmission and reception of speech is crucial for effective learning [12]. For example, being able to hear all sounds is fundamental when learning to read. The behavioral effects of hearing impairment are frequently subtle, and look similar to those of children who have attention deficit disorders, learning disabilities, or language and cognitive delays [13]. Common behaviors occurring with hearing loss include: difficulty in listening to speech or other auditory information (which may lead to frequent requests for repetition); tiredness while listening; wrong answers to questions; avoiding contacts with peers; and difficulties with reading and writing skills [14]. Children with mild unilateral hearing loss (UHL) exhibit difficulties in sound-source location and have problems with speech understanding, and these can significantly affect long-term educational outcomes [15]. Such difficulties can be improved by early diagnosis of hearing loss and interventions such as: hearing aids, cochlear implants, and hearing rehabilitation. These interventions facilitate the student’s speech and language, cognitive, and social development; consequently academic achievement is more likely to remain on target.

Children with UHL show more cases of failure and repetition of assessment levels, the need for additional educational help, and perceived behavioral problems in the classroom. Possible risk factors include lower cognitive ability, right ear hearing loss, and severe-to-profound hearing loss [16]. Speech and language development may be delayed in some children with UHL, but it is not clear whether children can “catch up” later [17].

In 2008, IPPH, in collaboration with the Polish Agricultural Social Insurance Fund (KRUS), performed hearing screening in school-age children in eastern Poland, during which 92,876 pupils were examined [18]. After this program, in the same partnership, the hearing screening was extended to western Poland. This study presents the results of the third stage of the program.

## Materials

The hearing screening program for children from primary schools in rural areas was carried out by a team from IPPH in cooperation with KRUS and the Association of Friends of Deaf People and Hearing People.

From September 2014 to June 2015, hearing screening tests were carried out in 3,687 pupils in 186 general primary schools. Then, from September 2015 to June 2016, hearing screening was performed in 2,610 children from 167 general primary schools. All schools were located in 18 communes in the Warmian – Masurian Voivodeship.

The number of children included in the program was 6,297 (3,050 girls; 3,247 boys) from grades 1 to 6 and aged from

**Table 1.** Grade distribution of children participating in the program

Grade of primary school	Number of children screened	Percent
I	5105	81.1
II	194	3.1
III	610	9.7
IV	280	4.4
V	86	1.4
VI	22	0.3
<b>Total</b>	<b>6297</b>	

6 to 13 years (see Table 1). The most numerous group were children from the first grade: 81.1% of all pupils examined.

The program focused on first-grade students, but in cases when some first-grade students did not want to undertake the test or were absent from school due to illness, then older children were examined. There were two main reasons why children did not participate in hearing screening: the first was lack of consent from parents or legal caregivers; the second was absence from school due to, for example, illness.

**Methods**

Screening Pure Tone Audiometry was performed using the Platform of Sensory Organs Examinations. In 2008, IPPH and the Institute of Sensory Organs (located near Warsaw, Poland) prototyped a new PC system for teleaudiology applications in hearing screening. This system became known as the Platform of Sensory Organs Examinations [1,19].

The platform is built around an internet network solution, interfacing a central computer system and a series of portable computers (remote client devices) equipped with audiometric headphones and a response button. The platform allows the user to conduct screening based on pure tone audiometry. The feature allows the user to perform air conduction audiometric testing for each ear separately over the frequency range 0.25 to 8 kHz and for levels not exceeding 80 dB HL. Tests were carried out in quiet rooms in accordance with the modified Hughson and Westlake procedure [20,21]. Air conduction thresholds were determined over the frequency range 0.5–8 kHz. An air test value of 25 dB HL or more for at least one frequency in at least one ear was assumed to be a positive test result [22–24].

Audiometric hearing tests were supplemented by results of a questionnaire filled in by parents or legal caregivers. The questionnaire included questions about potential causes of hearing problems, illnesses, possible occurrence of tinnitus, as well as noise at school breaks. In addition, all parents or legal caregivers gave written consent for participation of the child in hearing screening.

All results were carried out using the SZOK system, by means of which it is possible to perform statistical analysis and transfer collected data to IPPH in Kajetany, where

they can be evaluated by specialist doctors. Placing patient data into the SZOK system speeds up testing and shortens the patient’s waiting time for visits to IPPH or other specialized facilities. This is a unique solution in the field of telemedicine and e-health. After the results of the tests were transferred to SZOK, incorrect test results (according to fixed criteria) were separated out and a categorization into either bilateral or unilateral (right or left) hearing loss was made.

The next step performed by the IPPH specialists was to divide the abnormal hearing tests into three types of audiograms (separately for each ear):

1. Low-frequency hearing loss (LFHL), in which the threshold of hearing for 500 and/or 1000 Hz was 25 dB HL and more, while the hearing threshold for other frequencies did not exceed 20 dB HL.
2. High frequency hearing loss (HFHL), in which the hearing threshold value for frequencies of 4000 and/or 8000 Hz was 25 dB HL and more, while the hearing threshold for other frequencies did not exceed 20 dB HL.
3. Other: abnormal screening results in which the hearing threshold was greater than 20 dB HL at two or more arbitrary frequencies.

Based on the results of the hearing screening tests and the questionnaire, each child was qualified for one of two groups. The first group were children who required further specialist care. The second group were children who had abnormal screening results and where auditory prevention was recommended (the parents were provided with information about prevention of hearing disorders and factors that might cause them).

**Results**

Hearing screening showed that a positive result of the audiogram, according to the adopted criterion, was found in 1169 children, 18.6% of the surveyed population. Of these, 752 children (64.3%) had a single-sided hearing loss, which affected the left ear in 58% of cases (Table 2).

Table 2 shows that almost 1 in 5 children in grade I to III had an abnormal result of a hearing screening test (1124 students or 19%). In grades IV–VI, there were 45 people (11.6% of study group) who failed screening. In both grades I–III and IV–VI the distribution of unilateral and bilateral hearing loss was similar.

Table 3 shows that the positive results of hearing screening among boys and girls was similar.

Table 4 shows that among children in their early school years (grades I–III) with abnormal hearing, high frequency hearing loss (HFHL) was most common, affecting 43.9% (671 ears). Low frequency hearing loss (LFHL) accounted for 23% (352 ears), and the remaining 33.1% (505 ears) was made up of hearing losses at other frequencies. All types of hearing losses were more common in the left than the right (Table 4).

**Table 2.** Percentage of students with hearing loss and the frequency of unilateral and bilateral hearing loss, divided by grade

Grade of primary school	Number of children screened	Number of children with positive result	Bilateral	Unilateral	
				Right ear	Left ear
I–III	5909	1124 (19%)	404 (35.9%)	720 (64.1%)	
				301 (41.8%)	419 (58.2%)
IV–VI	388	45 (11.6%)	13 (28.9%)	32 (71.1%)	
				12 (37.5%)	20 (62.5%)
<b>Total</b>	<b>6297</b>	<b>1169 (18.6%)</b>	<b>417 (35.7%)</b>	<b>752 (64.3%)</b>	
				<b>313 (41.6%)</b>	<b>439 (58.4%)</b>

**Table 3.** Number of positive hearing screening results divided by gender

Grade of primary school	Number of girls screened	Number of girls with positive result	Number of boys screened	Number of boys with positive result
I–III	2855	538 (18.4%)	3054	586 (19.2%)
IV–VI	195	21 (10.8%)	193	24 (12.4%)
<b>Total</b>	<b>3050</b>	<b>559 (18.3%)</b>	<b>3247</b>	<b>610 (18.8%)</b>

**Table 4.** Number and incidence of types of audiograms

Grade of primary school	Type of audiogram	Number of ears and frequency of occurrence		
		Right ear	Left ear	Total
I–III	Low frequency hearing loss (LFHL)	142 (40.3%)	210 (59.7%)	<b>352 (23.0%)</b>
	High frequency hearing loss (HFHL)	321 (47.8%)	350 (52.2%)	<b>671 (43.9%)</b>
	Other hearing losses	234 (46.3%)	271 (53.7%)	<b>505 (33.1%)</b>
IV–VI	Low frequency hearing loss (LFHL)	3 (37.5%)	5 (62.5%)	<b>8 (13.8%)</b>
	High frequency hearing loss (HFHL)	20 (57.1%)	15 (42.9%)	<b>35 (60.3%)</b>
	Other hearing losses	6 (40%)	9 (60%)	<b>15 (25.9%)</b>

**Table 5.** Survey results for question no. 1

Grade of primary school	Do you think your child has hearing problems?	Number of responses (%)	Hearing screening result		
			Negative	Prevention recommended	Referral for additional tests
I–III	<b>Very often and often</b>	67 (1.1%)	46 (68.7%)	1 (1.5%)	20 (29.8%)
	<b>Rarely</b>	687 (11.7%)	508 (73.9%)	48 (7%)	131 (19.1%)
	<b>Never</b>	5155 (87.2%)	4232 (82.1%)	338 (6.6%)	585 (11.3%)
IV–VI	<b>Very often and often</b>	10 (2.6%)	6 (60%)	1 (10%)	3 (30%)
	<b>Rarely</b>	81 (20.9%)	64 (79%)	6 (7.4%)	11 (13.6%)
	<b>Never</b>	297 (76.5%)	273 (91.9%)	13 (4.4%)	11 (3.7%)

**Table 6.** Survey results for question no. 2

Grade of primary school	Was the child treated for ear inflammation?	Number of responses (%)	Hearing screening result		
			Negative	Prevention recommended	Referral for additional tests
I-III	yes	1422 (24.1%)	1088 (76.5%)	104 (7.3%)	230 (16.2%)
	no	4487 (75.9%)	3698 (82.4%)	283 (6.3%)	506 (11.3%)
IV-VI	yes	95 (24.5%)	81 (85.3)	6 (6.3)	8 (8.4%)
	no	293 (75.5%)	262 (75.5%)	14 (4.8%)	17 (5.8%)

**Table 7.** Survey results for question no. 3

Grade of primary school	Does the child complain about tinnitus?	Number of responses (%)	Hearing screening result		
			Negative	Prevention recommended	Referral for additional tests
I-III	<b>Very often and often</b>	67 (1.1%)	46 (68.7%)	1 (1.5%)	20 (29.8%)
	<b>Rarely</b>	687 (11.7%)	508 (73.9%)	48 (7%)	131 (19.1%)
	<b>Never</b>	5155 (87.2%)	4232 (82.1%)	338 (6.6%)	585 (11.3%)
IV-VI	<b>Very often and often</b>	10 (2.6%)	6 (60%)	1 (10%)	3 (30%)
	<b>Rarely</b>	81 (20.9%)	64 (79%)	6 (7.4%)	11 (13.6%)
	<b>Never</b>	297 (76.5%)	273 (91.9%)	13 (4.4%)	11 (3.7%)

The data confirm the need to increase the availability of medical services in rural areas, with hearing disorders showing up in a significant percentage of school-age children. Detecting hearing loss in a student starting school, and then treating it, is likely to significantly improve the child's chances of a successful school education and fulfil their potential [25].

**Results of surveys**

Table 5 shows that 585 out of the 736 parents of children from grades I-III for which the screening test was positive did not notice any problems with hearing in their child. In addition, 338 of the 387 children where prevention measures suggested to the parents also did not notice hearing problems. However, it should be added that in the majority of cases, this concerned unilateral hearing losses. Interestingly, 554 parents noticed that their child had hearing problems, but pure tone audiometry failed to confirm this. In these cases, we may be dealing with auditory processing disorders, characterized for example by a difficulty in understanding commands. For grades IV-VI, Table 5 shows that parents of children with normal

screening results were apt to report that their child had hearing problems (about five times more children than the number who were referred for screening).

Table 6 shows that about 24% of children in grades I-III, and a similar proportion in grades IV-VI, had previously been treated for otitis media. In addition, 230 out of 736 children in the first group who had an abnormal hearing test, and 104 out of 387 children who were prescribed hearing prophylaxis, had previously been treated for ear infections. However, for children in grades IV-VI, 8 out of 25 students who had an abnormal hearing test and one-fifth of those who were prescribed hearing prevention had had ear infection in the past.

The questionnaire also included the question of tinnitus, and the results are shown in Table 7. It was observed that 12.8% of all examined children complained of tinnitus, including 1.1% very often and often in grades I-III and 2.6% in grades IV-VI. It is worth noting that of children who had a positive hearing screening, 31.3% of them experienced tinnitus very often and often, compared to 26.1% of students who rarely experienced tinnitus. However, students from

**Table 8.** Survey results for question no. 4

Grade of primary school	Does the child complain about excessive noise during school breaks?	Number of responses (%)	Hearing screening result		
			Negative	Prevention recommended	Referral for additional tests
I–III	yes	677 (11.5%)	533 (78.7%)	49 (7.2%)	95 (14.1%)
	no	5232 (88.5%)	4253 (81.3%)	338 (6.5%)	641 (12.2%)
IV–VI	yes	54 (13.9%)	45 (83.3%)	3 (5.5%)	6 (11.1%)
	no	334 (86.1%)	298 (89.2%)	19 (5.7%)	17 (5.1%)

grades IV–VI complained of tinnitus almost twice as often as their younger cohort, with 23.5% experiencing tinnitus (2.6% very often and often). In addition, while 40% of the children experiencing tinnitus very often and often had a positive result of hearing screening, only 1 in 5 children experiencing tinnitus rarely had a positive test.

Finally, Table 8 shows that 11.5% of the examined children from grades I–III and 13.9% from grades IV–VI complained of excessive noise during school breaks.

## Discussion

The presence of hearing disorders among school-age children has been widely reported as a health issue [26,27]. Unfortunately, routine hearing screening is still not carried out, as most primary schools view this as an additional expense.

In this work, data were collected from primary school pupils, although the largest group were those from the first grades. The hearing screening was enriched with additional information from questionnaires, which has proved to be an appropriate tool in the assessment of information related to screening such as previous otitis media, tinnitus, and also the incidence of runny noses.

The results obtained in the hearing screening program among primary school students in the Warmian – Masurian Voivodeship indicates that 18.6% (1169 children) had a positive result. This figure is comparable with research carried out in Poland in 2008–11, which showed that almost 14% of first graders had a hearing problem [1]. In addition, data from hearing screening conducted by IPPH in 1999 showed a similar incidence of 20% (1 in 5 children screened) [1,28]. For comparison, the percentage of children in India with hearing loss in 1996 was found to be 11.9% (more than 1 in 8 children) [29]. In Tajikistan, hearing screening of school age children conducted by IPPH in 2013 found hearing impairments in 23.7% [3].

Some 23% of the children in grades I–III and almost 14% in grades IV–VI in the Warmian – Masurian Voivodeship were diagnosed with a low-frequency hearing loss. Data from an American study indicate a lower incidence

of LFHL – 7.1% [23]. A higher incidence of this type of hearing disorder was reported in a Nigerian study, where 33.4% (167 out of 500 examined children) presented LFHL in their right ear and 7.8% in their left ear [30]. Similar data have been reported in Tajikistan, where 34% of children were diagnosed with LFHL [3,31]. In some cases, a low-frequency hearing loss may be temporary, and depending on the individual case, pharmacological or surgical intervention may be effective. One of the most common reasons for temporary LFHL is inflammation of the middle ear. Otitis media with effusion is one of the most common childhood diseases [32]. In the current study, 24.1% of tested children had been previously treated for ear inflammation. The Tajikistan study showed that 34% of those referred for further hearing tests had had otitis media in the past [3]. Studies carried out at the Pediatric Clinic of Otolaryngology, Audiology and Phoniatrics at the Medical University of Lodz found a correlation between upper respiratory tract infections in children and temporary conductive hearing loss [33].

In our study, almost 44% of the tested children in grades I–III and 60.3% in grades IV–VI were diagnosed with high-frequency hearing loss. In comparison, the hearing screening in Tajikistan found that the percentage of children with HFHL was 25.5%. Children with high-frequency hearing loss may appear normal but they may experience difficulties in many situations. For example, they may seem distracted because of a difficulty in understanding speech in noise. Lunch breaks can be very noisy, which can lead to social problems if the child is unable to hear and misinterprets information. In HFHL, speech disorders and articulation problems can also arise. It is important that children with HFHL have a permanent support system both at school and at home [34].

According to Sekhar et al. [35], single-sided hearing loss can be as high as 88% (59 children from 67 with hearing impairments) in a group of 296 assessed children. According to Kuppler [36], the most common hearing impairment is unilateral hearing loss, which occurs in about 3% of school-age children. Niskar et al. [22] screened 6,166 American children aged 6–19 years. Almost 15% of them had a low or high frequency hearing loss, with 82% unilateral losses. Data from an Iranian child population [37]

indicate that, of all reported hearing losses, 75% were single-sided. In the present study, 64.5% of all positive hearing screening results were unilateral, which is lower than the figures given above. However, a similar proportion emerged from the IPPH hearing screening in Tajikistan, where the frequency of unilateral hearing disorders was 50% (17/34 cases) [3,9].

The proposed screening procedures make it possible to detect not only children with hearing loss, but also those with other hearing disorders, such as tinnitus. Tinnitus is becoming a common problem in school-age children. Of Polish children aged between 7 and 12 years, tinnitus incidence ranges from a few percent to 12% or more depending on the child's age and place of residence [38,39]. In some countries, tinnitus affects 6–14% of children aged 6 to 12 years [2]. Tinnitus is especially common in children with central hearing disorders [40]. Data from the current study showed that 9.9% of normal hearing children who passed the hearing screening had tinnitus. A similar result was reported in Tajikistan, affecting 9% of children with negative hearing screening results [3]. Additional data from screening tests in Poland indicate an

even higher percentage, showing that almost 32% of children with normal hearing have tinnitus [39,41].

## Summary

The detection of hearing impairments in school-age children is essential. The later that hearing disorders are detected, the greater will be the future consequences. Early diagnosis allows referral to specialists, who can provide prevention and appropriate rehabilitation, minimizing or eliminating effects on the child's cognitive, social, emotional, and communicative abilities. A hearing screening program was one of the priorities in the areas of health-care during the Polish Presidency of the European Union (2011). Pure tone audiometry screening using the Platform for Sensory Organs Examination is a cost-effective and safe tool for cooperating children. Our study shows that, with appropriate screening equipment and protocols and in close collaboration with pediatric otorhinolaryngologists, it is feasible for a medical team to conduct hearing screening among school-age children. We also suggest this protocol may be effective in identifying cases of postnatal hearing loss, where the most important factor is timely delivery of early intervention services.

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