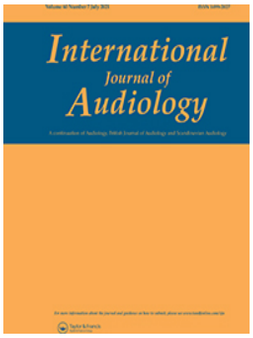

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Prevalence of tinnitus in a sample of 43,064 children in Warsaw, Poland

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ABSTRACT

Objective: Tinnitus affects both adults and children. Children rarely complain spontaneously of tinnitus, and their parents are not aware of the condition. The prevalence of tinnitus in children differs considerably between studies, and large studies are needed to reliably estimate how many children experience tinnitus symptoms. The goal of the study was to estimate the prevalence of tinnitus in a large sample of schoolchildren.

Design: This study was population-based, epidemiological research, conducted in the general, paediatric population of school-age children in Warsaw, Poland. Pure-tone audiometric testing was done, and hearing thresholds were determined from 0.5 to 8 kHz. Both the children and parents answered questions about the presence of tinnitus in the child.

Study sample: Results from 43,064 children aged 11 to 13 years old, as well as their parents, were collected.

Results: The study showed that tinnitus affected 3.1% of the children, but it was significantly more frequent (9%) in children with hearing loss. We found that 1.4% of the parents were aware of the presence of tinnitus in their children.

Conclusions: Children should be routinely asked whether they experience tinnitus and if so, they should be included in the thorough assessment and management of the condition.

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Tinnitus; prevalence; children; epidemiology

Introduction

Tinnitus is the phantom perception of sound without any external stimuli (Jastreboff 2015). Affecting both adults and children, it negatively impacts the quality of life and can lead to significant restrictions in everyday activity (Zeman et al. 2014; Hall et al. 2018; Smith et al. 2019). The pathophysiology of the tinnitus remains unclear, although it is thought to be connected with aberrant neural activity generated at some level of the auditory system (Jastreboff 1990; Haider et al. 2018).

For adults, much work has been done over the past several decades concerning tinnitus prevalence, and there are numerous publications (Davis 1995; Axelsson and Ringdahl 1989; Ries 1994; Adams and Marano 1995; Nondahl et al. 2002; Tambs et al. 2003; Fabijańska et al. 2000; Hasson et al. 2011; Shargorodsky, Curhan, and Farwell 2010; McCormack et al. 2016; Khedr et al. 2010). Tinnitus prevalence rates appear to vary from 5% to 30%, the wide range probably being due to different types of methodologies.

How does the prevalence of tinnitus in children compare to adults? The results of research on the incidence of tinnitus in children are not clear-cut. Rosing et al. (2016) undertook a systematic review of the epidemiology of tinnitus and hyperacusis in children and young people based on 25 articles which met their inclusion criteria and which showed rosing sufficient methodological consistency. The authors reported the estimated prevalence of tinnitus to be from 4.7% to 46% in the general paediatric population and among children with normal hearing; 6%–41.9% in mixed study population (children with hearing loss and normal hearing), and 3.2%–62.2% in the hearing impaired children (Rosing et al. 2016). Data from the latest studies are also very divergent. Kim et al. (2017) reported 32.3% tinnitus prevalence in the general population of South Korean adolescents, while the figure showed by Lee and Kim (2018) was 17.5%. Nemholt et al. (2020) published the findings from a study of Danish children aged 10 to 16 years, wherein 66.9% of the participants had tinnitus.

The estimates of tinnitus prevalence among children vary widely, depending on factors such as different criteria used to define tinnitus, different ages of the examined children, the range of questionnaires used interviewing in the child, different procedures, and the statistics used to analyse the results.

From the point of view of clinicians, healthcare providers, and health policymakers, there is a strong need to gauge the extent of tinnitus in the paediatric population accurately. The goal of this study was to assess the prevalence of tinnitus in

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children living in and around Warsaw. To ensure the reliability of the results, we carried out the study for five consecutive years, from 2013 to 2017. The guidelines STROBE Statement (The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (von Elm et al. 2014) were taken into account when reporting the results of the study.

Materials and methods

This study was a retrospective analysis of the responses of 43,064 school children (21,917 girls and 21,147 boys) and their parents, collected during a hearing screening program conducted from 2013 to 2017 by the Institute of Physiology and Pathology of Hearing. The children were aged 11 to 13 years old (27.9% of them were 11 years old, 67% were 12 years old, and 5.1% were 13 years old). The mean age was 11.77, and the standard deviation of 0.53. The number of children in the study, year by year, was: 8186 children in 2013; 9142 children in 2014; 8307 children in 2015; 9582 children in 2016; and 7847 children in 2017.

The study was conducted following the Declaration of Helsinki and was approved by the Research Ethics Committee (KB.IFPS:28/5/2018). The main objective of this project was to assess the hearing condition of the studied population. All primary schools in Warsaw were informed about the hearing screening and invited to take part in the program. Assessment of the prevalence of tinnitus was a secondary goal.

Before testing, the children's parents were informed of the testing procedure and gave written consent for their children to participate in the hearing examinations. Audiometric hearing tests have been supplemented by a questionnaire completed by parents/legal caregivers and children. Parents were asked to answer the following question – *Does your child complain of tinnitus in their ears/head when in quiet?* by choosing one of the possible answers *very often*, *often*, *rarely*, or *never*. The children were asked to answer a similar question – *Do you hear tinnitus, whistles, or squeaks as you are falling asleep or when it is quiet in your room?* by choosing an answer *yes, all the time*; *yes, periodically and for more than 5 minutes*; *yes, but only for a very short time*; *no* (both the parents and the children were asked the tinnitus question in writing). If the parents answered *very often* or *often*, and the children answered *yes, all the time*; *yes, periodically and for over than 5 minutes* they were considered positive outcomes, i.e. indicating the presence of tinnitus.

For hearing screening, the Sense Examination Platform, which is a portable screening audiometer, was used. The platform consists of a netbook linked to a central computer and several ancillary devices such as audiometric headphones, patient-operated button, and software allowing to perform pure tone audiometry. The platform carries Sennheiser HDA200 headphones which provide effective acoustic isolation of the ear from background noise. Details of the platform can be found in references (Skarżyński et al. 2011; Skarzyński et al. 2016; Skarżyński et al. 2020). Air conduction hearing thresholds were tested in the frequency range 0.5 to 8 kHz. The Hughson and Westlake procedure of threshold measurement was used (i.e. two out of three responses at threshold are required; (Śliwa et al. 2011)). All children were instructed to raise their hand when they hear the sound. When the sound stops, they were asked to lower their hands. Pure tone audiometry screening took place in a quiet room chosen by the school headmaster. Audiometry testing was conducted during school hours, excluding breaks. Experienced audiologists performed testing. The Bureau International d'Audiophonologie (BIAP) recommendation was used to divide children into two groups: children with normal hearing (with pure tone average (PTA) below 20 dB HL for 0.5, 1, 2, and 4 kHz) and children with hearing loss (with PTA above 20 dB HL). (Bureau International d'Audiophonologie and for 1996). Degrees of hearing loss were assessed as mild (21–40 dB), moderate (41–70 dB), or severe (71–90 dB) according to BIAP standards (the worse ear was considered).

The prevalence of tinnitus in children was estimated by assessing the parents' and children's ratings separately. The figures were derived by dividing the number of positive results by the total number of results. Positive results for the parents were two answers: *very often* or *often*; for the children also two answers were considered positive: *yes, all the time*; *yes, periodically and for over than 5 minutes*. Confidence intervals (95% CI) were calculated to indicate uncertainty of estimates. Odds ratios (ORs) were applied to evaluate differences between males and females, children with normal hearing and children with hearing loss, and children with various degrees of hearing loss. Additionally, sensitivity analysis was performed by calculating the rates of tinnitus in a different way. The questions were treated as yes/no questions. If the parents chose other answer than *never* (i.e. *very often; often; rarely*) and the children chose other answer than no (*yes, all the time*; *yes, periodically and for more than 5 minutes*; *yes, but only for a very short time*) they were considered indicating the presence of tinnitus. Statistical significance was specified as a p-value less than 0.05. The analysis was performed using IBM SPSS Statistics, version 24 and MedCalc.

Results

Generally, over the whole period 2013–17, 1.4% of parents said their child had often or very often complained about tinnitus. The rate was almost the same for both boys and girls (OR = 0.86; $p > 0.05$). A little over 12% of the parents reported that their child occasionally complained of tinnitus, and again there was only a slight difference between the answers given by parents of boys or girls. The majority of parents (86.2%) said that their child had never complained of tinnitus, and the difference between the parents of boys and girls was still negligible. The data are set out in Table 1.

Overall, 0.7% of the children reported tinnitus lasting all the time, and 2.4% of children said they experienced tinnitus periodically and that it lasted for more than five minutes. The rate was similar for boys and girls (OR = 0.93; $p > 0.05$). About 28% of children reported tinnitus which happened rarely and lasted for a very short time. Tinnitus was not experienced by 69.1% of the children, boys and girls similarly. Table 2 shows the data.

The parents' assessment of their child's tinnitus complaints was reasonably stable over the whole study period. The data are indicated in Table 3. In the period 2013 to 2017, the prevalence of permanent tinnitus reported by children was stable at 0.6–0.8%, equal between the sexes. The data are presented in Table 4.

Hearing loss was detected in 927 children (2.2%), of which 686 (1.6%) had unilateral hearing loss, and 241 (0.6%) had bilateral hearing loss. Mild hearing loss was observed in 808 children (1.9%), moderate hearing loss – in 104 children (0.2%), and severe – in 15 children (0.03%). Over the span 2013–17, the prevalence of hearing loss was varied slightly – from 2.4% in 2013, 2.6% in 2014, 1.6% in 2015, 1.5% in 2016, to 2.9% in 2017.

Parents of the hearing impaired children noticed tinnitus more frequently (4.1%) compared to the parents of normally

Table 1. Prevalence (%) of tinnitus in children as reported by their parents.

	All	Boys	Girls	Normal hearing	Hearing loss	Unilateral hearing loss	Bilateral hearing loss	Mild hearing loss	Moderate or severe hearing loss
Never	86.2 [85.9–86.6]	86.6 [86.1–87.0]	85.9 [85.5–86.4]	86.4 [86.2–86.8]	74.8 [72.0–77.6]	76.2 [73.1–79.4]	70.6 [64.8–76.3]	75.6 [72.7–78.6]	68.9 [60.6–77.2]
Rarely	12.4 [12.0–12.7]	12.1 [11.7–12.6]	12.6 [12.1–13.0]	12.2 [11.8–12.5]	21.1 [18.5–23.8]	20.0 [17.0–23.0]	24.5 [19.1–29.9]	20.2 [17.4–22.9]	27.7 [19.7–35.8]
Often	1.1 [1.0–1.2]	1.0 [0.9–1.2]	1.2 [1.1–1.4]	1.1 [1.0–1.2]	3.0 [1.9–4.1]	2.6 [1.4–3.8]	4.1 [1.6–6.7]	3.0 [1.8–4.1]	3.4 [0.1–6.6]
Very often	0.3 [0.2–0.3]	0.3 [0.2–0.3]	0.3 [0.2–0.4]	0.3 [0.2–0.3]	1.1 [0.4–1.7]	1.2 [0.4–2.0]	0.8 [0.0–2.0]	1.2 [0.5–2.0]	–
Odds ratio		OR = 0.86 [0.74–1.01]		OR = 3.13 [2.23–4.37]		OR = 1.33 [0.66–2.68]		OR = 1.29 [0.45–3.68]	
		Z = 1.80; $p = 0.071$		Z = 6.66; $p < 0.001$		Z = 0.80; $p = 0.425$		Z = 0.47; $p = 0.638$	

Confidence intervals (95%) are given in the brackets.

Table 2. Prevalence (%) of tinnitus as reported by children themselves.

	All	Boys	Girls	Normal hearing	Hearing loss	Unilateral hearing loss	Bilateral hearing loss	Mild hearing loss	Moderate or severe hearing loss
No	**69.1** [68.7–69.5]	68.6 [68.0–69.2]	69.6 [69.0–70.2]	69.4 [69.0–69.9]	54.5 [51.3–57.7]	55.6 [52.0–59.4]	51.1 [44.7–57.3]	54.4 [50.9–57.8]	55.5 [46.5–64.4]
Yes, but for a very short time	**27.8** [27.4–28.2]	28.4 [27.8–29.0]	27.2 [26.6–27.8]	27.6 [27.2–28.0]	36.5 [33.4–39.6]	36.2 [32.6–39.7]	37.3 [31.2–43.5]	36.1 [32.8–39.5]	38.7 [29.9–47.4]
Yes, periodically and for over five minutes	**2.4** [2.2–2.5]	2.3 [2.1–2.5]	2.5 [2.3–2.7]	2.3 [2.1–2.4]	7.2 [5.6–8.9]	7.0 [5.1–8.9]	7.9 [4.5–11.3]	7.5 [5.7–9.4]	5.0 [1.1–9.0]
Yes, all the time	**0.7** [0.6–0.8]	0.7 [0.6–0.8]	0.7 [0.6–0.8]	0.7 [0.6–0.8]	1.8 [1.0–2.7]	1.2 [0.4–2.0]	3.7 [1.3–6.1]	2.0 [1.0–2.9]	0.8 [0.0–2.5]
Odds ratio		OR = 0.93 [0.83–1.04]		OR = 3.25 [2.58–4.10]		OR = 1.48 [0.92–2.39]		OR = 1.49 [0.70–3.18]	
		Z = 1.34; $p = 0.181$		Z = 10.00; $p < 0.001$		Z = 0.80; $p = 0.110$		Z = 1.05; $p = 0.296$	

Confidence intervals (95%) are given in the brackets.

hearing children (1.4%) (OR = 3.13; $p < 0.05$). Parents reported tinnitus more often in children with bilateral (4.9%) than unilateral hearing loss (3.8%), but the difference was not statistically significant (OR = 1.33; $p > 0.05$). Parents reported tinnitus slightly more often in children with mild hearing loss (4.2%) than in children with moderate or severe hearing loss (3.4%), but the difference was not statistically significant (OR = 1.29; $p > 0.05$). (Table 1).

Among the children themselves, this tendency was also apparent – 3% of the children with normal hearing reported tinnitus, while the figure was 9% in the case of the children with hearing loss (OR = 3.25; $p < 0.05$). Tinnitus was reported more often by the children with bilateral (11.6%) than unilateral hearing loss (8.2%); however, the difference was not statistically significant (OR = 1.48; $p > 0.05$). Tinnitus was reported more often by the children with mild hearing loss (9.5%) than by those with moderate or severe hearing loss (5.8%), but again, the difference was not statistically significant (OR = 1.49; $p > 0.05$ (Table 2).

The additional results of sensitivity analysis showed that the main rates of tinnitus (1.4% in the parents and 3.1% in the children) would be much higher if three answers (instead of two answers) were taken into account. It would be 13.8% in the parents (5926 respondents out of 43,064) and 30.9% in the children (13,304 respondents out of 43,064).

Table 3. Prevalence (%) of tinnitus in children as reported by their parents (2013–17).

	All	Boys	Girls
2013			
Never	88.6 [87.9–89.3]	88.6 [87.6–89.6]	88.7 [87.7–89.6]
Rarely	10.6 [9.9–11.3]	10.6 [9.6–11.5]	10.6 [9.7–11.6]
Often	0.6 [0.4–0.7]	0.6 [0.4–0.9]	0.5 [0.3–0.7]
Very often	0.2 [0.1–0.3]	0.2 [0.0–0.3]	0.2 [0.1–0.4]
2014			
Never	86.8 [86.1–87.5]	87.2 [86.3–88.2]	86.4 [85.4–87.4]
Rarely	11.9 [11.2–12.5]	11.5 [10.5–12.4]	12.2 [11.3–13.2]
Often	1.1 [0.9–1.3]	1.1 [0.8–1.4]	1.1 [0.8–1.4]
Very often	0.2 [0.1–0.3]	0.2 [0.0–0.3]	0.3 [0.1–0.5]
2015			
Never	84.4 [83.6–85.2]	85.1 [84.0–86.2]	83.8 [82.7–84.9]
Rarely	13.7 [12.9–14.4]	13.1 [12.1–14.2]	14.1 [13.1–15.2]
Often	1.5 [1.3–1.8]	1.5 [1.1–1.9]	1.6 [1.2–2.0]
Very often	0.4 [0.3–0.5]	0.3 [0.1–0.5]	0.5 [0.3–0.7]
2016			
Never	85.6 [84.9–86.3]	85.9 [84.8–86.8]	85.3 [84.4–86.3]
Rarely	12.9 [12.2–13.6]	12.8 [11.9–13.8]	13.0 [12.1–13.9]
Often	1.2 [1.0–1.5]	1.0 [0.7–1.3]	1.5 [1.1–1.8]
Very often	0.3 [0.2–0.4]	0.3 [0.2–0.5]	0.2 [.1–0.3]
2017			
Never	85.8 [85.1–86.6]	86.1 [85.0–87.2]	85.6 [84.5–86.7]
Rarely	12.7 [11.9–13.4]	12.6 [11.6–13.7]	12.7 [11.6–13.7]
Often	1.2 [0.9–1.4]	0.9 [0.6–1.2]	1.4 [1.1–1.8]
Very often	0.3 [0.2–0.4]	0.4 [0.2–0.5]	0.3 [0.1–0.5]

Confidence intervals (95%) are given in the brackets.

Discussion

Definition of tinnitus

Comparison across studies of tinnitus prevalence in children is difficult because authors use different definitions. In our research, we asked parents and children about tinnitus experience when the child is falling asleep and in a quiet room (a question asked to children) and when in quiet (a question asked to parents). In such circumstances, the tinnitus is most likely to have an impact on everyday activities (Tyler and Baker 1983; Raj-Koziak et al. 2020). We also asked if they heard other sounds than sustained tinnitus. We consider that if a child perceives a sound other than the typically sustained tinnitus, for example, a short squeak or whistle, the sounds should not be regarded as tinnitus. Children may confuse transient ear noise with chronic tinnitus. What differentiates the two? Dauman and Tyler (1992) suggested that tinnitus must last at least five minutes and occur at least two times per week. Our time criterion for separating chronic tinnitus from occasional ear noises is five minutes and more. A positive indication of tinnitus requires the person to report his/her tinnitus as persistent or, if it is periodic, lasting longer than five minutes.

Table 4. Prevalence (%) of tinnitus as reported by children themselves (2013–17).

	All	Boys	Girls
2013			
No	63.9 [62.8–64.9]	62.5 [61.1–64.0]	65.2 [63.7–66.6]
Yes, but for a very short time	32.4 [31.4–33.4]	33.7 [32.2–35.1]	31.2 [29.8–32.6]
Yes, periodically and for over five minutes	3.0 [2.6–3.4]	3.0 [2.5–3.6]	3.0 [2.5–3.5]
Yes, all the time	0.7 [0.5–0.9]	0.8 [0.5–1.0]	0.6 [0.4–0.9]
2014			
No	64.5 [63.6–65.6]	63.7 [62.3–65.1]	65.4 [64.0–66.8]
Yes, but for a very short time	32.2 [31.2–33.1]	33.1 [31.8–34.5]	31.3 [30.0–32.6]
Yes, periodically and for over five minutes	2.5 [2.2–2.8]	2.5 [2.1–3.0]	2.4 [2.0–2.9]
Yes, all the time	0.8 [0.6–0.9]	0.7 [0.4–0.9]	0.9 [0.6–1.1]
2015			
No	67.1 [66.1–68.1]	67.0 [65.6–68.5]	67.2 [65.8–68.5]
Yes, but for a very short time	29.9 [28.9–30.9]	30.2 [28.7–31.6]	29.7 [28.3–31.0]
Yes, periodically and for over five minutes	2.3 [1.9–2.6]	2.0 [1.6–2.5]	2.4 [2.0–2.9]
Yes, all the time	0.7 [0.6–0.9]	0.8 [0.5–1.0]	0.7 [0.5–1.0]
2016			
No	75.6 [74.7–76.4]	76.2 [75.0–77.4]	75.0 [73.8–76.2]
Yes, but for a very short time	21.3 [20.5–22.1]	21.0 [19.8–22.2]	21.6 [20.5–22.8]
Yes, periodically and for over five minutes	2.4 [2.1–2.7]	2.0 [1.6–2.4]	2.7 [2.2–3.1]
Yes, all the time	0.7 [0.6–0.9]	0.8 [0.5–1.1]	0.7 [0.4–0.9]
2017			
No	74.1 [73.1–75.0]	73.1 [71.8–74.5]	75.0 [73.6–76.4]
Yes, but for a very short time	23.5 [22.6–24.5]	24.6 [23.2–25.9]	22.5 [21.1–23.8]
Yes, periodically and for over five minutes	1.8 [1.5–21.1]	1.6 [1.2–2.0]	2.0 [1.6–2.4]
Yes, all the time	0.6 [0.4–0.8]	0.7 [0.4–0.9]	0.5 [0.3–0.7]

Confidence intervals (95%) are given in the brackets.

Epidemiology

This study assessed tinnitus prevalence in children over the years 2013 to 2017. Measuring the prevalence of tinnitus is essential to gauge how extensive the condition is. In our study, 3.1% of the children reported tinnitus; 0.7% of them heard the noise all the time, and 2.4% said they experienced tinnitus only periodically, but it did last for more than five minutes. Our results are comparable with those of other authors who have examined the prevalence of tinnitus in children 11–13 years old; Kim and colleagues found a figure of 4.4,% while Mahboubi and co-workers found a figure of 3.0% (Kim et al. 2012; Mahboubi et al. 2013). In comparison, Bulbul et al. described the prevalence of tinnitus in this age group as much higher, 33.5% (Bulbul et al. 2009). The presence of tinnitus in that study was assessed on the basis of the yes/no question *Do you have tinnitus (ringing in the ears)?* Our sensitivity analysis showed that estimating the prevalence of tinnitus based on binary questions may result in elevated rates of tinnitus. We think that a more specific question would distinguish tinnitus from occasional earnoises and would reduce the rate of reported tinnitus.

Compared to the other research carried out in this area, the material presented in this paper is one of the most extensive so far. Our results show that tinnitus in children is a rather uncommon condition. Also, observation of the condition over several years, using the same methodology, allows us to confidently say that the prevalence of tinnitus does not show an upward trend. However, our study does make clear that tinnitus is more frequent in children with hearing impairment, and these children should be carefully but calmly questioned about tinnitus.

Interview

Most authors express the view that interviewing a child about their tinnitus is often tricky because children respond to questions in different ways. If they do not understand the question, they may still want to please the questioner and so answer all questions positively. Conversely, they may be confused by the questioning and respond negatively (Baguley and McFerran 1999). It is well known that children rarely report tinnitus spontaneously, but when asked about the condition in the right way, they can thoroughly explain what they are hearing. Savastano found spontaneously reported tinnitus in 6% of children, but the percentage describing a tinnitus sensation rose to 34% when they were directly asked about hearing the noise (Savastano 2002).

An explanation of why children fail to report tinnitus spontaneously is that children having permanent tinnitus may consider it a normal phenomenon. Similarly, if a family member, e.g. a parent, experiences tinnitus and informs about the condition, a child may consider tinnitus to be normal. Unlike many adults, children can more easily divert their attention to other things, because they are typically actively engaged with external stimuli from the external environment (Viani 1989; Baguley and McFerran 1999; Savastano 2002).

In our study, only 1.4% of parents reported that their children had mentioned tinnitus to them, whereas the children themselves reported it about twice as frequently (3.1%). It indicates that the child is the more reliable source of information and should be directly involved in any tinnitus assessment. Of course, the interview with the child should be conducted carefully so as not to arouse any concerns. The questions have to be adjusted to the child's age and cognitive and linguistic abilities. Some specialists recommend using techniques such as play and drawing to gather information about tinnitus in young children (British Society of Audiology 2015).

It is necessary to rely on children's answers to ensure the reliability of the study. Mills and Cherry (1984) found that below the age of 5 years, consistent answers could not be obtained. This is important for a child-specific measure to include questions at a level of language familiar to the child (Eiser and Morse 2001). When constructing the questions, we had used our experience from previous years, when we examined children aged 7 and 11 (Raj-Koziak et al. 2011, 2013). We believe that children aged 11–13 are able to answer the question about tinnitus knowingly. The oral interview collected with a child may be considered as more accurate as self-reporting to a hearing health care paediatric professional, but this way of collecting data limits testing a larger group of people.

In our study children answered the question at school before a hearing screening test. In case of doubt, the child could ask for re-explanation the question when necessary. Researchers did not report that children had a problem answering the question, despite the fact that it was more accurate than the question to parents. To increase parents' awareness and knowledge of hearing problems a series of information meetings were organised for parents at participating schools.

According to a comprehensive systematic review done by Rosing et al. (2016) such factors as age, gender and hearing status of the study population, and the manner of asking about tinnitus influence the variability of estimates. Results of our research, including 60,212 children, aged 7 y.o., living in villages and small cities in the region of Eastern Poland, were presented in 2011 (Raj-Koziak 2011). The analysis of the survey showed that 13.6% of parents report the occurrence of tinnitus in children. The percentage of children asked about tinnitus occurrence, by the interviewer during the school survey, reached 32.6%. The question addressed to parents was "Does your child complain of tinnitus when in quiet?" Parents were asked to indicate one of the possible answers: *never, rarely, often, very often*. On the day of the screening, children were asked: "Do you sometimes hear any noise, squeaks, buzzing or other sounds in your ears in a quiet environment?". Children could indicate one of the answers: *never, rarely, often, very often*. The answers: *very often, often* and *rarely* were considered positive (Raj-Koziak 2011). Based on this work, we can show that the result of the study depends on the qualification of the answer. Change of the qualification where only the answer *often* and *very often* will be treated as positive completely changes the outcome of the study and the prevalence of tinnitus reported by parents changes and decreases to 1.5% (earlier 13.65%). Whereas the tinnitus reported by children decreases to 5.8% (earlier 32.6%). Regarding the parents' responses, we did not ask who answered the survey (father or mother). We think it would be advisable to include in the subsequent testing additional information on the person who fills in the questionnaire (mother or father).

Tinnitus and hearing loss

Many researchers have found that tinnitus is more common in children with hearing loss than in children with normal hearing (19,26,30,45). Tinnitus is associated with both conductive and sensorineural hearing loss (Baguley and McFerran 2002). We also saw a statistically significant difference in the prevalence of tinnitus between children with normal hearing (3%) and those with hearing impairment (9%). Similarly, parents reported significantly more frequent tinnitus in children with hearing loss

(4.1%) than in children with normal hearing (1.4%), The more frequent reporting of tinnitus from parents of children with hearing loss may be due to the increased concern that their child may have another condition associated with hearing loss. At the same time, our findings need to be put alongside reports from other researchers that parents appear to have difficulty in identifying that their children have impaired hearing (Watkin, Baldwin, and Laoide 1990; Knobel and Lima 2012).

In our study tinnitus was reported less often by the children (and their parents) with moderate or severe hearing loss than by those with mild hearing loss; however, the difference was not statistically significant, and a relationship between tinnitus and the degree of hearing loss was not confirmed. Finally, our study shows the importance of performing hearing screening in school-age children, and for educating parents and caregivers about the symptoms of impaired hearing.

Limitations of the study

Our study is a retrospective analysis of data concerning tinnitus collected during the hearing screening of schoolchildren. The hearing screening program was conducted in all children in the sixth grade of primary schools in Warsaw. Until 2017, the sixth grade was the highest and last level of the Polish primary education system, after which graduates continued their education in lower secondary school. The health protection policy operated by Warsaw city authorities targeted this group of children. For this reason, our sample is not representative of schoolchildren of all ages. Another limitation of the study is a lack of follow-up data.

All Warsaw schools were invited to take part in the hearing screening, however only children of the parents who gave informed consent were examined. Audiological examination was conducted by certified and experienced audiologists, with calibrated equipment and in a controlled environment (in a quiet room, and was stopped when pupils had a break). These efforts were aimed at minimising bias in the study. The value of the study is that over 40,000 children were screened in a consistent way to detect potential hearing disorders; if necessary, they were referred for detailed audiological examinations.

Conclusion

Results of the study show that there is a need to introduce a routine question about experiencing tinnitus during paediatric check-ups. Particular attention should be paid in cases of children with hearing impairment because of the higher risk of comorbid tinnitus. Further management, if needed, should be conducted in appropriate paediatric settings by health care professionals who have the skills and knowledge to work with children.

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Statement of ethics

The study was conducted following the Declaration of Helsinki and was approved by the Research Ethics Committee (KB.IFPS:28/5/2018). Written consent was obtained from the children's parents.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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