

## Hearing Tests Combined with Noise Awareness Action in Elementary Schools

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### ABSTRACT

Exposure to loud music presumably affects hearing in youth. Results of our previous study in Slovenia showed that more than 12% of adolescent students might be at risk due to excessive listening to loud music and visiting concerts and clubs. Therefore we have explored our system for examination of hearing in youth as one of activities of health preventive program. We examined the results from 2001 to 2015, presenting nine Slovenian regions that were published in Health Statistics Yearbook. In order to raise awareness of possible hearing damage due to exposure to loud music and noise, we gave a questionnaire to students visiting a doctor for systematic hearing examination. The physician added data on testing method and hearing results. Three pilot studies were performed in two regions in order to test the procedure and to establish a common protocol. Participating in the study were 125 8th grade students, a generation of youth suitable for raising awareness on noise hearing damage.

### INTRODUCTION

There are several reasons why people listen to music. Schäfer et al. (2013) suggest three principal dimensions; to achieve self-awareness, social relatedness and to regulate arousal and mood. Music plays an important role in adolescents. Among several functions identified in music they mentioned emotions, friends, dancing, values, focus, venting and culture (Boer, 2009). With available portable music devices listening to music became an everyday habit for many adolescents.

In 2008 scientists draw attention to potential health risks of exposure to noise from personal music players (PMPs) and mobile phones. In their opinion, the sound level exceeding 89 dBA may represent the risk of hearing damage, when exposure to music is permanent – at least 1 hour per day for several years (SCENIHR, 2008). As listening to music is usually varies, it is hard to predict the risk. It is suggested that hearing loss, at least in case of occupational exposure, depends on noise energy (Burns and Robinson, 1970), meaning that in case of increase in noise level for 3 decibels, the exposure period should be halved to maintain the same level of safety. Based on lower exposure action values LEX, 8h = 80 dBA levels for safety exposure at work can be predicted (Directive 2003/10/EC). However, there is no

specific guidance for safety when listening to music using PMPs. Jiang et al. (2016) suggest that further research and better understanding of the relationship between daily recommendation of noise exposure and hearing problems in case of listening to music using PMPs is needed.

Adolescents prefer listening to loud music, which reflects their specific personalities and correlate to several psychological developmental aspects (Schwartz and Fouts, 2003, Vogel et al., 2007). The preferred listening level may be different, but to great extent depends on background noise (Jiang et al., 2016). Recent Brazilian study showed that significant exposure to amplified music is associated with alterations in otoacoustic emissions (OAE) (da Silva et al., 2017). Serra et al. (2014) suggest OAE detection and extended high frequency audiometry (EHFA) at 8.000–16.000 Hz should be used in addition to standard audiometry for early diagnosis of noise induced hearing loss (NIHL) and individual cochlear vulnerability to noise. Changes at frequencies above 8.000 Hz may be detected earlier and may predict later loss of hearing at lower frequencies. Apparently, good quality results that would demonstrate NIHL correlation to exposure to music and noise in adolescents are difficult to obtain on a larger scale. However, it is highly plausible that leisure noise can damage hearing in youth, therefore education and raising awareness is important in preventive health care (Twardella, 2013).

Among 1635 Slovenian students from 12 to 19 years old, 12.4% might be at risk of permanent hearing damage if they persist in frequent and extensive listening of loud music using PMPs (Jeram and Delfar, 2014). The weakness of this study was subjectivity in reporting of music listening habits, sound level settings and effects on hearing quality including tinnitus. Moreover, the results would maybe show higher risk if other sources of noise exposure were taken into consideration. For example, frequent users of PMPs that risk hearing damage, are also frequent visitors of various music events.

The aim of our study is to explore the system of preventive medical examinations in children and adolescents, including hearing tests and networking between medical and school personnel, in order to strengthen the awareness on noise hazards among adolescents, exposed to loud music in program "Music and hearing". Furthermore, we explore possibilities to introduce more sensitive methods into preventive medical system. In this way it could be easier to predict early stage hearing damage among students at risk.

## **METHODS**

### **Systematic preventive medical examinations for children and adolescents**

Hearing tests are performed according to national rules on preventive health care at the primary level through systematic preventive medical examinations for children and adolescents (Rules, 2015). Otoacoustic emission test is performed in infants. Screening whispering tests are used for pre-school children. In the first and eighth grade all students are given a hearing test – a whispered voice test or pure-tone audiometry. In the sixth grade hearing tests are given only to those children that had not been tested before or to students at risk, those that are exposed to loud noise at sport or other activities or had disease related to hearing quality (mumps, meningitis, ear infection ...). High school students undergo a hearing test only when at risk in first and third grade. Adolescents that are not involved in education programs are tested before age of eighteen.

We have examined existing database of the systematic preventive medical examinations in school children and adolescents for the time period from 2001 to 2012. The system to collect data has changed since 2013, so the comparison was no longer possible. Collected data are published in Health Statistical Yearbook under chapter Health Service for Schoolchildren and Youth (Health Statistical Yearbook, 2001–2012). Information about hearing disorders was

limited to identify damage in single or both ears. Details about the methodology, level of disorder (mild, moderate, severe or profound) or possible cause were not available. Therefore, we have explored possibilities to approach more detailed databases of systematic preventive medical examinations. The Speech and Hearing Center Portorož offered cooperation in offering their data for the period 2001–2015 for 13–14 years old students that were the focus of our “Music and hearing” study.

### **Participants involved in the “Music and hearing” program**

The study was made on students from two regions, Ravne na Koroškem and Koper. All students attend the 8th grade of elementary school and are 13–14 years old when they have the systematic preventive health check. 125 students participated from both regions.

### **Questionnaire**

The OHRKAN questionnaire (Twardella, 2010) was translated and slightly modified for the purpose of our study. 31 questions were aimed to explore students’ activities in relation to exposure to loud music when using PMPs, attending concerts and nightclubs, playing a musical instrument or exposure to noise from other leisure activities, like sport events and celebrations. Questionnaires were distributed to students by medical staff in a waiting room providing instructions and offering answers for clarification. Students filled in the questionnaire just before the systematic hearing test. Questions regarding the hearing ability were answered by the medical staff that performed the hearing test. Questionnaires were then collected by the staff from National Institute of Public Health.

### **Hearing tests for students in eighth grade**

The whispered voice test is most commonly performed at outpatient clinics as in case of Ravne na Koroškem. Only students in which hearing problems are identified are directed to more detailed audiological examination. In Koper region all students are tested with pure-tone audiometry (PTA) at Speech and Hearing Center. Hearing tests are performed with portable audiometer GSI 17 in a quiet room in a frequency range from 125 to 8.000 Hz. Students are using headphones for listening to test signals. Disabling hearing loss refers to loss greater than 30 dB at frequencies 500, 1.000, 2.000 and 4.000 Hz. Furthermore, noise notches are recorded at the same frequencies and additionally at higher frequencies of 6.000 and 8.000 Hz. When hearing loss is detected, students are further questioned and examined to identify the cause of hearing disability. Hearing disorders are classified as follows: mild hearing disorder (30–40 dB loss), moderate hearing disorder (41–60 dB loss), severe hearing disorder (61–90 dB loss) and profound hearing disorder (91–110 dB and > 110 dB loss). Students that use hearing devices are examined separately. Hearing notches (>30 dB loss) are examined with different frequencies and are also analysed separately.

### **Data analysis**

Data are presented with graphs and explanations. No statistical analysis was performed due to some uncertainties. At this stage of program our main purpose was to test the procedure and to develop a protocol for including the questionnaire in the systematic preventive medical examination. Networking with schools and medical centres was of great importance.

## Ethics

The participation of students was anonymous and voluntary. Parents or guardians agreed with the participation of their children in the study with a written consent. The study was approved by the Slovenian National Medical Ethics Committee at the Ministry of Health.

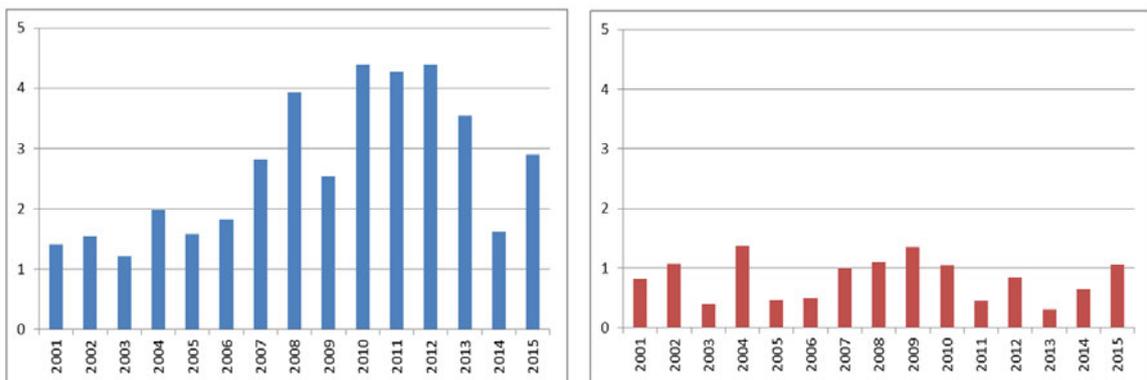
## RESULTS

### Systematic preventive medical examinations for children and adolescents

Data for the time period 2001–2012 were available for analysis. The number of all examined elementary school students in Slovenia decreased from 86.858 in 2001 to 69.149 in 2012. More than 95% of all students were examined in all Slovenian regions with few exceptions in three regions in 2005, 2008 and 2009. The lowest percentage was 84.4%. Hearing test results show that hearing disability was minimal (1.2%) in 2003 and 2004 and maximal (1.6 %) in 2007 when disability of one or both ears was considered the same. A higher percentage of hearing disability, up to 4%, was noticed only in one region. Details about the level of disorder or possible cause were not available. Because of many uncertainties regarding the methods and due to lack of details about the disability degree, these results should be interpreted with caution and are therefore not more precise.

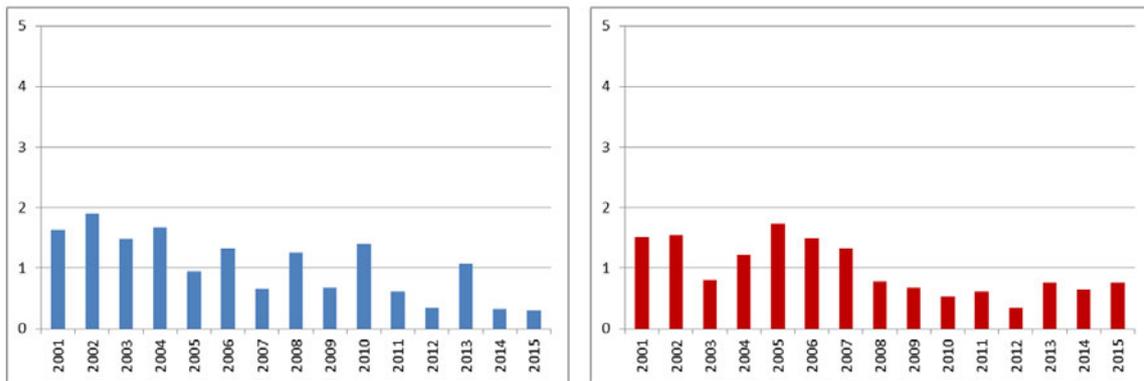
Database from the regional Speech and Hearing Center Portorož was more detailed and available for the period 2001–2015. The number of examined students was 855 in 2001 and 656 in 2015. All students were examined with pure-tone audiometry. Data were available for hearing disorders in separate ears and in both ears.

Detected hearing disorders present in separate ears and both ears together are presented in Figure 1. Mild hearing disorder was noticed in 1.2–3.9% of the students, moderate in 0.3–1.4% of the students and severe in 0–0.2% of the students. Profound hearing disorder was observed in 0.1% of the students in 2002 and 0.2% in 2007. Around 0.3% of students were using hearing devices.



**Figure 1:** Percentage of students examined with mild (left) and moderate (right) hearing loss in the time period 2001–2015

Hearing notches were mainly observed at 6.000 and 8.000 Hz in 2% of the students, which was the maximum. The decline in time can be observed so only at 0.3 % of students notches were detected at 6.000 Hz and at 0.8 % of them at 8.000 Hz in year 2015 (Figure 2). The percentage of students with the hearing notches declined in 2015; 0.3 % at 6.000 Hz and 0.8 % at 8.000 Hz.



**Figure 2:** Percentage of students examined with > 30 dB notch at 6.000 Hz (left) and 8.000 Hz (right) in the time period 2001–2015

### “Music and hearing” program

A network among our institute, schools and medical centers was established in two Slovenian regions; Ravne na Koroškem and Koper. The first pilot study was done in 2015 involving 27 and 35 students from each region respectively. The following year the second study was completed, with participation of 43 students from Ravne na Koroškem. The third study was done in Koper region and it involved 60 students from two schools. No hearing disorders were detected in students in the first study and only one student from the second study was found having a hearing disorder. No details were given for this disability.

Results of the first study showed that 12 among 62 students are often exposed to loud music. Half of them have already experienced ringing in the ears and seven of them are at risk of having a hearing damage if they continue with a habit of frequent exposure to loud music.

In the second study 11 students among 43 listen to the music using PMPs every day and 28 from 43 have already experienced ringing in the ears. Three students were exposed to music at such levels and durations that their hearing might be at risk.

The protocol presented in detail in Appendix 1 was established and discussed with teachers and medical staff and was based on the pilot studies experience. National Institute of Public Health coordinated the studies, providing materials and information to schools and medical centres. It also provided guidelines for students in order to understand precisely the role of them and the questionnaire in this study.

Recently we had our first presentation of the study results for students in Ravne na Koroškem. Students, teachers and medical staff involved in the study were present and active in discussions. It was interesting to observe the students react to the results and the fact that their behaviour in ordinary for their generation. The inclusion of the questionnaire in the systematic medical check was considered interesting and important and was not seen as inconvenient.

## CONCLUSIONS AND DISCUSSION

As expected, the present methodology of the systematic hearing tests in students in Slovenia is not detailed enough to detect hearing changes that would predict NIHL caused by frequent and prolonged exposure to music and leisure noise. Therefore, detailed analysis and interpretations were not performed at this stage. Nevertheless, we suggest that further knowledge and cooperation with students, their parents and teachers and health care centres is of great importance for prevention of hearing damages in adolescents.

It is known that hearing screening using self-report is not effective in identifying individuals with mild hearing loss and may underestimate the true prevalence of hearing loss (Feder et al., 2017). Changes detected with otoacoustic emissions precede the changes in audiometry and thus seem to be a more sensitive and precise method for detecting early cochlear damage due prolonged exposure to noise or music (Kotylo & Sliwiska-Kowalska, 2014). However, distortion product otoacoustic emission signal strength was discovered not to be sufficient in indicating the preclinical music induced hearing loss in adolescents with normal hearing. At this stage it is difficult to predict whether they will develop noise induced hearing loss in the future when exposed when exposed to it excessively (Colon et al., 2016). Nevertheless, it is recognised that hearing loss caused by recreational noise exposure represents a public health threat needing preventive strategies like educational campaigns for promotion of changes in behaviour of children and adults, avoiding and reducing exposure to noise and thus mitigating adverse health effects (Basner et al., 2014). It is also important to provide individuals with accurate information about peer group behaviours and peer beliefs as they often overestimate the volumes at which they believe their friends listene to music (Gilliver et al., 2012).

Even if noise induced hearing loss changes are difficult to detect in early stage, it is important to implement educational hearing conservation programs in schools. But the despite the numerous efforts, such programs often remain absent from school curricula. To address these problems, in 2002 Folmer and his co-workers suggested actions to raise public awareness about hearing and noise adverse effects and inform teachers in schools about hearing conservation programs and materials that can be used in classrooms (Folmer et al., 2002). Now several information and materials are available on Dangerous Decibels website ([dangerousdecibels.org](http://dangerousdecibels.org)). Educator source guide includes examples that we plan to use in our campaigns. Another interesting program called The Cheers for Ears was founded in Australia and showed to be effective in increasing knowledge on the harmful effects of noise and therefore in preventing future noise-induced hearing loss (Taljaard et al., 2013).

Our activities in “Music and hearing” program have shown that cooperation with students, teachers and medical staff is well accepted and has also been improved throughout several discussions. Therefore, our main focus at the moment is education of adolescents and rising public awareness about environmental noise hazards including leisure noise and music. We have prepared several promotional materials, from flayers to posters, that were published on our website and distributed at several campaigns at schools and at the International Noise Awareness Day. The translated picture book *Good that you have ears! Good that you can hear!* (Neyen, 2001) was well accepted at kindergartens and lower grades of elementary schools.

As presented in this paper, we have started the “Music and hearing” program to join efforts for further activities, to act together with schools and medical centres to improve hearing testing for students that are at risk because of their extreme passion of listening to music excessively. We want to promote the engagement of adolescents in music but also wish to warn them, in order to protect and save their hearing, so they can enjoy music at its best for as long as possible.

Furthermore, we plan to follow the students, who were involved in our program, so that they could be tested for their hearing abilities again at the age of 17–18. We would also like to explore options of including several test methods that would allow the detection of early stage hearing changes caused by leisure noise and music exposure. At least for students with higher risks for NIHL as predicted from their listening habits.

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# APPENDIX 1

## STUDY PROTOCOL

- National Institute for Public Health (NIJZ) prepares all documentation needed in the study: a questionnaire, form for parents' consent, correspondence for schools and medical centre.
- NIJZ selects the school, according to possibilities regarding the staff available at certain region.
- NIJZ informs schools of intention to perform the study and consults them by phone, e-mail or personal contact.
- If the school confirms the interest of cooperation, NIJZ prepares an official invitation, addressed to the school principal.
- When a school officially confirms its participation, NIJZ consults a health center, which carries out systematic examination of hearing for the corresponding school.
- When the invited health centre confirms the cooperation, NIJZ obtains further information on planned systematic medical examination (dates and places of examinations etc.).
- NIJZ informs the school about the agreement of the health center and asks the school for further information on the number of students involved in the systematic hearing examination and the authorised person from school.
- NIJZ prints the appropriate number of questionnaires for students and forms for parents to confirm their agreement for their children to participate in the study.
- NIJZ sends forms for parents to the school and questionnaires for students to the health center. The materials can be sent by mail or delivered in person.
- Students hand out forms to parents and ask for approval of their participation. Signed forms are recollected at school and handed over to NIJZ where they are archived.
- Only students whose parents approved their participation are involved in the study.
- The following step is the visit of students at the health centre.
- The staff of the health centre distributes the questionnaires to the students in the lobby and presents the purpose and guidelines for the survey.
- Students complete the questionnaire and hand it over to the doctor at the time of the hearing examination.
- The doctor completes the questionnaire with the data on the method of examination and the hearing test outcome.
- Completed questionnaires are collected by the health centre staff and then handed to NIJZ.
- Data are analysed by NIJZ.
- NIJZ provides feedback information to the health centre and the school by sending them the report and leaflets for students with information on study results and guidelines for detection of hearing problems and protection from permanent damage.
- NIJZ thanks the school and medical centre for cooperation and organises the presentation of study results for students and staff involved.
- NIJZ reports and education materials are published on the institute website.