ISSN 0137-5075 (print)
ISSN 2300-262X (online)

PAN POLISH ACADEMY OF SCIENCES
INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH
COMMITTEE ON ACOUSTICS • POLISH ACOUSTICAL SOCIETY

ARCHIVES of ACOUSTICS

QUARTERLY

Vol. 38, No. 2, 2013

WARSZAWA

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QUARTERLY, Vol. 38, No. 2, 2013

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PRINTED IN POLAND

Indexed and abstracted in Science Citation Index Expanded (also known as SciSearch®)
and Journal Citation Reports/Science Edition
Abstracted in Acoustics Abstracts, in Applied Mechanics Reviews
and indexed in Journal of the Acoustical Society of America
Recognised by the International Institute of Acoustics and Vibration, I IAV

Edition co-sponsored by Ministry of Science and Higher Education

Arkuszy wydawniczych 22 Arkuszy drukarskich 17,5
Skład i łamanie w systemie TEX: Dział Wydawnictw IPPT PAN

ARCHIVES OF ACOUSTICS
Vol. **38**, No. 2, pp. 259–264 (2013)

DOI: 10.2478/aoa-2013-0031

Noise Exposure of School Teachers – Exposure Levels and Health Effects

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(*received March 20, 2013; accepted May 2, 2013*)

Faculty of Natural and Technical Sciences and Faculty of Medical Sciences starting from December 2012, launched joint study in order to investigate personal noise exposure and associated health effects in general school teachers population, starting from kindergartens up to high schools in Stip, Macedonia.

In order to determine workplace associated noise exposure and associated health effects in this specific profession, a full shift noise exposure of 40 teachers from 1 kindergarten, 2 primary and 2 high schools were measured in real conditions using noise dosimeters.

A-weighted equivalent-continuous sound pressure levels (L_{Aeq}) of each teacher were recorded during single activities (classes). Normalized 8-hours exposure, termed the noise exposure level ($L_{ex,8\,\mathrm{h}}$) was also computed. Daily noise dose is another descriptor for noise exposure that was determined as a measure of the total sound energy to which workers have been exposed, as a result of working in the varying noise levels.

Health effects were assessed trough a full scale epidemiological study which included 231 teachers from the same schools. Specific questionnaire was used to extract information about subject's perception on occupational noise exposure, as well as theirs occupational and medical history.

Keywords: teachers, school, noise, exposure, health effects.

1. Introduction

Noise, one of the most widespread occupational hazardous agents, contributes to 16% mortality and morbidity due to the global burden of occupational diseases and injuries (Alberti, 1998). Noise in schools is also a harmful factor that affects the hearing organs of the pupils and teachers and disturb the speech reception and comprehension (Bradley, Sato, 2008; EN ISO 9921 (European Committee for Standardization [CEN], 2003, p. 18; Kreisman *et al.*, 2010). This may cause some irritation of both the teachers and pupils, tiredness, lack of concentration and consequently a deterioration of the teaching and learning processes (Augustynska, Radosz, 2009a; 2009b; Koszarny, 1992; Koszarny, Gorynski, 1990).

According to the report of the European Agency for Safety and Health at Work (2009) a safe and healthy school, which ensures a secure environment for the pupils as well as the safety and health of the teachers, is one of the main aims of membership countries of the European Union. Also the World Health Organization [WHO] report, Guidelines for Community Noise, (WHO,1999, p. 21) clearly indicate that noise-induced hearing loss (NIHL) is the most prevalent irreversible occupational hazard.

Exposure to excessive noise is one major cause of hearing disorders. It has been estimated that worldwide as many as 500 million individuals might be at risk of developing noise-induced hearing loss (Nelson *et al.*, 2005). Prolonged exposure to noise at high intensity is associated with damage to the sensory hear cells of the inner ear and development of permanent hearing threshold shift, as well as poor speech in noise intelligibility (Mikulski, Radosz, 2011; IEC 60268-16 (International Electrotechnical Commission [IEC], 2003, p. 15). There is also evidence that noise exposure frequently leads to tinnitus which might be due to alterations in the central auditory function (Nelson *et al.*, 2005). In the adult population it may significantly influence quality of life, and constitute a major limitation in relation to hearing-critical jobs, decreasing the potential worker's chance of employment. Thus, NIHL not only affects health, but is also a major social problem.

2. Aim of the paper

The objective of this study was to determine noise exposure and associated health effects in school teachers from kindergartens, primary and high schools in Republic of Macedonia.

3. Methods and materials

This paper presents cross-sectional study conducted from 01 of December 2012 until 31 of January, 2013. Full-day measurements of noise exposure were performed during 40 working days, in winter period when most of the children stay inside even on breaks. Health effects were assessed trough a full scale epidemiological study which included 231 teachers from the same schools.

In order to assess workplace noise exposure and associated health effects (irreversible hearing damage, psychological and physiological adverse effects) in this specific profession, a full shift noise exposure of 40 teachers from 1 kindergarten, 2 primary and 2 high schools were measured in real condition using, ER-200D Personal Noise Dosimeter (Fig. 1a) and Extech Sound Level Dataloger (Fig. 1b).

a) b)

Fig. 1. a) ER-200D Personal Noise Dosimeter,
b) Extech Sound Level Dataloger.

The default settings used by the ER-200D for calculation of noise dose are consistent with ANSI S1.25–1991 (R2002), ISO-1999 Specification for Personal Noise Dosimeters, and NIOSH Criteria for a Recommended Standard (NIOSH, 1998).

Default settings are:

- Exchange rate: 3 dB,
- Criterion level: 85 dB,
- Threshold level: 75 dB.

Dynamic range of dosimeter is 60 dB (70–130) dB. Dose values are obtained every 220 msec, summed over a 3.75 minute interval and saved in non-volatile memory every 3.75 minutes (16 times during one hour). At the end of measurement, equivalent noise exposure level for measurement period in dB(A), dose value in % and graphical display of dose exposure for the measurement period are received.

The A-weighted equivalent-continuous sound pressure level (L_{Aeq}) measured in dB of each teacher was recorded in classrooms, during various courses and lessons, in corridors (during pauses) and at the sports halls. A-weighted equivalent-continuous sound pressure level was measured following the procedures stated in the International Standard ISO 9612:2009, Acoustics – Determination of occupational noise exposure – engineering method (full-day measurement), sound pressure level was measured continuously over complete working days.

Normalized 8-hours exposure, termed the noise exposure level ($L_{ex,8\,\mathrm{h}}$) was also computed by the equation according to ISO 9612-2009:

$$L_{ex,8\,\mathrm{h}} = L_{Aeq,T_e} + 10\log_{10}\frac{T_e}{T_0} \quad \mathrm{dB(A)}, \tag{1}$$

where L_{Aeq,T_e} is the A-weighted equivalent continuous sound pressure level for T_e; T_e is the effective duration, in hours, of the working day; T_0 is the reference duration, $T_0 = 8$ h.

Daily noise dose was determined as a measure of the total sound energy to which a workers have been exposed, as a result of working in the varying noise levels.

Health effects were assessed trough a full scale epidemiological study which included 231 teachers from the same schools. Specific questionnaire was used to extract information about subject's perception on occupational noise exposure, as well as theirs occupational and medical history.

The epidemiological study of teachers has been conducted with questionnaires which contained questions about personal (demographic) data, characteristic of working conditions (general assessment of the working conditions, consequences and noticeable ailments arising from noise, subjective assessment of noise annoyance and the general assessment of the healthy state (subjective feelings and ailments and how often they appear). The examinations have been performed anonymously and in accordance with all the rules concerning the protection of personal data.

Both descriptive and analytical epidemiological methods were applied in the analysis of the parameters.

4. Results and discusion

Table 1 summarize the results of teachers' personal noise exposure in the examined schools (1 kindergarten, 2 primary and 2 high schools), recorded by Personal Noise Dosimeters, providing the mean value of the measured L_{Aeq}, mean value of calculated $L_{ex,8\,\mathrm{h}}$, exposure time of teachers and dose per type of school. Mean, standard deviation and range were calculated for the activities of each school. Results in Table 1 shows that the daily personal noise level exposure of teachers in examined schools does not exceed the limits in accordance with the Macedonian Occupational Health and Safety Regulations for employees exposed at noise risk (Official Gazette of Republic of Macedonia, No. 21/08), but still quite close to them (especially the exposure of teachers in the kindergarten). Macedonian Occupational Health and Safety Regulations for employees exposed at noise risk specifies that the maximum daily 8-hour exposure level should not exceed 85 dB(A) assuming that for the rest of the day the teacher is not exposed to loud noise (Patricia, Niquette, 2009). This criterion is also used by the National Institute for Occupational Safety and Health [NIOSH], American Conference of Governmental Industrial Hygienists [ACGIH] and the International Organization for Standardization [ISO].

Table 1. Results of teachers' Personal Noise Exposure in examined schools.

Type of school	Exposure time (hours)	Mean L_{Aeq} [dB]	Mean $L_{ex,8\,\mathrm{h}}$ dB(A)	Standard deviation	Range	Dose [%]
Kindergarten	7	80.4	78.8	2.5	77–85	23
Primary	6	79.8	78.6	3.1	75–84	22
High	6	78.7	77.5	2.8	74–83	19

Recorded results by Extech Sound Level Dataloger shows high noise levels present in classrooms during classes, corridors during pauses, sport halls in primary and high schools, as much as during almost all activities in kindergarten. A-weighted equivalent continuous noise levels are in wide range from 53.5 to 100.3 dB, depending of activities. In primary schools, A-weighted equivalent continuous noise levels are slightly higher in integrated teaching classes (grade I–IV) than in higher grades. A-weighted equivalent continuous noise levels in classes are defined as equivalent teacher's speech level and background noise, i.e. noise transmitted into classrooms from all external sources or interactive teaching (Augustyńska *et al.*, 2010). Two years noise monitoring and noise measurements outside of examined school buildings show exterior A-weighted equivalent continuous noise levels of 58.3 – 62.5 dB(A). Exterior noise can also affect background noise in classrooms with opened windows and therefore teachers use raised voice (Bronder, 2003). According to EN ISO 9921 (European Committee for Standardization [CEN], 2003, p. 20], teacher's voice effort is considered normal if the voice A-weighted sound pressure level, measured from a distance of 1 meter from the mouth of the speaker, equals 60 dB; voice is considered raised if that level has a value of 66 dB.

Measurements have shown that corridors in primary and high schools during pauses and lunch rooms during the lunch break in kindergartens are the loudest places. A-weighted equivalent continuous noise levels are 83.3 dB and 84.7 dB, respectively, and the peak level is 107.9 dB. Teachers supervising children during pauses and in lunch rooms during the lunch break in kindergartens are especially exposed to such noise levels. During lessons, the noise in all schools' corridors is significantly lower. The A-weighted equivalent continuous noise level ranges from 50.4 to 64.3 dB.

Sports halls during physical education classes are also considered as loud places. A-weighted equivalent continuous noise levels measured on these places are 79.2–81.7 dB.

Teachers' rooms are considered relatively quiet during classes. In teachers' rooms, the A-weighted equivalent continuous noise levels during pauses range from 63.9 to 75.2 dB. During classes, they are adequately lower at 46.3 dB and 48.9 dB.

In order to estimate presence of subjective and objective health problems that occur as a consequence of workplace noise exposure, 231 teachers were surveyed. 29 (N1) of the teachers were from kindergartens, 118 (N2) were from primary schools and 84 (N3) from high schools. In order to see if there are any statistically significant differences between the three examined groups according to numerical variables of interest (age / years, length of service/years and working hours), it is implemented one-way ANOVA (F). If ANOVA shows that there are significant differences, the differences between the three examined groups have been tested separately with post hoc – Tukey HSD Test. For testing the significance of differences between the three examined groups according to the attributive variable of interest (gender, hearing problems, headaches, dizziness, anxiety / tension, diagnosed hearing impairment and elevated blood pressure) it is applied Kruskal–Wallis Test (H), and the differences between the three examined groups have been tested separately with Mann–Whitney U Test.

Table 2 shows distribution of the examinees according to curtain demographic variables. Regarding to the gender, there are significant differences be-

Table 2. Distribution of examinees according to demographic variables.

Variables	Kindergartens ($N = 29$)	Primary schools ($N = 118$)	High schools ($N = 84$)	ANOVA
Gender	$m = 1$ (3.4%) $f = 28$ (96.6%)	$m = 38$ (32.2%) $f = 80$ (67.8%)	$m = 14$ (16.7%) $f = 70$ (83.3%)	$H = 13.59$ $p = 0.0011$
Age / years	47.1±10.4	55.6±8.9	44.0±10.9	$F = 1.22$ $p = 0.2971$
Length of service / years	20.6±14.7	18.7±10.2	170±11.1	$F = 1.24$ $p = 0.2892$
Working hours	6.93±0.75	6.21±1.05	6.05±1.12	$F = 8.029$ $p = 0.0004$

tween the three examined groups (Kruskal–Wallis Test: $H = 13.59$, $p = 0.0011$). Expectedly, women are considerably more represented compared to men, especially in kindergartens and in high schools. Teachers in the kindergartens were in an average age of 47.1±10.4 years, in the primary schools the average age was 55.6±8.9 years, while in the high schools 44±10.9 years. According to the age, there are no significant differences between the three examined groups (one-way ANOVA: $F = 1.22$, $p = 0.2971$). According to the average years of work experience there is also insignificant statistical difference between the teachers (one-way ANOVA: $F = 1.24$, $p = 0.2892$). Regarding to the daily working hours between the three examined groups were noticed meaningful differences (one-way ANOVA: $F = 8.029$, $p = 0.0004$). Kindergarten teachers are working noticeably longer then primary school teachers (post hoc – Tukey HSD Test: $p = 0.017$) and high school teachers (post hoc – Tukey HSD Test: $p = 0.0002$). Primary and high school teachers have same working time which means they are exposed in a workplace noise at the same time ($p = 0.5851$).

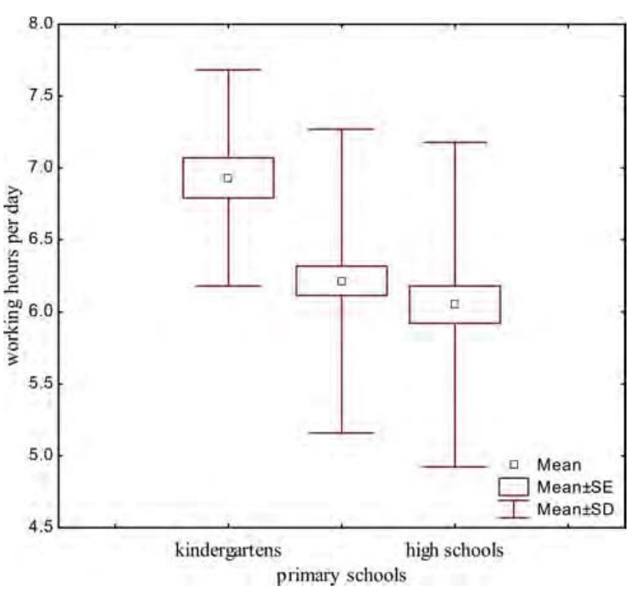

Fig. 2. Mean values of working hours per day.

Anamnestically hearing impairment (hearing loss, tinnitus, clogged ears) was confirmed by 6 (20.7%) of kindergarten teachers, 22 (18.6%) of primary school teachers and 9 (10.7%) of teachers from high schools – the differences are not statistically significant (Kruskal–Wallis Test: $H = 3.108$, $p = 0.2113$). According to the appearance of headache, there are statistically significant differences between the three examined groups (Kruskal–Wallis Test: $H = 7.422$, $p = 0.0245$). Primary school teachers complain about headache more often than high school teachers (Mann–Whitney U Test: $Z = 2.195$, $p = 0.0280$). Differences between kindergarten and primary school teachers ($p = 0.3102$) and differences between kindergarten and high school teachers ($p = 0.6142$) are not meaningful.

Temporary dizziness was confirmed by 9 (31%) of kindergarten teachers, 26 (22%) of primary and 12 (14.3%) of the high school teachers and the differences are not significant (Kruskal–Wallis Test: $H = 3.737$, $p = 0.1543$).

The biggest percent of the primary school teachers (52%) showed anxiety and tension after work. However, the differences according to this parameter are not meaningful ($H = 5.809$, $p = 0.0584$).

Medical documentation for objective hearing impairment and hearing loss was registered in 10.3% of the kindergarten teachers, 7.6% primary school teachers and in 3.6% of the high school teachers. The differences are not statistically significant ($H = 3.102$, $p = 0.2120$).

Higher blood pressure was registered in 34,5% of the kindergarten teachers, 20.3% of the primary school teachers and 19% of the high school teachers. The differences are not significant ($H = 2.757$, $p = 0.2519$).

Of the total number of examinees ($N = 231$), subjective and objective hearing impairment were noticed in 4 cases among people up to the age of 45 and in 33 cases among people over the age of 45. There is a strong correlation between the age of the teachers, i.e. the duration of the workplace noise exposure and the occurrence of the hearing impairment (Fisher exact test: $p = 0.00001$).

Table 3. Distribution of examinees according to subjective (anamnestic) health problems.

Variables	Kindergartens ($N = 29$)	Primary schools ($N = 118$)	High schools ($N = 84$)	ANOVA
Hearing problems	yes = 6 (20.7%) no = 23 (79.3%)	yes = 22 (18.6%) no = 96 (81.4%)	yes = 9 (10.7%) no = 75 (89.3%)	$H = 3.108$ $p = 0.2113$
Headaches	yes = 8 (27.6%) no = 21 (72.4%)	yes = 50 (42.4%) no = 68 (57.6%)	yes = 22 (26.2%) no = 62 (73.8%)	$H = 7.422$ $p = 0.0245$
Dizziness	yes = 9 (31.0%) no = 20 (69.0%)	yes = 26 (22.0%) no = 92 (78.0%)	yes = 12 (14.3%) no = 72 (85.7%)	$H = 3.737$ $p = 0.1543$
Anxiety / tension	yes = 12 (41.4%) no = 17 (58.6%)	yes = 64 (54.2%) no = 54 (45.8%)	yes = 33(39.3%) no = 51 (60.7%)	$H = 5.809$ $p = 0.0584$

Table 4. Distribution of examinees according to objective health problems.

Variables	Kindergartens ($N = 29$)	Primary schools ($N = 118$)	High schools ($N = 84$)	ANOVA
Diagnosed hearing impairment	yes = 3 (10.3%) no = 26 (89.7%)	yes = 9 (7.6%) no = 109 (92.4%)	yes = 3 (3.6%) no = 81 (96.4%)	$H = 3.102$ $p = 0.2120$
Elevated blood pressure	yes = 10 (34.5%) no = 19 (65.5%)	yes = 24 (20.3%) no = 94 (79.7%)	yes = 16(19.0%) no = 68 (81.0%)	$H = 2.757$ $p = 0.2519$

5. Conclusion

A-weighted equivalent continuous noise levels measured in classrooms, teacher rooms, corridors and sport halls are in the range of 58–88 dB and they exceed guideline values for community noise in specific environments, Guidelines for Community Noise (WHO, 1999, p. 47). High noise levels caused by the children activities especially in the corridors during pauses and in sports halls of primary and high schools often leads A-weighted equivalent noise level to exceed 80–90 dB.

High exterior noise levels (55–65 dB) in schools surrounding, also contribute to noise level in classrooms which often exceed 40 dB established as limit of the environmental noise level in Regulations for limits of the environmental noise levels (Official Gazette of Republic of Macedonia, No. 147/08) for a correct speech reception, thus forcing teachers to raise their voice. It can lead to the development of an occupational disease – chronic voice disorders due to excessive vocal effort (Bronder, 2003). The noise levels in classrooms during classes are within the limits of 53–79 dB, depending on the type of classes and activities performed.

Health consequences caused by workplace noise exposure between the teachers from the three examined groups are evidential and serious. Noise actually is causing not only medical, but socio-economical problems as well. Hearing impairment / hearing loss, dizziness, elevated blood pressure, headache and anxiety affects the social life of the teachers, their families and the people in their surrounding.

Data collected clearly indicate the need of immediate protective actions, as much as further investigations of this problem.

Acknowledgment

The paper will be presented during the 16th International Conference on Noise Control 2013.

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