SUBJECTIVE SENSITIVITY TO NOISE AND NON-AUDITORY HEALTH EFFECTS AMONG ADULTS IN NIŠ, SERBIA

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SUMMARY

Objective: The aim of this study was to examine subjective sensitivity to noise of the citizens of Niš and its impact on their non-auditory health effects.

Methods: This study was designed as a cross-sectional questionnaire survey among 908 adult residents of Niš, Serbia, of whom 387 were men (42.6%) and 521 women (57.4%). Streets with day $L_{eq} \geq 55$ dB(A) and night $L_{eq} \geq 45$ dB(A) were regarded as noisy and those with day $L_{eq} \leq 55$ dB(A) and night $L_{eq} \leq 45$ dB(A) were regarded as quiet, in accordance with WHO recommendations. Noise sensitivity was measured with the Weinstein's Noise Sensitivity Scale. Logistic regression analysis was used to assess the impact of noise sensitivity on non-auditory health effects.

Results: The study showed that the values of the Weinstein's Noise Sensitivity Scale were significantly higher for those surveyed in the noisy zone. Multiple regression analysis revealed a significant impact of noise sensitivity on night-sleep duration ($p = 0.04$), subjective assessment of sleep quality ($p < 0.01$) and daily rest disruption ($p < 0.001$).

Conclusion: Based on the study results, it can be confirmed that noise sensitivity has an important role in causing non-auditory health effects among adults.

Key words: adults, noise, noise sensitivity, health effects

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INTRODUCTION

Community noise can be considered as one of the main sources of pollution (1). The level of community noise is one of the indicators of environmental quality. Research data show that every year the noise level in noisy urban residential areas increases by 1 dB(A), and that the majority of the city population is exposed to noise levels over 50 dB(A) (2). These levels are not high enough to cause hearing damage, but they can cause a whole series of non-auditory health effects in the exposed population, including annoyance, cognitive impairment, sleep disturbance, and cardiovascular diseases (3).

The effects of noise exposure depend primarily on the characteristics of noise, frequency, intensity, exposure time, and also on subjective sensitivity to noise (4, 5). Noise sensitivity is a stable personality trait, reflected in the individual's attitude towards the source of noise (6, 7) and represents a decisive predictor of the degree of disturbance in relation to community noise. People who are sensitive to noise do not hear sounds better than non-sensitive people (8). Their response time to sounds is also not different from the response time of the insensitive people. People who are sensitive to noise do not receive sound as louder (9). However, they pay more attention to noise and its sources, respond more intensely to sudden noise, more often they experience noise as threatening and dangerous, and emphasize that they have less control over noisy situations than people who are not sensitive to noise. Because of that, subjective sensitivity to noise is highly correlated with harmful effects of noise: sleep disorders, behaviour change, cardiovascular diseases, psychological symptoms, etc. The results of many studies (10–13) show that if a person is more sensitive to noise, the non-auditory effects of noise are more frequent.

The aim of this paper was to examine subjective sensitivity to noise of the adult residents of Niš, Serbia, and its impact on their non-auditory health effects.

MATERIALS AND METHODS

Noise Measurements

Traffic noise was measured at six sites in the centre of Niš, of which three were in the busiest streets of the city and three in quiet side streets. Measurements were done with a Brüel and Kjær noise level analyser type 4426 in accordance with Serbian and ISO noise regulations (14, 15).

The total number of samples was 9,000 with a period of sampling 0.1 s in a fast dynamic range during three day-time (9 a.m. to noon, 1 p.m. to 4 p.m. and 5 p.m. to 8 p.m.) and two night-time

intervals (10 p.m. to 1 a.m. and 2 a.m. to 5 a.m.). Streets with day $L_{eq} \geq 55$ dB(A) and night $L_{eq} \geq 45$ dB(A) were regarded as noisy and those with day $L_{eq} \leq 55$ dB(A) and night $L_{eq} \leq 45$ dB(A) were regarded as quiet, in accordance with WHO recommendations (16) and Serbian regulation on noise in residential areas (14).

Study Design

This study was designed as a cross-sectional questionnaire survey among residents of the centre of a Serbian city of Niš with about 253,000 inhabitants, which makes it the third largest city in the country. A total of 3,000 questionnaires were distributed to residents of three busy streets and three quiet side streets, who served as control. The number of distributed questionnaires corresponded to the number of adult dwellers in each flat. The residents were asked to fill out the questionnaires by the next day when these were collected.

The criteria for inclusion of persons in the research were age between 18 and 80 years and the period of residence in the given apartment is not shorter than a year. The exclusion criterion was exposure to noise at work and hearing loss.

Of the 3,000 distributed questionnaires, 1,063 were completed (35.4%), but when applying exclusion criteria, the study included 908 participants, of whom 387 (42.6%) were men and 521 (57.4%) women, 461 participants lived in noisy streets and 447 participants in quiet streets.

Questionnaire

The first part of the questionnaire was related to general demographic data, age, gender, material status, education, and employment.

In the sleep section of the questionnaire, the participants were asked about their average duration of night sleep, difficulties in falling asleep (1 – not at all, 2 – generally no, 3 – generally yes, 4 – very much), their average time to fall asleep, average number of night awakenings, subjective assessment of sleep quality (1 – very bad, 2 – bad, 3 – changeable, 4 – good, 5 – excellent), tiredness after sleep (1 – very tired, 2 – tired, 3 – changeable, 4 – rested, 5 – completely rested), use of sleeping pills (1 – every day, 2 – several times a week, 3 – several times a month, 4 – rarely) and whether residents kept bedroom windows open at night in the summer.

In the third part of the questionnaire, the participants were asked about the psychological symptoms that could be associated to noise exposure: headache, feeling depressive moods, nervousness, frequency of their occurrence, use of analgesics and sedatives (1 – rarely or never, 2 – once a week, 3 – more than once a week, 4 – every day), as well as the frequency of visiting psychologists or psychiatrists (1 – never, 2 – rarely, 3 – sometimes, 4 – regularly).

The fourth part of the questionnaire contained questions related to the degree of noise disturbance during regular daily work (1 – does not disturb me, 2 – disturbs me, 3 – disturbs me very much).

Noise Sensitivity Assessment

To assess sensitivity to noise, the questionnaire included 21 questions, where the answers were scored using the original Weinstein's Noise Sensitivity Scale (6). This scale has already proven to have satisfactory psychometric properties, that is, reliability, internal consistency, factor structure, and construct validity (17). A person with a score of 60 or more was considered noise sensitive.

Statistical Analysis

We used Student's t-test to compare the values of noise as well as the means of age and time spent in their apartment every day, between the two independent samples of residents from the noisy and the quiet area, and between male and female. Mann-Whitney U test was used to compare values: apartment size, period of residence and sensitivity to noise between two groups. Categorical variables are compared using Pearson's chi-square test. Logistic regression analysis was used to assess the impact of noise sensitivity on non-auditory health effects. All statistical analyses were performed using standard program for processing data such as Excel and software package SPSS in version 16.0.

RESULTS

Noise measurements showed that the average night L_{eq} was significantly higher in noisy streets than in quiet streets (61.33 ± 2.31) dB(A) vs. (43 ± 3.46) dB(A), respectively; $p < 0.05$, Student's t-test, as well as average day L_{eq} (64.33 ± 2.18) dB(A) vs. (49.62 ± 2.31) dB(A), respectively; $p < 0.05$, Student's t-test (Table 1).

A comparison of demographic data between the groups showed that noisy area residents were four years older on average, enjoyed fewer square metres of the living area per tenant, and fewer of them had only elementary school education compared to the quiet area residents (Table 2).

There was no statistically significant difference in the distribution of noise sensitivity score by age categories ($\chi^2 = 2.792$; $p = 0.425$). In the overall age group, more than 50% of residents were sensitive to noise (Table 3).

Also, in the sample as a whole, high values of the Weinstein's Noise Sensitivity Scale were determined. The mean values were significantly higher in subjects from the noisy zone ($p < 0.001$). Regarding gender differences, no significant difference was found in the noisy environment. In a quiet zone, men had significantly higher values than women (Table 4).

The values of the Weinstein's Noise Sensitivity Scale increased with the age of the residents (Fig. 1).

Noisy area residents needed more time to fall asleep, woke up more often at night, consumed sleeping pills more often, and kept the windows open in the summer less often than quiet area residents. Sleep quality showed that noisy area residents assessed their sleep more frequently as bad ($\chi^2 = 40.54$; $p < 0.001$) whereas

Table 1. *Noise characteristics of investigated areas in Niš*

Measurement parameters	Noisy area	Quiet area	p-value
L_{eq} (dB(A)) day	64.33 ± 2.18	49.62 ± 2.31	< 0.05
L_{eq} (dB(A)) night	61.33 ± 2.31	43 ± 3.46	< 0.05

Table 2. *Basic demographic data about noisy and quiet area residents (N = 908)*

Variable	Noisy streets (n = 461)	Quiet streets (n = 447)	p-value
Age (years), mean (SD)	45.00 (16.32)	41.71 (13.64)	< 0.01*
Males (%)	44.10	41.10	> 0.05#
Apartment size (m^2 per tenant), mean (SD)	63.28 (18.31)	77.67 (30.18)	< 0.01$
Period of residence (years), mean (SD)	17.89 (13.03)	17.92 (11.64)	> 0.05$
Daily time spent in apartment (h), mean (SD)	14.45 (3.44)	14.45 (3.44)	> 0.05*
Education (%)			
Elementary	1.9	4.9	< 0.05#
Secondary	59.8	58.3	
Higher	10.8	13.4	
University	27.4	23.4	

*Student's t-test; #Pearson's chi-square test; $Mann-Whitney U-test; noisy area: day L_{eq} ≥ 55 dB(A) and night L_{eq} ≥ 45 dB(A); quiet area: day L_{eq} ≤ 55 dB(A) and night L_{eq} ≤ 45 dB(A).

Table 3. *Noice sensitivity distribution according to age groups*

Score/years	≤ 30 n (%)	31–45 n (%)	46–60 n (%)	≥ 60 n (%)
≤ 60	56 (28.9)	98 (29.1)	72 (32.9)	56 (35.2)
> 60	138 (71.1)	239 (70.9)	147 (67.1)	103 (64.8)
Total	194 (100.0)	337 (100.0)	219 (100.0)	159 (100.0)

Table 4. *Mean values of Weinstein's Noise Sensitivity Scale by gender*

Area	Male		Female		Total		p-value
	n	mean (SD)	n	mean (SD)	n	mean (SD)	
Noisy	204	87.89 (17.33)	257	86.80 (17.87)	461	87.28 (17.63)	> 0.05
Quiet	183	82.62 (15.01)	264	77.61 (23.06)	447	79.66 (20.29)	< 0.05
Total	387	85.40 (16.47)	521	82.14 (21.15)	908	83.53 (19.35)	< 0.05
p-value	< 0.05		< 0.001		< 0.001		

15.1% of noisy area residents reported tiredness after sleep, in comparison with 6.0% from quiet streets ($\chi^2 = 52.65$; $p < 0.001$). The subjects living in the noisy areas reported feeling depressed ($\chi^2 = 8.75$; $p = 0.03$) and nervous ($\chi^2 = 12.43$; $p = 0.006$) more frequently than those living in the quiet parts of the city. There was no difference in the occurrence of headache in the subjects of both groups as well as the use of analgesics and sedatives. However, the subjects living in the noisy areas turned to psychologists or psychiatrists more frequently than subjects living in the quiet parts of the city ($p = 0.04$). The subjects who lived in noisy areas were most disturbed during the daily rest (59.2%) and mental work (43.9%), and slightly less during conversations, watching TV and reading. A large number of examinees from the control group estimated that they do not mind noise in their daily activities.

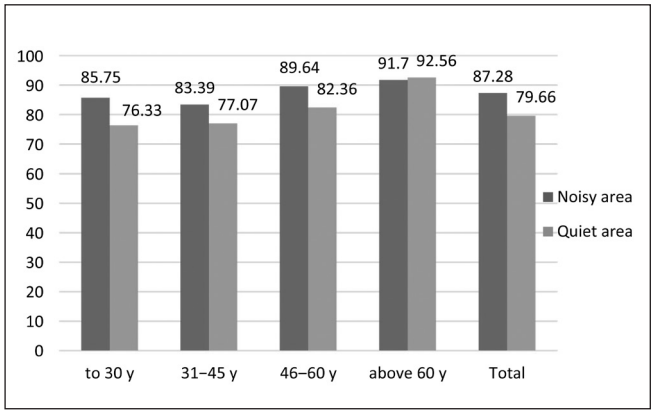

Fig. 1. *Mean values of Weinstein's Noise Sensitivity Scale by age groups.*

After assessing the risk of the consequences occurring due to noise sensitivity, as independently variable in logistic regression model adjusted for age, gender and residential area, statistical analysis revealed a significant impact of noise sensitivity on night-sleep duration, subjective assessment of sleep quality and daily rest disruption (Table 5).

DISCUSSION

Our study showed that a large number of residents of the city of Niš (more than 50%) in both zones (noisy and quiet) had a

Weinstein's Noise Sensitivity Scale score greater than 60, that is, a large number of residents were generally sensitive to noise. Similar results were obtained by a group of scientists from Belgrade, who found that the subjective sensitivity to noise equally occurs in residents exposed to higher noise levels ($L_{eq} > 65$ dB(A)) and in residents exposed to lower noise levels ($L_{eq} < 55$ dB(A)) (18). However, in our study, statistically higher average values of Weinstein's Noise Sensitivity Scale were found in residents who lived in a noisy zone. In addition, the subjective sensitivity in our study increased with age of residents in both zones. The mean value of the scale in subjects aged over 60 was 92.56. Residents of the noisy zone were on average four years older compared to quiet zone residents, so these higher average values in the elderly could affect the final obtained results. This connection between subjective sensitivity to noise and the age was found in previous studies as well. So a group of Macedonian authors found the highest noise sensitivity to occur in people aged 51 to 65 (19).

Regarding gender differences, we found that men were more vulnerable to noise than women, but only in quiet zone. Thus, average value of Weinstein's Noise Sensitivity Scale was 82.62 for men, and for women 77.61. The results of some other researches (20, 21) show that women are more sensitive to noise. There is some evidence that gender may affect noise sensitivity (22). However, the mechanisms in which gender impacts that relation – be it psychosocial or biological – have not yet been fully examined.

In numerous studies (23, 24), it has been found that higher noise sensitivity leads to more frequent occurrence of harmful health effects.

Good sleep is an essential condition for the proper physiological and mental functioning of the person. Therefore, sleep disorder is considered the biggest consequence of community noise. Harmful effects of noise can occur during falling asleep, during sleep itself and after waking up (subsequent psycho-physical effects such as tiredness, mood and poorer sleep quality assessment). In people who are sensitive to noise, these effects can be more emphasized and may also occur at lower noise levels. Our study found that subjective noise sensitivity significantly affects night-sleep duration as well as the subjective assessment of sleep quality.

A survey conducted in Gothenburg has also established a significant connection between subjective noise sensitivity and sleep disorder like the time required to fall asleep and more pronounced tiredness after sleep in a population exposed to traffic noise (25). Noise sensitive individuals may experience greater sleep disturbance because of greater stress reactivity, which, in turn, may contribute to increased awakenings through the night (22).

Noise sensitivity was consistent predictor of symptoms of depression and psychological distress as well as mental illness (13). In our study, the results of multivariate logistic analysis did not show that subjective noise sensitivity significantly influenced the occurrence of psychological disturbances such as depressed mood, nervousness, headaches, use of sedatives and analgesics, or visits of psychiatrists or psychologists.

In contrast to our research, the results of some other studies have shown that greater subjective noise sensitivity can affect psychological reactions. A cross-sectional study performed in the Netherlands has shown that people who are more sensitive to noise use antidepressants and sedatives more often (26). Norwegian study and studies from England found that people who are more sensitive to noise suffer from depression more often (27, 28). The Japanese study recorded similar results (29). The results of a recent study from South Korea of 1,836 adult cases have shown that subjects in the high noise sensitivity group were more than two times more likely to experience depression and 1.9 times more likely to have anxiety, compared with those in the low noise sensitivity group (30).

Noise is defined as unpleasant sounds that disturb the human being, among other things (31), in carrying out everyday activities. Generally, the greatest harmful effect of noise during daily activi-

Table 5. *Multivariate model of logistic regression analysis of subjective noise sensitivity and non-auditory health effects among adults in Niš*

Variables	OR	95% CI	p-value
Duration of night sleeping	0.88	0.77–0.99	0.04
Difficulties in falling asleep	0.64	0.72–1.22	0.94
Time of fall asleep	1.00	0.99–1.01	0.99
Subjective sleep quality	1.38	1.05–1.826	0.01
Tiredness upon awakening	0.80	0.61–1.06	0.12
Sleeping pills	1.17	0.75–1.84	0.49
Frequency of headache	0.86	0.61–1.22	0.40
Use of analgesics	0.87	0.67–1.25	0.46
Use of sedatives	1.21	0.96–1.53	0.11
Depressed mood	0.89	0.64–1.02	0.07
Nervousness	1.09	0.89–1.33	0.39
Watching TV disturbance	0.80	0.52–01.24	0.33
Reading disturbance	0.74	0.47–1.17	0.19
Conversation disturbance	1.32	0.84–2.08	0.23
Daily rest disruption	0.46	0.33–0.65	< 0.001
Mental work disturbance	0.87	0.61–1.23	0.43

The model was adjusted by gender, age structure and residential area.

ties is expected in some mental work, but also in daily resting, which we also found in this study. Residents who lived in noisy areas were most disturbed during the daily rest (59.2%) and mental work (43.9%), and slightly less during conversations, watching TV or reading newspapers. In modern research the emphasis is precisely on the impact of noise on mental work because it has been found that noise has little or no impact on work involving simple motor activities without greater mental engagement. The bigger the mental activity, the greater the probability of the negative effects of the noise. A significant moderator of these effects is the subjective sensitivity to noise because people with a particularly negative attitude towards noise are more susceptible while performing a mental activity with unwanted sounds. In our study, the results of multivariate logistic analysis did not show a significant impact of noise sensitivity on mental work, on the other hand, they showed a significant impact of noise sensitivity on daily rest disorder.

A survey conducted in Gothenburg, Sweden, showed that noise-sensitive individuals reported interference with daily activities to a higher extent than non-sensitive persons (32). Even persons who are more sensitive to noise rarely listen to music during work or reading. Taking into account the fact that human beings are continuously exposed to noise in different daily activities, it is important to develop tools for evaluating the noise annoyance occurring during leisure time, at work and at home (1).

Despite our efforts to ensure that the study is properly designed and implemented, its main limitation is the low response rate.

CONCLUSION

Based on the above mentioned results, it can be confirmed that noise sensitivity has an important role in causing non-auditory health effects among adults in Niš, such as night-sleep duration, subjective assessment of sleep quality and daily rest disruption. Accordingly, further investigation of noise mediators is crucial rather than simple measurements of noise.

Conflict of Interests

None declared

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