

*Original article*

## The Relationship between Community Noise and Arterial Hypertension in the Population of the City of Niš

Ljiljana Stošić<sup>1</sup>, Dušica Stojanović<sup>1</sup>, Konstansa Lazarević<sup>2</sup>

<sup>1</sup>University of Niš, Faculty of Medicine, Niš, Serbia

<sup>2</sup>State University of Novi Pazar, Department of Biomedical sciences, Novi Pazar, Serbia

### SUMMARY

**Aim:** The aim of the study was to examine the relationship between noise exposure and the incidence of arterial hypertension as well as the relationship of noise annoyance and noise sensitivity with hypertension.

**Methods:** A cross-sectional questionnaire survey was performed on 911 adult residents of Niš, Serbia, of whom 388 were men (42.6%) and 523 women (57.4%). The criterium for the diagnosis of arterial hypertension was that it was diagnosed by a physician. Based on measurement results of noise, residents, streets were marked as noisy [daily equivalent noise level (Leq)  $\geq 55$  dB (A) and night Leq  $\geq 45$  dB (A)] and as quiet [daily equivalent noise level (Leq)  $\leq 55$  dB (A) and night Leq  $\leq 45$  dB (A)]. The numerical and verbal noise annoyance scales were used to assess the degree of noise annoyance, while noise sensitivity was measured with the Weinstein's Noise Sensitivity Scale.

**Results:** Arterial hypertension was statistically significantly more frequent in residents in the noisy area compared to residents in the quiet area. After the inclusion of independent variable factors in the logistic regression models, no significant difference was found ( $p = 0.66$ , OR = 1.11; 95% CI: 0.69 - 1.78). A correlation analysis between noise annoyance which was measured by verbal and numeric scales and arterial hypertension showed a highly significant positive relation. The same case was between the relationship between subjective sensitivity and arterial hypertension.

**Conclusion:** The introduction of the limit for the community noise level that corresponds to the requirements of highly sensitive persons is a significant measure in preventing the harmful effects of noise on the exposed population.

**Keywords:** adults, hypertension, noise sensitivity, noise annoyance

Corresponding author:  
Ljiljana Stošić  
e-mail: ljstosic@live.com

## INTRODUCTION

Noise is considered as a very important part of environmental pollution, with a major negative impact on the life quality in urban areas. Long-term noise exposure is associated with a number of effects on health and well-being (annoyance, sleep disturbance, disturbance of daily activities) (1).

Stress due to exposure to chronic noise can negatively affect the cardiovascular system and increase the risk of hypertension. Numerous studies that monitored the effect of noise on the increase in blood pressure in professionally exposed individuals have shown a high correlation (2, 3). There are some difficulties in applying the results of these studies to the community environment. First of all, the noise levels at the workplace are significantly higher than the levels in the community environment, and the noise effects are time-limited and related to the specific noise source. Unlike the urban population, workers usually use protection. A small number of studies have investigated the association between community noise. The results of these studies are inconsistent.

A more pronounced effect of noise on hypertension is expected in elderly and obese people who are physically inactive. Less known factors that could also have an impact are subjective sensitivity to noise and noise annoyance.

The aim of this study was to examine the effects of noise on hypertension and the relationship of noise annoyance and noise sensitivity with hypertension.

## PARTICIPANTS AND METHODS

Traffic noise was measured at six locations in Niš. Three locations were in the busiest streets, while three were in side streets with lower traffic intensity. Measurements were done with a „Brüel & Kjaer“ noise level analyzer type 4426, in accordance with applicable noise regulations (4, 5). The noise level was measured in three day-time (09 h to 12 h, 13 h to 16 h and 17 h to 20 h) and two night-time intervals (22 h to 01 h and 02 h to 05 h). Streets with day Leq  $\geq$  55 dB (A) and night Leq  $\geq$  45 dB (A) were regarded as noisy and those with day Leq  $\leq$  55 dB (A) and night Leq  $\leq$  45 dB (A) were regarded as quiet, in accordance with WHO recommendations (6).

This study was designed as a cross-sectional questionnaire. A total of 3,000 questionnaires were

distributed to residents of three busy streets and three quiet side streets. The criteria for inclusion were age between 18 and 80 years and the period of residence in the given apartment longer than a year. The exclusion criteria were exposure to noise at work and hearing loss. The study included 911 participants, of whom 388 (42.6%) were men and 523 (57.4%) women. The research was done at the end of 2009 and the beginning of 2010.

The first part of the questionnaire was related to general demographic data. In the part of questionnaire on arterial hypertension, the examinees were the about the diagnosis of hypertension by physicians, use of antihypertensive therapy, family history of hypertension, smoking habits, alcohol consumption, physical activity, weight and height. The criterium for the diagnosis of arterial hypertension was that diagnosed by a physician. The Weinstein's Noise Sensitivity Scale was used to assess sensitivity to noise (7). A verbal (not at all; slightly; moderately; very; extremely) and a numeric noise annoyance scales (from 0-not at all, to 10-extremely) were used (8).

Standard data processing programs such as Excel and SPSS software package in version 16.0 were used in statistical data processing.

## RESULTS

Noise measurements showed that the average night Leq was significantly higher in noisy streets as well as average day Leq (Table 1).

Residents from noisy area were four years older on average, enjoyed fewer square metres of flat area per tenant, and fewer of them had only elementary school education than quiet area residents. Smoking habits and habits of alcohol consumption were the same, but the quiet area residents were more physically active and on average had higher body mass. The values of the Weinstein's Noise Sensitivity Scale and noise annoyance were higher in subjects exposed to higher noise levels (Table 2).

Arterial hypertension was significantly more frequent in residents in the noisy area. Consequently, subjects in the noisy area statistically significantly more frequently used antihypertensive therapy (Table 3).

A correlation analysis between noise annoyance which was measured by verbal and numeric scales and arterial hypertension showed a highly significant positive relation. The same case was with

**Table 1.** Noise levels in Niš

Noise levels	Noisy area	Quiet area	p-value
Leq (dB(A)) day	64.33 ± 2.18	49.62 ± 2.31	< 0.05
Leq (dB(A)) night	61.33 ± 2.31	43 ± 3.46	< 0.05

**Table 2.** Basic characteristics of noisy [day Leq ≥ 55dB(A) and night Leq ≥ 45dB(A)] and quiet area residents [day Leq ≤ 55dB(A) and night Leq ≤ 45dB(A)]

Variables	Noisy area (N = 463)	Quiet area (N = 448)	p-value
Age (years)	45.00 ± 16.32	41.71 ± 13.64	< 0.01*
Males (%)	44.10	41.10	> 0.05#
Apartment size (m <sup>2</sup> per tenant)	63.28 ± 18.31	77.67 ± 30.18	< 0.01\$
Period of residence (years)	17.89 ± 13.03	17.92 ± 11.64	> 0.05\$
Daily time spent in apartment (h)	14.45 ± 3.44	14.45 ± 3.44	> 0.05*
Employment (%)	47.8	61.9	< 0.001#
Education (%)			
Elementary	1.9	4.9	< 0.05#
Secondary	59.8	58.3	
Higher	10.8	13.4	
University	27.4	23.4	
Body mass index (kg/m <sup>2</sup> )	24.3 ± 3.6	24.9 ± 3.8	< 0.05\$
Smoking habits (%)			
Smoker	36.1	35.5	> 0.05#
Non-smoker	53.1	12.5	
Ex-smoker	10.8	52.0	
Long-term smoking status (years)	19.6 ± 12.0	17.6 ± 9.6	> 0.05\$
Alcohol consumption (%)	24.2	26.3	> 0.05#
Physical activity (h/day)	4.28 ± 3.81	5.37 ± 4.24	< 0.01\$
Family history of hypertension (%)	60.3	57.8	> 0.05#
Subjective noise sensitivity	85.4 ± 16.47	82.14 ± 21.15	< 0.01\$
Noise annoyance			
Verbal scale	3.01 ± 0.92	2.69 ± 0.97	< 0.001#
Numeric scale	3.82 ± 2.41	3.29 ± 2.18	< 0.001#

\*Students' t-test

#Pearsons Chi-square test

\$Mann-Whitney U-test

**Table 3.** The incidence of arterial hypertension among noisy [day  $Leq \geq 55$  dB (A) and night  $Leq \geq 45$  dB (A)] and quiet area residents [day  $Leq \leq 55$  dB (A) and night  $Leq \leq 45$  dB (A)]

Variables	Noisy area		Quiet area		p-value
	Male	Female	Male	Female	
Diagnosed hypertension (%)	37.7	29.3	32.1	18.6	0.003
Use of antihypertension therapy (%)	31.4	26.3	27.2	17.8	0.04

**Table 4.** Correlation between arterial hypertension with subjective noise annoyance and arterial hypertension with subjective sensitivity to noise in noisy area residents

Variables	N	Spearman R	t (ss = N-2)	p-value
Values of verbal scale	463	0.216	4.41	< 0.001
Values of numeric scale	463	0.211	4.38	< 0.001
Values of verbal Weinstein's Noise Sensitivity Scale	463	0.160	3.10	< 0.001

**Table 5.** Multivariate logistic regression for exposure to noise and incidence of arterial hypertension

Variable	OR ( 95% CI)	p-value
Arterial hypertension	1.11 (0.69-1.78)	0.66

the relationship between subjective sensitivity and arterial hypertension (Table 4).

After the inclusion of independent variable factors in the logistic regression models (body mass index, age, sex, marital status, education, employment status, material status, number of household members, comfort in the apartment, smoking habits, alcohol consumption and physical activity), no significant correlation was found (Table 5).

## DISCUSSION

This study showed that the incidence of arterial hypertension as well as the use of antihypertensive therapy were statistically significantly higher in the residents in noisy streets. A higher incidence

of arterial hypertension was reported in the female population. Other investigations, but not all, have given similar results. A study among the adult population in Pančevo, Serbia, who were exposed to 24-hour noise levels between 55 and 65dBA, showed that hypertension was more frequent only in men who were strongly disturbed by noise, but not in women (9).

The results of a study in the Dutch city of Groningen showed that noise exposure is associated with the occurrence of arterial hypertension in people between the ages of 45 and 55 (10). People exposed to higher levels more often use antihypertensive therapy compared to those who are not exposed. A group of scientists in India investigated the relationship between hypertension and noise

exposure on 909 adults aged 18 - 80 years in Asansol City. For each 5 dB (A) noise increase, the risk of developing hypertension increased by 1.99 (11).

However, regarding the noise of road traffic and its influence on arterial hypertension, as we have already said, there are still contradictions in the conclusion of various studies. The results of a study in Sweden in the adult population did not establish a relationship between traffic noise and hypertension (12).

Further, after assessing the risk of the effects of traffic noise, in which, as the only independent variable in logistic regression models included the place of residence, a risk assessment was carried out with the control of the impact of associated factors. Statistical analysis did not confirm the significant impact of dwelling in the noisy zone on the existence of arterial hypertension. This means that some of the individual characteristics of the examinees have exceeded the noise, which is logical, since the noise is not the most important factor for the occurrence of hypertension. Thus, the body mass index was statistically significantly higher in the control zone subjects, which means that they were more obese. Obesity is known to be a risk factor for the arterial hypertension, which could have caused a more frequent hypertension in examinees living in the control zone.

In his review, Babish emphasizes that subjective noise annoyance is also very important (13). Thus, in our study, a statistically significant direct correlation was established between subjective noise annoyance measured by verbal and numerical scales and arterial hypertension. Also, a high direct correlation between subjective sensitivity to noise mea-

sured by Weinstein's scale and hypertension correlation was established. People more sensitive to noise pay more attention to noise and its sources, react more intensely to noise, more often perceive noise as threatening and dangerous, and point out that they have less control over noisy situations than insensitive people (14).

Some limitations of our study should be considered. We researched both day and night noise levels, however epidemiological studies show that nocturnal noise exposure may be more relevant for cardiovascular system (1). The measurement of pressure was not performed, and the hypertension which was established by the physician was an included criterion. There was also no measurement of noise in the apartments, and no control of the existence of sound insulation.

## CONCLUSION

Hypertension is an important problem in developed countries, with an incidence estimated at 30 - 40% in the adult population (15). In this respect, each and even a small contribution to the study of risk factors from the environment such as noise, which affect the increase in blood pressure, has public health significance. This study showed that exposure to traffic noise may be associated with hypertension. The results of this study should be taken into account when deciding on the introduction of a limit for the community noise level that corresponds to the requirements of highly sensitive persons. This is, of course, a significant measure in preventing harmful effects of noise on the exposed population.

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# Povezanost između komunalne buke i arterijske hipertenzije kod stanovnika Grada Niša

Ljiljana Stošić<sup>1</sup>, Dušica Stojanović<sup>1</sup>, Konstansa Lazarević<sup>2</sup>

<sup>1</sup>Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija

<sup>2</sup>Državni univerzitet u Novom Pazaru, Departman za biomedicinske nauke, Novi Pazar, Srbija

## SAŽETAK

**Cilj.** Cilj studije bio je da se istraži veza između izloženosti buci i učestalosti arterijske hipertenzije u urbanoj populaciji, kao i povezanost ometanja bukom i osetljivosti na buku sa hipertenzijom.

**Metode.** Studija preseka urađena je kod 911 stanovnika Grada Niša, starosti preko 18 godina, od kojih 388 muškaraca (42,6%) i 523 žene (57,4%). Kriterijum za postojanje arterijske hipertenzije bila je činjenica da je bolest dijagnostikovana od strane doktora medicine. Na osnovu rezultata merenja buke, ulice stanovnika označene su kao bučne (dnevni ekvivalentni nivo buke (Leq)  $\geq 55$  dB (A) i noćni Leq  $\geq 45$  dB (A)) i kao tihe (dnevni ekvivalentni nivo buke (Leq)  $\leq 55$  dB (A) i noćni Leq  $\leq 45$  dB (A)). U cilju procene stepena ometanja bukom korišćene su numerička i verbalna skala, dok je osetljivost na buku merena Veinsteinovom skalom osetljivosti na buku.

**Rezultati.** Arterijska hipertenzija bila je statistički značajno češća kod stanovnika bučnog područja, u poređenju sa stanovnicima tihog dela grada. Nakon uključivanja nezavisnih promenljivih faktora u modele logističke regresije, nije pronađena značajna razlika ( $p = 0,66$ , OR = 1,11; 95% CI: 0,69 – 1,78). Korelaciona analiza između ometanja bukom, koje je mereno verbalnom i numeričkom skalom i arterijske hipertenzije pokazala je izuzetno značajnu povezanost. Takođe, utvrđena je i pozitivna korelacija između subjektivne osetljivosti na buku i arterijske hipertenzije.

**Zaključak.** Uvođenje ograničenja nivoa buke u zajednicu, koji odgovara zahtevima visoko osetljivih osoba značajna je mera u sprečavanju štetnih efekata buke na izloženo stanovništvo.

**Ključne reči:** odrasli, hipertenzija, osetljivost na buku, uznemiravanje bukom