The importance of non-acoustical factors on noise annoyance of urban residents

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INTRODUCTION

Noise annoyance is a feeling of displeasure or disturbance caused by noise. It is a sensitive indicator of adverse noise effects. Noise annoyance can only be partially explained by acoustical characteristics of noise – its level, frequency, duration, source etc. Non-acoustical factors, such as personal characterisitcs (age, gender, noise sensitivity), and social, residential or environmental factors are also related to noise annoyance (Ouis 2001). Noise annoyance experiments typically do not consider all non-acoustical factors, because they are interested in average response of a large population.

Several mechanisms explain the onset of noise annoyance in relation to noise. Noise annoys because it masks other sounds, it makes intellectual activities difficult, it disturbs one's attention and concentration, leads to physiological arousal, and triggers "negative" or distressing affective/emotional reactions (Miedema 2007). According to this model, personal characteristics, such as neuroticism (Ohrström et al. 1988), introversion (Belojevic et al. 2001), and noise sensitivity (Ohrström et al. 1988; van Kamp et al. 2004) are highly correlated with noise annoyance.

Social factors that trigger stressful reactions are also strongly correlated to noise annoyance. For example, marital status, presence of children, or longer duration of stay at home at day (due to unemployment or retirement) may increase stress level in many persons (Wallenius 2004). Residential factors (type of dwelling, number of dwellers, floor level, years of residence), and environmental characteristics (neighborhood safety, air pollution etc.) may be related to socio-economic status, which in turn means that people with lower socio-economic status are exposed to multiple adverse environmental conditions, including high noise levels (Evans & Kantrowitz 2002).

The aim of this study was to assess the influence of personal and residential factors on noise annoyance of residents of Belgrade.

METHODS

The study was performed in a city center of Belgrade, Serbia, from 2004-2006. We interviewed all adult residents in every tenth flat in all streets, thus obtaining a randomized sample of 6,000 people (10 % of the population of the municipality, according to census data). The questionnaires were distributed to post boxes inside the buildings according to the list of dwellers. The response rate was 52.8 %, with 3,169 filled questionnaires. After applying the inclusion criterion for the study (period of residence for at least 3 years), the study sample comprised 2,155 middle-aged residents (1,003 men and 1,152 women).

Noise measurements were performed in all 70 streets of the municipality, using Noise Level Analyzer type 4426 "Brüel & Kjær" (ISO 1982). A composite 24-hour equivalent

noise level [Leq (dBA)] was calculated from noise measurement at daytime, evening and night.

Noise annoyance was assessed using a self-reported numeric scale (range 0-10); high-level annoyance was identified as score ≥ 6. A questionnaire on personal characteristics (age, gender, marital status, education, income) and residential factors (flat size, number of dwellers, years of residence, floor level) was anonymous.

Descriptive statistic is presented as mean values ± standard deviation (SD) for numeric variables, or as percents (relative numbers) for categorical variables. The differences between groups were tested using Student's test, Chi-square test and Mann-Whitney U test. The association between parametric data was measured by Pearson's correlation coefficient. Univariate logistic regression was performed to calculate odds ratios for high-level annoyance in relation to relevant independent variables. The influence of personal and social characteristics on high-level annoyance was estimated using multivariate logistic regression.

RESULTS

The investigated population comprised 1,453 residents with low-level of noise annoyance and 702 highly annoyed residents (Table 1). The prevalence of highly annoyed residents was 32.6 %. The studied groups were similar by age, gender, marital status, having children, education and income. They also had similar dwelling characteristics. However, highly annoyed residents more often reported having windows of their bedroom oriented toward the streets (30.5 % compared to 9.9 % of not annoyed residents).

Table 1: Basic characteristics of investigated population in relation to noise annoyance

Residential and environmental characteristics	Low-level annoyance	High-level annoyance	Total	p value
Number of subjects	1453 (67.4 %)	702 (32.6 %)	2155 (100.0 %)	
Age (years)	41.7±16.7	43.6±16.8	42.4±16.8	0.088*
Gender (male)	407(40.6 %)	367 (36.6 %)	774 (35.9 %)	0.074†
Married subjects	696 (47.9 %)	362 (51.6 %)	1058 (49.1 %)	0.293†
Subjects with children	800 (55.1 %)	425 (60.5 %)	1225 (56.8 %)	0.101†
Education (college/ university)	782 (53.8 %)	392 (55.8 %)	1174 (54.5 %)	0.148†
Income (very good/ excellent)	1001 (68.9 %)	491 (69.9 %)	1492 (69.2 %)	0.719†
Type of work (intellectual)	946 (65.1 %)	462 (65.8 %)	1408 (65.3 %)	0.591†
Years of employment	20.2±12.6	20.6±11.9	20.4±12.5	0.699‡
Years of residence	17.3±14.1	18.4±14.9	17.7±14.4	0.367‡
Flat size per dweller	23.1±12.6	23.9±11.8	23.4±12.4	0.052‡
Floor	2.6±1.8	2.7±2.2	2.6±1.9	0.623‡
Windows of bedroom oriented toward the street	144 (9.9 %)	214 (30.5 %)	358 (16.6 %)	<0.0001†

* Student's t-test

† Chi-square test

‡ Mann-Whitney U test

The correlation between mean score on noise annoyance scale and personal and social characteristics is presdented in Table 2. Mean annoyance score showed strong positive correlation with residents' age, years of employment, length of residence, and number of hours spent at home. Inverse correlation was found only

with floor level. No association was found with gender, social characteristics: marital status, number of children, income, education; and some residential charateristics: number of dwellers, flat size, and number of hours spent at work. There was no correlation with equivalent 24-hour noise level in the investigated group.

Table 2: Correlation coefficients between mean score on noise annoyance scale and personal and social characteristics of investigated population

Personal and social characteristics	Correlation coefficients*	p value
Age (years)	0.164	<0.0001
Years of employment	0.149	<0.0001
Length of residence	0.119	<0.0001
Floor	-0.088	<0.0001
Hours spent at apartment at day	0.061	0.014
Number of children	0.045	0.054
Flat size	-0.018	0.450
Working hours	-0.017	0.583
Flat size per dweller	-0.007	0.785
Education	0.006	0.801
Income	-0.005	0.839
24-hour equivalent noise level (Leq)	-0.002	0.939

***** Pearson's correlation coefficient

Univariate logistic regression was performed to calculate odds ratios for high-level annoyance in relation to relevant independent variables. Significant variables from the univariate models were floor level, hours spent at apartment at day, and orientation of bedroom windows toward the street.

Multivariate logistic regression identified orientation of windows toward the street as the strongest predictor of high-level noise annoyance, adjusted for age and gender. Floor level was protective factor for high-level of noise annoyance (Table 3).

Table 3: Odds Ratios (95 % Confidence Interval) for high-level noise annoyance* in relation to personal and social characteristics of investigated population, adjusted for age and gender

Personal and social characteristics†	OR	95 % CI	p value
Windows of bedroom oriented toward street	3.380	2.292-4.984	<0.0001
Floor	0.928	0.873-0.987	0.018

* High-level noise annoyance defined as mean score on annoyance scale ≥ 6

† Variables in model: age, gender, floor, hours spent at apartment at day, windows of bedroom oriented toward the street

DISCUSSION

In our study, the strongest independent predictor for high level of noise annoyance is the orientation of windows of bedroom toward the street. One of the possible explanations for such strong association is that people whose windows are oriented toward the street are inevitably exposed to higher levels of noise, even if they had similar sound isolation in buildings. Furthermore, under those circumstances residents cannot keep their windows open (at summer, or for longer time), which is essential for general well-being. Such a change in daily behavior may provoke dissatisfaction with residential neighborhood, leading to change of attitude toward all environmental hazards, including noise – fear of danger from the noise source, beliefs that noise cannot

be prevented, feeling of insecurity, increased noise sensitivity, and even distrust toward environmental authorities (Fields 1993; Guski 1999).

The preventive effect of floor level is explained by lower level of noise in the apartment. On the other hand, living on higher floors may prevent people from doing some everyday activities – feeding, clothing – especially for the elderly and disabled. Such circumstances alone can lead to higher stress level and probably lead to higher annoyance (Wallenius 2004).

The limitation of the study is that we did not assess the hearing capacity of the participants, their general stress level and noise sensitivity.

CONCLUSIONS

This cross-sectional study identified orientation of bedroom toward the street as the most significant independent predictor of high annoyance in adult population of a Belgrade municipality. This finding may help exposed residents find other efficient behavioral strategies of coping with noise.

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