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Community response to environmental noise and the impact on cardiovascular risk score

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ABSTRACT

Objective: The objective of our study was to investigate and evaluate the relationship between road traffic noise and cardiovascular risk.

Methods: The study sample ($n = 659$; 36.9% male, 63.1% female university students, mean age 22.83 ± 1.58 years) included a group exposed to road traffic noise ($n = 280$, $L_{eq,24\ h} = 67 \pm 2$ dB(A)) and a control group ($n = 379$, $L_{eq,24\ h} = 58.7 \pm 6$ dB(A)). Subjective response was determined by a validated noise annoyance questionnaire. The ten year risk of developing a coronary heart disease event was quantified as an evaluation of cardiovascular risk (SCORE60, Framingham 10-year risk estimation and projection to the age of 60, relative risk SCORE chart).

Results: Cardiovascular risk scores were significantly higher in the exposed group based on the Framingham scores projected to the age of 60, SCORE60 (AOR = 2.72 (95% CI = 1.21–6.15)) and the relative risk SCORE chart (AOR = 2.81 (1.46–5.41)).

Conclusions: These findings highlight the association between road traffic noise and cardiovascular risk.

1. Background

The harmful effects of noise on human health and development have been underestimated for a relatively long time. This may be due to the fact that noise endangers human health in an indirect manner, as opposed to other harmful substances in the workplace or environment. However, in contrast to some other environmental problems, noise pollution continues to increase, and with it we see an increasing number of complaints from those who are exposed (Berglund et al., 2000).

Noise acts as an environmental stressor, activating the body's compensatory mechanisms to stress (Maschke et al., 2000; Babisch, 2002). Acute noise exposure activates responses from the autonomic and endocrine systems, leading to temporary changes in the body, such as increased blood pressure, increased heart rate and vasoconstriction (Berglund et al., 2000). After prolonged exposure, susceptible individuals in the general population may develop permanent health effects, which can reveal themselves ten to fifteen years after the time of exposure in different functional systems (Niemann et al., 2006).

Many experimental and epidemiological studies have identified the stressful influence of noise on humans (Parrot et al., 1992; Petiot et al., 1992; Lercher et al., 1993; Babisch et al., 2005; Hubka et al., 2006; Jarup et al., 2008). Studies investigating both occupational and residential noise exposure (including airports, noisy streets and industrial zone noise) have shown that noise may have both temporary and permanent impacts on physiological functions in humans (Lercher et al., 1993; Regecová and Kellerová, 1995; Babisch et al., 1999; Lercher et al., 2000; Lercher et al., 2002; Babisch et al., 2005; Jarup et al., 2008). In spite of their limitations, epidemiological studies are valuable because they evaluate an issue (in this case community noise, especially road traffic noise) as it occurs naturally.

The adverse health effects of community noise include subjective annoyance, interference with speech communication, disturbance of rest and sleep, impaired psychological function and negative behavioural effects. The predominant source of noise annoyance in residential quarters is traffic followed by neighbourhood noise (Berglund et al., 2000; Björk et al., 2006; Niemann et al., 2006; Jakovljevic et al., 2009). Besides the psychosocial effects of community noise, there is concern about the impact of noise on the cardiovascular system (Babisch, 2000; Berglund et al., 2000; Lercher et al., 2000; Babisch et al., 2005; Jarup et al., 2008).

An updated review of epidemiological studies on transportation noise and cardiovascular risk has been presented recently (Babisch, 2006). The evidence of an association between transportation noise

Abbreviations: AOR, adjusted odds ratio; BMI, body mass index; BP, blood pressure; CHD, coronary heart diseases; CVD, cardiovascular diseases; CI, confidence interval; ESC, European Society of Cardiology; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; $L_{eq,24\ h}$, 24 hour equivalent noise level; L_{den}, day–evening–night noise indicator; Log TG/HDL-C, atherogenic plasma index; OR, odds ratio; OR_{MH}, Mantel–Haenszel weighted odd ratio; SCORE, systematic coronary risk evaluation system, model to predict the risk of CHD in asymptomatic subjects; SCORE60, systematic coronary risk evaluation system (SCORE) chart at the projected age of 60; TC, total cholesterol level; TG, triglycerides; TC/HDL-C, atherogenic plasma index.

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and cardiovascular risk, especially regarding coronary heart disease (CHD) has increased since the previous reviews (van Kempen et al., 2002; Babisch, 2006).

There are three levels of physiological outcome which are of interest in epidemiological noise research concerning cardiovascular effects. These are: stress indicators (e.g. stress hormones), CHD risk factors (e.g. blood pressure, blood lipids, haemostatic factors) and manifest diseases (e.g. hypertension, ischaemic heart disease) (Babisch, 2002).

Although the findings in most studies seem to be reasonably consistent, many of the studies have low statistical power, rated by expert groups to have from “limited” to “sufficient” evidence of association (Babisch, 2000, 2006). Nevertheless, even small risks are potentially important from a public health point of view, because a large number of persons are currently exposed to these noise levels, or are likely to be exposed in the future (Babisch et al., 1999; Jarup et al., 2008).

The objective of the present study was to investigate and evaluate the effects of community noise, especially noise from road traffic, on human health parameters, and to further investigate the relationship between road traffic noise and cardiovascular risk on a group of young healthy individuals in an urban environment.

2. Methods

2.1. Characteristics of the study sample

There were 659 eligible subjects, 36.9% male and 63.1% female, enrolled in the study sample. The mean age was 22.83 ± 1.56 years old. The sample included the group exposed to road traffic noise ($n = 280$) and the control group ($n = 379$).

The source population was composed of students enrolled at Comenius University. The respondents represented a homogenous sample of young healthy individuals of comparable age, education and lifestyle (Table 1). The response rate was 90%. Only those students living in the Bratislava agglomeration were eligible to participate in the study (659 subjects from 700 were eligible).

2.2. Noise exposure measurements

Equivalent noise levels were assessed for both the control and exposed groups living in the Slovakian capital city Bratislava (about half a million inhabitants) by a Brűel–Kjaer measuring technique (calibrated integrating sound level meter type 2230). The exposed group consisted of students living in noisy area (the dormitory at Comenius University), whereas the control group was made up of students living in quiet areas of other dormitories and residential areas surrounding Bratislava proper. Several multistorey buildings of the dormitory at Comenius University are situated near the major transportation route out of Slovakia, including an aboveground highway crossing. For the exposed and the control group, A-weighted outdoor equivalent noise levels were measured manually during a 24 hour period; there were 20 measuring stations assessed and the arithmetic averages were calculated.

Two separate measurements were done at both the exposed and control areas during the regular work week in both the spring and autumn. All measurements were recorded according to the standard STN ISO 1996-1, 2 method during the day (6.00–12.00), afternoon (12.00–18.00), evening (18.00–22.00) and night (22.00–6.00). The time interval of each measurement was 15 min. Measuring stations were situated 2 m from the building facades. The average equivalent noise levels ($L_{eq,24\ h}$) were calculated and compared for exposed and control areas.

The L_{DEN} (day–evening–night noise indicator) was determined for each area and was used to assess the overall noise annoyance in the exposed and control areas. These were estimated from the Bratislava agglomeration strategic noise map, which is based on prediction methods and 3D-Models, and is compiled by the EC Directive on Environmental Noise (Directive, 2002/49/EC, 2002; Strategic Noise Map of Bratislava Agglomeration, 2005).

The purpose of these measurements and estimations was to reasonably categorize the subjects by levels of noise exposure for epidemiological study purposes.

Table 1
Descriptive data on the sample of university students.

Variable	Exposed group ($n = 280$)[a]		Control group ($n = 379$)[a]		*p*-value
	N	(%)	*N*	(%)	
Gender					
Male	101	36.2	142	37.5	0.74
Female	178	63.8	237	62.5	
Age[b]					
Male	22.82 ± 1.60 years		22.83 ± 1.58 years		0.99
Female	22.79 ± 1.43 years		22.84 ± 1.61 years		
Flat noise (subjectively)					
In noisy area	239	5.7	149	39.9	<0.001
In quiet area	40	14.3	225	60.1	
Flat position					
Ground floor and 1st floor	14	5.0	105	28.2	<0.001
2nd–4th floor	44	15.7	148	39.8	
5th–8th floor	132	47.2	98	26.3	
9th floor and higher	90	32.1	21	5.7	
Windows orientation					
Facing quiet street	122	43.7	314	83.0	<0.001
Facing noisy street	158	56.5	60	16.0	
Years living in flat					
Less than 1 year	28	10.0	50	13.3	<0.001
1–3 years	54	19.3	50	13.3	
4–5 years	184	65.7	62	16.5	
6 and more years	14	5.0	214	56.9	
Satisfaction with flat surroundings					
Satisfied	53	19.0	169	44.8	<0.001
Partially satisfied	77	27.5	70	19.4	
Not satisfied	150	53.5	135	35.8	
Smoking					
Yes	55	19.6	69	18.4	0.64
No	225	80.4	308	81.6	
Spirits					
1–2 times/week	12	5.5	10	4.2	0.06
1–2 times/month	51	23.4	36	15.3	
Never	155	71.1	190	80.5	
Psychogenic stress					
Yes	84	38.2	98	40.0	0.57
No	136	61.8	147	60.0	
Systolic blood pressure (mmHg)	112 ± 14.1		112 ± 14.4		0.63
Diastolic blood pressure (mmHg)	68.3 ± 8.6		67.9 ± 8.8		0.57
Body mass index[c] (BMI — kg m^{-2})	21.51 ± 2.66		21.70 ± 8.18		0.46

[a] There are missing values for each variable category.
[b] Average age in the sample (arithmetic mean ± standard deviation).
[c] Average BMI in the sample (arithmetic mean ± standard deviation).

2.3. Subjective response and questionnaire

Subjective response was assessed by a validated noise annoyance questionnaire administered in person (Radulov and Rolný, 1988; Ághová et al., 1992; Sobotová et al., 2001). Besides questions on personal (age and gender), behavioural (smoking, coffee and alcohol consumption) and home characteristics (building construction and type of residence), it also included questions on possible non-auditory noise effects (noise annoyance from different sources, interference with various activities and sleep disturbance). We used a five-graded verbal scale (Not at all; Slightly; Moderately; Very; Extremely), that was developed and recommended by experts from the ICBEN (The International Commission on the Biological Effects of Noise) research team to coordinate and