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Problems of road traffic noise annoyance and sleep disturbance in some Slovakian cities

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ABSTRACT

The paper presents the results of a pilot cross-sectional study focused on subjective traffic noise annoyance and sleep disturbance among the residents living close to major inner city corridors in several Slovakian towns including the capital Bratislava and Kosice. The subjective adaptation to traffic noise, subjective evaluation of health status and well-being were assessed as well.

The questionnaire survey was distributed to the pilot sample of 543 respondents (average age 45.3 ± 4.5 years, 73.1% of respondents in the age from 35 to 65 years, 26.9% in the age up to 35 years, 53% females, 81% living in houses more than five years). The inhabitants with bedroom windows facing noisy streets or quite streets represented the exposed and the control group. Road traffic noise annoys significantly more daily and night activities of respondents in the exposed group who are unable to adapt to it neither by day nor by night (OR=2.66; 95 % CI=1.64−4.31 for falling asleep disturbance).

The questionnaire was supplemented by traffic noise-measurements in Bratislava, Martin, Trenčín, Piešťany on noisy facades 50 meters ($L_{Aeq,day}$ = from 57 dB to 72.4 dB, $L_{Aeq,night}$= from 52.5 dB to 61.9 dB) and more than 100 meters from noisy traffic communication or inner city corridor.

After completion of the results, we plan to propose interim measures to noisy facades of the apartment buildings as well as intervention procedures in the prevention of adverse effects of traffic noise on health.

Keywords: Road traffic noise, annoyance, sleep disturbance

1. INTRODUCTION

Traffic noise is harmful to the health of almost every third person in the WHO European Region. One in five Europeans is regularly exposed to sound levels at night that could significantly damage health [1].

According to the results of the LARES study in panel block buildings in three cities of Eastern Europe sponsored by WHO, noise represents a traditional urban problem and noise annoyance and sleep disturbance were recognized as the most prevalent problems affecting residential health and well-being [2].

Health effects were identified also for selected physical and stress-related symptoms, such as hypertension and migraine, which showed significantly increased relative risks. The results also indicated that particular attention must be paid to night time noise exposure in homes [2, 3]. According to WHO and environmental burden of disease (EBD) approach, traffic noise exposure features cause

an annual loss of 31 Disability-Adjusted Life Years per 100 000 population in the WHO European Region [1].

The review of Basner et al., 2018 demonstrated effects of traffic noise on objectively measured sleep physiology and on subjectively assessed sleep disturbance (including sleep quality, problems falling asleep, and awakenings during the night) and the link between acute noise-induced sleep [3].

The paper presents the results of a pilot cross-sectional study focused on subjective traffic noise annoyance and sleep disturbance among the residents living close to major inner city corridors in some larger Slovakian towns including the capital Bratislava (more then 250 000 inhabitants) and Kosice (more than 100 000 inhabitants). The subjective adaptation to traffic noise, subjective evaluation of health status and well-being were assessed as well.

2. MATERIAL AND METHODS

Objective measurements of noise in the external facades of selected residential buildings were performed as a continuous 24 hour measurement of equivalent levels $L_{Aeq,OUT}$ of traffic noise at a given day of working week [4,5].

Noise annoyance was subjectively assessed using a a modified standardized Noise annoyance questionnaire [6,7]. Information from the 543 respondents (average age 45.3 ± 4.5 years, 73.1% of respondents in the age from 35 to 65 years, 26.9% in the age up to 35 years, 53% females, 81% living in houses more than five years) was obtained by a correspondence form and also by electronic form using a Google questionnaire. University education had 91% of all respondents and 95% of them rated their standard of living as average or above average, 86% of all respondents worked mentally and 15% were retired. About 82 % respondents were not exposed to occupational noise and only 5 % were working on shifts. Approximately 57.6% of respondents remain and spend weekends in their dwellings and 74.9 % devote their time regularly or irregularly to relaxing activities or personal interests.

Residents filled out questionnaires writing a subjective assessment of quality parameters of housing, including the level of annoyance and interference with activities, self-evaluation of their health and lifestyle by using a four grade rating scale. The questionnaire comprised 43 questions divided conceptually into the fields: house and home, traffic noise and housing, traffic noise and sleep, work place and noise, lifestyle and health and the overall level of housing quality.

For statistical processing of data descriptive and bivariate analyses were used (t-test, chi-square test, 2x2 tables) using the software packages EPI Info 7 and SPSS ver. 25.

3. RESULTS AND DISCUSSION

3.1 Exposure assessment

The questionnaire was supplemented by traffic noise-measurements in Bratislava, Martin, Trenčín, Piešťany on noisy facades 50 meters ($L_{Aeq,day}$ = from 57 dB to 72.4 dB, $L_{Aeq,night}$= from 52.5 dB to 61.9 dB) and more than 100 meters from noisy traffic communications or inner city corridor (table 1).

Outdoor noise levels in Tables 1 and 2 apply to noisy residential building facades within 1.5-2.0 m in front of the window of the living room on the floor level of the overhead floor in accordance with the valid Slovak legislation [8].

Measurements were carried out by accredited companies and professionally qualified persons with calibrated sound-level technology, in some cases also as final approval measurements of new block of flats or residential buildings (RB) or after their reconstruction [4,5] (tables 1,2, graphs 1,2). The corresponding 24-hour road traffic intensity assessments in selected Bratislava sites during working days were during the day and evening in summer period 15,532 – 46,449 vehicles and during the night 1,583-5,116 vehicles (Municipality, Bratislava, 2016).

Tab. 1. Equivalent noise levels $L_{Aeq,T}$ and the indicator L_{den} for 24h measurements on noisy facades 50 meters from noisy traffic communications

No.	**Locality of RB** Bratislava	**Floor**	**L Aeq.T /dB/ T=06h-18h day**	**L Aeq.T /dB/ T=18h-22h evening**	**L Aeq.T /dB/ T=22h-06h night**	**L dvn (2002/49/EC) /dB/**
1	Gagarinova	7	72.0	68.0	60.3	71.7
2	Račianska	4	72.4	69.3	61.4	72.5
3	Námestie SNP	3	62.4	62.8	59.7	67.0
4	Námestie 1.mája	4	64.8	63.1	61.9	68.9
5	Hodžovo námestie	4	71.0	68.7	64.0	72.7
6	Vajnorská	3	68.4	65.0	61.0	69.7
7	Námestie Slobody	5	66.6	65.0	58.5	68.0

(source: Sky-Eco, AZ Acoustic), Legend: RB=Residential Building

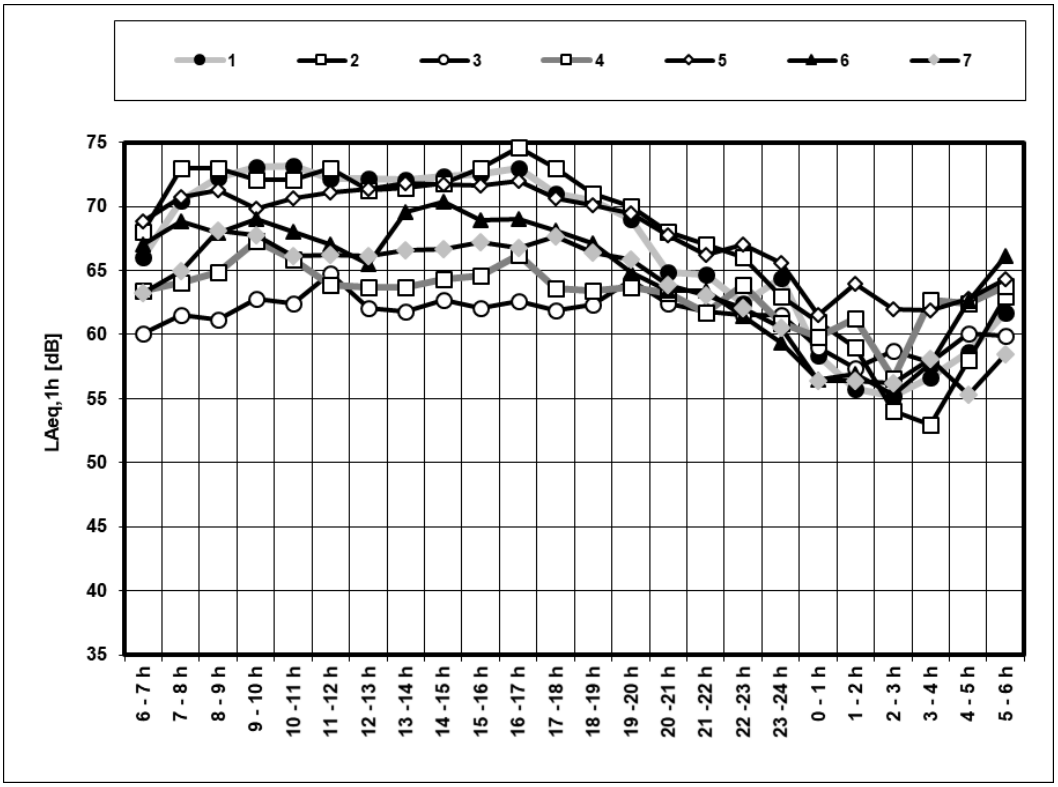

Fig. 1. The course of LAeq/1h measurements on noisy facades up to 50 meters from noisy traffic communications (numbers from 1 to 7 according the table 1)

Tab. 2 Equivalent noise levels $L_{Aeq,T}$ and the indicator Lden for 24h measurements on noisy facades 100 meters from noisy traffic communications and inner city corridors

No.	**Locality of RB** Bratislava (BA), Trenčín (TN), Martin (MT), Piešťany (PN)	**Floor**	**L Aeq,T /dB/ T=06h-18h day**	**L Aeq,T /dB/ T=18h-22h evening**	**L Aeq,T /dB/ T=22h-06h night**	**L dvn (2002/49/EC) /dB/**
1	BA, Račianska	5	57.4	53.9	49.7	58.5
2	BA, Strojnícka/Mierová	4	59.1	56.4	53.5	61.4
3	BA, Jégeho	5	57.7	54.1	48.5	58.3
4	BA, Lipského	3	60.5	57.8	49.7	60.7
5	MT, Kuzmányho	3	51.8	49.4	42.6	52.6
6	TN, Legionárska	3	53.4	52.3	48.3	56.3
7	PN, A.Hlinka	2	52.1	49.5	41.9	52.6

(Source: Sky-Eco, AZ Acoustic, Akustech), Legend: RB=Residential Building

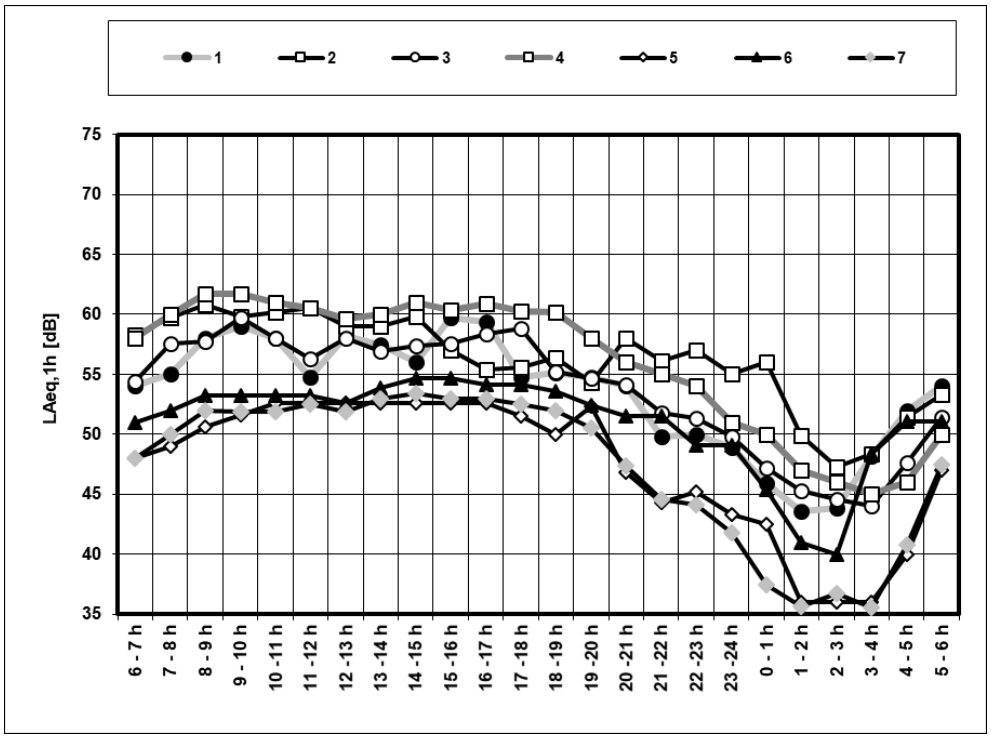

Fig. 2. The course of LAeq/1h measurements on noisy facades more then approximately 100 meters from noisy traffic communications and inner city corridors (numbers from 1 to 7 according the table 2)

3.2 Questionnaire – noise annoyance and sleep disturbance

The inhabitants with bedroom windows facing noisy streets or quite streets, inhabitants living in the large cities or in the rural area and also at the distance less than 50 meters from noisy facades and more than 100 meters from noisy traffic communications or inner city corridors represented the exposed and the control group.

Falling asleep, night and early morning awakening and closing windows due to annoyance are significantly more frequent in respondents facing the bedroom window to noisy communications (OR=2.66; 95 % CI=1.64−4.31). Inhabitants living in the distance less than 50 meters from noisy facades are significantly more awakened by road traffic noise (OR=1.76; 95 % CI=1.04−2.97). Respondents from large cities use to close windows due to noise annoyance as well (OR=2.22; 95 % CI=1.47−3.37) (Table 3).

Tab. 3 Activities interfered by road traffic noise during the night (22h-06h) (n=543)

Activity interfered by road traffic noise	**Exposed and control group of respondents**	**Odds ratio (OR)**	**Confidence interval (95%)**		**P-value**
			Lower limit	Upper limit	
Falling asleep	Bratislava /large cities + rural area	1.36	0.84	2.21	0.206
	Distance from the noisy communication	1.09	0.64	1.83	0.760
	Orientation of bedroom windows	2.66	1.64	4.31	**< 0.001**
Night and early morning awakening	Bratislava /large cities + rural area	1.71	1.17	2.49	**0.005**
	Distance from the noisy communication	1.76	1.04	2.97	**0.035**
	Orientation of bedroom windows	1.90	1.17	3.08	**0.009**
Closing windows due to annoyance	Bratislava /large cities + rural area	2.22	1.47	3.37	**< 0.001**
	Distance from the noisy communication	2.66	1.68	4.19	**< 0.001**
	Orientation of bedroom windows	2.87	1.84	4.36	**< 0.001**

Tab. 4 Adaptation to noise and well-being during the day and night (n=543)

Activity	Exposed and control group of respondents	Odds ratio (OR)	Confidence interval (95%)		P-value
			Lower limit	Upper limit	
Adaptation to road traffic noise in the night	Bratislava /large cities + rural area	2.02	1.36	3.01	**0.001**
	Distance from the noisy communication	1.18	0.78	1.78	0.438
	Orientation of bedroom windows	1.16	0.75	1.78	0.507
Satisfaction with quality of living	Orientation of bedroom windows	0.35	0.20	0.61	**< 0.001**
Subjective noise sensitivity	Orientation of bedroom windows	0.507	0.34	0.75	**< 0.001**
Sleeplessness	Orientation of bedroom windows	2.54	1.38	4.92	**< 0.001**

The answers of respondents to their potential ability to adapt and to get used to traffic noise during the night are shown in Table 4. In the exposed group from large cities 26.8% of respondents cannot adapt to traffic noise compared to 35.5% in the control group. These results are also highly statistically significant (p=0.001). Inhabitants with window orientation into noisy communications are significantly less satisfied with their quality of living, are less noise sensitive and report more sleeplessness (Table 4)

Preliminary results of our study are compatible and support the results of the other studies held in Slovakia and abroad [7, 9,10,11,12]. However, subjective adaptation to noise the other authors did not study in such detail.

The outcomes of this pilot study support the hypothesis of subjectively higher level of interference with traffic noise of inhabitants living near urban transport communications (with a traffic of around 20,000 vehicles per day) and over-limit exposure to traffic noise on the noisy facades of residential buildings. The summer nights during working week (between 22h and 06h) are especially risky, when noise acts especially troublesome during the time designated for regeneration and sleep. That was proved by closing the windows of bedrooms especially in the summer night on the side of noisy facades.

The comparison of selected groups of respondents may be affected by confounding factors, such as relatively small sample size overall and the small sample size of the control group of respondents, orientation of residential rooms and windows in residential buildings due to noisy communications, floor height, and the subconscious psychological barrier of respondents in the exposed group as property owners resulting from economic interest in their housing.

In the future analysis, we plan to enlarge the sample size, especially in the control group, and to further evaluate the health and lifestyle of respondents and to suggest precautions and interventional procedures including of noise monitoring and evaluation inside of bedrooms.

There are three possible approaches to protect residents from road traffic noise; the first directed at reducing the noise sources, the second at the modification of housing, and the third at reducing the

possibility of noise reaching the housing [1,2].

4. CONCLUSIONS

Our study was aimed at noise exposure assessment and subjective annoyance by traffic noise of inhabitants living in big cities, near urban transport communications and with bedroom windows facing noisy streets. The outcomes of this pilot study support the hypothesis of subjectively higher level of interference with different day and night activities and the assumption of increased health risk. Respondents from the large cities seems to better adapt to road traffic noise and respondents with bedroom windows oriented toward noisy communication are less noise sensitive.

After completion of the results, we plan to propose interim measures to noisy facades of the apartment buildings as well as intervention procedures in the prevention of adverse effects of traffic noise on health. Reliable information's about quite zones, facades or silent bedrooms in new apartment buildings and urban area can be important for noise sensitive inhabitants etc.

The health impact of noise from neighbor housing and indoor noise sources should be taken into account as well.

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