Problems of noise annoyance in the newly built apartment buildings in Slovakia

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ABSTRACT

The paper presents preliminary results of a pilot cross-sectional study focused on subjective traffic noise annoyance and sleep disturbance among the population groups in selected new apartment houses situated close to major inner city corridors in Slovakian capital Bratislava.

The noisy facades of these buildings have noise exposure above the limit during the day and the night ($L_{Aeq,day}$ =72 dB, $L_{Aeq,night}$=60 dB).

Statistical outcomes of the questionnaire survey on the pilot sample of 176 respondents (average age 41.7 ± 9.3 years, 57% females, living in houses in the average for four years), are presented comparing the exposed and control group of inhabitants with bedrooms windows facing noisy streets or quite streets. Road traffic noise annoys significantly more daily and night activities of respondents in the exposed group (OR=2.86; 95 % CI=1.27-6.44 for sleep disturbance), who are unable to adapt to it neither by day nor by night.

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.

INTRODUCTION

Housing belongs to the basic biological needs of man. The quality of housing greatly affects human health, because people spend a substantial proportion of their time in buildings (about 80 %). The main function is to protect from weather and other adverse environmental factors, provides the opportunity to rest and family life, including the time needed for sleep. The quality of housing determines also the broader residential environment in which the apartment is located, for example the city center, housing estate, family houses in rural areas, etc. From the physical pollutants in the residential environment, with regard to major transport corridors, the problem of noise is still topical [1, 2, 3, 4].

Community noise (also called environmental noise, residential noise or domestic noise) is defined as the noise emitted from all noise sources except the industrial workplace. Main sources of community noise include road, rail and air traffic, industry, construction and public work, and the neighbourhood. The main indoor noise sources besides road traffic noise are heating and ventilation systems (i.e. HVAC noise - heating, ventilation, air-conditioning), office machines, home appliances, neighbors and surroundings. This includes for example the noise from catering facilities and restaurants, the entertainment facilities and nightclubs, from live and recorded music, from domestic animals (e.g. barking dogs) and noise from parks and playgrounds [5,6,7]. Sources of technical equipment in buildings with insufficient vibroinsulation generate relatively strong low-frequency tonal noise that is annoying to humans [8].

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 was recognized as one of the most prevalent problems affecting residential health and well-being. 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 [1, 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 [3].

This also applies to newly built apartment buildings in Slovakia, often built close to the busy urban communications. In addition, those are multifunctional buildings, with shops, services and other facilities placed inside.

AIM OF THE STUDY

The aim of this pilot cross-sectional study was to assess the subjective traffic noise annoyance and sleep disturbance among the population groups in selected newly built apartment houses situated close to major inner city corridors in Slovakian capital Bratislava. The transport parameters of the sites were objectively assessed as well.

METHODS

In the pilot cross-sectional study, we assessed the exposed and control groups of inhabitants in Bratislava. The exposed group lived in newly built apartments with windows of bedrooms at noisy facades oriented towards the major inner city transport corridors and the control group in the same newly built apartment buildings with windows of bedrooms oriented to the side facing away the noisy corridors, to the courtyard. We selected newly built or renovated multi-stage multifunctional high-rise buildings with a residential operation from the second or the third aboveground floor located in the wider center of Bratislava at a distance of about 50 meters from the main inner city roads, which are significantly exposed to traffic noise from the road or urban rail transport (trams). The survey was conducted in agreement with the administrators of the apartment buildings on the street Gagarinova (Perla Ruzinova) Racianska (Manhattan) and Racianske Myto Square, Radlinskeho and Cernysevskeho Street. Objective measurements of noise in the external facades of selected residential buildings (RB) oriented to the nearest major transport corridors were performed as a continuous 24 hour measurement of equivalent levels L_{Aeq} of traffic noise at a given day of working week [9].

At the same time the measurements and prediction of indoor noise in the given living room, were performed, while ensuring a minimum-ventilation through the window in the position of

ventilation or using so-called ventilation slots in the window frame of the projection ventilation system in the apartment [9].

Noise annoyance of residents was assessed subjectively using a modified standardized Noise annoyance questionnaire [10,11]. Information from respondents was obtained by correspondence. Residents filled out questionnaires at home 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 package EPI Info 7 and Microsoft Excel, 2016.

RESULTS

Objectification of traffic parameters

Outdoor and indoor noise levels in Tables 1 and 2 apply to noisy residential building facades within 1.5 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 [12]. These noisy facades show the above-limit exposure, but so called quiet façades facing away from the dominant communications have windows of residential rooms with a sub-limit exposure. The equivalent noise levels difference from the noisy and the quiet façade was 7-13 dB, depending on the particular situation. On these facades the barrier effect or so called soundproof barrier effect of the building itself or the surrounding buildings occur.

Intensity of traffic flows related to the main city roads and trends in recent years, according to data from Bratislava Municipality collected in selected transport hubs, or selected city crossroads, show relatively long-term stability in the range +/- 5%. Table 3 shows the recent situation in Gagarinova Street close to the center and in the Panonska Street in the suburb of Petrzalka.

Subjective noise annoyance assessment

In selected residential buildings (RB) there were totally 645 questionnaires distributed, the response rate was 27%. In the study sample of 176 respondents, there were 57% of women and 43% men. The mean age was 41.7 ± 9.3 years, 91% of respondents lived in RB for more than one year, 75% lived there for more than two years and the average length of living in those apartments was 4.5 ± 2.7 years. Of the respondents, 82% work mentally, 11% are pensioners; 72% are not annoyed by noise at work and only 5.7% of respondents work on shifts.

Concerning traffic noise annoyance the sample was divided into respondents living in apartments with windows of bedrooms oriented into busy, noisy streets (n=132) (exposed group) and respondents with windows of bedrooms oriented into quiet street or courtyard (n=44) (control group). The two groups were followed in terms of increased noise annoyance risks from road traffic for day and night interval separately.

Table 1: Traffic noise levels for day, evening and night in the noisy facades of RB

Locality/street	Overhead floor	$L_{Aeq,T,OUT}$ (dB)		
		06-18 h Day	18-22 h Evening	22-06 h Night
Gagarinova	7	72	68	60
Cernysevskeho	11	65	63	62
Racianska	24	69	61	54
Racianske Myto	4	65	56	52
Radlinskeho	4	71	66	63

Table 2: Traffic noise levels from indoor noise for day, evening and night inside houses with windows in ventilation position or with ventilation slots (*), in the noisy facades of RB

Locality/street	Overhead floor	$L_{Aeq,T,IN}$ (dB)		
		06-18 h Day	18-22 h Evening	22-06 h Night
Gagarinova	7	55	51	43
Gagarinova*	7	-	30*	26*
Cernysevskeho	11	48	46	45
Racianska	24	52	44	37
Racianska*	24	-	32*	25*
Racianske Myto	4	48	39	35
Radlinskeho	4	54	49	46

Note: * ventilation slot in the window frame

Table 3: Number of vehicles on the profile of Gagarinova and Panonska streets in the summer period (source: Bratislava Magistrate, 2016)

Road profile (street)	Year	06-18 h Day	18-22 h Evening	22-06 h Night
Gagarinova (wider center)	2011	18 675	3 481	1 451
	2013	18 603	3 602	1 443
	2015	18 248	3 584	1 506
Panonska (Petržalka)	2010	12 766	3 197	1 379
	2012	13 034	2 678	1 226
	2014	12 006	2 938	1 219

In the exposed group there were 56% females and 44% males. The mean age was 41.13 years. In the control group there were 59% females and 41% males and the mean age was 43.57 years. The differences in sex and age were not significant ($p = 0.7$ and $p = 0.3$). The significant difference, however, was in the floor height for the exposed group, that live on the higher floors ($p = 0.003$). More than 40% of them live from the 8th floor up comparing to the 16% percent of respondents in the control group.

Respondents subjectively assessed their overall health in 62% as good or more than good and age-appropriate in 32% of cases. Fairly bad or very bad health stated respondents only in 6% of cases. Approximately 53% of respondents remain and spend weekends in their dwellings and 84% devote their time regularly or irregularly to relaxing activities or personal interests. The subjective assessment of health status was not significantly different ($p = 0.8$).between the exposed and the control group.

In the summer period 57 % of respondents are annoyed by traffic noise at night and 23 % of respondents disturb traffic noise for the whole year.

In the summer period 61 % of respondents sleep with the open windows or windows in the ventilation position. Disturbance by noise is the cause of closing the window at night during sleep for 56 % of respondents.

Trafic noise annoys 48 % of respondents in the summer period during the day, 42 % during the whole year in the exposed group; in the control group 34 % respondents in summer period and 23 % during the whole year. Traffic noise does not annoy 30 % respondents in the control group, comparing to the exposed group (only 5 % of respondents). Traffic noise interfers with listening to radio and TV in 73 % of respondents in the exposed group (yes, probably yes)

comparing to 32 % in the control group. In 51 % of respondents from the exposed group, traffic noise disturbs reading and mental work comparing to 23 % in the control group. About 17 % respondents from the exposed group are not able to get used to noise comparing to 7 % from the control group. Those results are highly statistically significant ($p<0.001$) (Figure,1, 2).

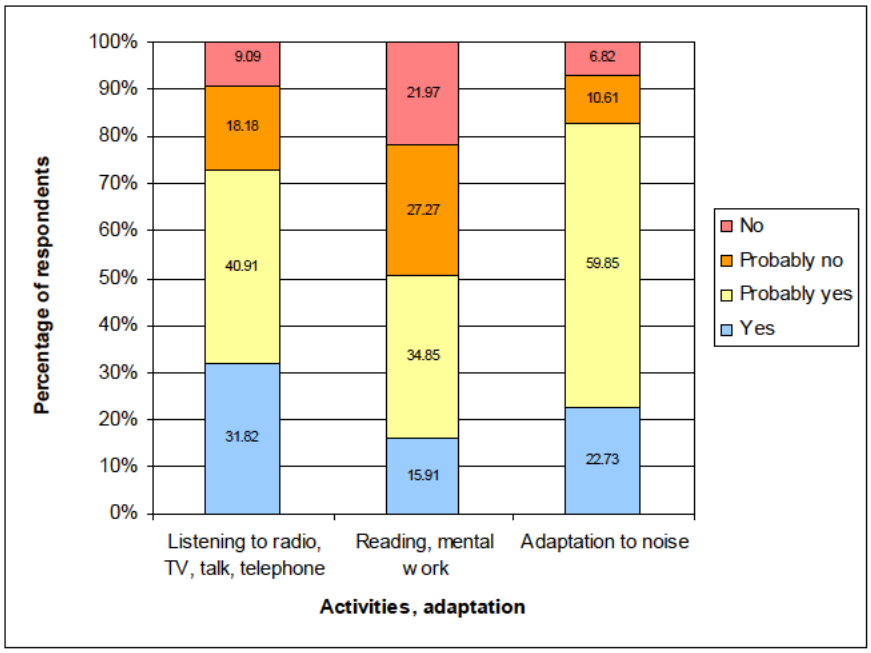

Figure 1: Annoyance and adaptation to traffic noise in the exposed group during the day (06.00-22.00) at open windows

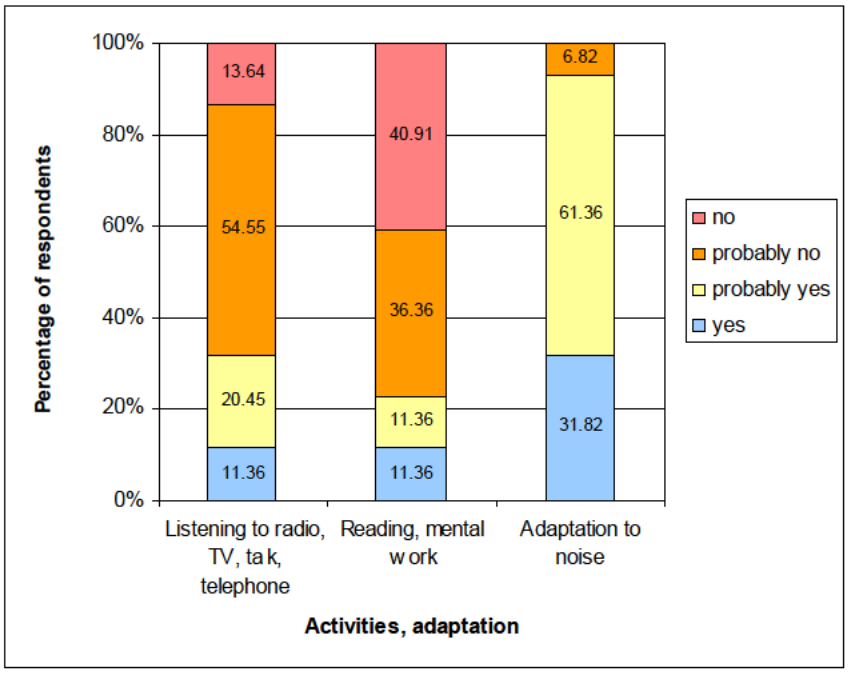

Figure 2: Annoyance and adaptation to traffic noise in the control group during the day (06.00-22.00) at open windows

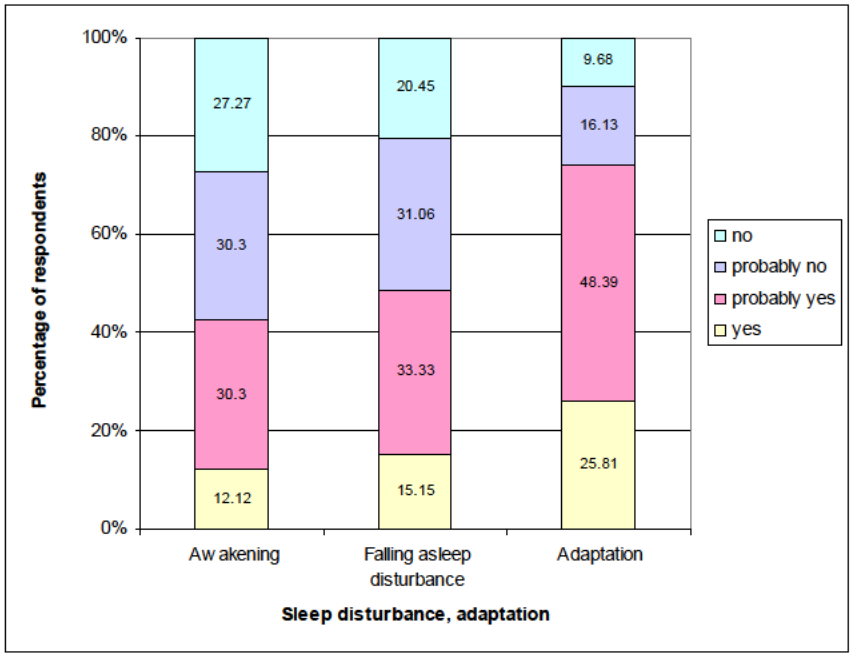

Figure 3: Sleep disturbance and adaptation to traffic noise in the exposed group during the night (22.00h - 06.00 h)

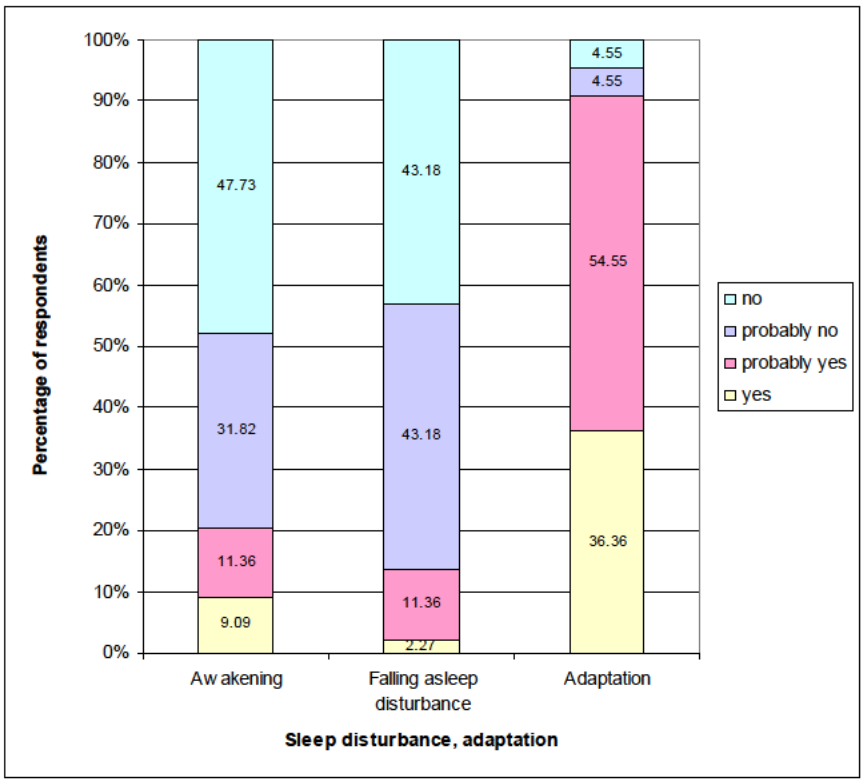

Figure 4: Sleep disturbance and adaptation to traffic noise in the control group during the night (22.00h - 06.00 h)

In Figures 3 and 4 the reactions of respondents from the exposed and the control group to sleep disturbance and awakening are expressed. Traffic noise annoys mostly in summer in

the exposed (61.4%) and in the control group (45.5%). Falling asleep in the exposed group annoys 48 % of respondents compared to 13 % in the control group, 42 % of respondents wake up from sleep in the exposed group compared to 20 % in the control group.

Table 4: The analysis of traffic noise annoyance during the day and night in the exposed and in the control group (odds ratio)

Activities of respondents in flats	OR (odds ratio)	Confidence interval 95 %	P value
Listening to radio, TV, talk and telephone during the day	5.71	2.72 - 11.99	<0.0001
Reading, mental work during the day	3.50	1.60 - 7.67	0.001
Adaptation to noise during the day	2.88	0.82-10.12	0.009
Falling asleep	5.96	2.36−15.05	<0.0001
Sleep	2.86	1.27-6.44	0.009
Adaptation to noise during the night	3.20	1.06-9.63	0.031

The answers of respondents to their potential ability to adapt and to get used to traffic noise during the night are shown in Figures 3 and 4. In the exposed group, 26% of respondents cannot adapt to traffic noise compared to 10% in the control group. These results are also highly statistically significant ($p < 0.001$).

Table 4 shows the data from contingency tables from responses in the exposed and in the control groups for selected activities of inhabitants and their annoyance including the subjective ability to adapt and to get used to traffic noise in the followed residential buildings. According to our analysis, traffic noise annoys significantly the day and night activities of respondents in the exposed group, who are unable to adapt to it neither by day nor by night.

DISCUSSION

Statistical outcomes of the questionnaire survey on the pilot sample of 176 respondents are presented comparing the exposed and control group of inhabitants with bedrooms windows facing noisy streets or quite streets. Road traffic noise annoys significantly more daily and night activities of respondents in the exposed group (OR=2.86; 95 % CI=1.27-6.44 for sleep disturbance), who are unable to adapt to it neither by day nor by night.

Preliminary results of our study are compatible with the results of the other studies held in Slovakia and abroad [11, 13, 14, 15]. 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 and poorer adaptation to 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.

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 [3].

CONCLUSION

Our study was aimed at noise exposure assessment and subjective annoyance by traffic noise of inhabitants living near urban transport communications of the Slovakian capital Bratislava.. The outcomes of this pilot study support the hypothesis of subjectively higher level of interference and poorer adaptation of inhabitants to noise and the assumption of increased health risk. 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.

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

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