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ADVERSE HEALTH EFFECTS IN RELATION TO URBAN RESIDENTIAL SOUNDSCAPES

A. Skånberg and E. Öhrström

Department of Environmental Medicine, Göteborg University, Box 414, *SE* 405 30, *Göteborg, Sweden.*
E-mail: *annbritt.skanberg@envmed.gu.se*

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Noise pollution from road traffic in residential areas is a growing environmental problem. New approaches to turn the negative trend are needed. The programme "Soundscape Support to Health" will achieve new knowledge about the adverse health effects of noise pollution on humans and will investigate the link between well-being and health and perceived soundscapes for optimizing the acoustic soundscapes in urban residential areas. This paper will briefly present the programme and presents preliminary results from the first study of how various adverse health effects are related to individual noise exposures among individuals in residential areas with and without access to a quiet side of the dwelling.

1. BACKGROUND

Noise is a major environmental health problem. In contrast to many other environmental problems, noise pollution is still growing [1]. In residential areas, traffic is normally the dominating noise source. The number of individuals exposed to traffic noise levels $L_{Aeq,24h} > 55$ dB is approximately 2 million or 25% of the population in Sweden [2]. The technical development of noise abatement at the source (emission), road surfaces, etc., will not be enough to turn the present negative trend. Additional approaches are needed. One attempt to solve the problem is to utilize the variations in the soundscape to create healthier sound environments.

2. THE SOUNDSCAPE

In a residential area, the soundscapes vary with space and time. Acoustical shielding by buildings and special sound barriers results in great variations in the soundscape. The variations can be created and utilized in a much more systematic way than hitherto, giving residents access to soundscapes—especially quiet sectors—which are supportive to their well-being and health. Thorough knowledge of effects on humans of such variations in soundscapes, and how these variations are perceived and used by the residents, are necessary for optimal city and traffic planning. Such knowledge is lacking today and must be developed.

3. ADVERSE HEALTH EFFECTS

Among the directly observable adverse health effects, population annoyance is the most commonly recognized effect from traffic noise. Dose–response curves between population

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annoyance and traffic noise show a great scatter of data points caused by type of noise and individual and situational factors. At the individual level, at most 30% of the variance in annoyance may be explained by noise exposure (L_{Aeq}). One possible reason for the low association repeatedly found between annoyance and noise exposure is the lack of assessment of individual noise–dose immission. The exposure is given as one number only for relatively large geographical areas: the outdoor sound level. It is unclear to what extent the respondents are exposed to estimated levels outside their dwellings, if the sound insulation against traffic noise is medium or high, etc. Existing dose–effect relationships between exposure to road traffic noise and adverse health effects do not take into account the fact that people are exposed to a variation of very different sound levels in different parts of their dwellings and their adjacent outdoor areas.

More recently, sleep disturbance due to noise has been considered in land-use planning. Physiological as well as psychological effects have been documented (difficulties in falling asleep, awakenings, impaired sleep quality, adverse after-effects). For a review of the literature, see references [3, 4].

Noise interference with speech communication is well known for continuous noise but only a few studies exist for real sounds like traffic noise. In a “good environment” the signal-to-noise ratio should be 15–18 dB [5]. The most important activity interference seems to be interference with rest/recreation/watching television [6].

4. OBJECTIVES

A program has been created with the goal to develop methods and models for predicting and optimizing acoustic soundscapes in connection with traffic and city planning, including the construction of new dwellings and rebuilding of dwellings in noise polluted areas, with regard to desired perceived soundscapes and effects on well-being and health. The programme started in the year 2000 and will continue over a four-year period. It involves researchers from the disciplines of applied acoustics, psychology and environmental medicine [7].

The new approach addressed by this programme uses the link between well-being and health and perceived soundscapes for optimizing the soundscapes in urban residential areas with heavy traffic noise. It involves the steps illustrated by the block diagram in Figure 1.

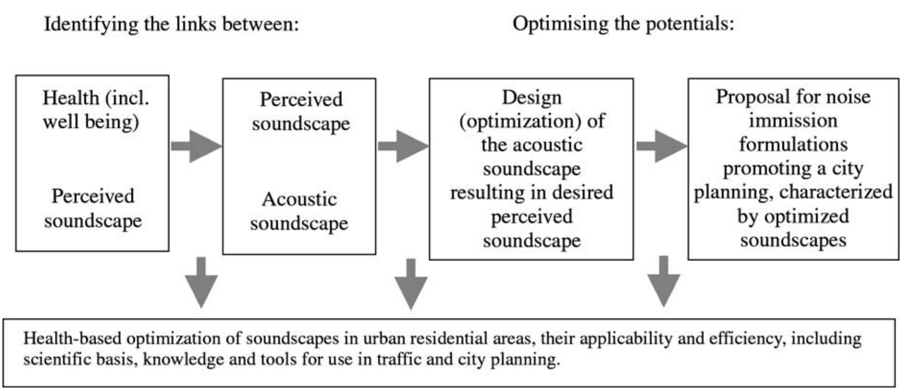

Figure 1. Description of research approach

5. METHODS AND MATERIALS

A number of application examples play a central role in the programme development and in the evaluation of the effects of changes of soundscapes. The goal is to test the methods and models developed on the application examples and to demonstrate that an optimized design of the soundscapes, from the point of view of perception and health, can be realized and that the effects can be assessed and represent a significant improvement.

One set of examples is residential areas in which the residents today are exposed to high noise levels throughout the soundscape. After an intervention they will have access to a quiet side of the living space and to at least one quiet outdoor area, whilst still keeping one side of the living space as noisy as before the renewal. Two longitudinal studies of this type will be performed.

The other type of examples are pairs of residential areas, one of which where residents are subjected to a soundscape including at least one indoor/outdoor side exposed to high noise levels (from traffic) and at least one indoor/outdoor quiet side, and the other where residents are subjected to a soundscape with a moderate sound level throughout. Five pairs of cross-sectional studies of this type will be performed. The study sites will be chosen to cover L_{Aeq}-levels ranging from about 45 to > 65 dB to allow for studies of exposure–effect relationships.

In both types of studies, assessments of the individual noise exposure are made for the indoor and outdoor situations considering the location of bedroom, living room and balcony and areas for outdoors recreation. The examples will provide knowledge on how adverse health effects, well-being and sleep; behaviours and self-estimated noise sensitivity are related to individual noise exposure and perceived soundscapes. This knowledge is the basis for establishing the desired characteristics of the individual soundscapes.

In the following, some preliminary results on adverse health effects from the first pair of study sites at a street in Stockholm, Sweden are presented.

5.1. DESCRIPTION OF THE AREA

The dominating noise source was road traffic from the main road (Hägerstensvägen). The apartment buildings were located either parallel with the main road or with the gable towards the main road. The dwellings in buildings that had windows only facing the streets were classified as "noise/noise" and dwellings with access to a quiet side to the back of the building or a backyard were classified as "noise/quiet".

5.2. ASSESSMENT OF NOISE EXPOSURE

Assessments of the individual noise exposure for day, evening and night were made at several measurement points in each site. Noise levels were measured or calculated according to the Nordic calculation model for road traffic noise [8]. Noise levels were assessed for all facades of the building, outside living room and bedroom windows, on balconies and areas for outdoor recreation. The noise exposure levels were assessed for L_{Aeq} day, evening and night, L_{Amax}, L_{90} and L_{10} and number and type of vehicles. Since $L_{Aeq24\,\mathrm{h}}$ levels in the noise/noise site in some cases were lower than in the noise/quiet site, analyses on various effects were only performed for dwellings with $L_{Aeq24\,\mathrm{h}}$-levels > 59 dB in both sites.

5.3. EVALUATION OF EFFECTS

The effects were evaluated by postal questionnaires with 59 main questions. The study was performed in February–March 2000. The study was described as a general study about well-being and housing and housing environment. It contained questions about the dwelling and the neighbourhood, annoyance from different sources (e.g., noise, dust, exhausts, vibration) including road traffic noise. Questions were asked on interference from noise on various activities and on sleep, sleeping environment and sleep disturbances, health and well-being including questions on noise sensitivity.

6. RESULTS

6.1. NOISE LEVELS

The number of vehicles at the main road varied between 7000 and 10 000 per 24 h. Noise levels in $L_{Aeq\ 24\,\mathrm{h}}$ on the noisiest side of the façade varied between 52 and 65 dB(A) (Mean: 61·1 SD: 3·3). There was a very good agreement between measured and calculated noise levels on the noisy side of the façade. Noise levels in $L_{Aeq\ 24\,\mathrm{h}}$ on the quiet side varied between 42 and 54 dB in seven measurement points. The agreement between measured and calculated noise levels on the quiet side was poor. One reason for this was that noise from a motorway further away added to the noise levels on the, presumed, quiet side. Further calculations and measurements will give a more definite result on noise levels on the quiet side of the dwellings.

6.2. POPULATION SAMPLE

The response rate for the questionnaire was 56·8% or 227 respondents. Of these, 103 respondents were without access to a quiet side and 124 respondents had access to a quiet side of the building. There were no significant differences according to socio-demographic variables between persons who lived in dwellings with access to a quiet side and those who did not.

6.3. ANNOYANCE

Table 1 shows results on general annoyance.

Table 1 shows that there were no significant differences in annoyance between noise/noise and noise/quiet. However, a tendency towards a lower extent of very and extremely annoyed individuals was seen in noise/quiet ($p = 0{\cdot}11$). In both sites, a significantly higher annoyance was reported in the open window situation as opposed to a closed window situation ($p < 0{\cdot}0001$). Annoyance in the outdoor situation, however, was significantly lower than annoyance in the open window situation ($p < 0{\cdot}0001$).

7. COMMENTS

This study represents the first of five pairs of study sites that will be selected for the project. Preliminary results show only a tendency to lower general annoyance among residents who have access to a quiet side of the dwelling. The reason for the small differences might be that the presumed quiet side was not experienced as quiet, since noise from a motorway further away added to the perceived noise levels on the more quiet side of the buildings.

TABLE 1

Annoyance by road traffic noise in relation to type of dwelling

	Noise/noise $n = 74$		Noise/quiet $n = 115$		p-Value
"*Thinking about the last* 12 *months then you are here at home, how annoyed… …*":	Number	%	Number	%	
Not at all annoyed	9	12·2	18	15·7	
Not very annoyed	35	47·3	56	48·7	
Rather annoyed	17	23·0	28	24·3	
Very annoyed	9	12·2	7	6·1	0·11
Extremely annoyed	4	5·4	6	5·2	
Scale 0–10 (*Not at all annoyed–Extremely annoyed*)	Mean	SD	Mean	SD	
"*When you are here at home….*"	3·92	3·0	3·78	3·02	n.s.
"*If you are, indoors with*":					
Closed windows	3·49	2·91	3·12	2·91	n.s.
Open windows	4·88	3·32	4·71	3·29	n.s.
Outdoors	3·27	2·86	3·74	2·81	0·13

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