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ADVERSE HEALTH EFFECTS IN RELATION TO NOISE MITIGATION - A LONGITUDINAL STUDY IN THE CITY OF GÖTEBORG

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ABSTRACT
Two socio-acoustic surveys on adverse health effects of road traffic noise were executed along Västra Bräckevägen in Gothenburg city, Sweden in 1986 and 1987 before and after traffic regulations during night. The results from these studies indicated that the traffic regulations were not effective in reducing the adverse effects of noise. This paper presents results from new studies performed 1997 and 1999 in the same area before and after the opening of a new tunnel for road traffic. The road traffic was reduced from about 25,000 to 2,400 vehicles per 24 hours and the percentage of highly annoyed respondents decreased from 58 to 7 percent. It is concluded from these long term investigations that exposure to high levels of road traffic noise not only induces adverse effects in terms of annoyance but also significantly affects sleep quality and psycho-physiological health and wellbeing.

1 - INTRODUCTION

There is substantial evidence in the literature that environmental noise causes various adverse health effects and the evidence are strongest for annoyance, acute sleep disturbances and performance by school children [1]. Concerning long term non-auditory health effects, e.g. effects on psychosocial wellbeing, the evidence is weaker and more research is required. Longitudinal studies and intervention studies in connection with extensive noise abatement activities, 'natural experiments' are far more informative than cross-sectional studies.

2 - BACKGROUND AND AIM

Västra Bräckevägen on the island of Hisingen in the city of Gothenburg, Sweden has had a very heavy traffic load for many years, with about 25 000 vehicles per day. To improve the environmental situation of people living along this road, a number of measures have been put into effect over the years. Socio-acoustic surveys were carried out along Västra Bräckevägen before and after these measures in 1986 and 1987 (Öhrström 1989 [2]) for the purpose of shedding light on the occurrence of different effects of noise among the population and on whether the measures had an effect on the experience of disturbance caused by noise, on sleep quality and on health and wellbeing. These investigations showed that the measures against noise (prohibition of heavy traffic during night, porous asphalt, reduced speed and traffic signs indicating "You drive too fast") were not sufficient.
To improve the living environment around Västra Bräckevägen and facilitate road transport, very extensive changes were made in the road system and a new tunnel, the Lundby Tunnel, was opened for traffic in January 1998. A new longitudinal study was performed before and after the opening of the tunnel. The first part of this new study was presented in 1998 [3].
The aim of the study was to elucidate effects of road traffic noise and the effect of the changes in noise exposure on annoyance, various activity disturbances, sleep quality and psychological and physiological wellbeing. Other aims of the study were to compare different methods to study sleep disturbance effects by repeated questionnaires on perceived sleep quality and by actimetry. The method and the results from these other sleep studies are not presented in this paper.

3 - METHOD AND MATERIALS

3.1 - Method

The survey and the area of investigation. The first part of the socio-acoustic survey was performed in October − December 1997 before the opening of the new tunnel for road traffic. The tunnel was opened in January 1998 and a first, minor, follow up study on sleep was performed 3 months later. The final part of the investigation was executed in April − May 1999.

The area of investigation was located between 25 and 400 m from the trafficked main road (Västra Bräckevägen). The area was divided into an exposure and a control area in which the houses were situated about 25 − 70 m and 125 − 400 m respectively from the main road. All houses were relatively small private-owned 11/2-storey buildings from the 1930ies and each house was surrounded by a small garden.

Evaluation of effects. The effects on the population were evaluated by a main questionnaire that was delivered by a project assistant at the door/mailbox together with an introductory letter to one, or two, persons in each household between 18 and 75 years of age. The questionnaire was similar to those previously used [2] and contained questions about the dwelling, annoyance to different sources in the neighbourhood, sleep and sleep disturbances and health and psycho-social symptoms and wellbeing. In the follow up study specific questions on the various effects were added where the respondents compared the situation before and after the changes in road traffic.

Assessment of noise exposure. Outdoor L_{Aeq}-levels were calculated for both sides of each house based on traffic statistics obtained from the local Traffic Office. Indoor L_{Aeq}-levels were calculated for living-rooms and bedrooms based on measurements and calculations of noise reduction of the façade. Façade reduction (R'45°, w) was measured in the bedrooms of a sample of 7 houses according to Swedish Standard SS 02 52 54 and ISO 140-5 with Norsonic AS type 840. Evaluation was done according to SS EN ISO 717-1.

A noise level meter, Larson & Davis type LD 820, which was operated as a remote station via a wireless transmission system was used. Measurements were done 3-4 days continuously in 5 different positions in the garden. A mean for each position was calculated for: L_{Aeq}, L01, L90, L_{Amax}, Noise events >70 dBA for 3 periods; 24 hours, daytime (06-22) and night time (22-06).

3.2 - Materials

The total number of respondents in 1997 was 142 persons (exposed area; 50 and control area; 92) and the response rate was 62 % for the main questionnaire. Of these respondents 120 persons (exposed area; 45 and control area; 75) took part in the follow up study in 1999.

4 - RESULTS

4.1 - Noise exposure

The road traffic was substantially reduced when the new tunnel was built, from about 25,000 to 2,400 vehicles per 24 hours resulting in a decrease in L_{Aeq}-levels of 9-14 dBA in the exposed area. In the control area a small reduction of 0 − 4 dB was seen. With the exception of 1 or 2 houses, all homes in the exposed area now have an acceptable environment in terms of noise, i.e. the recommended value (Swedish Parliament 1997) for noise ($L_{Aaeq.24h}$55 dB) is not exceeded. Table 1 shows the variation in calculated L_{Aeq} 24 hours before and after traffic regulations.

	Exposed area		Control area	
$L_{Aeq.24H}$:	1997	1999	1997	1999
Northwest facade	56 − 69	44 − 57	40 − 52	39 − 48
Southeast facade (quiet side)	48 − 64	38 − 50	40 − 51	40 − 48
Outside bedroom	43 − 67	39 − 55	40 − 51	39 − 48
Outside living-room	48 − 67	38 − 55	40 − 51	39 − 48

Table 1: Calculated outdoor $L_{Aeq.24h}$ − levels before and after traffic regulations.

4.2 - Noise annoyance

Not all disturbance due to noise in the area disappeared after the traffic regulations, but the proportion of very annoyed persons (4-graded verbal scale) fell significantly ($p<0.001$) from 58 to 7%. The size of this extent of annoyance agrees well with expected disturbance at $L_{Aaeq.24h}$55 dB. Annoyance measured

by a numeric scale 0-10 decreased from 8.9 to 1.4 mean value ($p<0.001$) in the exposed area and from 2.3 to 1.7 in the control area ($p<0.01$).
The most obvious effect of the road traffic noise in 1997 was not being able to have windows open as often as one wished. Rest, relaxation and sleep were otherwise the indoor activities that were experienced as being most affected by the traffic noise. Outdoor activities such as relaxation and conversation, as well as being able to be on the terrace or patio, was judged by half of the residents as being disturbed. After the traffic regulations all disturbances decreased significantly in the exposed area.

4.3 - Sleep quality
Sleep quality was poorer in the exposed area. Residents experienced more difficulty in falling asleep, they slept less frequently with open windows, they awoke more often, had poorer sleep quality and felt more tired in the morning. After the tunnel was built, sleep quality in the exposed area improved (less difficulties falling asleep, less tiredness during the morning) and no differences in comparisons with the control area could be observed.

4.4 - Psycho-social symptoms and general wellbeing
Previous investigations in the residential area carried out in 1986 and 1987 indicated that road traffic noise can give rise to different psycho-social symptoms and can give poorer wellbeing. The new studies confirm that road traffic noise leads to different symptoms and negatively affects wellbeing. Table 2 shows that the frequency of psycho-social symptoms was higher in the exposed area in 1997.

	Exposed area		Control area		sign. level Exp/Contr
Percentage who mentions symptoms sometimes a week or every day:	1997	1999	1997	1999	1997
Headaches	12	13.3	19.6	17.3	-
Very tired	48	31.1	35.8	29.4	-
Uneasiness in the stomach	24	15.6*	8.7	8	#
Depressed	24	11.1	8.7	5.3*	#
Low social orientation	32	20 *	15.2	12	#
Irritable	28	17.8*	17.4	10.7	-
Anxious/nervous	20	15.6*	10.9	5.3*	-

Table 2: Psycho-social symptoms (* $p<0.05$ Wilcoxon test, # $p<0.05$ Students t-test).

After the traffic regulations feelings of nervousness, irritation, uneasiness in the stomach and low social orientation were significantly reduced in the exposed area. There was a significant correlation between all symptoms, except for headaches, and annoyance to noise and noise sensitivity (r_s $0.24 - 0.37$, $p<0.01 - p<0.001$). Wellbeing in the exposed area improved after the changes in road traffic. About half of the residents in the exposed area and 1/4 in the control area said they believed that their general wellbeing had improved.
Half of the residents in the exposed area versus 27 % in the control area ($p<0.01$) changed their use of their homes and were more often out in their gardens and more often had their windows open. A general feeling was that it had become easier to speak with one another outdoors because it had become quieter and calmer. They were no longer disturbed by noise and exhaust fumes and it had become possible to enjoy being outdoors and to hear birds.

5 - COMMENTS AND CONCLUSIONS

It is concluded from these longitudinal investigations that exposure to high levels of road traffic noise not only induces adverse effects in terms of annoyance but also significantly affects sleep quality and psycho-physiological health and wellbeing. An extensive reduction in road traffic leads to a reduction in noise annoyance, more time spent outdoors, improved sleep quality and general wellbeing and reduced frequency of various psycho-social symptoms.

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