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TRANSPORTATION NOISE AND BLOOD PRESSURE: THE IMPORTANCE OF MODIFYING FACTORS

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ABSTRACT

Inconsistent risk estimates from non-auditory health effects research of environmental noise exposure have hampered widespread acceptance of results by regulatory agencies. One line of reasoning blamed differences in lifestyle, working and living conditions - not sufficiently accounted for in these studies. Others suspected differences in coping behaviour being the main culprit of inconsistent results. A third line blamed methodological aspects of outcome measurement. In the framework of an EHIA in the Tyrol area (Austria) we tried to address these problems. Based on a GIS-stratification of noise exposure we sampled 807 people from 648 housholds out of 31 areas around a noise measurement site (participation 50.5%). Individual assignment of noise exposure (dB, A, day, night, Ldn) was made after calibration of the modeling results against the obtained measurements. The intensive standardized questionnaire covered socio-demographic data, housing, satisfaction with the environment, general annoyance, attitudes toward tranasportation, interference, coping with noise and health. Body mass was obtained during the first visit and blood pressure was measured twice within 10 days. The analysis of the noise-blood pressure-relationship revealed a complex pattern of modifying factors that are not easily to interpret.

1 - INTRODUCTION

Inconsistent risk estimates from non-auditory health effects research of environmental noise exposure have hampered widespread acceptance of results by regulatory agencies. Of the cardiovascular health outcomes commonly used in non-auditory health effects research blood pressure is the one where the evidence for an effect of transportation noise exposure is weakest [1], [2], [3]. While a limited number of studies have shown an increased risk for hypertension a dose-response relationship is completely lacking [1]. This is clearly a surprise because the patho-physiologic plausibility for a relationship between blood pressure and noise is compelling and sufficient experimental evidence is available. Several authors thoughtfully tried to explain this obvious paradox.

A first line of reasoning blamed general methodological aspects in exposure assignments and problems regarding outcome measurement, definition and analysis.

Others suspected differences in coping opportunities and behaviour being the main culprit of inconsistent results. A last line of reasoning blamed differences in lifestyle, working and living conditions – not sufficiently accounted for in these studies.

In the framework of an EHIA in the Tyrol area (Austria) we had the opportunity to address at least some of the mentioned problems. The availability of a Geographical Information System (GIS) was helpful in many ways. We took special care of accurate exposure assessment and modifying factors such as bedroom and living room orientation as well as window opening behaviour were taken into account. Several noise indices and distance measures, including percentiles of Zwicker loudness were applied. With a list of coping activities and questions regarding environmental, housing and occupational conditions we tried to address the problem of confounding as well as that of modification. Through repeated blood pressure readings within 10 days we tried to counteract the commonly known reliability issue in blood pressure measurements. Finally, we used different definitions of hypertension and did analysis on continuous blood pressure readings as well.

2 - BACKGROUND AND METHODS

Sampling and areas: Based on a 'a priori' GIS-stratification of noise exposure we sampled 807 people from 648 households out of areas circles (radius = 500 m) around 31 noise measurement sites. The sampled persons represent a participation of 50.5 % and were between 20 and 75 years of age. The mainly rural alpine areas (Inn valley, eastern of Innsbruck, Austria) consist of small towns and villages with a mix of industrial, small business and agricultural activities. The primary noise sources are road and rail traffic. In the last decade a slight increase took place for freight trains during night while a night ban on non-noise-abated trucks led to a slight decrease in noise levels from highway traffic.

Individual assignment of source specific noise exposure (dB, A, day, night, Ldn) was made after calibration of the modelling results against the obtained measurements. All procedures were carried out according to Austrian guidelines (OAL Nr 28+30, ONORM S 5011).

The intensive standardised questionnaire covered socio-demographic data, housing, satisfaction with the environment, general noise annoyance, attitudes toward transportation, interference of activities, coping with noise, occupational exposures, lifestyles, dispositions such as noise and weather sensitivity, health status and medications.

Body mass was obtained during the first visit and blood pressure was measured twice within 10 days in the home of the participant. A complete set of blood pressure readings (2 ×2) was available only for 572 participants on which the analysis was conducted. A careful socio-demographic analysis could rule out significant selection factors for this sample.

For the current analyses the mean of the last two measurements was used in the continuous analysis of blood pressure and for the definition of hypertension after WHO.

Overall 4 definitions of hypertension were used:

Current use of anti-hypertensives	->17 %
WHO-definition ($\geq$ 160 mm systolic or $\geq$ 95 mm diastolic)	->21 %
Questionnaire (diagnosis of hypertension ever/within last 12 months	->25 %
WHO and current use of anti-hypertensives combined	->31 %

Table 1.

Exposure and survey data were linked via GIS and statistical analysis was conducted with S+ 4.5 including F Harrell's HMISC- and DESIGN-libraries. Multiple linear and logistic regression techniques were used and approximate 95 % confidence intervals were calculated.

3 - RESULTS

Taking either one of the four definitions of hypertension or systolic/diastolic blood pressure as a continuous variable – neither one did show any reasonable interpretable relationship with either rail or highway noise or the combined noise exposure using the raw data and a categorical approach for the exposure as a first step in the analysis.

A similar picture shows up by the use of subjective source annoyance (rail and road) as indicator of noise exposure. Here however, contrary to the expected relationship the highest proportion of hypertensives is found in the group of the 'not at all' annoyed.

In a combined analysis using both indicators – noise exposure and noise annoyance – with systolic/diastolic blood pressure the dose-response curves are pretty inconsistent with a tendency to be more in the hypothesised direction only in the groups of the least annoyed persons.

In the multiple logistic regression models neither rail or highway noise or the combined noise exposure did show any significant contribution to the full model. However, distance to the main local road contributed consistently. Consequently, neither distance to the highway or distance to the rail track were meaningful predictors. The full model (Table 2) with all the interactions explained 47 % in the case of the combined hypertension definition (see above).

Age, body mass, weather sensitivity and heart rate were the strongest predictors of hypertension. Self rated health status and health worry did make separate significant contributions. Among the environmental and occupational variables bedroom facing the main local road was the most interesting variable because of its interaction with distance to the main local road (Figure 1). Night shift work showed a similar contribution as family history of hypertension. Surprisingly again, people rating themselves as 'not at all annoyed' through work noise exposure show a highly significant relationship with hypertension. Neither annoyance due to road or rail traffic did make it to the final model. Again of interest that those having estimated correctly an increase in traffic volume are better off than those obviously showing 'optimistic bias'.

In the multiple linear regression analyses with systolic/diastolic blood pressure as a continuous outcome variable we used a different approach. In order to account for those under anti-hypertensive medication we built up a basic adjusted model with the variables age, sex, bmi, education, family history of hypertension and treatment for hypertension. These variables accounted for roughly 35 % of the variance in the systolic model and 17 % in the diastolic model. Kept again in the model was distance to the main road, as the noise exposure indicators did not show significant contributions. Then we included step by step several situational, environmental, occupational and housing variables and assessed their additional effect in terms of mm Hg. There was some but not full consistency between the two models.

In the systolic regression model the most important modifying effects were:

Item content	**mean (mm Hg) and 95 % CI**
Main road (distance from 500 to 25 m)	1.58 (0.42 to 2.74)
Windows closed during night	-3.11 (-6.04 to -0.17)
Switched bedroom/living room due to noise	-5.45 (-9.39 to -1.51)
In communication with neighbours about traffic	-3.42 (-6.13 to -0.71)
Interference of communication outdoors	-4.27 (-8.27 to -0.27)
Noise sensitivity (very high)	-3.98 (-7.35 to -0.60)
Vibration sensitivity (very high)	-3.71 (-7.23 to -0.19)
Air pollution sensitivity (very high)	-4.49 (-8.36 to -0.63)
Density (persons/room)	-2.21 (-4.30 to -0.13)
Modifying dwelling design due to noise	-2.76 (-7.09 to 1.56)
Having a garden	-2.41 (-5.68 to 0.86)
Work noise annoyance (very)	-4.26 (-8.73 to 0.22)

Table 2.

In the diastolic regression model the equivalent modifying effects were:

Item content	**mean (mm Hg) and 95 % CI**
Main road (distance from 500 to 25 m)	0.62 (-0.19 to 1.42)
Windows closed during night	-0.31 (-2.34 to 1.73)
Switched bedroom/living room due to noise	-3.30 (-6.02 to -0.57)
In communication with neighbours about traffic	-1.21 (-3.08 to 0.67)
Interference of communication outdoors	-1.08 (-3.86 to 1.69)
Noise sensitivity (very high)	-1.83 (-4.17 to 0.51)
Vibration sensitivity (very high)	-1.86 (-4.31 to 0.60)
Air pollution sensitivity (very high)	-2.54 (-5.22 to 0.13)
Density (persons/room)	-0.55 (-1.99 to 0.90)
Modifying dwelling design due to noise	-4.59 (-7.54 to -1.63)
Having a garden	-2.91 (-5.16 to -0.66)
Work noise annoyance (very)	1.85 (-1.30 to 4.99)

Table 3.

4 - DISCUSSION AND CONCLUSION

Methodologically speaking, a sample with a prevalence of 17 % under anti-hypertensive medication makes it very difficult to analyse data with respect to environmental effects. Because differential rigor in treatment of high blood pressure (different attitudes of doctors) in the areas may introduce serious bias that is difficult to control. Furthermore, although we do not see an overt selection pattern out of the noisy areas the consistent lower prevalence of hypertension in the noisiest area seems to indicate such a process.

Moreover, under such circumstances it gets more difficult to choose the appropriate modelling strategy. Although we tried to use a consistent strategy and conducted several sensitivity analyses it cannot be excluded that some of the revealed effects is due to chance.

In contrast to others [4] we were not able to demonstrate a relationship between various noise indices for rail and road noise exposure and either hypertension or continuous blood pressure. Instead we found a consistent small effect of distance of the dwelling to the main local road.

This finding is corroborated through the interaction of bedroom facing the main local road with distance to the main local road. It seems at least for this rural sample where noise sources are further away − although adding to the annoyance through its effect on the outdoor space − that these sources do not have sufficient physical impact on a population large enough to see *direct* effects. Noticeable is the repeated results that persons expressing annoyance or worry are not at higher but at lower risk regarding hypertension. At least for the work noise annoyance results this is contrary to a report we have given earlier [5]. However, the question asked differed from the one used in this survey and the effect of night shift work was confirmed. This also points to the need for standardisation of our health questionnaires. Striking is also the consistent positive effect of any kind of sensitivity (from noise to weather and air pollution) across the models.

Nevertheless, some differences can be observed between the models using hypertension or blood pressure. However, based on the applied analysis strategy only the continuous models should be compared. Due to the lower variance accounted for in the diastolic model chance variation may play a larger role in this model and interpretation should therefore be more cautious.

This is especially necessary for the results on density, because the observed range of density was small in this sample and needs further work.

Nevertheless, similar results could be obtained with respect to active coping behaviour on a wider range of activities than in an earlier study of the authors [6].

Persons actively seeking to cope with the noise (switching bedrooms, modifying dwelling design, closing windows) show lower blood pressure readings.

To sum up: The detailed analyses of several blood pressure models revealed a complex pattern of modifying factors possibly involved in the development of blood pressure elevations and hypertension which is not easily to interpret. However, the results show that the focus of further research should be placed on the advanced *analysis of indirect exposure-effect pattern.*

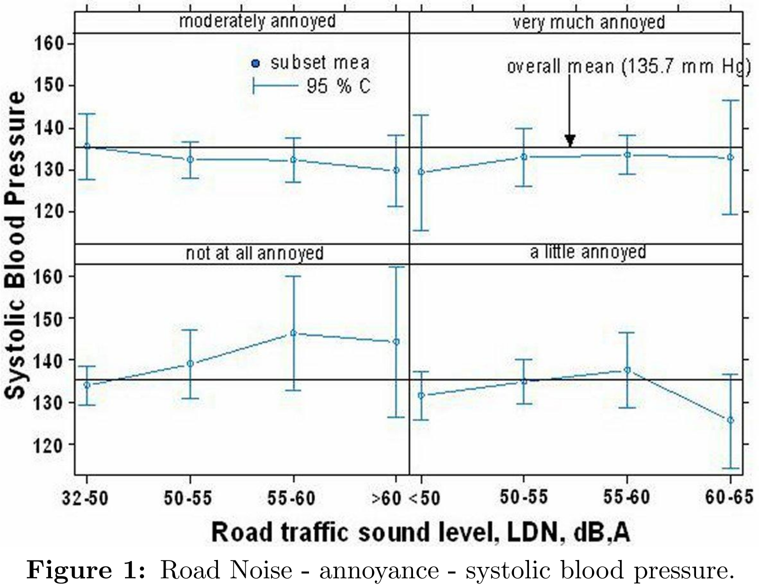

Figure 1: Road Noise - annoyance - systolic blood pressure.

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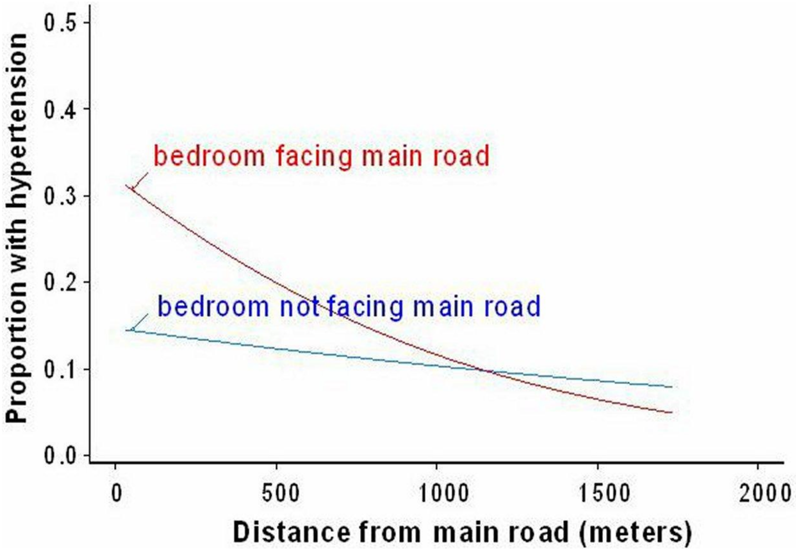

Figure 2: Road distance, bedroom orientation, hypertension.

REFERENCES

1. **Babisch W.**, *Epidemiological studies of cardiovascular effects of traffic noise*, N.L. Carter & R.F.S. Job (Eds.), Noise as a Public Health Problem, Sydney, Australia: Noise Effects 98, pp. 221-229, 1998

2. **Lercher, P., Stansfeld, S.A., Thompson, S.J.** , *Non-auditory health effects of noise: Review of the 1993-1998 period*, In N.L. Carter & R.F.S. Job (Eds.), Noise as a Public Health Problem, Sydney, Australia: Noise Effects 98, pp. 213-220, 1998

3. **Berglund, B., Lindvall, Th, Schwela, D.H.** , *Guidelines for community noise*, WHO. Geneva 2000, http://www.who.int./peh/noise/noiseindex.html

4. **Bluhm, G., Berglind, N.**, Traffic noise and health effects, *N.L. Carter & R.F.S. Job (Eds.), Noise as a Public Health Problem, Sydney, Australia: Noise Effects 98*, Vol. 1, pp. 247-250, 1998

5. **Lercher, P., Hörtnagl, J., Kofler, W.W., Work**, Noise annoyance and blood pressure: combined effects with stressful working conditions, *Int Arch Occup Environ Health*, Vol. 63, pp. 23-28, 1993

6. **Lercher. P., Kofler, W.**, *Adaptive behavior to road traffic noise: Blood pressure and cholesterol*, Vallet M, Ed. Noise as a Public Health Problem, Nice: Institut National de Recherche sur les Transports et leur Sécurité, pp. 465-468, 1993