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Traffic noise exposure, education and annoyance: longitudinal experience from crosssectional surveys over time (1989-2004)

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Noise exposure is often differentially distributed with respect to indicators of socioeconomic status such as education, social class and income. Less consistent are the results regarding noise annoyance. Meta-analyses concluded that none of the investigated social or economic position variables have an important effect on annoyance – while weak effects may be possible. It is argued here, that have to be taking into account to fully understand the moderation due to education. The relationship of education with exposure and annoyance is evaluated here by socio-medical studies across time, taking into account additional social and health characteristics. The investigated areas are predominantly rural, where the tracks of the main road, the highway and the rail are running close in parallel through densely populated narrow alpine valleys. The results revealed a differential increase in noise exposure over time across the social strata. This change in exposure is not equivalently mirrored in the annoyance response. Overall, annoyance does not differ much by education. But, across communities the effect of education on annoyance varies significantly. Furthermore, vulnerability indicators differ significantly by education and coping is not a sufficient explanation for differencences in annoyance among ducational groups. Obviously, a broader framework is needed to understand the moderation by education when people try to cope with the side-effects of transportation noise.

1 Introduction

Predominantly, research in the US under the label "environmental justice" has demonstrated that considerable environmental health disparities exist in urban agglomerations (Sexton 2000, Morello-Frosch et al 2001, Evans & Kantrowitz 2002, Mielk & Heinrich 2002, Northridge et al 2003,Frumkin 2005). Notably, most of this research was concerned with air pollution, housing and industrial toxicants.

However, social noise surveys have also shown that noise exposure is sometimes differentially distributed with respect to indicators of socioeconomic status such as education, social class or income (Glasauer 1991, Forkenbrock and Schweitzer 1999, Evans & Kantrowitz 2002, Evans & English 2002, Mielck & Heinrich 2002, Hoffmann et al 2003, Evans & Marcynyszyn 2004). Less consistent are the results in the area of noise annoyance. Meta-analyses (Fields 1993, Miedema & Vos 1999) concluded that none of the investigated social or economic position variables have an important effect on annoyance – while weak effects may be possible.

From the viewpoint of health effects research and community prevention a more complete Stress–Exposure Disease Framework (Gee & Payne-Sturges 2004) is needed. We need to understand both, the processes which lead to higher exposure and the pathways which may contribute to more or also less annoyance. Incomplete understanding of these relationships may lead to distorted assessments and neglect potential adverse consequences on wellbeing and health (Staples 1997, Gordon 2003). While it is well established that increasing urban population density and residential segregation processes can lead to higher noise exposure levels of poor people who cannot afford to move out of these areas it is less clear why the annoyance response is sometimes spread differentially across social strata and sometimes not.

Data on this issue are largely missing. The complex moderation process between exposure and annoyance expression (and health) has been less often investigated. This further step needs to account for other social, contextual and health variables.

Here, we study the relationship of education with exposure and annoyance in three socio-medical studies across time with the same questionnaire items. The investigated areas are predominantly rural, where the tracks of the main road, the highway and the rail are running close in parallel through densely populated narrow alpine valleys.

This type of land use pattern, the specific topography and meteorology may differ significantly from the one in surveys summarized in meta-analyses. We have reported deviating exposureresponse relationships for both road and rail traffic in this area earlier (Lercher et al 1998, Lercher et al 1999). Our data show also that the population composition is rather stable and the proportion of long-term residents remains still high over the years. This provides the opportunity to study

persons from all educational levels and monitor whether social selection takes place over the years as observed in urban agglomerations.

Therefore, the change over time in exposure is an important issue which has not received sufficient attention. Although, after the first survey (December 1989), a night ban on trucks without noise abatement has been in effect and EU-noise regulation let decrease the number of loud trucks, recent traffic data show that the overall increase in traffic has compensated the improvements (a 50% increase in heavy trucks from 1998 to 2004).

2 Methods

All the surveys were planned as representative population studies and the selection was based either on random or cluster sampling procedures. The approached age range was 25 to 64 in the earlier and 18 to 75 in the recent studies. For the purpose of this analysis the interviewer based study from 1989 (N=1989) is compared with the phone survey in 2004 (N=2007).

The participation rate was higher for the shorter phone survey (around 80%). In the interviewer study rates varied between 50 and 80 % in the communities (62 % overall). Non-responder analysis did not provide evidence for an exposure related participation bias in the interviewer study as a whole, although at the community level a small bias could be observed in two villages.

The surveys took place either in late spring or fall to avoid the winter where the different acoustical situation (snow cover) may distort the annoyance response.

In the earlier survey a four point annoyance scale was used while in the more recent surveys we followed the recommendation of Fields et al (2001) to use one of the Icben-scales: in the 2004 phone survey the 5-point verbal scale was utilized.

Education was measured in 5 grades (basic, skilled labour, vocational school, A-level, University degree). For sample size and content reasons in all further analyses the top two grades (University degree and A-level) were combined.

In the 1989 study, individual noise exposure assignments (5 dB classes, ranging from 40 - 75 dBA, Leq) were based on standardized day/night recordings, combining information from long- and shortterm measurements.

In the 2004 survey several steps were involved. IMMI (implementing ISO 9613 propagation and DIN 18005-part1, 1987 emission) including additional terrain modeling and accounting of existing noise barriers was used for the basic noise mapping. The model was then improved by calibration with an extensive day-night measurement base (>100 positions across seasons).

Individual noise assignments were provided by GIS-linkage to the participant's home.

Statistical analyses were conducted with S+ for Windows (2002 version) from Insightful Corp.

3 Results: first part

This part covers the question of change in exposure over time and whether there is a difference in exposure or annoyance due to educational level.

3.1 Noise exposure pattern over time

Comparing the Wippvalley surveys (1989 vs 2004) the proportion exposed to noise levels above 65 dBA and above 55 dBA increased (5 to 9% resp. 31 to 44%). On the other hand the proportion living in quiet areas (<45 dBA) increased as well from 10% to 14%. This may indicate a certain moving activity towards quiet areas.

3.2 Education and exposure

While in 1989 there was nearly no educational gradient visible – in 2004 the lowest grade had a doubling in exposure above 65 dBA and the third grade (business school etc) even more (Table 1). Interestingly, the second lowest grade and the highest grade did not experience an increase in exposure. Both groups had also higher proportions living in quieter areas in 2004 (+5% and +10%).

3.3 Education and highly annoyed: crude

A comparison of the annoyance response by education at different noise levels shows an inconsistent picture. A cutoff at 55dBA shows a pretty uniform response with 30% - except the lowest grade with 25%. At 65 dBA, the proportion of highly annoyed spreads out enormously. The group with the highest education is now lowest (25%) compared with 57% in grade 2.

This shows that the crude data – keeping only noise level constant – are too sensitive to cutoff point decisions to draw reliable conclusions.

Table 1: Change in noise (1989-2004) by level of education - in percentage of the total number of people in this education category

	Level of education				
noise level	basic	skilled labour	vocational school	higher education	**Overall**
>55 dBA 1989	30% (177)	33% (247)	32% (119)	30% (80)	31% (623)
>55 dBA 2004	49% (250)	42% (175)	46% (186)	39% (169)	44% (780)
>65 dBA 1989	6% (36)	6% (44)	4% (15)	5% (13)	5% (108)
>65 dBA 2004	12% (60)	7% (28)	11% (43)	5% (24)	9% (155)

3.4 Exposure-response relations by education: adjusted

When the proportion of highly annoyed is adjusted for noise level, gender and age - only a small, non-significant difference remains between the educational groups (about 4%) with the highest grade to be most annoyed. Age, gender is non-significant too. Duration of living remains as a significant parameter (OR=1.29 (1.06 - 1.56 comparing 10 vs 30 yrs). However, when we conduct a subset-analysis by community then education turns out to be a highly significant predictor in selected communities (Figure 1: see end of paper) and not in others. This points to the importance of differences in contextual factors even in a small area with seemingly homogeneous conditions (such an analysis is beyond the scope here).

4 Results: second part

This part of the analyses deals with possible differences in attitudes toward noise and coping with noise in the educational groups.

4.1 Vulnerability attitudes by education

People with lower education feel less vulnerable and at the mercy of exposure - think the effects of noise are overestimated – and belief to have better coping abilities at their disposal (Table 2). It is surprising how consistent the differences between the educational grades are.

4.2 Noise sensitivity by education

The differences are minor and not much dependent on the cutoff-point (Table 3). This may come as a surprise after observing clear differences in reported vulnerability in Table 2, however, it is also consistent with the idea of noise sensitivity as a more general indicator of perceived vulnerability.

4.3 Coping with noise by education

Coping activities like installing noise abated windows or moving rooms (different use due to noise exposure) are considered to be strong signs of active coping. No significant, systematic difference between educational groups can be observed (Table 4).

This does change when the unweighed sum of 12 coping items is considered. The difference remains significant in a logistic regression model (cutoff point at the 75th percentile) after adjustment for noise level, age, sex, noise sensitivity and duration of living (OR= 1.45 (1.20-1.75)).

Table 2: Attitudes concerning vulnerability towards noise by level of education (N=1988)

	Level of education				
Attitudes*	basic	skilled labour	vocational school	higher education	**Overall**
less vulnerable	48% (277)	44% (210)	43% (188)	34% (165)	42% (840)
better coping abilities	50% (290)	44% (210)	41% (181)	32% (155)	42% (836)
feels unduely exposed	29% (171)	34% (164)	40% (175)	39% (188)	35% (698)
effects overestimated	24% (137)	22% (107)	18% (78)	10% (47)	19% (369)
* completely+somewhat agree (from a 4 graded scale)					

Table 3: Noise sensitivity (5 grades) by level of education (N=1988)

	Level of education				
Sensitivity*	<10 years	<10-12 years	10-12 years	higher education	**Overall**
noise sensitivity > 3	16% (92)	13% (64)	16% (72)	21% (100)	17% (328)
noise sensitivity > 4	5% (27)	4% (21)	5% (23)	6% (30)	5% (101)

Table 4: Reported actions to protect against noise by level of education (N=1988)

	Level of education				
Type of activity*	basic	skilled labour	vocational school	higher education	**Overall**
abatement: windows	13% (72)	13% (61)	16% (70)	13% (61)	14% (264)
moving rooms	4% (24)	7% (34)	6% (28)	8% (40)	6% (126)

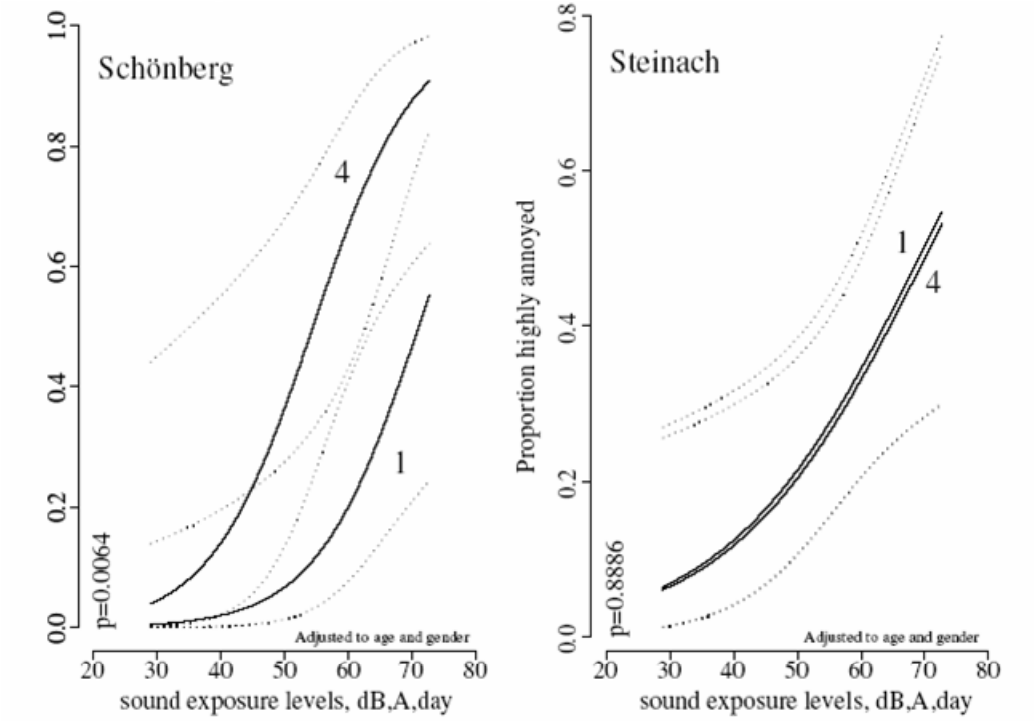

Figure 1: Exposure - annoyance by level of education

5 Summary and Discussion

The exposure of the population in the alpine area to transportation noise has increased over the 15 years. This is not compatible with the targets of the European noise policy, where exposure above 65 dBA should be phased out and no increase in population exposure between 55 and 65 should happen (Green paper on noise policy 1996). While in 1989, no educational gradient in noise exposure could be found, in 2004, a differential change for the worse was observed in selected educational groups. This is an indication that segregation processes may take place also in rural areas over time.

Interestingly, this change in noise exposure is not reflected in the annoyance response of the concerned educational groups. This analysis has also demonstrated that unadjusted data are not reliable enough to demonstrate differences in annoyance among educational groups.

The results confirm, however, the conclusions of the large meta-analyses that overall differences in annoyance are small between social strata (Fields 1993, Miedema & Vos 1999). However, when comparing

communities – this can be quite different. Additionally, the data also show significant differences in perceived individual vulnerability of persons differing in education, which is not mirrored equivalently in the annoyance results. We (Botteldooren & Lercher 2004) have recently shown that the relationship between noise exposure, coping activities and annoyance is not following a simple pattern. Therefore, further analyses are needed to understand this relationship. In addition, it is important, to evaluate further, more specific health endpoints beyond annoyance. This can further contribute to the understanding, whether the increased transportation load does or does not exhibit unwanted side-effects in different educational groups due to an unduely burden of coping for some of them.

Our analysis has demonstrated that the inclusion of further vulnerability indicators is helpful to better understand the complex moderation taking place by educational level in the field of environmental health. The framework, outlined by Gee & Payne-Sturges (2004) is useful to guide investigations of "environmental justice" from both the individual and the community level.

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