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SUBJECTIVE WORK NOISE - A MAJOR RISK FACTOR IN MYOCARDIAL INFARCTION

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1. INTRODUCTION

There is general agreement that noise acts as a non-specific stressor [1] and that its non-auditive effects, i.e. its effects on the organism as a whole, are essentially stress reactions [2-4]. Stress reactions are not only determined by external factors, but first and foremost by the internal assessment of external load [5,6]. This is especially true of noise as a stressor. Non-auditive (i.e. vegetative) noise effects are more closely correlated to noise-induced disturbance than to the noise level [7]. Effects of acute noise-induced stress, such as changes in serum concentrations of cholesterol and triglycerides as well as blood pressure increases, point to an increased risk of myocardial infarction (MI) [8-10]. Furthermore, in two cross-sectional epidemiological studies several risk factors in MI showed a non-significant increase in the group with maximum traffic noise level [11,12]. In a work noise study, cholesterol and triglycerides were significantly increased in men working under noise exposure of more than 85 dB(A) [13].

However, the existing literature about long-term health effects of work noise is inconclusive [14]. The reasons for this are mainly of a methodological nature [15,16]. Few studies on the relationship between traffic noise and cardiovascular risk have been performed. One of these, the Berlin traffic noise study, resulted in a small borderline significant increase of MI-risk in the most highly noise exposed group [17]. In this paper we reanalysed the data of the Berlin traffic noise study using subjective work noise as the exposure variable and traffic noise as one confounder among several others.

2. METHOD

The Berlin traffic noise study is a population based case-control study. Men aged 31 to 70 years who were treated for acute MI (ICD 410) in the major Berlin hospitals were considered as "cases". They were interviewed by a physician and questioned about potential confounding variables (age, social status, employment status, shift work, smoking habits, body mass index, family status, residential area) as well as about work noise (see below) and their home address. The study area itself was clearly defined by the island situation of Berlin (West) before 1990. All surviving MI patients in 17 (out of 24) major hospitals with intensive care units were identified in the course of one year. A total of 693 subjects co-operated and satisfied the inclusion criteria, yielding a participation rate of 91%. Since not all hospitals were included, 80-85% of the source population co-operated (see [18] for details).

For controls, a random sample of the source population with the same age and gender characteristics was drawn by the local registration office. Of the 6002 men identified, 3865 responded by sending back a completed questionnaire, yielding a participation rate of 64%. Obvious hints at the aim of the study (in particular noise) were avoided, both in the questionnaires and the interviews with the patients. The most probable effect of the 36% non-responders seemed to be a distortion of social class in the control group. Therefore we compared the social class data of the source population with the data of our control group using official census data. The biggest difference occurred between workers in the source population (37%) and in our control group (29%). The effect of this distortion of social class distribution was taken into consideration when estimating the population attributable risk percentage.

For the work noise analysis, the age range was limited to 65 years (normal upper working age limit). Persons in early retirement and unemployed persons were excluded. The numbers of cases and controls for the work noise analysis are given in Table 1. Subjective work noise was quantified by questionnaire. The instruction for the subjects was: Of the following noise sources please mark that which best describes how loud it is at your workplace: 1) refrigerator, 2) typewriter, 3) electric lawnmower, 4) electric drill, 5) pneumatic drill. Logistic regression analyses were performed using the PC-Windows 6.0 version of the SPSS statistical software package, and test-based confidence limits of relative risks were calculated.

3. RESULTS

The relative risks of MI were almost identical in the first two noise categories. Therefore these were combined and used as a reference. The relative MI-risks were adjusted with respect to the above-mentioned confounding variables. In Table 2. they are listed in relation to the work noise categories together with the 95% confidence intervals. The risk of MI increased significantly and monotonously with the subjective work noise exposure.

Additionally we studied the interaction of smoking, noise and age. For this purpose the MI cases and controls were divided into two age groups (up to 50 years and 51-65 years) and two noise groups (categories 1+2 and categories 3+4+5). The other control variables were included in the model. The results of the full model including interaction terms are given in Table 3. The only borderline significant interaction was that between age and noise at 0.46, indicating that men in the age group of 51-65 years with subjective work noise of category 3 or more had a decreased relative risk as compared to the younger ones.

Since the control group of the Berlin traffic noise study consisted of a random sample, and the distortion of social class distribution was corrected according to that of the source population it was possible to approximate a population attributable risk percentage based on the subjective noise distribution. The population attributable risk percentage (PAR) without correction for social class was PAR=0.33, suggesting that 33% of all MI of the source population may be attributable to subjective work noise. Correction for social class distribution of the source population led to an attributable risk percentage of PAR=0.27. Consequently, subjective work noise appeared to be the second most important risk factor for MI after smoking (PAR=0.5).

4. DISCUSSION

A population attributable risk percentage of PAR=0.27 for subjective work noise in relation to MI is unexpectedly high and might have been overestimated due to several influences, i.e. the subjective noise rating may have been influenced by the experience of the MI, thereby causing a systematic overestimation of noise by the MI patients. However, it has been shown in a small case-control study when comparing noise level measurements and subjective noise rating that only 8% of the controls and 16% of the MI patients overestimated the subjective noise load [19]. In our study, the magnitude of this kind of bias is unknown, because no sound levels have been measured. However, in a review paper on work related cardiovasclar risk, an estimation of PAR=0.01 for noise as a risk factor in MI was suggested [20]. This figure was based on a relative risk of work noise-induced MI of 1.2, which was derived solely from noise-induced blood pressure increases.

The influence of non-responders in our controls led to an 8% under-representation of workers. Since social class was included in the confounders and model adjusted, the estimation of relative risks was not affected by the distortion of social class distribution. Population attributable risk percentage was calculated on the basis of subjective work noise distribution in the MI group, from which only 9% of identified patients did not participate. Additionally the distortion of the control group was corrected according to the social class distribution of the source population. The duration of the work noise exposure has not been assessed since the original study focused on traffic noise. However, exposure misclassification due to missing information on length of exposure would dilute the true noise effect.

Moreover, the difference between subjective and objective noise rating seems to be of major importance. In general, sound parameters, which can be measured objectively, determine subjective noise perception to a degree of about 30% to 40%. Situative and personal influences are responsible for this perception to about the same extent [7]. It is most likely that people who were stressed by work noise will have rated the loudness higher than non-stressed people. Therefore, long-term health effects of noise, when the noise is acting as a psycho-physiological stressor, are theoretically more closely correlated to subjective than to objective noise parameters.

However, if our results do reflect a true noise effect, then also objective work noise parameters, i. e. noise levels, should be clearly related to the cardiovascular risk. This is possible since nearly all studies on this relationship lack from two serious problems. The first problem is that of a suitable control group. Since the ideal "no noise" does not exist, objective noise studies should compare groups with clearly increasing noise levels and use the group with the lowest exposure as a reference. The second problem occurs at levels above 85 dB(A). In western industrialized countries ear protectors must be provided above 85 dB(A). If the partial use of ear protectors is not taken into account, noise effects will be underestimated. This is true, because people, who suffer from noise stress, are more likely to use ear protectors than those who are less sensitive to noise. If such people work below 85 dB(A) and therefore are not provided with ear protectors, their noise-induced stress will be higher than the noise stress of workers with 90-100 dB(A) external noise and a 20-30 dB level reduction by their ear protectors.

This seems to be the reason, that an otherwise well performed case-control study [21] failed to show any cardiovascular risk of noise. Subjective noise rating in our study avoids these two problems but it is open to bias due to overreporting and misclassification etc., as discussed above. However, a prospective cohort study [22] with 1002 persons during 11 years resulted in a noise related relative MI-risk of 2.78 (95%-confidence interval: 1.01-7.63).

According to our present knowledge, subjective work noise has to be considered as a major risk factor in MI. Interdisciplinary studies on the relationship between cardiovascular diseases and work-related stressors including subjective and objective noise assessment are necessary to clarify the open questions, especially the quantitative risk of MI due to work noise.

5. REFERENCES

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6. TABLES

Table 1. Numbers of cases and controls in the Berlin work noise study.

Cases: n = 583 (German, male, 31-65 years old, response rate:91%), employed till MI: n = 395 (32% unemployed).

Controls: n = 3228 (German, male, 31-65 years old, response rate of persons who received the questionaire: 68%), employed at time of inquiry:
n = 2148 (34% unemployed).

Noise category	1+2	3	4	5
MI incidences	149 (37.7%)	71 (18.0%)	88 (22.3%)	87 (22.0%)
Controls	1221 (56.8%)	397 (18.5%)	358 (16.7%)	172 (8.0%)

Table 2. Relationship between work noise and relative risks (RR) of MI adjusted for co-variates (smoking, body mass index, age, social class, education, marital status, shift work, housing area), 95% confidence intervals are given in brackets.

Noise category	RR for MI (ICD 410)	
1+2 refrigerator/typewriter	**1.0**	(ref.level)
3 electric lawn-mower	**1.4**	(1.03/1.97)
4 electric drill	**2.0**	(1.45/2.74)
5 pneumatic drill	**3.8**	(2.68/5.44)

Table 3. Results of full model analysis including interaction terms.

Variable	Exponent	Signif.
body mass index [$kg*m^{-2}$]	1.05	0.001
social class [high/low]	0.71	0.015
education [college degree/others]	0.60	0.002
marital stat.[divor.+ widow./others]	1.86	0.000
resident.area [outskirts/inner city]	0.85	0.167
shift work [yes/no]	0.72	0.053
age [31-50/51-65 years]	1.64	0.095
current smoking [yes/no]	3.10	0.000
noise [categories 1+2/3+4+5]	2.47	0.009
age by smoking	0.69	0.333
noise by smoking	1.52	0.319
age by noise	0.46	0.058
noise by age by smoking	1.05	0.919