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Aircraft noise and health of residents living in the vicinity of Frankfurt Airport

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ABSTRACT

In 2005 a field study on the effects of aircraft noise on annoyance, disturbances and health-related quality of life was done with residents living around Frankfurt Airport. Face-to-face studies with 2312 residents were carried out, for each address aircraft noise levels were calculated on the base of flight movements of the 6 busiest months of the year.

This contribution deals with analyses of the data from this field study with regard to the relationship between aircraft noise level, reactions to aircraft noise (in particular noise annoyance), noise sensitivity and physical as well as mental health.

The results do not support the assumption of a direct effect of aircraft noise exposure on physical and mental health. However, associations between noise annoyance, noise sensitivity and self-reported health could be observed. Three approaches may explain the observed relationships. According to the first approach, it is not the noise exposure itself but the psychological reaction to noise which leads to further health effects. The second model suggests that the assessed complaints, health diseases and noise sensitivity increase psychological reactions to noise like annoyance. The third approach combines the first two models and describes a recursive process of health complaints and noise sensitivity intensifying noise annoyance, which in the long run lead to further health effects.

1. INTRODUCTION

No doubt, environmental noise like noise from aircraft disturbs and annoys human beings. A growing number of studies report further impacts of aircraft noise on mental and physical health.

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Associations between aircraft noise exposure and health effects are reported for cardiovascular risks such as hypertension[1-2], medicine use[3], and reported mental health complaints[4-5]. However, the empirical support of a direct effect of noise exposure on health is inconsistent[6-8].

In several studies an association between noise annoyance and further health effects was found[9-10]. This association is often interpreted as a mediator effect of annoyance, i.e. annoyance (as well as other psychological responses to noise[11]) leads to psychological stress, which causes directly or indirectly adverse mental and/or physical health effects[8,12-13].

Noise sensitivity, defined as a stable trait, an attitude or an internal state that increases the susceptibility of an individual to noise in general[14], play a major role as a co-factor[15] or moderator[16] of noise annoyance and as a factor associated with subjective health complaints [17-19] and physiological functions[20-21]. Some authors suggest that noise sensitivity is part of an individual elevated personal susceptibility to stressors in general[19,22] or an indicator of a general disposition to experience aversive emotional states and to view oneself and the environment in a negative way ('negative affectivity'[23])[5]. Negative affectivity again is known to be associated with stress and health complaints[24].

However, the causal path of the association between noise sensitivity and health effects is not yet clear. It may be that pre-existing illness increases the sensitivity to environmental stressors like noise or that an underlying third 'vulnerability' variable affects both noise sensitivity and health complaints and diseases[22].

The aim of the study presented in this contribution is to investigate the assumed impact of aircraft noise exposure and aircraft noise annoyance on reported mental and physical health in terms of complaints, diagnosed cardiovascular health diseases and medical consumption. Furthermore the relationship between noise sensitivity and the assessed health effects is analysed.

2. METHODS

A. Procedure / study design

The data used for the analyses described in this paper derived from the Frankfurt Noise Annoyance Study[25] carried out in 2005. 2312 residents (1276 female, 1034 male, age range from 17 to 97 yrs, mean = 53 yrs). living within a 40-kilometre distance from Frankfurt Airport were interviewed in face-to-face interviews (on average 45 minutes long) with regard to their residential situation, health-related quality of life, annoyance and disturbances due to noise, in particular to aircraft noise. The subjects were sampled using a stratified random sampling method. That is, 66 residential areas were selected according to the aircraft noise exposure in 2003 with equivalent sound level contours for daytime $L_{Aeq,16h}$ (6am to 10pm) as strata. Within the selected areas subjects were sampled by random using official register data.

The subjects were informed in a letter about the study and that interviewers will contact them in a few days asking for participating in the study. The interviews were carried out from April to December 2005. The month in which a subject was contacted by the interviewer was selected by random. 3795 residents were asked for an interview, 2312 of them took part in the study (response rate 61%). For the addresses of all participants exposure to noise from aircraft, railway and road traffic noise were calculated (see below).

The interview contains (in the order of appearance in the questionnaire) questions on the residential situation and environmental quality of life, questions related to environmental noise, in particular aircraft noise (noise sensitivity, annoyance in the last 12 months, annoyance at different times of day, disturbances, measures and preventive activities against aircraft noise),

attitudes (trust in authorities, impairment by air traffic, expectations concerning the future airport extension) health variables (health-related quality of life, diagnosed diseases, use of medicine, sleep quality, life satisfaction) and socio-demographic aspects.

B. Variables selected for the analyses in this study

Noise exposure

Aircraft noise exposure was indicated by equivalent sound level for daytime ($L_{Aeq,16h}$, 6am to 10pm), and night time (L_{night}, 10pm to 6am). The aircraft noise levels were calculated for the address of each subject on the base of the flight movements of the 6 busiest months of the year 2005 according to the German aircraft noise calculation procedure AzB. Individual road traffic noise levels were taken from noise maps.

As the result patterns were similar for both measures, this paper presents results concerning daytime noise levels ($L_{Aeq,16h}$) only. $L_{Aeq,16h}$ ranged from 41 to 63 dB (mean: 52 dB).

Noise annoyance

Annoyance due to aircraft noise together with annoyance due to other sources during the last 12 months before the interview was ascertained with the standardised verbal 5-point scale as recommended by Team #6 of the International Commission on Biological Effects of Noise (ICBEN)[26]. In addition, aircraft noise annoyance during the last 12 months before the interview was assessed with the ICBEN numerical 11-point scale. The annoyance judged on the 5-point scale correlates with noise level ($L_{Aeq,16h}$) with r = .45, the correlation between annoyance ascertained with the 11-point scale and noise level is r = .44. (Spearman rank correlation coefficients are similar.) For the analyses in this study the 5-point annoyance scale was used.

Noise sensitivity

Noise sensitivity was assessed by one item: 'How sensitive to noise do you think you are in general? Not, a little, moderately, rather, very.' The correlation between noise sensitivity and annoyance (assessed on 5-point scale) is r = .32 and rho = 32, respectively. As expected, noise sensitivity does not correlate with noise level $L_{Aeq,16h}$ (r = .08, rho = .07).

Self-reported health

Health complaints: Health complaints were assessed with a short form of the Giessen Subjective Complaints List (GSCL-24, 'Giessener Beschwerdebogen'[27]) including the four subscales exhaustion, stomach complaints, limb complaints, and cardiac complaints with six items for each subscale. The complaints were rated on a 5-point scale from 0 (not) to 4 (strongly) bothered. The ratings were summed up to subscale scores and to a total score of health complaints. All sum scores were normalized by transformation on a scale from 0 to 100 with mean = 50 and standard deviation = 10. That is, values above 50 indicate higher health complaints in comparison to a reference sample[27] of the population of Germany.

Diagnosed health diseases: The interviewees named from a list of 18 diseases those that were diagnosed by a physician (ever, the last 12 months). The list of diseases was taken from the German National Health Study 1998[27] and from the ALPNAP study on health effects of traffic in the Alpine space[29]. In this paper results on cardiovascular diseases are presented.

Medicine use: A list of eight medicine groups (anti-hypertensive drugs, cardiac drugs, headache drugs, sleeping drugs, mood mediating drugs, calmatives, antiallergics, asthma drugs) was presented to the subjects to ascertain the frequency of medicine use (ever, the last 12 months: never, seldom, 1-3 times per months, less than ones per week, 1-2 times per week, several times per week, daily).

Habitual sleep quality was ascertained with the German version of the Pittsburgh Sleep Quality Index (PSQI)[30]. Here the global PSQI score, i.e. the sum of seven subscales, was used. Score values vary from 0 (no sleep problems) to 21 (highest intensity of sleep problems). Values above 5 indicate a bad sleep quality.

Residential situation, socio-demographic variables

The following socio-demographic variables and variables concerning the residential situation, which turned out to be associated with the self-reported health in correlation analyses, were included in the analyses of this study: Age, gender, socio-economical status, home ownership (home owner vs. tenant), residential satisfaction, usual window position at night in the sleeping room (windows usually closed, tilt, or open), number of hours away from home. To determine the socio-economical status of the interviewees an index including income, education, and occupational status was ascertained (Scheuch-Winkler-Index[31]). Residential satisfaction was assessed with 14 items that describe several attributes of the residential areas including aspects of infrastructure, quietness, and attractiveness. All items were averaged to a global score of residential satisfaction.

3. RESULTS

The following tables show descriptive statistics for health complaints, diagnosed cardiovascular health diseases, and medicine use grouped by noise level and aircraft noise annoyance (Table 1) and noise sensitivity (Table 2). Although on a descriptive level subjects of different noise level groups differ with regard to the investigated health variables no systematic increase with increasing noise exposure could be found (Table 1).

On the other hand those subjects being higher annoyed due to aircraft noise report – again, on a descriptive level – stronger health complaints and more often the use of medicine at least once per months than those less annoyed. The extremely annoyed residents report more often diagnosed cardiovascular diseases in comparison to the other subjects. Among the not at all annoyed subjects less number of people report high blood pressure than subjects from the other annoyance groups (Table 1).

Similar, those subjects who assessed themselves as higher sensitive to noise seem to have stronger health complaints and report more often diagnosed high blood pressure, cardical diseases, and the use of medicine than those less sensitive to noise (Table 2).

Table 1: Description of health variables grouped by noise level $L_{Aeq,16h}$ and aircraft noise annoyance

	Aircraft noise level $L_{Aeq,16h}$ [dBA]					Aircraft noise annoyance				
	40-45	45-50	50-55	55-60	>= 60	not at all	slightly	moder ately	very	extrem ely
N	363	565	497	700	186	361	472	532	526	417
GSCL-24 health complaints (mean)										
Exhaustion	46.1	47.6	48.0	47.7	46.5	44.8	45.1	46.4	48.7	51.7
Stomach complaints	48.1	48.5	48.6	49.1	46.8	47.5	47.3	48.5	49.1	50.1
Limb complaints	45.9	47.8	47.1	47.5	44.3	45.7	45.2	46.3	47.9	49.9
Cardiac complaints	47.6	47.8	48.4	48.4	46.7	46.3	46.5	47.8	49.1	50.1
Overall score	45.5	47.0	47.0	47.2	44.3	44.4	44.4	46.0	47.8	50.2
Diagnosed cardiovascular health diseases (% 'ever had')										
Hypertension	22.3	22.3	17.4	20.3	14.0	16.6	20.8	20.5	20.6	20.7
Cardiac insufficiency	3.6	4.6	4.0	4.3	1.6	3.0	2.5	2.6	5.4	6.5
Angina pectoris	2.8	3.0	2.2	3.3	2.7	3.3	1.9	2.8	2.3	4.3
Myocardial infarction	4.2	1.9	2.8	3.0	4.8	3.0	1.9	2.6	3.6	4.1
Medicine use (% at least one time per month)										
Anti-hypertensive drugs	23.1	22.7	19.4	19.6	17.7	16.9	22.2	21.5	21.9	20.0
Cardiac drugs	11.3	10.3	12.1	11.0	12.9	9.7	8.9	13.4	13.3	10.1
Headache drugs	6.9	11.0	12.3	11.5	5.4	8.0	8.9	8.3	12.2	14.2
Sleeping drugs	3.3	3.4	3.2	3.2	4.8	1.1	1.5	2.4	5.3	6.3
Mood mediating drugs	0.8	2.5	2.0	1.7		1.4	1.1	1.5	1.7	2.9
Calmatives	1.7	2.0	2.2	2.0	1.6	1.1	1.5	1.7	2.5	2.9
Antiallergics	4.7	7.8	9.5	5.6	6.5	6.6	6.4	7.3	6.9	7.2
Asthma drugs	5.8	5.3	6.7	6.5	5.9	3.3	4.9	7.0	6.9	7.7
Sleep quality (PSQI)										
% bad sleep quality (PSQI score > 5)	17.4	21.4	25.1	27.2	19.6	10.0	13.8	21.5	27.4	41.5

Table 2: Description of health variables grouped by noise sensitivity

	Noise sensitivity				
	not	a little	moderately	rather	very
N	281	835	753	321	120
GSCL-24 health complaints (mean)					
Exhaustion	45.0	45.8	47.9	50.0	54.1
Stomach complaints	46.0	48.0	49.1	49.5	51.7
Limb complaints	44.4	45.7	47.5	49.2	52.6
Cardiac complaints	46.1	47.0	48.1	50.2	52.7
Overall score	43.4	45.2	47.3	49.2	52.9
Diagnosed cardiovascular health diseases (% ever had)					
Hypertension	11.4	19.4	21.0	24.6	25.6
Cardiac insufficiency	2.1	3.5	3.1	7.5	8.5
Angina pectoris	1.4	3.1	2.1	4.4	5.1
Myocardial infarction	1.8	2.9	2.5	4.7	5.9
Medicine use (at least one time per month)					
Anti-hypertensive drugs	12.8	20.0	21.4	25.9	26.1
Cardiac drugs	7.8	10.6	12.1	13.4	13.4
Headache drugs	2.8	8.5	13.6	10.9	18.5
Sleeping drugs	1.1	1.8	3.3	7.5	9.2
Mood mediating drugs	1.4	0.8	1.7	2.8	5.0
Calmatives	0.7	1.2	1.9	3.4	6.7
Antiallergics	3.9	6.4	7.3	6.5	16.1
Asthma drugs	2.5	4.7	6.7	8.8	13.4
Sleep quality (PSQI)					
% bad sleep quality (PSQI score > 5)	10.8	16.0	26.3	36.0	48.6

Multivariate logistic regression analyses were done with health variables as criterion and noise exposure at daytime ($L_{Aeq,16h}$), noise annoyance, and noise sensitivity as predictors. All regression models were adjusted for age, gender, socio-economical status, home ownership, residential satisfaction, usual window position in the sleeping room at night, number of hours away from home (Table 3).

The results of the regression analyses do not suggest a direct impact of noise exposure on heath effects in terms of higher prevalence of health complaints, cardiovascular diseases and medical consumption with increasing noise level at daytime ($L_{Aeq,16h}$). This is similar for the equivalent night-time sound level (L_{night}, not presented here). Aircraft noise annoyance is significantly associated with all subscales of GSCL-24, in particular exhaustion, cardiac complaints and the overall GSCL-24 score. With regard to cardiovascular diseases a slight trend of higher cardiovascular risk with increasing annoyance can be observed. However, this is only significant for cardiac insufficiency. Among the investigated medicine groups only the use of sleeping drugs is significantly related to aircraft noise annoyance which corresponds to the association between annoyance and bad sleep quality.

Noise sensitivity is associated with all reported health complaints, sleep quality, and the use of medicine against headaches, sleep and mood problems, and with the consumption of calmatives and asthma drugs. Furthermore, noise sensitivity is related to hypertension and myocardial infarction.

Table 3: Associations between aircraft noise exposure $L_{Aeq,16h}$, aircraft noise annoyance, noise sensitivity, and health variables (Odds ratios [OR] per unit and $^{+}/_{-}$ 95% confidence interval [CI])

	Aircraft noise level $L_{Aeq,16h}$			Aircraft noise annoyance			Noise sensitivity		
	OR	CI-	CR+	OR	CI-	CR+	OR	CI-	CR+
GSCL-24 health complaints (above 50% = average of population in Germany)									
Exhaustion	**0.97**	0.96	0.99	**1.36**	1,24	1,50	**1,38**	1,25	1,54
Stomach complaints	**0.98**	0.96	1.00	**1.11**	1,01	1,21	**1,14**	1,03	1,26
Limb complaints	**0.97**	0.95	0.99	**1.22**	1,11	1,34	**1,45**	1,30	1,61
Cardiac complaints	**0.96**	0.94	0.98	**1.32**	1,20	1,46	**1,32**	1,19	1,47
Overall score	**0.97**	0.95	0.99	**1.38**	1,25	1,53	**1,48**	1,33	1,65
Diagnosed cardiovascular health diseases (ever had)									
Hypertension	**0.97**	0.94	0.99	1.05	0,93	1,18	**1,22**	1,07	1,38
Cardiac insufficiency	**0.94**	0.90	0.98	**1.41**	1,12	1,79	1,21	0,95	1,54
Angina pectoris	0.99	0.95	1.04	1.08	0,83	1,39	1,24	0,95	1,62
Myocardial infarction	0.99	0.95	1.04	1.24	0,95	1,61	**1,37**	1,05	1,80
Medicine use (at least once per month)									
Anti-hypertensive drugs	**0.96**	0.94	0.99	1.05	0,92	1,18	1,19	1,04	1,35
Cardiac drugs	0.99	0.96	1.02	1.00	0,86	1,16	1,12	0,96	1,32
Headache drugs	0.99	0.96	1.02	1.14	0,98	1,32	**1,30**	1,11	1,52
Sleeping drugs	**0.94**	0.89	0.98	**1.64**	1,24	2,17	**1,58**	1,22	2,04
Mood mediating drugs	0.97	0.91	1.04	1.05	0,73	1,49	1,18	0,81	1,70
Calmatives	0.97	0.91	1.03	1.11	0,79	1,56	**1,67**	1,19	2,34
Antiallergics	1.01	0.98	1.04	0.86	0,72	1,01	1,26	1,06	1,51
Asthma drugs	0.99	0.96	1.03	1.11	0,92	1,33	**1,43**	1,18	1,73
Sleep quality (PSQI)									
Bad sleep quality (PSQI > 5)	**0.96**	0.94	0.98	**1.46**	1.30	1.65	**1.40**	1.25	1.58

Adjusted for age, gender, socio-economical status, home ownership, residential satisfaction, usual window position in the sleeping room at night, number of hours away from home.
Bold: OR significant on significance level $p < .05$

4. DISCUSSION AND CONCLUSION

Whereas in this study noise exposure seems not to have a direct impact on subjective health complaints, reported cardiovascular diseases, sleep quality and medical consumption, noise annoyance and more consistently noise sensitivity are related to the investigated health outcomes in adjusted regression models. This is true regardless whether noise level, annoyance and noise sensitivity are analysed separately or combined in regression models, whether equivalent noise level for daytime or night-time is used, or whether noise levels from other sourced (road traffic, railway) are additionally included in the models or not.

In principle, three models which are simplified sketched here may explain the relationships found in this study. According to the first one noise exposure generates psychological noise reaction like annoyance which lead to psychological stress which again causes further physical and mental health effects. Babisch's noise effects reaction schema[12] and the psychological model of noise effects on health proposed by Job[13] are examples of this

approach. According to this approach annoyance functions as a mediating factor between noise and health outcomes. However, one would expect that with the statistical control of annoyance (and other factors) the impact of noise exposure on health outcomes could be detected. This is not the case in this study.

Another explanation, which is for example recently suggested by Fyhri & Klaeboe[22] with regard to road traffic noise assumes that the noise-health relationship may be spurious and that e.g. noise annoyance is associated with health effects because noise sensitivity as a core variable is related on the one hand to annoyance and on the other hand to health. Whether noise sensitivity and (reported) health are both indicators of a general 'vulnerability' or pre-existing illness modify the sensitivity to noise (and other environmental stressors) in general and therewith causes an increase in noise annoyance could neither be resolved by Fyhry & Klaeboe, nor can it be in this study. However, in this study noise annoyance still remains associated with the investigated health variables after control for noise sensitivity, which indicates that noise sensitivity or an underlying third 'vulnerability' variable alone does not explain the annoyance-health relationship.

According to the transactional stress model developed by Lazarus and collegues[32] a recursive process of evaluation of the noise situation (primary appraisal), evaluation of the personal resources available to cope with the noise (secondary appraisal) and a reappraisal of the noise situations as more or less stressful can be assumed. Noise annoyance and health effects are outcomes of this process. Personal and situational factors and among them noise sensitivity as well as pre-existing health problems and complaints may contribute to the secondary appraisal. That is, pre-existing health problems and/or higher noise sensitivity may limit the resources to cope with environmental stressors such as noise and therewith cause elevated psychological reactions (annoyance), which in the long run have an impact on further health outcomes. According to this approach the (perceived) resources for coping and the style of coping are core variables[33]. Of course, the assumed recursive process cannot be tested in a cross-sectional study. However, among the three sketched approaches the latter transactional approach seem to be the most suitable one to explain the data of this study as well as results from previous studies which show evidence of an impact of noise exposure and on health.

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