19th INTERNATIONAL CONGRESS ON ACOUSTICS
MADRID, 2-7 SEPTEMBER 2007

LONGITUDINAL EFFECTS OF A SUDDEN CHANGE IN AIRCRAFT NOISE EXPOSURE ON ANNOYANCE AND SLEEP DISTURBANCE AROUND AMSTERDAM AIRPORT.

PACS: 43.50 Qp

Breugelmans, Oscar[1]; Houthuijs, Danny[1]; Kamp, Irene van[1]; Stellato, Rebecca[2]; Wiechen, Carla van[1]; Doornbos, Gerda[1]
[1] National Institute of Public Health and the Environment, PO Box 1, 3720 BA, Bilthoven, the Netherlands; oscar.breugelmans@rivm.nl
[2] University of Utrecht, Centre for Biostatistics, Padualaan 14, 3584 CH, Utrecht, the Netherlands; R.K.Stellato@uu.nl

ABSTRACT
The opening of a new runway at Amsterdam Airport in February 2003 offered an excellent opportunity to study the longitudinal effects of a significant change in noise exposure on annoyance, sleep disturbance and self reported health status. A panel study was carried out as part of an ongoing monitoring program: the Health Impact Assessment Schiphol Airport. To create contrast, participants were selected based on their expected change in noise exposure (L_{den}). Once a year, the 640 members of the panel filled out a postal questionnaire in the period 2002-2005, resulting in 4 measurements.

An increase in the annual average exposure to aircraft noise resulted in an additional increase in severe annoyance, irrespective of the actual noise level. This 'overreaction' did already occur when noise exposure levels increased by less than 3 dB(A). The effect is driven by changes in noise alone, as adjustment for non-acoustical factors did not diminish the relationship. The 'overreaction' gradually decreases within 2 years, although the results are not conclusive. There was no indication of an overreaction in severe sleep disturbance or self reported health status due to the sudden change in noise exposure.

INTRODUCTION
Major changes in airport operations, such as the opening of a new runway, can cause large changes in noise exposure. These rapid, or abrupt changes in noise exposure levels can result in public unrest and increased annoyance in airport neighborhoods. Regular dose-response curves are often based on more or less stable noise environments, making them unreliable predictors of the magnitude of attitudinal changes when noise changes are abrupt rather than gradual (Horonjeff, 1997; Brown & van Kamp, 2005). Based on studies that have investigated this phenomenon over the years, the general hypotheses is that people 'overreact' to changes in noise levels and that, with time, this overreaction subsides. However, there is considerable scatter in the data and the results are based mostly on road traffic studies (Horonjeff, 1997). For policy decisions and forecasting, it would be very useful to better understand the changes that take place in people's reactions due to abrupt changes in noise exposure, the non-acoustical factors that influence this relationship, and the time period that people's 'overreaction' persists after the onset of the changes.

The Health Impact Assessment Schiphol Airport program has been monitoring the influence of aircraft noise on health and public perception since 1992. Three cross-sectional surveys have been carried out in 1998, 2002 and 2005. The survey of 2002 offered an excellent starting point for a panel study to explore the longitudinal effects of the opening of the new, fifth, runway at Amsterdam Airport in February 2003. The panel study focused on changes in annoyance, sleep disturbance and self reported health status.

METHODS

For the panel study 1000 persons were selected from the 2002 survey based on their expected change in noise exposure that would occur after the opening of the new runway. To ensure exposure contrast, the selection consisted of respondents with an expected increase or decrease of at least 3 dB(A) L_{den} and a control group with a maximum expected change of 1 dB(A) L_{den}. Of the 1000 persons selected, 640 enrolled in the study. A self-administered postal questionnaire was sent to the participants on a yearly basis, starting in November 2002 until autumn 2005. To adjust for possible seasonal effects, half the population received their questionnaires in spring and the other half in autumn of each year.

The questionnaires contained questions about annoyance from a variety of sources, sleep disturbance, whether the participants filed a complaint with the relevant authorities over the past 12 months, disturbance of daily activities, general health, mental health, hypertension, and medication use (sleeping pills, tranquilizers and antihypertensives). Information on possible confounding factors had already been obtained in the survey of 2002.
Aircraft noise exposure levels were calculated by the National Aerospace Laboratory (NLR), using the Dutch standard calculation model. The NLR delivered annual and biannual exposure levels for aircraft noise (L_{den} and L_{night}) on a 250x250 meter grid. The x,y-coordinates of the residential addresses were linked to the modeled exposure levels using GIS, and the L_{den} and L_{night} values during the last 12 months preceding each questionnaire administration were calculated.

In the questionnaire, single item 11-point scales (0-10) were used to measure annoyance and sleep disturbance due to aircraft noise (ISO/TS, 2003). Participants scoring 8 or higher were considered to be severely annoyed or sleep disturbed. Results from the first panel round of November 2002 were used to derive dose-response curves for the relationships between noise exposure over the last 12 months and the percentage severely annoyed, severely sleep disturbed and those indicating low general health (using the Dutch version of the RAND-36 (van der Zee & Sanderman, 1993)). For each panel wave the expected percentage of participants that were severely annoyed, severely sleep disturbed or that indicated low general health were calculated based on the dose-response relations and the noise exposure of the participants over the last 12 months preceding the questionnaire administration. This expected percentage was contrasted to the observed percentages of the endpoints at each panel wave.

A Generalized Linear Mixed Model (GLMM) was used to study the effects of aircraft noise exposure level over the last 12 months, change in noise exposure between the last 12 months and last 12-24 months and several non-acoustical factors on annoyance and sleep disturbance. Noise levels were analyzed as continuous variables. The following non-acoustical factors were taken into account: age, sex, ethnicity, home ownership, degree of urbanization, time of residence, living satisfaction, noise sensitivity, expectations about the airport and the neighborhood, coping behavior, fear for aircraft crashes, and a negative attitude towards the airport. Analyses were performed using SAS/STAT software and the GLIMMIX procedure (SAS/STAT, 2003)

RESULTS

When the actual noise levels of 2003 were available it became clear that the changes in noise levels followed a different spatial pattern and were less profound than expected. This made redistribution of the participants over the 3 exposure groups necessary (see Table 1).

Table 1.- Distribution of study participants over 3 exposure groups and change in noise exposure after opening of the new runway

Change in L_{den} between 2002 and 2003	Number of subjects	Average change in noise exposure (dB(A))	Range dB(A)
Increase >1,5 dB(A)	118	2,5	1,5 / 13,7
Decrease <-1,5 dB(A)	117	-1,9	-2,2 / -1,5
“Control”	405	0,1	-1,4 / 1,4

In total, 478 respondents completed all 4 panel waves, resulting in a drop-out rate of approximately 25% during the course of the study. Only respondents participating in 2 or more panel waves were considered during the analyses.

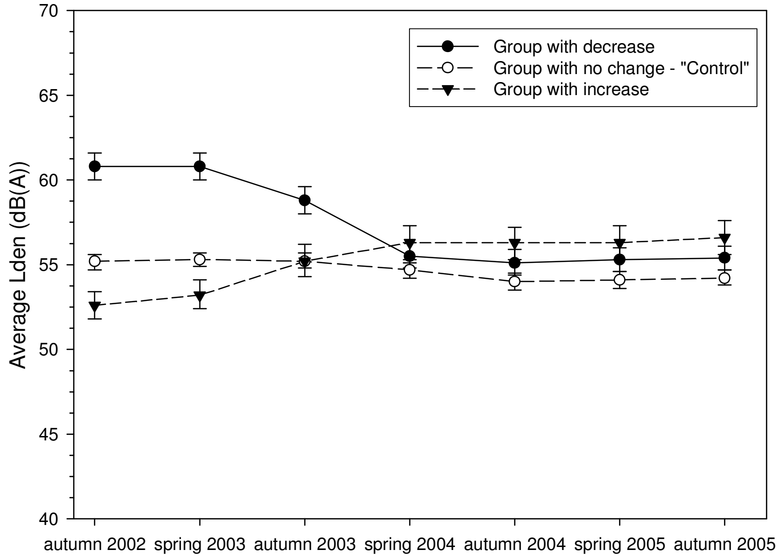

Figure 2.- Change of yearly average noise exposure L_{den} for each of the 3 study groups

The development of the yearly average noise exposure levels of the 3 study groups is shown in Figure 2. Noise levels for the control group decreased only slightly during the study from 55 dB(A) to 54 dB(A). For the group with an increase, noise levels went up from 53 dB(A) to 57 dB(A), whereas noise levels went down from 61 dB(A) to 55 dB(A) for the group with a decrease.

Figure 3 shows the observed and expected percentage of severely annoyed respondents in the 3 groups. The observed percentages of severely annoyed respondents for the groups with decreasing noise levels and the controls are in agreement with the expected annoyance percentages during the whole study period. The observed percentage of severely annoyed respondents for the group with an increase in noise exposure increases significantly over and above the expected percentage, starting in autumn 2003. This 'overreaction' continues to exist during the panel waves of spring and autumn 2004. The results are less clear for 2005 when annoyance levels seem to drop in spring, but increase again in autumn.

The same analyses were repeated for self-reported severe sleep disturbance and self-reported change in general health compared to the preceding year. For both endpoints the observed and expected percentages did not show significant differences for each of the 3 study groups during the whole period of the panel study.

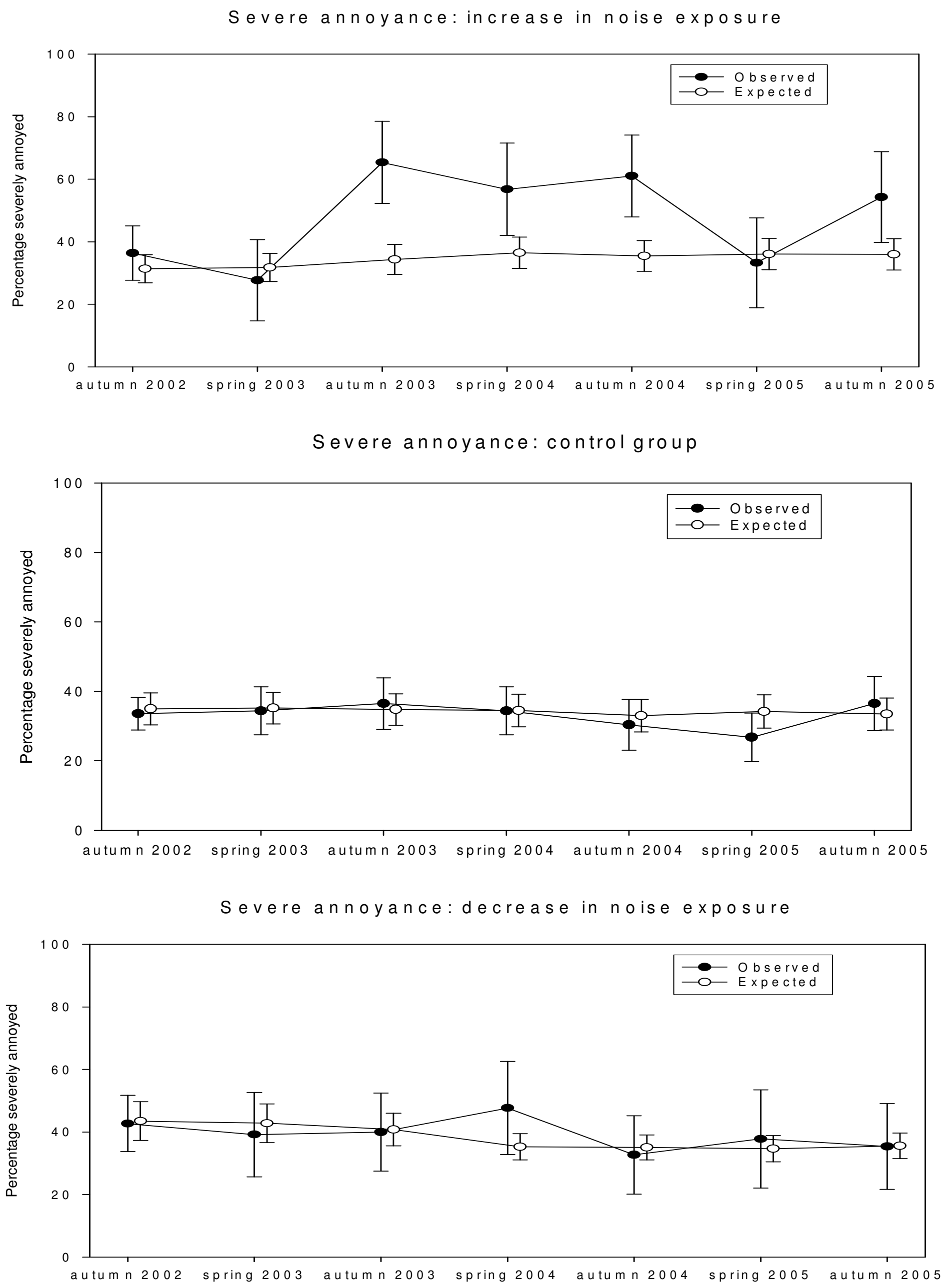

Figure 3.- Change in severe annoyance in the 3 study groups; observed annoyance versus expected annoyance

The odds ratios in Figure 4 show that persons exposed to a higher noise level of 3 dB(A) (L_{den}) report approximately 40% more severe annoyance (OR=1.44). After correction for non-acoustical factors this effect slightly diminishes, but remains significant. A stronger association was found for a 3 dB(A) *change* in noise level over the past 12 months (OR=1.73). Correction for the influence of non-acoustical factors did not alter this effect. The number of persons filing a complaint with the authorities increases significantly with approximately 35% when people are exposed a 3 dB(A) higher noise level (OR=1.36). A 3 dB(A) *change* in noise level results in a 60% increase in number of complainants. Adjustment for non-acoustical factors does not alter this effect. The results for annoyance and complaints are comparable.

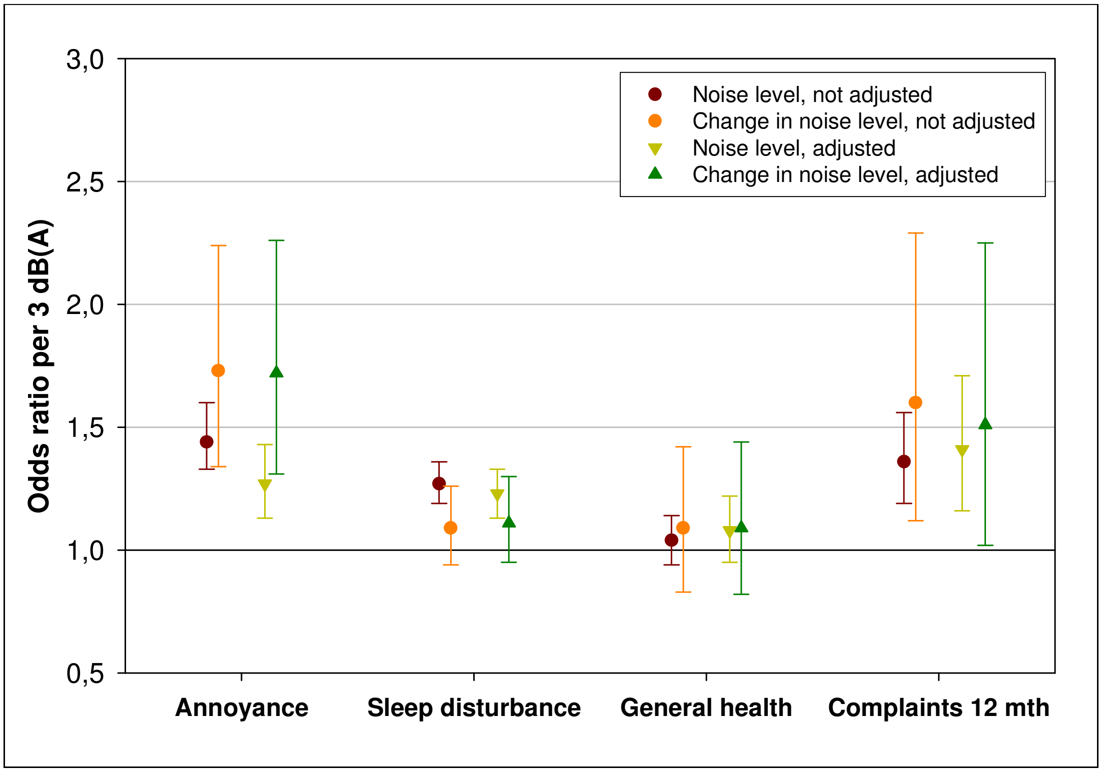

Figure 4,- Effect of noise level and change in noise level over the past year on annoyance, sleep disturbance, change in general health over the past year, and number of complaints over the past 12 months, adjusted and unadjusted for non-acoustical factors

For sleep disturbance, the effect of nighttime noise level (L_{night}) and *change* in nighttime noise level during the past 12 months was studied. Exposure to a higher nighttime noise level of 3 dB(A) (L_{night}) results in a significant increase in reporting of severe sleep disturbance (OR=1.27). This effect did not alter after adjustment for non-acoustical factors. A 3 dB(A) *change* in noise level resulted in a small, but insignificant increase in reporting of severe sleep disturbance that was not influenced by adjustment for non-acoustical factors. No effect of either the noise level or the *change* in noise level was found on the reporting of a change in general health compared to the preceding year.

CONCLUSIONS

Respondents subjected to an increase in aircraft noise exposure due to the opening of a new runway at Amsterdam Schiphol Airport in February 2003, reported significantly higher levels of severe annoyance than was predicted based on exposure-response curves. This 'overreaction' did not seem to diminish until spring 2005 when the observed percentage of severely annoyed became in agreement with the expected percentage. However, the observed annoyance again went up in autumn 2005. This unexpected increase might be related to an additional survey that had been carried out in summer 2005, which might have, again, sensitized the respondents to their changed noise situation. Apart from the noise source and the change in noise level, the 'overreaction' could not be explained by the non-acoustical factors that were taken into account. The 'overreaction' was only found in the group subjected to increasing noise levels: observed percentages of severe annoyance for the groups that did not experience a change in noise exposure or were subjected to decreasing noise levels, were in accordance with the expected percentages.

During the whole four-year study period, the observed number of severely sleep disturbed and persons indicating a change in general health compared to the preceding year were in accordance with the expected numbers based on the exposure-response curves derived at the start of the study. This indicates that changes in noise exposure have an impact on annoyance levels in particular.

References

Brown A.L., Kamp I. van,. Towards a design for studies of response to a change in noise exposure. InterNoise 2005, Rio de Janeiro, Brazil, 7-10 August 2005: Paper 1436.

Horonjeff RD. Attitudinal Responses to Changes in Noise Exposure in Residential Communities. HMMH Final Report No. 293350. Prepared under NASA Contract No. NAS1-20102, Task 8. 1997.

ISO/TS 15666:2002. Assessment of Noise Annoyance by means of Social and Socio-Acoustic Surveys. International Organization for Standardization. 2002.

SAS/STAT software, Version 9.1.3 of the SAS System for Windows. Copyright © 2003 SAS Institute Inc.

Zee KI van der, Sanderman R. Het meten van de gezondheidstoestand met de RAND-36: een handleiding. Groningen: Noordelijk Centrum voor Gezondheidsvraagstukken, 1993.