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ANNOYANCE BY AIRCRAFT NOISE AROUND SMALL AIRPORTS

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Studies on annoyance caused by aircraft noise exposure were undertaken in eight areas near three small and medium sized airports to assess the validity of a previously developed principle to express the relevant noise exposure. The results showed a dose–response relationship for the extent of annoyance when the noise exposure was expressed as the number of noise events $\geqslant 70$ dB(A). The maximum noise levels did not influence the extent of annoyance. The practical application of this principle for control of aircraft noise is illustrated.

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1. INTRODUCTION

When man is exposed to noise, the noise impulse is registered in the ear and the subsequent signal in the auditory nerve is interpreted in the central nervous system. The interpretation determines the individual's reaction to the noise. The mode of function of the neurophysiological reaction mechanism is such that the values most noticed are those that deviate from the background level. Unusually noisy events are thus important for the reaction that follows exposure.

Environmental noise comprises a number of individual events whose levels may vary considerably. This noise exposure is traditionally expressed as an average value of all noise events occurring within a given time period (the equal energy principle = the equivalent level; L_{Aq}). The relation between this unit and the effect in an exposed population is considered to be linear or near linear.

The noise exposure can also be described as the number of noise events, either all events or events that exceed a certain level, and the noise value of these events, for example the maximum value. These variables are independent of one another.

During the past 20 years, a large number of field studies has been performed to investigate the relationship between exposure to noise different sources in the environment and annoyance in the exposed population. The annoyance is usually expressed as the proportion of persons within a population with a similar exposure who consider themselves to be annoyed.

In the great majority of these investigations the noise level has been expressed as the equivalent noise level. Some studies on aircraft, road traffic and train noise have, however, investigated the number of noise events above a certain level and maximum noise levels separately [1–8].

The results of these studies show a non-linear dose–response relationship. When the number of events increases, the extent of annoyance increases, but only up to a certain breakpoint. If the number of events increases further, the extent of annoyance is not

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affected. Of all noise levels from individual events, the most important is the noisiest event (maximum noise level-MNL). The dose–response relationship using levels and number of events as exposure characteristics is not linear. There is thus no direct mathematical relationship between an L_{Aq} value and the MNL/number of events values.

In previous studies on aircraft noise, the number of events has been defined as those $\geqslant 70$ dB(A) [2, 5] and the breakpoint was set at about 70/24 h. The present study was undertaken to study areas around medium and small airports to focus on the part of the dose-response curve that is below this breakpoint. The noise exposure was measured and expressed as the number of overflights $\geqslant 70$ dB(A) and the noise level in dB(A) from the noisiest aircraft overflying at least three times/24 hours. The effects were evaluated by using questionnaires and expressed as the percentage of annoyed persons in each area.

2. MATERIAL AND METHODS

2.1. SELECTION OF AREAS

The investigation was performed in eight areas around three smaller Swedish airports (Landvetter, Säve and Everöd). The investigation in Landvetter was performed during May 1988, Säve during October 1989 and Everöd during May 1993. Each area was designed to extend along the noise contours of the airport in order to obtain a relatively uniform noise exposure within the area.

2.2. NOISE MEASUREMENTS

Noise measurements were made in the middle of each area, using computer based measurement equipment that registered the maximum noise levels (MNL) of each flyover during a two week period. MNL was defined as the highest A-weighted noise level from a single flyover, occurring at least three times per 24 h.

Information was obtained from the local air traffic control about the number of take-offs and landings, at what time they occurred and which type of aircraft and runway was used. The number of noise events in each area was defined as all events equal to or exceeding $\geqslant 70$ dB(A) during 24 h.

The noise dose was also expressed as a time weighted L_{Aq} value (FBN-an equal energy level where events during the evening are weighted with $+5$ dB and during the night with $+10$ dB). These values were obtained from calculations using standard methods.

2.3. QUESTIONNAIRE INVESTIGATION

In each area, all individuals between 18 and 75 years of age having lived there for at least one year were identified by using local tax registers. A random sample was selected from this population, using households as the basis. A total of 726 individuals was selected for the study.

Each person selected received a letter in which the investigation was presented as a general study of the living environment. An enclosed questionnaire contained questions about the respondents' general satisfaction with the living area and about annoyance from different sources in the environment. The respondent was asked to grade the annoyance experienced as not annoyed, a little annoyed, rather annoyed or very annoyed. The results were expressed as the percentage of persons in each area who reported that they were "rather" or "very annoyed" by aircraft noise.

TABLE 1

Noise exposure characteristics in the different areas investigated

Area	Number of events $\geqslant 70$ dB(A)	MNL (dB(A))	FBN (dB(A))
L1	48	86	57
L2	42	81	55
L3	38	81	58
L5	22	76	56
L7	5	70	49
S1	24	78	55
E1	7	73	50
E2	2	70	45

3. RESULTS

3.1. NOISE MEASUREMENTS

The results of noise measurements in the different areas are shown in Table 1. It is seen that the number of noise events with a level $\geqslant 70$ dBA ranged from two to 48 per 24 h. The MNL ranged from 70 to 86 dB(A) and the FBN units from 45 to 58.

3.2. QUESTIONNAIRE STUDY

The number of persons who responded to the questionnaire and the extent of annoyance is shown in Table 2. The average response rate was 74% and there was no apparent selection with regard to age or sex in the drop-out (data not reported). The proportion of persons reporting that they were "rather or very annoyed" ranged from 5 to 48%.

3.3. DOSE–RESPONSE RELATIONSHIPS

Figure 1 shows the relation between the extent of annoyance and the number of events $\geqslant 70$ dB(A). It is seen that a linear dose–response relationship was present. The correlation coefficient for the regression line was $r_{xy} = 0{\cdot}93$. For persons expressing that they were "very annoyed", the relation was $r_{xy} = 0{\cdot}80$. There was no indication that the MNL in the different areas influenced the extent of annoyance.

The relation between FBN and the extent of annoyance was $r_{xy} = 0{\cdot}48$ for "very annoyed" and $r_{xy} = 0{\cdot}80$ for the extent of "rather + very annoyed".

TABLE 2

Population sample, respondents and extent of annoyance in the different areas

Area	Sample	Responded (*n*)	Very annoyed (%)	Rather + very annoyed (%)
L1	39	25	28	48
L2	48	35	17	40
L3	61	40	20	48
L5	75	59	2	23
L7	65	41	3	10
S2	112	83	10	27
E1	77	62	8	18
E2	226	168	1	5

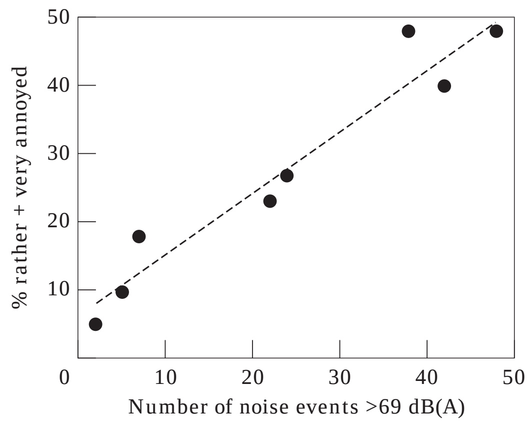

Figure 1. The extent of annoyance in relation to number of events $\geqslant 70$ dB(A).

4. DISCUSSION

The studies were performed with well established techniques, using social survey methods employed in many previous studies on the effects of aircraft and other environmental noises.

The study investigated areas around small and medium sized airports, where one previous study in the US also found that the use of equal energy levels to express the noise exposure gave less precise relationships [9]. In a re-analysis using the dose–response principle, where the number of event and noise levels are treated as independent variables, a linear dose–response relationship was obtained for this type of area [7]. These results are supported by the data from the present investigation. There was no influence by the MNL on the extent of annoyance. This is in contrast to previous studies in which clear dose–response relationships were reported [2]. However, these conclusions were based on annoyance data from areas exposed to more than 70 events (breakpoint), whereas the present study comprised areas below the breakpoint for events.

This could mean that noise levels are less important when the number of events is low and become important when the numbers lose importance (above the breakpoint).

The MNL principle can be used to establish guidelines. For areas around an airport where the number of overflights exceeds the breakpoint (about 70/24 h), the guidelines can be based on MNL only. For areas below the break point, the number of events seems to be the crucial factor.

Critical noise contours used in the MNL principle are narrower sideways from the runway, owing to the calculation of the breakpoint in the number of events. At the end of the take-off path, the critical noise contour is longer because it is determined by a relatively small number of noisy aircraft in a mixed fleet. If these are banned from the airport, or regulated to take off in one direction only, the extent of annoyance in the community will decrease and the other aircraft can continue to operate as before.

By using the MNL principle, actions can now be taken against individual aircraft. This represents an important improvement in the implementation of aircraft noise control around an airport, in comparison with previously used methods in which the equal energy principle made it impossible to regulate individual overflights.

In summary, the MNL principle, as illustrated here, can be used to determine which types of aircraft can use the airport on the basis of the aircraft's noise contours and flight paths. It is possible to adjust flight paths (control for numbers) and make requirements on the aircraft to decrease the noise level in order to be able to fly over certain areas, as well as to detect individual aircraft that exceed the noise limit. The application of this principle in aircraft noise control thus represents an important improvement in the work to provide a better environment around airports.

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