Health risks by nocturnal aircraft noise - do persons exposed get more ill on average?

C. Maschke

[2] FBB-Maschke, 10997 Berlin, Germany, Email: post@fbb-maschke.de

Introduction

The noise effect research assumes that aircraft noise induced impairment of health is mainly caused by chronically noise disturbed sleep. From this statement it follows that aircraft noise induced impairment of health can be avoided if noise induced sleep disturbances are prevented. As a modern indicator to prevent aircraft noise induced sleep disturbances the nocturnal wakening probability [1] is used. On the other hand the extent of aircraft noise induced impairment of health can directly be determined in epidemiological studies.

In epidemiological studies the (nocturnal) traffic noise is in general described by the A weighted continuous sound pressure level (SPL). Sleep examinations suggest in contrast, that sleep is mainly disturbed by the maximum SPL and the event frequency. The nocturnal wakening probability is therefore calculated by the number of nocturnal flights and their maximum SPL's [1]. Both approaches lead in the practice, however, to very different definition of protection requirements.

Findings from epidemiological studies

The HYENA and the Cologne Bonn airport studies are short introduced exemplarily:

Jarup et al. [2] examined 4861 adults between the ages of 45 and 70 years in the vicinity of 6 European airports with regard to hypertension. The A weighted continuous SPL for aircraft noise was charged with an accuracy of 1 dB separated for day and night. The hypertension findings were obtained by automatic blood pressure measurements repeated three times on the test persons and completed by interviews about cardiovascular medical treatments.

The main result is a steady increase in the hypertension risk with an increasing A weighted continuous SPL for nocturnal aircraft noise (solid line in Figure 1). If we look at the 5 dB categories (blue points in Figure 1) the onset of the risk increase can be observed as of 40-44 dB(A).

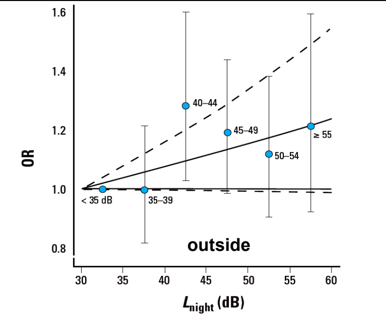

Figure 1: Odds Ratios of hypertension in relation to nocturnal aircraft noise. Adjusted for country, age, sex, Body Mass Index, alcohol intake, education, and exercise.

Greiser et al. [3] examined more than 800 000 insured persons between the ages of 0 and over 90 years in the vicinity of the Cologne Bonn airport. The aircraft noise levels at home were charged for different time windows (22:00-6:00 hours, 23:00-1:00 hours and 3:00-5:00 hours) in the night. In the study the objective health insurance company data about prescriptions of drugs was statistically evaluated

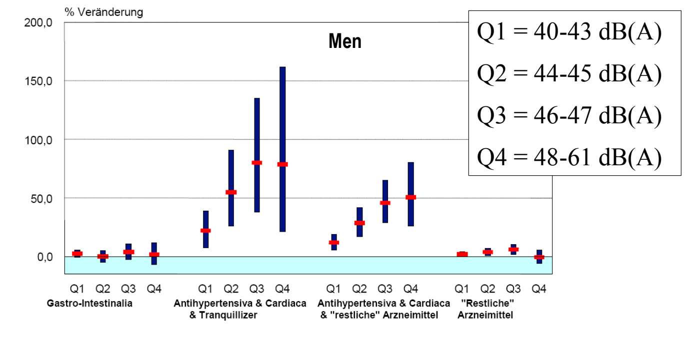

Figure 2: Change of prescriptions ((OR-1) in %) in regions with nocturnal aircraft noise (3-5 o' clock). Adjusted for age, street traffic and railway noise, welfare, interaction: aircraft noise*welfare, interaction: age*aircraft noise, option of noise protection

The main result is a steady increase in the drug prescriptions with an increasing A weighted continuous SPL for nocturnal aircraft noise. The onset of the risk increase for the drug prescriptions can be observed at a continuous SPL from 40 to 43 dB(A). Altogether, the recent epidemiological studies suggest a need for action at nightly continuous SPL's in the range of 40-45 dB(A).

Findings from sleep research

The sleep research has established a dose effect curve [1] between the probability of aircraft-noise-induced awakenings and the maximum SPL for a single aircraft noise event (figure 3).

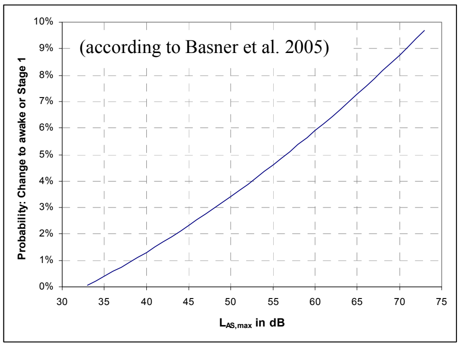

Figure 3: Aircraft noise induced wakening probability plotted against the maximum SPL of a single aircraft noise event [1]

To protect noise exposed sleepers, the concept of nocturnal wakening probability (NWP) was developed. The NWP is defined as the sum of the probabilities of all single flight events in the night. Accordingly, [1] there is a need for action if the NWP is 100% or higher. The NWP is normally calculated for a time-averaged night (e.g. mean value of the six busiest months).

Data from a real immission place

On the whole, continuous SPL's and NWP cannot be converted to each other. Figure 4 shows the relationship for a real immission place (civilian air traffic).

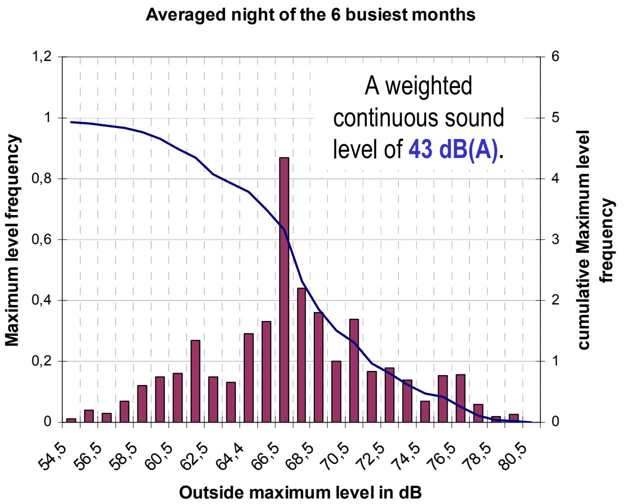

Figure 4: Immission place in the vicinity of the Frankfurt a.M. airport

For the selected immission place the NWP (according [1]) is about 20% for a partly open window. The calculated NWP is therefore far removed from a need for action. If we look at the continuous sound level, the threshold for protection is in contrast (nearly) reached according to the results of the epidemiological studies.

What is the reason for the discrepancy?

To understand the difference we examine the epidemiological approach as first. A typically epidemiological parameter is the relative risk (RR). The Figure 5 illustrates the calculation as a simple example.

Simple example: Prevalence 30%	Risk factor			
	With aircraft noise		Without aircraft noise	
With hypertension	a)	257	b)	246
Without hypertension	c)	543	d)	574
Number of persons	e)	800	f)	820
Odds Ratio	$OR = \frac{a}{d} \Big/ \frac{b}{c} = \frac{257 * 574}{246 * 543} = 1{,}10$			
Relative Risk	$RR = \frac{a}{e} \Big/ \frac{b}{f} = \frac{257 * 820}{800 * 246} = 1{,}07$			

Figure 5: Fourfold table to illustrate the calculation of the RR. In multiple analyses the Odds Ratio is used as an estimator of the RR

It can be recognized from the example that the RR indicates the number of persons who fall in ill due to aircraft noise. In contrast to the epidemiological approach the sleep medical approach calculates the NWP only for the whole group of exposed persons together. The NWP is therefore a group mean value (Group-average) for a time-averaged night. Since there are however chronically good and chronically bad sleepers, the NWP does not contain information about the wakening reactions on an individual level. In the context of the concept of the NWP (according [1]) 3 chronically good sleepers without awakening reactions can compensate e.g. one chronically bad sleeper who wakes up 3 times in the time-averaged night. The group-averaged NWP for this simple example is considerably smaller than 100%, although the sleep is disturbed seriously for one of the exposed persons. The individuals awakening reactions induced by noise are normally not known, however, they can be estimated by the Bernoulli distribution.

$$B(k,n,p) = \binom{n}{k} p^k (1-p)^{n-k}$$

If the noise induced awakenings are independent, a sequence of n flight events can be understood as a Bernoulli chain of the length of n, the wakening probability p and the waking frequency k. The result of this estimate for 100% NWP shows the following table.

Table 1: Estimated wakening probabilities for different noise induced awakening frequencies

Wake up probability	Waking up 0 times	Waking up 1 times	Waking up 2 times	Waking up 3 times
100%	36%	38%	19%	6%

The estimate shows, that 64% of all exposed persons wake up at least once in the time-averaged night. 28% of all exposed person wake up more than once. For 28% of the exposed sleepers their sleep is still seriously disturbed. The sleep medical approach does not indicate the number of persons at serious risk. That is an essential reason for the difference.

Conclusions

A NWP of 100% is not suitable to avoid noise induced serious sleep disturbances in the time-averaged night for bad sleepers. Therefore, a wakening probability of 100% cannot prevent noise induced illnesses. People do not get ill on average, only individual humans can fall ill. Epidemiological findings indicate all noise induced sick person and they are therefore much more appropriate for health protection.

References

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