

## **IF HIGH AIRCRAFT NOISE EXPOSURE INCREASES HEART ATTACK RISKS, WHAT DO WE DO ABOUT IT?**

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### **Introduction**

Is high aircraft noise exposure actually dangerous to people's health? Is there a good way of identifying 'significant danger'? What are the policy implications for government and airport operators of people being exposed to significant danger?

One of the most difficult questions faced by medical researchers is often that of judging whether an exposure to some potential hazard causes a disease or some other kind of impairment or ill health. There is a huge literature on 'Epidemiology' – the scientific study of factors affecting the illnesses and health of individuals and populations.

There are inherent problems in measuring possible causation effects of aircraft noise: 'causation' may often mean an increased probability of an effect. . There are generally large variations in individual responses and 'statistical confounding factors' are often present (Hill, 1965). Confounding covers possible alternative explanations and mechanisms that produce modifications to the nature or scale of people's responses. Examples of confounding airport-related health factors are:

If people living near an airport tend to be in particular socio-economic or ethnic groupings that frequently have poor diets and/or are grossly obese, then they will tend to have more illnesses than the population generally (British Heart Foundation, 2006)..

If air pollution causes or exacerbates illnesses, people living near airports, especially if aircraft emissions are combined with those from the very busy roads associated with airport activity, will have poorer health than people in general (COMEAP, 2006).

There are hundreds of research papers on noise and health, many which deal with aircraft noise. The quality of the underlying research appears to be very variable:

There are varying degrees of medical assessment of the conditions examined.

Some studies are qualitative, although recent research tends to be quantitative.

Some authors are willing to make quite definitive statements on the basis of statistically 'light' evidence, while others come to no conclusions (other than 'more research is needed').

Some studies appear in peer-reviewed journals, other in un-refereed reports.

Some journal editors have a policy of not publishing material critical of published work (other than complete proof that that research is invalid).

Even for studies carried out by professionally experienced researchers, there can be major disagreements about statistical analyses, e.g. Stafford (2006). Thus, it can be very difficult to come to conclusions about what research is telling us. The authors' conclusions must always be viewed with caution. Several review papers have been published in the last decade, which try to collate and compare the many research findings. They include: Morrell et al (1997); Porter et al (1998); Passchier-Vermeer and Passchier (2000); Miedema (2001); Kluizenaar et al (2001); Kempen et al (2002; 2005); Griefahn (2004); enHealth Council (2004); Babisch (2005; 2006).

The next major problem, even if the authors' conclusions are robust, is what to do with the results. What level of danger to health is 'significant'? What does this imply for policy about the people exposed? The following attempts to illustrate how these questions can be answered, by integrating recent results on heart attack risks with UK government policies on health and safety.

### **Myocardial Infarction Risks**

Babisch (2006) discusses the evidence for the relationship between transportation noise and cardiovascular health, in particular acute myocardial infarctions. An acute myocardial infarction (MI) is a 'heart attack', i.e. where a blood clot blocks a coronary artery, and thus leads to heart muscle being starved of necessary oxygen). His critical review and re-evaluation of the 'best' past studies led to the conclusion that (Babisch, 2005):

"The results of epidemiologic noise studies suggest an increase in cardiovascular risk with increasing noise exposure....Transportation noise from road and air traffic is the predominant sound source in our communities; outdoor sound levels for day-evening-night ( $L_{den}$ ) > 65–70 dBA were found to be associated with Odds Ratios of 1.2–1.8 in exposed subjects compared with unexposed subjects [ $< 55$ –60 dBA]. Studies use magnitude of effect, dose–response relationship, biological plausibility, and consistency of findings among studies as issues in epidemiologic reasoning."

[The 'Odds Ratio' is the relative risk level.]

Babisch's work has led to the German Federal Environmental Agency [Umweltbundesamt – UBA] issuing 'Requirements for the protection against aircraft noise' (Wende and Ortscheid, 2004):

“The assessment periods were chosen analogously to the regulations on other traffic noise sources (rail traffic, road traffic)...avoiding of impairment of health by limiting the exposure to aircraft noise (outside) to equivalent levels below 60 dBA by day and 50 dBA at night.”

An earlier UBA publication noted: “at aircraft noise loads of 60 dBA in the daytime and 50 dBA at night, there is reason to fear adverse health effects from a point of view”. It recommended ‘adequate structural soundproofing to be provided’ but noted that “Since adverse effects in outdoor living still remain despite such measures, compensation may become necessary”.

A key quantitative source for Babisch’s conclusions and these UBA targets is the data in his Figure 14 [page 62], shown here as Figure 1. This suggests that, for road traffic above 60 Leq, risks of MI increase markedly with increased Leq. However, the statistical confidence bands in the Figure are very wide. Is there a real increase from 60 Leq onwards? Are the effects from air traffic the same as for road traffic? How large does an increase have to be for it to be ‘significant’ in terms of health policy? Should health policy be based on comparatively rare increases in risk? What is appropriate preventative medicine action? What amount/type compensation would be appropriate?

## **PSZ Policy and ALARP**

A way of addressing the questions about MI risks and health policy is to study what has been done to resolve an analogous safety problem. This is the problem of public safety zones (PSZ) near airports. There are two compelling reasons why this is a useful analogy. First, the methodology uses principles established over many years by the UK Health and Safety Executive (HSE). Second, the techniques developed have been endorsed by the UK government’s Department for Transport (DfT).

Aircraft crashes are rare, but their potential effects to people on the ground near airports cannot be ignored. Studies on the risks to these ‘third parties’ have led to changes in UK policies on development near to airports. The results have been an important issue in planning inquiries, most especially the Heathrow Terminal 5 Inquiry.

Crashes are now most likely to occur in areas that are close to airport runways, because take-off and landing generally produce the most risks, generally occurring because of operational factors rather than from problems with aircraft design or engine technology. The UK Government established a system of PSZs for the busiest airports more than 40 years ago. PSZs are areas of land at the ends of the runways at the busiest airports. Within PSZs, development is restricted in order to minimise the number of people on the ground at risk of death or injury in the event of an aircraft crash.

The current UK policy on PSZs is set out in DfT (2002). It explains how the PSZ policy was developed through risk contour modelling and by setting limits on the degree of risk that is ‘tolerable’ for people on the ground near airports. The phrase ‘tolerable risk’ arises from extensive work by the UK Health and Safety Executive (HSE) on risk decision-making (HSE, 2001). Thus, DfT PSZ policy is built upon long-established HSE risk guidance material.

Figure 2 presents HSE's diagram of the Tolerability of Risk Framework (HSE, 2001 and earlier documents). There is actually only one axis in the diagram: it runs vertically, and represents individual risk, with low values at the bottom and higher values at the top. The narrowing triangle illustrates diminishing individual risk. Individual risk in this context is the risk of death per year to an individual located at a particular place near to the airport.

Two boundary points in Figure 2 divide the range of individual risk for some system of interest into three regions: the intolerable risk threshold and the acceptable risk, the former being greater than the latter. The decision processes are:

If a system's risk falls into the intolerable category, then action must be taken to redress this. If this is not possible, the system should be halted or not implemented.

If a system's risk falls into the tolerable category, it must be proven that it is 'as low as reasonably practicable' (ALARP) within that region for the system to be considered acceptable. Thus, showing a system is ALARP means demonstrating that any further risk reduction in the tolerable zone is either impracticable or 'grossly disproportionate' (i.e. it can be shown that the cost of the measure is far in excess of any benefit to be gained).

If a system's risk falls into the negligible category, no action is required other than monitoring to ensure that the negligible risk is maintained.

'Reasonably practicable' is a difficult phrase. It is essentially the adoption of good practice in health and safety for the activity concerned. Risk reduction is defined to be practicable if and only if it is possible to find cost-beneficial risk reduction measures. The Notes to Figure 2 provides some definitions and more detail.

The methodology used to develop DfT's PSZ policy combined individual risk criteria and cost benefit analysis; termed 'constrained cost-benefit analysis', This is a complex subject, explained in detail in Evans et al (1997). Summarising very drastically, the main quantitative outputs are a set of individual risk contours and corresponding policy guidance. Risk contours are cautiously-estimated lines of equal risk, analogous to noise exposure contours. The risk modelling produces contours off the runway ends that are wide near the runway ends, becoming much narrower with increasing distance from the runway eventually to form a point, i.e. are roughly triangular).

Three standard contours are used:  $10^{-4}$ ,  $10^{-5}$  and  $10^{-6}$ . A person spending all their time on the  $10^{-4}$  contour line would have a 1 in 10,000 chance of being killed per year because of an aircraft crash. The  $10^{-4}$  value was assessed as being an appropriate upper tolerability limit in Evans et al (1997):

"For the upper tolerable risk level for members of the public, the only widely used value is a risk of death of  $10^{-4}$  per year. This is recommended by the Health and Safety Executive (HSE) for use in other safety critical industries."

The  $10^{-4}$  individual risk level was subsequently accepted by DfT as the intolerable risk threshold for PSZ policy. Key DfT (2002) PSZ policy recommendations – *which obviously apply equally to new airport developments* – include:

- Any existing housing, and other development occupied by third parties for a high proportion of the day, should be removed from within the  $10^{-4}$  individual risk contours.
- New housing development, and most types of new non-housing development, within the  $10^{-5}$  individual risk contour should not be approved.
- It may also be sensible to restrict development for new, sensitive or high density land uses, such as schools, hospitals, or places of assembly, somewhat beyond the  $10^{-5}$  contour. Such restrictions should be considered on a case by case basis.

### **ALARP and Myocardial Infarction Fatalities**

If ALARP is taken as a sensible principle for assessing risk, and the PSZ ‘intolerable risk threshold’ analysis is taken as an appropriate methodology for aviation, how should Leq values corresponding to increased risk of fatality from MIs be analysed?

First, increased risk factors have to be converted into mortality rates – the number of deaths occurring in the population under consideration, per year. The starting point is the current mortality rate for MI. Figure 3 shows the most recent – 2004 – statistics for MI deaths in England and Wales, from UK Office of National Statistics (ONS) data. Also from UK ONS data, the population for England and Wales in 2004 was about 53 million. Thus, the mortality rate for 2004 was about  $39,215 \div 53 \text{ million} = 7.4$  per 10,000. [NB: The rate has been improving significantly over the last decade, e.g. see Goldacre et al (2006).]

Babisch (2006) suggests that MI risks increase progressively above 60 Leq – Figure 1. At the 71-75 Leq datapoint, the increased risk is 19%. If the risk of a fatality from a noise-induced MI were similar that for MIs from all causes, then aircraft noise at 71-75 Leq would increase the MI mortality rate per 10,000 people by  $\sim 7.4 \times 0.19$ , which is  $\sim 1.4$ . This means that the aircraft noise-induced MI mortality rate at this Leq level would exceed a  $10^{-4}$  risk level. The Leq value actually corresponding to a  $10^{-4}$  risk would in fact be at  $\sim 70$  Leq, based on Babisch’s curve-fitting (his Figure 10, with fitted cubic equation [page 53]). This is a slightly cautious calculation, given that the incidence rate estimate includes ‘excess fatalities’ arising from aircraft noise in its denominator.

But this  $10^{-4}$  risk level is the ‘intolerable risk threshold’. In HSE risk assessments, deaths are deaths, whether from aircraft crashes or the cumulative effects of noise on a person’s health. Therefore, the policy for  $10^{-4}$  individual risks should be the same, i.e.:

If myocardial infarction risks ‘surge’ above 60 Leq as calculated by Babisch, then the increased risk at  $\sim 70$  Leq is at an intolerable risk threshold of  $10^{-4}$  individual risks. Any existing housing, and other development occupied by third parties for a high proportion of the day, should be removed from within the  $\sim 70$  Leq contours.

## Points for Debate

Is the above a reasonable conclusion? Do the facts and logic above support this kind of answer? The assumption has already been made that the risk of a fatality from a noise-induced MI is similar to the fatality risk for MIs from all causes. The following notes debate some of the issues.

*Are the statistical uncertainties in the Babisch's results too great?* There are certainly wide confidence bands around the trend line in Figure 1. Babisch emphasizes that this exposure-effect curve was not derived for significance testing, but rather to provide a best-fit curve for quantitative risk assessment. The ~70 Leq value is simply taken from Babisch's data – but what should government adopt as 'cautious' parameters? As noted, there are inherent problems in carrying out epidemiological studies. Has Babisch – have the other researchers? – successfully disentangled all the socio-economic and ethnic differences? What about air pollution effects (COMEAP, 2006)?

*The Babisch results are for road traffic not aviation.* True, because that is where the bulk of the research data is available. But Babisch offers reasons why aircraft noise might have increased effects over those from road traffic, e.g. because "of the lack of evasive possibilities in the home" and because of aircraft noise effects on sleep. This view has support from research results, e.g. see Figure 2 [page 15] of Babisch (2006), which reviews epidemiological studies of road and air traffic. Note that here is some evidence from studies of annoyance that aircraft noise effects are stronger than those from road traffic noise.

*An individual risk  $10^{-4}$  and a mortality rate of  $10^{-4}$  are actually different concepts in population terms.* The former refers to 'the risk of death per year to a representative or specified individual as a result of the realisation of specific hazards' (Evans et al, 1997). Mortality rate is 'the number of deaths occurring in the population during the stated period of time, usually a year, by the number of persons at risk of dying during the period'. The definitions are consistent if the population is in both cases representative of the general population. It is surely essential that there is consistency in governmental safety and health decision-making.

*MI rates are reducing over time, so calculations for future years should be based on a lower figure.* This factor needs to be taken into account, but the noise-induced MI rate may not be reducing, i.e. the Odds Ratio may be increasing over time.

*What about health damage arising from non-fatal MIs?* The PSZ policy is based on fatalities, rather than trying to include both fatalities and impaired life states post-MI, e.g. as represented by 'QALYs' (e.g. see Rawlins and Culyer (2004). If the latter were to be included through QALYs or a similar scheme then the critical Leq value would presumably need to be set a lower value. [NB: About two thirds of MIs are not fatal but produce varying degrees of impairment and the need for care to be provided.]

*Fatal MI rates are reducing because of improvements in medical care, so the rates will be lower in cities, with nearby ambulance services and hospitals, which mean that clot dissolving drugs can be given quickly.* This certainly could be a factor. Note, however, that Heathrow currently has no hospitals within its current 'daytime' 63 Leq contour (BAA, 2006 – Community Buildings Noise Insulation Scheme [page 9]).

*Why pick on one medical effect?* To a degree, MIs serve as a single example of potential health effects. A key point is that it relates to fatalities rather than lower degrees of health impairment. A policy decision on a 'high Leq' value would need to take account of the evidence on all health effects.

*Are the numbers of MIs accurately assessed?* The numbers are probably underestimates. This is because MIs as counted by Babisch and other researchers are generally restricted to the 'International Statistical Classification of Diseases and Related Health Problems' (ICD-10) codes I21-22 (ONS, 2006). Other forms of Coronary Heart Disease (CHD: ICD-10 codes I23-I25) are not counted statistically as MIs, but in many cases there are similar causal factors. MIs could be viewed a surrogate for all CHD diagnoses, as they are very definite event. [NB: Norris (2002) comments on the difficulties of CHD/MI classification.]

*Could not other means besides removing houses solve the problem?* Noise insulation would reduce indoor Leq levels markedly, but it would obviously not produce improvements outside the house, nor when people have their windows open in hot summer weather. Significant reductions in source noise would of course reduce Leq levels.

## **Conclusion**

If high levels of aircraft noise exposure dangerously affect people's health, then this issue deserves serious attention. There is evidence in the medical research literature that high levels of aircraft noise exposure increase the risks of myocardial infarction. This information can be combined with the HSE's ALARP principle for assessing risk, and DfT endorsed levels of 'intolerable risk'. The combination would lead to policy guidance that people should not live within ~70 Leq contours. This rests on the belief that the government's health policy criteria should be consistent with its safety policy criteria. This paper has sketched the logic, but is obviously not the 'final word' on the subject.

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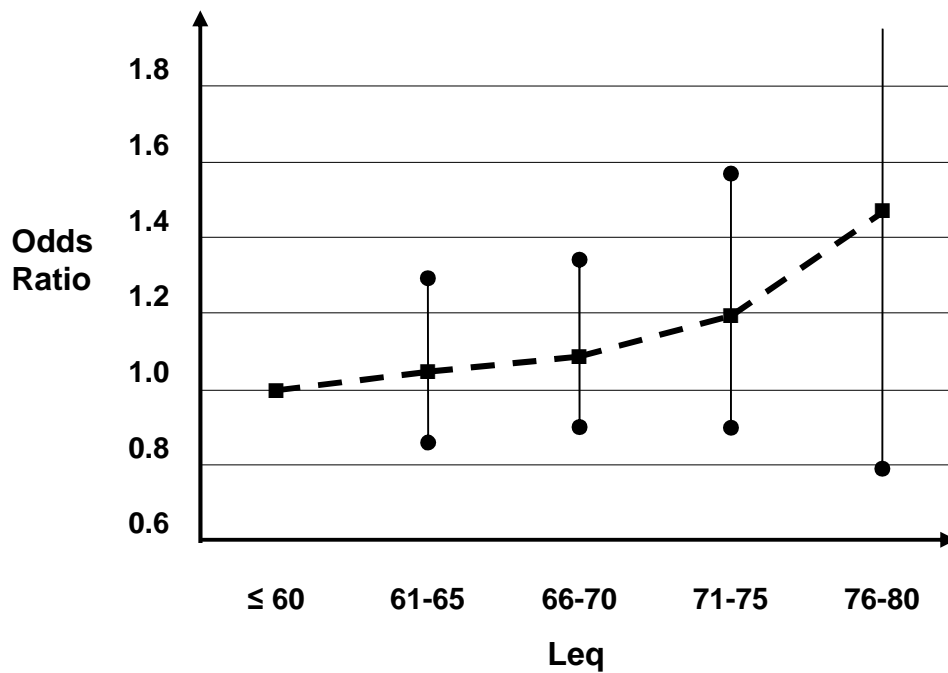


Figure 1. Association between Road Traffic Leq level and MI Incidence, pooled analytic studies

Adapted from Figure 14 of Babisch (2006). The Odds Ratio is the MI incidence relative to the  $\leq 60$  Leq incidence. The vertical bars are 95% confidence bands.

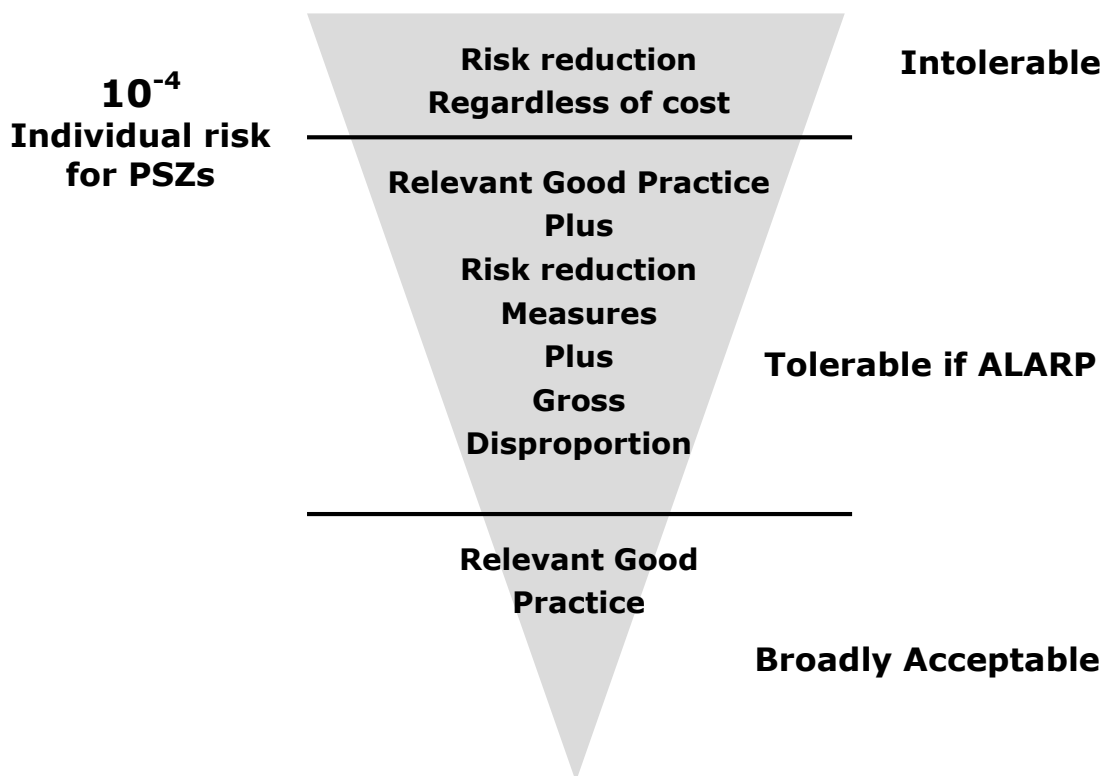


Figure 2. ALARP Approach (taken from HSE)

Notes

Risk is classified by the HSE as being in one of three categories: intolerable, tolerable if ALARP, and broadly acceptable ('negligible' in some variants). The boundary lines between the risk categories negligible, tolerable, and intolerable need to be specified; they are not automatically set.

Simplified HSE definitions:

*ALARP principle* The principle that no risk in the tolerability region can be accepted unless reduced 'As Low As Reasonably Practicable'.

*Broadly acceptable risk* A risk which is generally acceptable without further reduction.

*Individual risk* The risk of death per year to a representative or specified individual as a result of the realisation of specific hazards.

*Intolerable risk* A risk which cannot be accepted and must be reduced.

*Tolerability region* A region of risk which is neither high enough to be unacceptable nor low enough to be broadly acceptable. Risks in this region must be reduced ALARP.

<b>Age group</b>	<b>Number</b>	
	<b>Men</b>	<b>Women</b>
<b>0-34</b>	70	17
<b>35-44</b>	343	74
<b>45-54</b>	1137	242
<b>55-64</b>	2787	780
<b>65-74</b>	5434	2570
<b>75+</b>	12283	13478
<b>all age</b>	22054	17161
<b>Total</b>	39215	

Figure 3. Myocardial Infarction Mortality in England and Wales, 2004

Adapted from ONS (2006) Table 2.9, pages 92, 93. Code I21.

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