DNWG

DEPARTMENT OF DEFENSE
NOISE WORKING GROUP

TECHNICAL BULLETIN

Non-Auditory Health Effects of Aircraft Noise

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This Technical Bulletin offers advice on how to address public concerns about non-auditory health effects due to exposure from military aircraft in residential areas. The intent is to help program officials disclose what is known about health effects when the issue comes up through public inquiries or as part of the environmental analysis process.

INTRODUCTION

Noise impacts from military aircraft are often the most contentious issue in DOD environmental impact analysis documents prepared in compliance with the National Environmental Policy Act of 1969 (NEPA). Members of the public often bring up the issue of non-auditory health effects due to exposure from military aircraft in residential areas. The non-auditory health effects typically raised include birth defects, low birth weight, mental problems, cancer, stroke, hypertension, sudden cardiac death, myocardial infarction, and cardiac arrhythmias. This Technical Bulletin summarizes the existing credible scientific research on non-auditory impacts of aircraft noise and provides conclusions on the state of the research. The intent is to help program officials disclose what is known about health effects when the issue is brought up by the public or as part of the environmental analysis process.

This bulletin is one of a series of Technical Bulletins issued by the Department of Defense (DoD) Noise Working Group (DNWG) under the initiative to educate and train DoD military, civilian and contractor personnel, and the public on noise issues. The ability to convey the effects of military aircraft noise exposure should facilitate both the public discussions and the environmental analysis process.

BACKGROUND

The primary goal of all public efforts to control noise exposure within communities is, as with all environmental issues, to provide a protection mechanism for the health and welfare of the population. It attempts to answer the question – what are the allowable or "safe" noise levels that will protect the health and welfare of the general population?

Within the context of the U.S. Federal noise control regulations and guidance, the term health has been defined, not simply by the absence of disease, but as the total psychological and physiological well-being of the community. The term public health indicates that the common interests of society must be taken into account when evaluating potential noise effects. In other words, noise effects must be related to the long-term, cumulative effects of the population as a whole, not the isolated, occasional impacts on individuals.

The reaction of people to a given noise environment is extraordinarily complicated. This is particularly evident when trying to evaluate the potential health effects of people exposed to aircraft noise. One reason for this is the intermittent nature and the character of aircraft noise, in which noise levels fluctuates significantly from high to low over time. Other important elements are the complex psychological and physiological reactions of people to the actual noise environment, and their attitudes toward the source of the noise. Further aggravating this difficult issue is the possibility that short-term community reaction can be different than the long-term community reaction.

In an effort to better understand people's responses to noise, the scientific community has divided the noise effects on people into two general categories. Psychological effects refer to behavioral reactions that are indicators of the population's "well-being" – essentially, people's psychological reactions to their noise environment and their reactions to interference with their various day-to-day activities. The primary examples are the potential effects on long-term community annoyance, speech interference (includes effects in the home, school, church, and auditoria), sleep disturbance (home), effects on children's learning (at school and at home), and interference with work performance. The second category for human response to noise is for the physiological effects – essentially, real medical effects on the human body's systems. The primary example of this is noise-induced hearing loss, although other medical health effects such as cardiovascular disease have been postulated by various researchers and communities over the years. For each of these indicators that attempt to describe the long-term community reaction to noise, the scientific community has spent considerable effort since the mid-1950s researching the noise metrics and associated noise levels that best relate to community response.

Non-auditory effects of noise, as dealt with in this bulletin, can be defined as those physiological effects on health and well-being which are caused by exposure to aircraft noise, but excluding the effects on hearing. The physiological effects discussed in this bulletin include:

- Stress Response,
- Cardiovascular Effects,
- Birth Defects,
- Mortality Rates.

Stress Response -- The human stress response is a natural coping mechanism that occurs when there is a perceived threat. For people who are susceptible, the stress response triggers a sudden release of stress hormones. These hormones can cause temporary changes in heart rate and

blood pressure. The postulate is that, for some people, a sudden or uncontrollable intense noise may be enough to cause a stress response. In most cases, the stress response is short-term, and the person's heart rate and blood pressure soon return to normal.

Cardiovascular Effects – Hypertension and Heart Disease --The assumption is that noise exposure causes elevated blood pressure (hypertension) characterized by a lack of oxygen to the heart muscle, which could lead to angina or heart attack (myocardial infarction).

Birth Defects -- The assumption is that high aircraft noise exposure leads to increased incidences of central nervous system defects in the offspring of parents residing near airports.

Mortality Rates -- The assumption is that stress-related effects of high aircraft noise exposure lead to increased incidences of deaths due to strokes (sudden disruption in blood flow to the brain) and deaths due to cirrhosis of the liver (primarily attributed to alcoholism).

DISCUSSION

This section of the bulletin draws upon two recent and independent reviews of the scientific literature on aircraft noise effects; one funded by the Department of the Navy and the other through the Airport Cooperative Research Program (ACRP). These reviews cite many of the same studies, including references, described in the World Health Organization (WHO) Guidelines for Community Noise (WHO 2000), which was the outcome of the WHO-expert task force meeting held in London, United Kingdom, in April 1999, and in a more recent report issued by the World Health Organization (WHO 2011).

The Department of the Navy review produced the report "Improving Aviation Noise Planning, Analysis and Public Communication with Supplemental Metrics – Guide to Using Supplemental Metrics" (December 2007). The intent was to provide more useful information on the noise environment than is available through solely using the long-term, cumulative metrics such as Day-Night Average Noise Level (DNL). The guide includes a review of the scientific literature on the effects of aircraft noise.

In September 2008, the Transportation Research Board (TRB) published Airport Cooperative Research Program Synthesis Report #9, "Effects of Aircraft Noise: Research Update on Selected Topics." This synthesis study was intended to inform airport operators, stakeholders, and policymakers of updated information about aviation noise effects. In the decades since FAA Report FAA-EE-85-2 "Aviation Noise Effects" was first published in 1985, much has changed in the understanding of this complex issue. Increased air travel, new and quieter aircraft, increased awareness of land use planning and aviation noise, and mitigation of previously incompatible land uses are just a few of the changes. Knowledge of the effects of aviation noise has also changed. The greatest increases in knowledge have come in the areas of health effects, annoyance, sleep disturbance, and potential effects on children's learning

As noted in the ACRP Synthesis, identifying and quantifying any potential effects of aviation noise on health is a complex and difficult field of study. Approaches on how to identify and measure the noise exposure and how to separate the effects from other life events are difficult at best. For example, lifestyles, life stressors, hereditary factors, and genetic composition are just a few factors (also called confounding factors) that may distort potential results of an aviation noise health effects study.

The reviews of the research have been summarized in the following subject areas: stress response, cardiovascular effects (hypertension and heart disease), birth defects, and mortality. Each is discussed separately here.

Stress Response

Exposure to high noise levels, far greater than those produced by aircraft in the community, can elevate blood pressure and also stress hormone levels. However, the response to such loud noise is typically short in duration. After the noise stops, the physiological effects reverse and levels return back to normal. In the case of repeated exposure to aircraft noise, the connection is not as clear. The results of most cited studies are inconclusive, and it cannot really be stated that a causal link exists between aircraft noise exposure and the various types of non-auditory health effects that were studied. There are just too few studies, and, among the studies that have been performed, the results are often contradictory.

A case in point is a study of school children near Munich airport (Evans et al 1995 and 1998) which examined stress hormone levels in children attending schools located near a civilian airport. The study showed that levels of stress hormones (called catecholamines, which include

epinephrine and norepinephrine) became elevated in children attending schools exposed to aircraft noise, when compared against children in schools not exposed to aircraft noise. Elevated levels of these hormones may result in elevated blood pressure. The authors noted that, as in any field study, they could not disentangle the effects of chronic noise. For example, while the new airport was the primary change, the study area also experienced dramatic increases in noise due to increased land development and road traffic.

The ACRP Synthesis cites another German study (Poustka et al 1992), which examined effects on children in contrasting geographic regions. These regions differed according to the noise made by jetfighters exercising frequently at low altitude. Neither psychiatric disorders nor environmental factors showed any relationship to noise; however, physiological parameters (e.g., heart rate and muscle tension) demonstrated some relationship to noise. The synthesis notes that the meaning of this is unknown and requires further research.

Cardiovascular Effects – Hypertension

Studies have suggested that noise exposure may cause hypertension and other stress-related effects in adults. Near an airport in Stockholm, Sweden, the prevalence of hypertension was reportedly greater among nearby residents who were exposed to energy averaged noise levels exceeding 55 dB and maximum noise levels exceeding 72 dB, particularly for older subjects and those not reporting impaired hearing ability (Rosenlund et al 2001). A study of elderly volunteers who were exposed to simulated military low-altitude flight noise reported that blood pressure was raised by a maximum noise level of 112 dB (Michalak et al 1990).

Another paper, from the Munich airport study described above, found elevated blood pressure levels among children near the exposed schools when compared with the control group (Hygge et al 1998). The researchers found a statistically-significant rise in both systolic and diastolic blood pressure. An earlier study of children living near airports, located near Los Angeles International Airport, also showed an increase in blood pressure among children in the experimental group. That study involved peak noise levels of up to 95 dB indoors, within a flight corridor with up to 300 flights per day (Cohen et al 1980 and 1981).

The ACRP Synthesis also addressed claims concerning hypertension. Several recent studies, through a review of previous work, suggest that increased hypertension or other cardiovascular effects may be associated with long-term noise exposure. For example, the WHO Guidelines for Community Noise (WHO 2000) suggests a weak association between long-term environmental noise exposure and hypertension, but does not establish a dose-response relationship between the two. Another study reviewed existing literature that stated there was sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension, and ischemic heart disease (Passchier-Vermeer 2000). It concluded there were no obvious effects from noise exposure on mean diastolic and mean systolic blood pressure; however, some effects were observed in terms of an increase in the percentage of individuals with hypertension.

Studies related to blood pressure are problematic and inconclusive in general. Blood pressure varies considerably from person to person, and it can also be inconsistent within an individual. It is difficult to control other factors that may affect blood pressure, which makes it hard to identify the exact effects aircraft noise alone might have. Those other factors, such as family history, diet, or socioeconomic conditions may also affect blood pressure. To control all other factors, in the interest of isolating aircraft noise as the only possible cause, is practically impossible.

The ACRP Synthesis came to a similar conclusion. No differences in systolic and diastolic blood pressure were found in cross-sectional studies comparing areas near an airport with calm,

suburban areas. Cross-sectional studies are notoriously difficult to interpret. They often report conflicting results, generally do not identify a cause and effect relationship, and often do not report a dose-response relationship between the cause and effect.

The European Union (EU) HYENA (Hypertension and Exposure to Noise near Airports) Project deserves special attention because it is a recent major scientific effort involving several EU member states that drew considerable publicity, at least in Europe (Babisch et al 2009, Haralabidis et al 2008, Järup et al 2005, 2007, and 2008 and Selander et al 2009).

The overall project aim was to assess the impacts on cardiovascular health of noise generated by aircraft and road traffic. The project evaluated the modifying effects of air pollution on noise associated cardiovascular effects, and analyzed the difference in blood pressure resulting from different noise exposure patterns. The role of annoyance and sleep disturbances on blood pressure was assessed, and the impact of aircraft and road traffic noise on stress hormone levels investigated. The project also examined acute changes in blood pressure that follow short-term changes in noise levels.

Cross-sectional studies were conducted near major airports in Germany (Berlin Tegel), Greece (Athens), Italy (Milano Malpensa), the Netherlands (Amsterdam Schiphol), Sweden (Stockholm Arlanda) and the UK (London Heathrow), including a total of 6,000 study subjects. The studies were conducted in the vicinity of airports with a wide range of exposures from different transportation noise sources, which the HYENA researchers believed allowed for detailed analyses of exposure-response relationships for the general population as well as for susceptible subgroups.

Some of the important conclusions drawn by the authors are as follows:

- "… exposure to aircraft noise increases morning saliva cortisol levels in women, which could be of relevance for noise-related cardiovascular effects" (Selander et al 2009).
- Significant response between nighttime aircraft noise exposure and hypertension risk as well as between daily road traffic noise and hypertension among middle-aged subjects (Jarup et al 2008).
- Noise exposure, regardless of source, affects nocturnal blood pressure; providing acute effect support for the hypertension finding. (Haralabidis et al 2008).

While not directly related to the subject of non-auditory health effects, one of the HYENA papers concluded that annoyance ratings due to aircraft noise were higher than predicted by the EU standard curves suggesting that the people's attitude towards aircraft noise has changed over the years (Babisch et al 2009).

A TIME Magazine article on the HYENA study offers observations and quotes that provide important perspective on interpreting the findings (Nighttime Noise and Blood Pressure, Sara Song, February 13, 2008, http://www.time.com/time/health/article/0,8599,1713178,00.html). The article notes that "The response was consistent across all sources of sound, whether from the runway or the other side of the bed. …. A snoring partner and road traffic had similar impact. And the effect was dose dependent." The article quotes one of the study coauthors, Dr. Lars Jarup, who specializes in environmental and occupational medicine at Imperial College London, as saying "It's a small increase in the blood pressure, obviously, but it is significant." The article points out that this increase in blood pressure at night is still a bit of a mystery for the researchers and quotes Dr. Jarup as saying: ""It seems plausible that if you have a lot of these transient [blood pressure] changes during the night — if you live around the airport for many years, for example — that in the end you might get some long-term effects on your blood pressure, but we don't really know." Part of the mystery might be due to problems in the data

and methods. The ACRP Synthesis cites this paper, but, after closer review of the data for night-time aircraft noise, raises some questions about the data and the methods.

Two recent studies examined the correlation of aircraft noise with hospital admissions for cardiovascular disease. Hansell et al (2013) examined neighborhoods around London's Heathrow airport. Correia et al (2013) examined neighborhoods around 89 airports in the United States. Both studies included areas of various noise levels. They found associations that were consistent with the HYENA results. The authors of these studies noted that further research is needed to refine the associations and the causal interpretation with noise or possible alternative explanations.

Cardiovascular Effects – Heart Disease

Very few studies have been conducted to draw links between aircraft noise and heart disease. The potential for noise to affect the cardiovascular system has been speculated for many years; however, no unequivocal evidence exists to support such claims. Conclusions drawn from a review of health effect studies involving military low-altitude flight noise with its unusually high maximum levels and rapid rise in sound level have shown no increase in cardiovascular disease.

The ACRP Synthesis found that most reviewers concluded that previous studies were not carried out in a systematic way, which makes the studies prone to bias. Part of the problem seems due to inadequately reporting noise exposure data. For example, Van Kempen et al. (2002) concluded that whereas "noise exposure can contribute to the prevalence of cardiovascular disease, the evidence for a relation between noise exposure and ischemic heart disease is still inconclusive, because of the limitations of exposure characterization, adjustment for important confounders, and occurrence of publication bias." The WHO Guidelines for Community Noise (WHO 2000) concluded that cardiovascular effects may be associated with long-term exposure; however, the associations are weak albeit the effect is somewhat stronger for ischemic heart disease than for hypertension.

Birth Defects

Some decades ago, researchers from the University of California at Los Angeles (UCLA) studied the population near Los Angeles International Airport (LAX) and found a higher rate of birth defects for 1970 to 1972 when compared with a control group residing away from the airport (Jones et al 1978). Based on this report, a separate group at the Center for Disease Control (CDC) performed a more thorough study of populations near Atlanta's Hartsfield International Airport (ATL) for 1970 to 1972 (Edmonds et al 1979). They found no relationship in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB.

The ACRP Synthesis does not address birth defects but does discuss studies on birth weights. The synthesis describes how recent studies have focused on relationships between noise exposure during pregnancy and low birth weights. However, no association was found between personal noise exposure (measured in decibels) and birth weight (Wu et al. 1996; Passchier-Vermeer and Passchier 2000). Other possible noises (e.g., occupational, traffic noise, and history of listening to amplified music) also showed no effect on infant birth weight.

Mortality Rates

A 1979 study performed near LAX identified a substantial increase in mortality rates in the area where noise was the highest (Meacham et al 1979). Specifically, the study claimed a 15 percent increase in deaths due to strokes and 100 percent increase in deaths due to cirrhosis of the liver as a result of jet noise. However, a reanalysis of the data published in 1980 did not confirm the

original results (Frerichs et al 1980). Instead, the 1980 study indicated that "once the confounding effects of age, race, and sex were taken into account by direct and indirect methods of standardization, there was little difference in the mortality experience of the airport and control areas."

The ACRP Synthesis does not address mortality. The WHO Guidelines for Community Noise (WHO 2000) asserts that "Pollution and degradation of the indoor environment cause illness, increased mortality, loss of productivity, and have major economic and social implications," but does not cite any studies that relate noise exposure to mortality. In 1997, researchers from the University of Sydney published a review of the health effects of aircraft noise in the Australian and New Zealand Journal of Public Health (1997, 21 : 221-236). They concluded that "population-based studies have not found strong evidence that people living near or under aircraft flight paths suffer higher rates of clinical morbidity or mortality as a consequence of exposure to aircraft noise. A dearth of high quality studies in this area precludes drawing substantive conclusions."

Summary of Current Understanding

The ACRP Synthesis best summarizes the state of knowledge:

"Despite decades of research, including review of old data and new research efforts, health effects of aviation noise continue to be an enigma. Most, if not all, current research concludes that it is as yet impossible to determine causal relations between health disorders and noise exposure, despite well-founded hypotheses."

FINDINGS/CONCLUSIONS

DNWG finds that the current state of scientific knowledge cannot yet support inference of a causal or consistent relationship between military aircraft noise exposure and non-auditory health consequences for exposed residents. The large scale HYENA study offers some promising leads for further research, but it is not possible to establish a quantitative cause and effect based on the currently available scientific evidence. A valid predictive relationship requires both evidence of causality between aircraft noise exposure and adverse non-auditory health consequences, and knowledge of a quantitative relationship between the amount of noise exposure (dose) and specific health effect (responses). Because the results of published studies of aircraft noise on human health are unclear, there is at the present time no sound scientific basis for concluding that aircraft noise has a negative non-auditory health impact. This conclusion should not be construed as evidence of no health effect, nor should DoD environmental assessment documents be silent on the issue.

DoD should use the NEPA process as the opportunity to discuss the current state of scientific knowledge on issues such as non-auditory health effects where it is relevant to the noise environment of the proposed project being studied.

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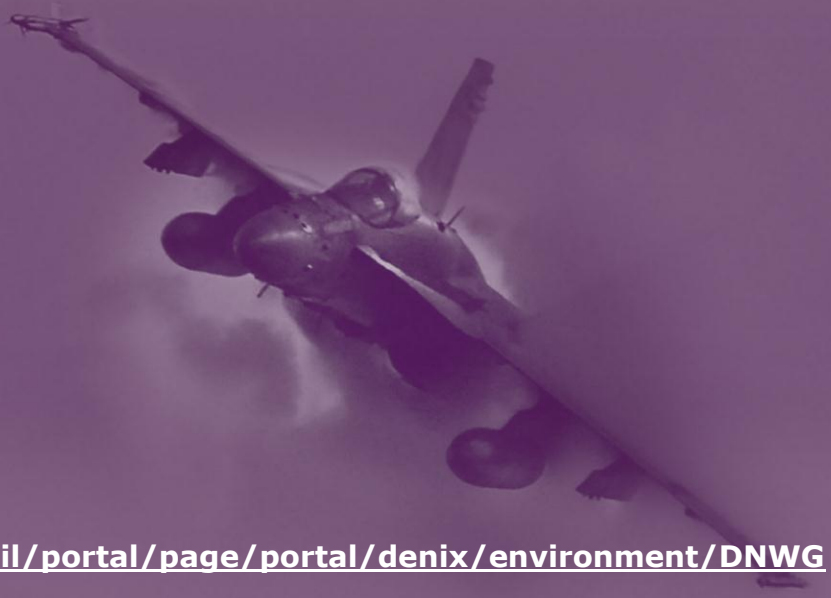
A complete list of references supporting the information in this Technical Bulletin is available in a document entitled: “Improving Aviation Noise Planning, Analysis and Public Communication with Supplemental Metrics – Guide to Using Supplemental Metrics.” Copies of this document are available upon request from DNWG.

The Airport Cooperative Research Project (ACRP) Synthesis Report #9, “Effects of Aircraft Noise: Research Update on Selected Topics” (9/26/2008) contains annotations of 21 recent scientific studies on health and hearing. Copies of this report can be obtained through the Transportation Research Board at: http://www.trb.org/news/blurb_detail.asp?id=9528.



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