

# ADVERSE HEALTH EFFECTS OF NOISE

The following summary is taken from a 100+ page World Health Organization Guideline (*Guideline for Community Noise*) that provides information about the harmful effects of noise on human health. This document can be seen in its entirety at:

<http://www.who.int/docstore/peh/noise/guidelines2.html>

## Preface

Community noise (also called environmental noise or domestic noise) is defined as noise emitted from all sources except from that arising in the workplace. Many countries have regulated community noises of many types such as that arising from road, rail and air traffic, construction, public work, and noises of various types originating in the neighborhood, such as that from residential and business premises. In large cities throughout the world, as the population grows, there is increasing exposure to community noise that creates an increasingly important public health problem. The *Guidelines for Community Noise* were prepared as a practical response to the need for action on community noise at the local level, as well as the need for improved legislation and management.

Noise has always been an important environmental problem for humans. In ancient Rome, legislation was enacted to control the noise emitted by the iron-covered wheels of wagons on paving stones, which disrupted sleep and caused annoyance to the citizens. In some cities in Medieval Europe, horse drawn carriages and horses were banned from the streets at night in order to ensure peaceful sleep for the inhabitants. The noise problems of the past pale in significance to those experienced by modern city-dwellers; noise pollution continues to grow in extent, frequency, and severity as a result of population growth, urbanization, and technological developments. The growth in urban noise pollution involves direct and cumulative adverse health effects; it affects future generations by degrading residential, social, and learning environments with corresponding economic losses.

In comparison to other pollutants, the control of environmental noise has been hampered by insufficient knowledge about its effects on humans and about dose-response relationships. However, it is clear that the effects of noise are widespread and impose long-term consequences on health. It is equally clear that guidelines based on health effects of noise are not often taken into account. Studies in Europe suggest that about half of all EU residents live in zones that do not ensure acoustical comfort. At night, it is estimated that over 30% of EU residents are exposed to sound pressure levels (expressed as decibels) that are sufficient to disturb sleep. In the United States, a Noise Control Act was enacted in 1972; however, recent administrations have essentially eliminated any support for activity in this area.

## **Introduction**

The perception of sound in everyday life is essential for human well-being. Unwanted sound and vibration is defined as noise. An adverse effect of noise is defined as a change in the morphology and physiology of an organism that results in impairment of functional capacity, impairment of capacity to compensate for additional stress, or increased susceptibility to the harmful effects of other environmental influences. This definition includes temporary or long-term lowering of the physical, psychological, or social functioning of humans or their organ systems.

## **Noise Induced Hearing Impairment**

Hearing impairment is typically defined as an increase in the threshold of hearing. It is assessed clinically by audiometry. Depending on severity, hearing impairment can affect a person's ability to carry out the activities of daily living. Worldwide, noise-induced hearing impairment is the most common, irreversible occupational hazard. In addition to occupational noise, environmental noise is an increasingly prevalent risk factor. Men and women have been shown to be at equal risk of noise-induced hearing impairment. The damage caused by both occupational and environmental noise is related to duration and intensity of exposure.

Apart from noise-induced hearing impairment, hearing damage may be due to hereditary or acquired disease, industrial chemicals, ototoxic drugs, accidents, and the normal aging process. Some of these causes may be additive in nature, leading to permanent damage of the part of the inner ear that perceives sound.

There is general agreement that exposure to sound levels less than 70 dB does not cause hearing damage. There is also general agreement that environmental noise in excess of 80dB produces the same degree of hearing impairment as an equivalent occupational noise exposure. Hearing impairment has been shown in young adults and children following a variety of leisure time exposures. These include shooting, riding motorbikes, listening to music in discotheques, concerts, and through headphones.

Large scale, long-term studies have not been done in all at-risk populations. However, the following information may be relevant in considering noise induced hearing loss.

1. Study data suggest that children may be more vulnerable to noise-induced hearing impairment than adults.
2. At high instantaneous sound pressure levels, mechanical damage to the ear may occur.
3. Risk for noise-induced hearing impairment may increase when the noise exposure is combined with exposure to vibration or with exposure to ototoxic drugs or chemicals.

Noise induced hearing impairment is accompanied by abnormal loudness perception (loudness recruitment), distortion (paracusis), and a disturbing ringing in the ears (tinnitus). Tinnitus has become a common risk for individuals attending pop concerts and discotheques. Tinnitus may be temporary or may take on a more permanent character, especially after prolonged exposure.

Given the importance of the problem, occupational noise exposure is fairly well regulated and controlled worldwide. Environmental noise exposure, especially that related to leisure-time activities, has not been controlled in the same way. Given both the increasing number of noisy activities and the increasing exposure duration (such as in loud cars) regulatory activities are to be encouraged. Whereas dose-response data are lacking, based on the limited data that are available, there appears to be no risk to hearing with exposures to 70 dB or less. Daily 1 hour exposure levels should not exceed 85 dB. It is recommended that exposure to sound levels greater than 100 dB should be limited to a 4-hour period and should not occur more than four times per year. Exposure to higher sound pressure levels and greater duration of exposure are significant risk factors. To avoid hearing impairment, impulse noise exposure should never exceed 140 dB peak sound pressure in adults and 120 dB peak sound pressure in children.

### **Interference with Speech Communication**

Noise may interfere with a person's ability to hear and comprehend normal speech. This may result in a number of personal disabilities, handicaps, and behavioral changes. Problems with concentration, fatigue, uncertainty, lack of self confidence, irritation, misunderstandings, decreased working capacity, problems in interpersonal relations, and a number of stress reactions have been identified. Particularly vulnerable are the elderly, children, and those not familiar with the spoken language.

### **Effects on Sleep**

Uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning of healthy persons. Whereas sleep disturbance is considered to be a major effect of environmental noise, data on the effects of environmental noise on sleep are limited. Recent research on sleep disturbance has been conducted for aircraft noise, road traffic, and railway noise. For example, road traffic noise in excess of 30 dB disturbs sleep. The probability of being awakened increases with the number of noise events per night. When background noise is low, noise exceeding 45 dB should be limited; for sensitive individuals, an even lower level is preferred.

The primary sleep disturbance effects are: difficulty falling asleep, frequent awakenings, waking too early, and alterations of sleep stages and depth, especially a reduction of REM sleep. Other effects of noise during sleep include increased blood pressure, increased heart rate, increased finger pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmias, and increased body movement. For each of these, the threshold and response relationships may be different. Studies have shown that the

frequency of noise-induced awakenings decreases over eight consecutive nights; however no such habituation has been shown for heart rate and after effects.

Exposure to night-time noise also induces secondary effects, or so-called after effects. These are effects that can be measured the day following the night-time exposure while the person is awake. These include reduced perceived sleep quality, increased fatigue, depressed mood or well being, and decreased performance.

Long-term effects on psychosocial well-being have been related to nocturnal noise exposure. Noise annoyance during the night increases total noise annoyance for the following 24 hours. People exposed to night-time noise report an increased use of sedatives, closed bedroom windows, and use of personal hearing protection. Particularly sensitive groups include the elderly, shift workers, persons vulnerable to physical or mental disorders, and those with sleeping disorders.

Other factors that influence the problem of night-time noise include its occurrence in residential areas with low background noise levels, combinations of noise and vibration such as that produced by trains and heavy duty vehicles, and sources with low-frequency components which are more disturbing, even at very low sound pressure levels. These low-frequency components have a significant detrimental effect on health.

### **Cardiovascular and Physiological Effects**

Epidemiological and laboratory studies demonstrate that noise has both temporary and permanent effects on human physiology. It has been postulated that noise acts as an environmental stressor. Acute noise exposure activates the autonomic and hormonal systems leading to temporary increased blood pressure, increased heart rate, and vasoconstriction. After prolonged occupational noise exposure, susceptible individuals may develop permanent effects such as hypertension and ischemic heart disease. Sudden unexpected sounds evoke reflex responses as well.

If the noise exposure is temporary, the physiologic systems return to normal. If the exposure is of sufficient intensity and unpredictability, cardiovascular and hormonal effects may appear; these include increased heart rate and peripheral resistance; changes in blood pressure, blood viscosity and blood lipids; shifts in electrolytes, especially calcium and magnesium, and increased levels of epinephrine, norepinephrine and cortisol. These effects are of interest because of noise related coronary artery disease. There is a growing body of evidence that suggests noise may be a risk factor for cardiovascular disease. Workers exposed to high levels of industrial noise have increased blood pressure and statistically significant increases in risk for hypertension compared to workers in control areas. Few studies have been done on the effects of environmental noise; those that have been done found a weak association between long-term noise exposure and either ischemic heart disease and hypertension

Nevertheless, these small increases in risk may be important because of the large numbers of persons who are currently exposed to these noise levels and the increasingly

large numbers who are likely to be exposed in the future. Only average risk has been considered; there may be highly sensitive subgroups in the population that have not been characterized or studied. A small increase in risk to the general population may be, in these groups, a clinically significant increase.

The effects of noise on immunologic function and on gastrointestinal disturbances have also been subjects of limited evaluation.

### **Effects on Mental Health**

Mental health is defined as the absence of identifiable psychiatric disorders according to current norms. Environmental noise is not believed to be a cause of mental illness, but it is assumed to accelerate and intensify the development of latent mental disorders. The adverse effects of environmental noise on mental health include the following catalog of complaints; anxiety, emotional stress, nervous complaints, nausea, headache, instability, argumentativeness, sexual impotency, changes in mood, increase in social conflicts as well as neurosis, hysteria, and psychosis. Population studies have suggested associations between noise exposure and mental health indicators such as rating of well-being, symptom profiles, use of psychoactive drugs and sleeping pills, and mental hospital admission rates. There may be great differences in the ability of various populations to cope with noise pollution; particularly vulnerable groups may include, children, the elderly, and those with preexisting disease, especially depression.

### **Effects on Performance**

The adverse effects of occupational and environmental noise on performance of cognitive tasks are well established. Field studies showed that noise produces task impairment and increases the number of errors in work. Among the cognitive effects, reading attention, problem solving, and memory are most strongly affected by noise. The observed noise-induced decrease in motivation as measured by persistence with a difficult cognitive task may either independent or secondary to cognitive impairments. Two types of memory deficits have been identified under experimental conditions; both are adversely influenced by noise exposure.

Experimental noise exposure consistently produces negative after-effects on performance. This is particularly true in children in whom the negative effects are intensified. It appears that the longer the exposure, the greater the damage. Thus, schools and daycare centers should be located in areas that are relatively noise-free. Children from noisier areas have been found to have heightened sympathetic arousal, indicated by increased levels of stress hormones and elevated resting blood pressure.

### **Effects on Social Behavior and Annoyance**

Noise annoyance is a global problem. The definition of annoyance is a feeling of displeasure associated with any agent or condition, known or believed by an individual or

group to adversely affect them. Apart from annoyance, people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Thus, the term annoyance, while widely used, does not begin to cover the range of negative reactions associated with noise pollution.

Noise can produce a number of social and behavioral effects apart from annoyance. The social and behavioral effects are often complex, subtle, and indirect. Social and behavioral effects include changes in everyday behavior (e.g., closing windows, not using balconies, turning television and radio sets to louder levels, writing petitions, complaining to authorities); changes in social behavior (e.g., aggressiveness, unfriendliness, disengagement, nonparticipation); changes in social indicators (e.g., residential mobility, hospital admissions, drug consumption, accident rates); and changes in mood (e.g., reporting being more depressed or less happy).

Noise exposure, per se, is not believed to produce aggressive behavior. However, in combination with provocation, preexisting anger or hostility, it may trigger aggression. It is also suspected that people are less willing to help others, both during and after a brief period of exposure to noise. Noise above 80 dB is consistently associated with reduced helping behavior and increased aggressive behavior. There is concern that high levels and continuous environmental noise may contribute to feelings of helplessness in schoolchildren.

Studies have shown that equal levels of different kinds of noise result in different magnitudes of annoyance. Some of this difference may be related to the time of day at which the noise occurs, the duration and intensity of the noise, and the nature of the activity which is interrupted.

Annoyance in populations varies not only with the acoustical characteristics of the noise, but also with many non-acoustical factors of social, psychological, or economic nature. These include fear associated with the noise source, conviction that noise could be reduced by third parties, individual noise sensitivity, the degree to which an individual feels able to control noise, and whether or not the noise originates from an important economic activity. Demographic variables such as age, sex, and socioeconomic status are less strongly associated with annoyance. The correlation with annoyance is much higher at the group level than at the individual level.

Greater annoyance has been observed when noise is accompanied by vibrations that contain low-frequency components or when the noise contains impulses such as the noise of gun shots. Annoyance is also greater when noise progressively increases over time rather than remaining constant.

### **Effects of Combined Noise Sources**

Most environments consist of a mixture of sounds from more than one source. For these, health effects are associated with the total noise exposure rather than with the noise

from any single source. In cases where one noise source clearly dominates, the magnitude of an effect may be assessed by taking into account the dominant source only. There is no consensus on a model for measuring the total annoyance due to combination of environmental noise sources. Not enough is known to assess the potential additive or synergistic effects of noise combined with other environmental agents such as vibration or ototoxic agents.

The evidence related to low-frequency noise is sufficiently strong to warrant immediate concern. Various industrial sources emit continuous low frequency noise (such as diesel engines) and intermittent low-frequency noise (such as railway traffic). Low frequency noise is associated with vibrations and rattles as secondary effects. Adverse health effects due to low-frequency noise are estimated to be more severe than for community noises in general. These noises are generally underestimated with the usual types of sound measurement.

In residential populations, noise pollution will be associated with a combination of health effects, such as cardiovascular disease, annoyance, interference at work and at home, and sleep disturbances, among others.

## **Vulnerable Groups**

Protective standards are derived from observations on the health effects of noise on “normal” or “average” populations. People who are elderly, ill, or depressed are not usually included in study populations; as a general rule, neither are infants or young children. These groups may be less able to cope with the impacts of noise exposure and may be at greater risk for harmful effects. Vulnerable groups, generally underrepresented in study populations for a variety of reasons, include people with various diseases (e.g., hypertension); people in hospitals or those rehabilitating from disease or injury; people dealing with complex cognitive tasks; the blind, the hearing impaired; fetuses, babies, and young children; and the elderly.

Persons with impaired hearing are obviously the most adversely affected by noise, especially with respect to speech perception. Their problems are compounded in noisy environments.

Children have been identified as particularly vulnerable to noise exposure. The evidence on the effects of noise pollution on children’s health is strong enough to warrant monitoring programs in schools and elsewhere to protect children from the effects of noise.

The issue of vulnerable subgroups in the population should be considered when developing regulations or recommendations for the management of community noise. Such management should take into account the environment (home, school, public place), the types of effects (recreation, annoyance), and specific lifestyles (headphones, concerts, motor cycling).

## **WHO Guidelines**

Based on the known health effects, guidelines for community noise should address the following: annoyance, speech intelligibility, disturbed concentration, sleep disturbance, and hearing impairment.

Because health effects are relevant to specific environments, specific guideline values have been proposed for the following: dwellings, including bedrooms; schools and preschools; hospitals; industrial, commercial, shopping, and traffic areas; ceremonies, festivals, and entertainment events; use of headphones for music and other sounds; impulse sounds from toys, fireworks, and firearms; and outdoors in parklands and conservation area.

## **Trends in Noise Pollution**

A number of trends are expected to increase environmental noise pollution in the future. The following factors are considered to be of importance: the expanding use of increasingly powerful sources of noise; the wider geographic dispersion of noise sources along with greater individual mobility; and increased invasion of noise, especially in the early mornings, evenings, and weekends.

## **Conclusions and Recommendations**

The potential health effects of community noise include hearing impairment, startle and defense reactions, aural pain, speech interference, sleep disturbance, cardiovascular effects, performance reduction, and annoyance responses. These health effects can lead, in turn, to social handicaps, reduced productivity, decreased performance in learning, absenteeism, increased drug use, and accidents. Another significant effect, unrelated to health, is loss of property value. The aim of governmental controls should be to protect the population from these adverse effects of noise.