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## **Noise Pollution: A Modern Plague**

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Disclosures

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### Adverse Health Effects of Noise

The WHO has documented seven categories of adverse health effects of noise pollution on humans. Much of the following comes from the WHO Guideline on Community Noise and follows its format. The guideline provides an excellent, reasonably up-to-date, and comprehensive overview of noise-related issues, as do the other recent reviews on this subject.

Hearing is essential for well-being and safety. Hearing impairment is typically defined as an increase in the threshold of hearing as clinically assessed by audiometry. Impaired hearing may come from the workplace, from the community, and from a variety of other causes (eg, trauma, ototoxic drugs, infection, and heredity). There is general agreement that exposure to sound levels less than 70 dB does not produce hearing damage, regardless of the duration of exposure. There is also general agreement that exposure for more than 8 hours to sound levels in excess of 85 dB is potentially hazardous; to place this in context, 85 dB is roughly equivalent to the noise of heavy truck traffic on a busy road. With sound levels above 85 dB, damage is related to sound pressure (measured in dB) and to time of exposure. The major cause of hearing loss is occupational exposure, although other sources of noise, particularly recreational noise, may produce significant deficits. Studies suggest that children seem to be more vulnerable than adults to noise induced hearing impairment.

Noise induced hearing impairment may be accompanied by abnormal loudness perception (loudness recruitment), distortion (paracusis), and tinnitus. Tinnitus may be temporary or may become permanent after prolonged exposure. The eventual results of hearing losses are loneliness, depression, impaired speech discrimination, impaired school and job performance, limited job opportunities, and a sense of isolation.

In 2001, it was estimated that 12.5% of American children between the ages of 6 to 19 years had impaired hearing in one or both ears. As many as 80% of elementary school

children use personal music players, many for extended periods of time and at potentially dangerous volume settings. There is little doubt that the use of consumer products, which produce increasingly high levels of noise and which are used with headsets or earphones, is growing and may well be responsible for the impaired hearing that is being seen with growing frequency in younger people. This form of noise is largely unregulated, despite warnings by the manufacturers.

In the young, hearing loss affects communication, cognition, behavior, social-emotional development, academic outcomes, and later vocational opportunities. These effects have been well documented in a number of large scale investigations in children.

Leisure-time exposure, which is generally unregulated, is increasing in other ways as well with resultant adverse effects. In a recent survey, a majority of young adults reported having experienced tinnitus or impaired hearing after exposure to loud music at concerts or in clubs. Very few (8%) considered loss of hearing a significant problem. Many of the respondents said they would be motivated to use ear protection if they were aware of the potential of permanent hearing loss (66%) or if such protection were advised by a medical professional (59%).

Those working in clubs, bars, and other places of entertainment are also at risk. It is well known that rock musicians frequently have noise-induced hearing loss. Apart from the musicians themselves, employees of music clubs, where noise frequently exceeds safe levels, are at risk. Thus, nearly a third of students who worked part time (bar staff or security staff) in a university entertainment venue were found to have permanent hearing loss of more than 30 dB.

The WHO recommends that unprotected exposure to sound levels greater than 100 dB (for example, the sound of a jackhammer or a snowmobile) should be limited in duration (4 h) and frequency (four times/yr). The threshold for pain is usually given as 140 dB, a level readily achieved in today's boom-cars. Impulse noise exposure (gunfire and similar sources of intense noise of brief duration) should never exceed 140 dB in adults and 120 dB in children. Firecrackers, cap pistols, and other toys can generate sufficient sound levels to cause sudden and permanent hearing loss. Levels greater than 165 dB, even for a few milliseconds, are likely to cause acute cochlear damage. It is important to remember to counsel patients that ears do not get used to loud noise. As the League for the Hard of Hearing notes-they get deaf.

In 1974, in an attempt to protect public health and welfare against the adverse effects of noise, the EPA published so-called safe levels of environmental noise that would permit normal communication both in and out of doors. Noise pollution interferes with the ability to comprehend normal speech and may lead to a number of personal disabilities, handicaps, and behavioral changes. These include problems with concentration, fatigue, uncertainty, lack of self confidence, irritation, misunderstandings, decreased working capacity, disturbed interpersonal relationships, and stress reactions. Some of these

effects may lead to increased accidents, disruption of communication in the classroom, and impaired academic performance. Particularly vulnerable groups include children, the elderly, and those not familiar with the spoken language.

Uninterrupted sleep is known to be a prerequisite for good physiologic and mental functioning in healthy individuals. Environmental noise is one of the major causes of disturbed sleep. When sleep disruption becomes chronic, the results are mood changes, decrements in performance, and other long-term effects on health and well-being. Much recent research has focused on noise from aircraft, roadways, and trains. It is known, for example, that continuous noise in excess of 30 dB disturbs sleep. For intermittent noise, the probability of being awakened increases with the number of noise events per night.

The primary sleep disturbances are difficulty falling asleep, frequent awakenings, waking too early, and alterations in sleep stages and depth, especially a reduction in REM sleep. Apart from various effects on sleep itself, noise during sleep causes increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmias, and increased body movement. For each of these, the threshold and response relationships may be different. Some of these effects (waking, for example) diminish with repeated exposure; others, particularly cardiovascular responses, do not. Secondary effects (so-called after effects) measured the following day include fatigue, depressed mood and well-being, and decreased performance. Decreased alertness leading to accidents, injuries, and death has also been attributed to lack of sleep and disrupted circadian rhythms.

Long-term psychosocial effects have been related to nocturnal noise. Noise annoyance during the night increases total noise annoyance for the following 24 hours. Particularly sensitive groups include the elderly, shift workers, persons vulnerable to physical or mental disorders, and those with sleep disorders.

Other factors that influence the problem of night-time noise include its occurrence in residential areas with low background noise levels and combinations of noise and vibration such as produced by trains or heavy trucks. Low frequency sound is more disturbing, even at very low sound pressure levels; these low frequency components appear to have a significant detrimental effect on health.

A growing body of evidence confirms that noise pollution has both temporary and permanent effects on humans (and other mammals) by way of the endocrine and autonomic nervous systems. It has been postulated that noise acts as a nonspecific biologic stressor eliciting reactions that prepare the body for a fight or flight response. For this reason, noise can trigger both endocrine and autonomic nervous system responses that affect the cardiovascular system and thus may be a risk factor for cardiovascular disease. These effects begin to be seen with long-term daily exposure to noise levels above 65 dB or with acute exposure to noise levels above 80 to 85 dB. Acute exposure to noise activates nervous and hormonal responses, leading to temporary

increases in blood pressure, heart rate, and vasoconstriction. Studies of individuals exposed to occupational or environmental noise show that exposure of sufficient intensity and duration increases heart rate and peripheral resistance, increases blood pressure, increases blood viscosity and levels of blood lipids, causes shifts in electrolytes, and increases levels of epinephrine, norepinephrine, and cortisol. Sudden unexpected noise evokes reflex responses as well. Cardiovascular disturbances are independent of sleep disturbances; noise that does not interfere with the sleep of subjects may still provoke autonomic responses and secretion of epinephrine, norepinephrine, and cortisol. These responses suggest that one can never completely get used to night-time noise.

Temporary noise exposure produces readily reversible physiologic changes. However, noise exposure of sufficient intensity, duration, and unpredictability provokes changes that may not be so readily reversible. The studies that have been done on the effects of environmental noise have shown an association between noise exposure and subsequent cardiovascular disease. Even though the increased risk for noise-induced cardiovascular disease may be small, it assumes public health importance because both the number of people at risk and the noise to which they are exposed continue to increase.

Children are at risk as well. Children who live in noisy environments have been shown to have elevated blood pressures and elevated levels of stress-induced hormones.

Noise pollution is not believed to be a cause of mental illness, but it is assumed to accelerate and intensify the development of latent mental disorders. Noise pollution may cause or contribute to the following adverse effects: anxiety, stress, nervousness, nausea, headache, emotional instability, argumentativeness, sexual impotence, changes in mood, increase in social conflicts, neurosis, hysteria, and psychosis. Population studies have suggested associations between noise and mental-health indicators, such as rating of well-being, symptom profiles, the use of psychoactive drugs and sleeping pills, and mental-hospital admission rates. Children, the elderly, and those with underlying depression may be particularly vulnerable to these effects because they may lack adequate coping mechanisms. Children in noisy environments find the noise annoying and report a diminished quality of life.

Noise levels above 80 dB are associated with both an increase in aggressive behavior and a decrease in behavior helpful to others. The news media regularly report violent behavior arising out of disputes over noise; in many cases these disputes ended in injury or death. The aforementioned effects of noise may help explain some of the dehumanization seen in the modern, congested, and noisy urban environment.

The effects of noise pollution on cognitive task performance have been well-studied. Noise pollution impairs task performance at school and at work, increases errors, and decreases motivation. Reading attention, problem solving, and memory are most

strongly affected by noise. Two types of memory deficits have been identified under experimental conditions: recall of subject content and recall of incidental details. Both are adversely influenced by noise. Deficits in performance can lead to errors and accidents, both of which have health and economic consequences.

Cognitive and language development and reading achievement are diminished in noisy homes, even though the children's schools may be no noisier than average. Cognitive development is impaired when homes or schools are near sources of noise such as highways and airports. Noise affects learning, reading, problem solving, motivation, school performance, and social and emotional development. These findings suggest that more attention needs to be paid to the effects of noise on the ability of children to learn and on the nature of the learning environment, both in school and at home. Moreover, there is concern that high and continuous environmental noise may contribute to feelings of helplessness in children.

Noise produces negative after-effects on performance, particularly in children. It appears that the longer the exposure, the greater the effect. Children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress-related hormones and elevated resting blood pressure. These changes were larger in children with lower academic achievement. As a whole, these findings suggest that schools and daycare centers should be located in areas that are as noise-free as possible.

Annoyance is defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her. Perhaps a better description of this response would be aversion or distress. Noise has been used as a noxious stimulus in a variety of studies because it produces the same kinds of effects as other stressors. Annoyance increases significantly when noise is accompanied by vibration or by low frequency components. The term annoyance does not begin to cover the wide range of negative reactions associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Lack of perceived control over the noise intensifies these effects.

Social and behavioral effects of noise exposure are complex, subtle, and indirect. These effects include changes in everyday behavior (eg, closing windows and doors to eliminate outside noises; avoiding the use of balconies, patios and yards; and turning up the volume of radios and television sets); changes in social behavior (eg, aggressiveness, unfriendliness, nonparticipation, or disengagement); and changes in social indicators (eg, residential mobility, hospital admissions, drug consumption, and accident rates); and changes in mood (increased reports of depression).

Noise exposure per se is not believed to produce aggressive behavior. However, in combination with provocation, pre-existing anger or hostility, alcohol or other psychoactive agents, noise may trigger aggressive behavior. Our news is filled with examples of this kind of behavior.

The degree of annoyance produced by noise may vary with the time of day, the unpleasant characteristics of the noise, the duration and intensity of the noise, the meaning associated with it, and the nature of the activity that the noise interrupted. Annoyance may be influenced by a variety of non-acoustical factors including individual sensitivity to noise. These include fear of the noise source, conviction that noise could be reduced by third parties, individual sensitivity, the degree to which an individual feels able to control the noise, and whether or not the noise originated from an important economic activity. Other less direct effects of annoyance are disruption of one's peace of mind, the enjoyment of one's property, and the enjoyment of solitude.

Greater annoyance has been observed when noise is of low frequency, is accompanied by vibrations that contain low-frequency components, or when it contains impulses such as the noise of gunshots. Annoyance is greater when noise progressively increases rather than remaining constant. Average outdoor residential day-night sound levels below 55 dB were defined as acceptable by the EPA; acceptable average indoor levels were less than 45 dB. To put these levels into perspective, sound levels produced by the average refrigerator or the sounds in the typical quiet neighborhood measure about 45 dB. Sound levels above this produce annoyance in significant numbers of people.

The results of annoyance are privately felt dissatisfaction, publicly expressed complaints to authorities (although underreporting is probably significant), and the adverse health effects already noted. Given that annoyance can connote more than slight irritation, it describes a significant degradation in the quality of life, which corresponds to degradation in health and well-being. In this regard, it is important to note that annoyance does not abate over time despite continuing exposure to noise.

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