The Science on the Health Consequences of Noise

By the Santa Cruz Coalition for a Healthy and Safe Environment (C.H.A.S.E.)
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Noise pollution has long been recognized as impacting quality of life and well-being, and in recent decades noise has been increasingly understood as an important public health issue.[1] Furthermore, as population levels and density continue to grow, and noise-producing technological devices continue to become more numerous and pervasive, researchers and public health advocates are warning that the risks from excessive noise will grow even more in the coming years[2].

Physiological Effects of Noise

The effects of excessive noise on human health are well established by science and under-appreciated by the public at large. Research on the effects of noise beyond hearing loss has grown substantially in recent years, and has looked beyond occupational sources to include social and environmental sources. Environmental sources include cars, airplanes, and other forms of transport; construction equipment; leaf blowers and other neighborhood machinery; etc.

A common perception is that noise is merely an annoyance—something experienced only by the over-sensitive and having no real consequences anyway. Decades of scientific research refute this.

The literature on the health effects of noise cites annoyance as the most prevalent community response to environmental noise,[3] and though the term annoyance may seem to downplay the impact, it is the result of symptoms that are indeed harmful to human health and of concern to the medical community. It is the result of noise "interfering with daily activities, feelings, thoughts, sleep, or rest, and might be accompanied by negative responses, such as anger, displeasure, exhaustion, and by stress-related symptoms."

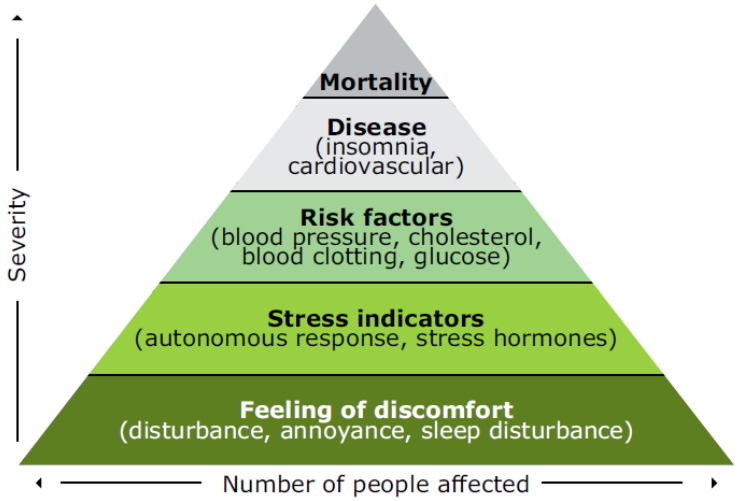
The pyramid below summarizes the range of human responses to environmental agents, in this case noise. The researchers who adapted this model for noise note that key points to consider in this context are that:

- Sound/noise is a psychosocial stressor that activates the sympathetic nervous and endocrine systems

[1] European Environment Agency. Noise in Europe 2014. 2014; Publications Office of the European Union.
[2] Goines, L, Hagler, L. Noise Pollution: A Modern Plague. Southern Medical Journal. 2007; Mar. Vol. 100, N. 3.
[3] Basner, Mathius, *et al.* Auditory and non-auditory effects of noise on health. Lancet. 2014; Apr 12; 383(9925): 1325–1332.

- Acute noise effects occur not only at high sound levels in occupational settings, but also at relatively low environmental sound levels when activities such as concentration or relaxation are disturbed[4]

Figure 1.1 Pyramid of noise effects



Source: Babisch, 2002, based on WHO, 1972.

Moving up the pyramid towards more serious effects, the link between noise and stress is well documented; it is the result millions of years of human evolution during which our ability to hear prey and other forms of danger determined our very survival. Loud, unusual, or pervasive noise triggers the release of the hormone cortisol, preparing the human body for "fight or flight." This is beneficial if one needs to escape immediate danger, but chronic exposure to environmental stress results in frequent or persistent elevated cortisol levels that can lead to numerous physical and psychological harms.

Studies have documented deleterious effects of elevated cortisol levels on the immune system, finding, for example, significantly longer recovery time from wounds among healthy adult males[5] and a reduction in the body's supply of disease-fighting immune cells.

Considerably more research, going back decades, has been conducted on the effects of stress on the cardiovascular system. Results show increased risk of myocardial infarction (heart attack) from noise-induced stress.[6] A meta-review of studies found that the evidence "clearly supports a causal link" between elevated noise levels and harmful cardiovascular outcomes like hypertension and coronary heart disease.[7]

So far we have not yet mentioned the most widely appreciated health impact of noise—hearing loss.

Loss of hearing is a function of both the intensity of sound and the amount of time exposed to it. For neighborhood residents, school children, etc., hearing loss from leaf blowers is not likely a health

[4] Babisch W. The noise/stress concept, risk assessment and research needs. Noise Health. 2002;4:1-11
[5] Ebrecht M, Hextall J, Kirtley LG, Taylor A, Dyson M, Weinman J. Perceived stress and cortisol levels predict speed of wound healing in healthy male adults. Psychoneuroendocrinology. 2004, July. 29 (6): 798–809.
[6] Ising H, Babisch W, Kruppa B. Noise-induced endocrine effects and cardiovascular risk. Noise Health. 1999;1:37-48.
[7] Davies H, Kamp IV. Noise and cardiovascular disease: A review of the literature 2008-2011. Noise Health. 2012;14:287-91.

concern due to distance from source. But it is a serious concern for the equipment operators, especially those employed in the landscape maintenance industry. These workers are not only exposed to high-intensity sound at its source, where sound levels of backpack-style leaf blowers commonly reach 90-100dB(A)—they are exposed to the noise for hours each work day. (Sounds above 80 dB have the potential to cause permanent hearing loss.)

Hearing protection like earplugs can reduce the intensity, but such protection is less effective for certain frequencies of sound; it is dependent on the employer's provision of the protection and the worker's compliance and proper use; and even reduced intensities of sound achieved by ear protection can still result in hearing loss when the exposure occurs across hours, weeks, and years, as in the case of landscape workers.

Excessive noise results in hearing loss through by damaging the auditory sensory cells in the cochlea. In mammals, these cannot regenerate, so hearing loss is permanent.[8]

Besides the obvious effects of hearing loss on a person's ability to communicate with others, it can affect cognitive performance, decrease attention to tasks, and increase accidents and falls, leading to an excess rate of mortality of 10-20% in 20 years.[9]

Increased knowledge of the ways in which noise affects normal biological functioning has pointed scientists to even more potential effects of noise on health, like higher rates of diabetes and breast cancer.[10] While studies to test these hypotheses have not yet been completed, it is quite possible that science is so far aware of only a portion of the negative health effects of noise on humans and animals.

Noise in the Human Environment

Much of the research concerning the effects of noise on human health has been conducted in the laboratory, which allows for controlled conditions. Yet there is also ample research conducted in the field demonstrating the real, negative, health effects of environmental noise in real-world situations. Much of this research investigates noise from road and airplane traffic.

The European office of the World Health Organization quantified several health impacts caused by road traffic noise, including cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus, and annoyance. It found significant, measurable increases, which were most pronounced in hypertension and cardiovascular disease. The study also revealed and quantified the resulting premature mortality: the researchers calculated that in the region studied (western Europe, with a population of about 345 million people), noise from automobile traffic alone results in at least *one million* healthy life years lost, every year.[11]

In their study of 2014, The European Environment Agency found that noise contributed to 10,000 premature deaths, 43,000 hospital admissions, and 900,000 cases of hypertension in Europe in that year alone[12].

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[8] Basner, Mathius, *et al.* Auditory and non-auditory effects of noise on health. Lancet. 2014; Apr 12; 383(9925): 1325–1332.

[9] Karpa MJ, Gopinath B, Beath K, *et al*. Associations between hearing impairment and mortality risk in older persons: the Blue Mountains Hearing Study. Ann Epidemiol. 2010;20:452–59.

[10] European Environment Agency. Noise in Europe 2014. 2014; Publications Office of the European Union.

[11] Fritschi L, Brown AL, Kim R, Schwela DH, Kephalopoulos S, eds. Burden of disease from environmental noise. Bonn: World Health Organization; 2011.

[12] European Environment Agency. Noise in Europe 2014. 2014; Publications Office of the European Union.

Such findings are of particular note in the context of the pervasive societal attitude mentioned earlier: that noise which is considered to be a normal part of urban life should be considered a "mere annoyance."

Many more studies of noise impacts in real-world situations have found significant impacts on the ability of adults and children to perform, at work and at school.

More than 20 studies show that environmental noise exposure negatively affects children's learning outcomes and cognitive performance.[13,14] Among school children exposed to increased environmental noise, researchers found specific deficits in attention, concentration, auditory discrimination, speech perception, memory, reading ability, and performance on standardized tests. In fact, researchers have classified as "overwhelming" the strength of the evidence that noise can significantly impair cognitive performance.[15]

Schools may be the most thoroughly studied real-world environment for the impacts of noise, but research has also examined other environments where noise is of particular concern. For example, Basner *et al.*, cited above, also looked at hospitals. They found that noise levels in hospitals have been increasing since the 1960s and are now, on average, 15-20dB above World Health Organization-recommended levels. Regarding impacts, they found noise exposure to be linked to increased burnout, diminished well-being, and reduced work performance among staff, as well as diminished patient health outcomes.

Many of the studies on environmental noise have examined noise from road traffic. It is hard to guess exactly how those findings would apply to excessive noise from other sources, like leaf blowers; road noise is more pervasive, and occurs at night as well. Yet road noise is more consistent, and the noise from leaf lowers is usually much louder and more variable in pitch, making it much more difficult for children—or anyone—to become habituated to.

Thankfully, there are examples of real-world studies on the effects of leaf blower noise. But before we get to that, it's important to mention a landmark study with particular relevance here.

It was the first longitudinal study to examine the same group of people before and after noise pollution. Authorities inaugurated a new international airport in Munich in 1992, in a different location from the old airport. Researchers performed physiological and psychological tests on 327 children aged 9-12 around both locations, before and after the relocation.

Children in the vicinity of the new airport showed significant decline in the cognitive tasks of memory recall and language mastery after construction of the new airport. And the children around the closed airport showed improvements in the same cognitive skills after that airport closed. Also, children around the new airport showed a reduced ability to discern auditory signals after the new airport opened.[16]

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[13] Basner, Mathius, *et al.* Auditory and non-auditory effects of noise on health. Lancet. 2014; Apr 12; 383(9925): 1325–1332.

[14] Stansfeld, Stephen A, Matheson, Mark P. Noise pollution: non-auditory effects on health. British Medical Bulletin. 2003; Dec 1. Volume 68, Issue 1, Pages 243–257.

[15] Passchier-Vermeer, W, Passchier, W F. Noise exposure and public health. Environmental Health Perspectives. 2000 Mar; 108(Suppl 1): 123–131.

[16] Hygge, S, Evans, G W, Bullinger, M. Chronic Noise Exposure and Physiological Response: A Prospective Study of Children Living Under Environmental Stress. Psychological Science. 1998; Jan 1; 9:75-77.

These findings are even more relevant to the issue of noise from leaf blowers than studies of road noise due to the similarities in noise profile. Like aircraft noise, leaf blower noise in the environment is intermittent (it comes and goes, throughout the day) and varies substantially in pitch and intensity.

Leaf Blower Noise in Neighborhoods

Habituation—that is, "getting used to it"—can mollify some of the impact of noise on the body, but this is only possible for sound that is relatively consistent in volume and pitch, like distant road noise. In contrast, the nature of noise from leaf blowers—constantly varying in pitch and volume—prevents habituation.

The intensity of such noise far surpasses that of nearly every other neighborhood noise, and most models of leaf blower exceed 65 dB even at a 50-foot distance. The lower frequencies they emit travel long distances (than other frequencies do) because they penetrate the walls and windows of houses, schools, offices, etc.[17] In fact, real-world measurements of the distance that leaf-blower noise carries across neighborhoods found that both the low and middle frequencies of leaf blower noise exceed the

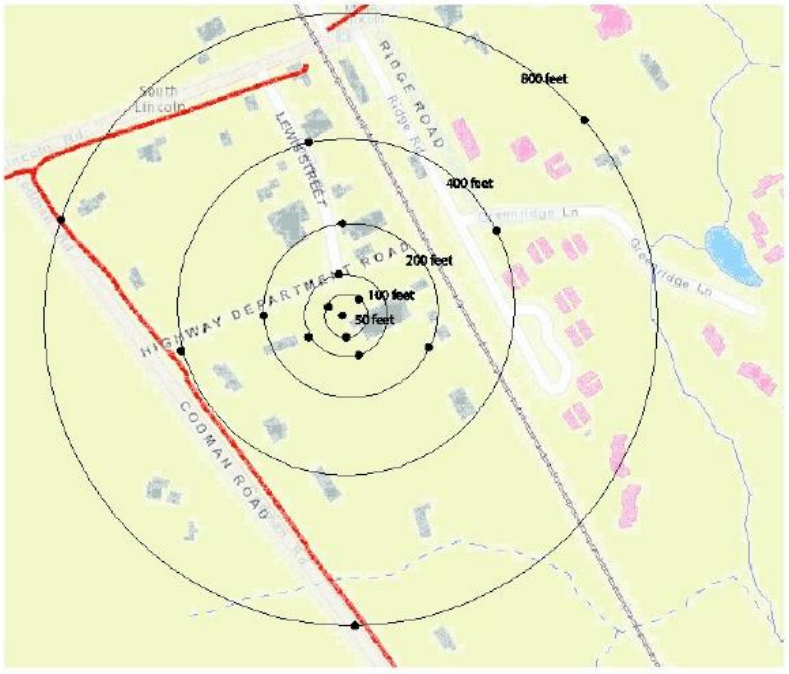

Figure 2: The 800 feet radius was delineated into concentric circles 50, 100, 200, 400, and 800 feet from the centroid

World Health Organization standard for daytime noise *even 800 feet away from the machine* (figure 2).[18]

It should be noted that decibel levels used by scientists, equipment manufacturers, etc. are often interpreted as a measure of loudness. However, it is not so simple. Decibels—dB—are an objective

[17] Pasanen, T, Rytkönen, E, Sorainen, E. Leaf Blower Noise. Kuopio Regional Institute of Occupational Health Acoustics Laboratory. Presented at Joint Baltic-Nordic Acoustics Meeting 2004, 8-10 June, Mariehamn, Åland, Finland.

[18] Walker E, Banks, JL. Characteristics of Lawn and Garden Equipment Sound: A Community Pilot Study. 2017; Journal of Environ Toxicological Studies 1(1).

measure of sound pressure, but perceived loudness consists of physiological, psychological, and other physical components, too. The addition of A-weighting to decibels—dB(A)—is intended as a better measure of loudness as perceived by the human ear, and is a common measurement of environmental and industrial noise. However, there is a limitation when employing the dB(A) measure in a public policy context for the enforcement of noise ordinances. A typical ordinance might limit the loudness of a noise source to a certain dB(A) at a certain distance, with the inherent expectation that the level of noise will drop proportional to distance. But because lower frequencies travel through buildings, as mentioned above, and therefore further than higher frequencies, the use of decibel measurements to limit noise in urban environments allows for more noise from sources that emit low frequencies—like leaf blowers—than the legislation intends.

The aforementioned study details the negative impacts of leaf blower noise over and above other sources of environmental noise due to the middle and lower noise frequencies and their ability to penetrate buildings and travel farther. Also of note in this study is the geographic factor: because leaf blowers exceed recommended noise limits 800 feet away from the source, a single leaf blower operating in a neighborhood impacts the health of everyone in a circle of 1,600-foot diameter—about 1/3 of a mile. When you consider that, like any mid-sized town, Santa Cruz has several landscape companies working throughout its neighborhoods on any given day, and many crews have more than one leaf blower, much of the city is blanketed in unhealthy levels of noise throughout the week.