Effects of Noise on Hearing

William W. Clark, PhD, and Barbara A. Bohne, PhD, Central Institute for the Deaf, St Louis, Mo

Few would deny that we live in a noisy world. Noise, whether a result of air traffic, crowded urban streets, personal stereos, or high-powered machinery, rifles, and shotguns, is one of America’s most widespread nuisances. Excessive noise disrupts sleep, produces stress, impairs communication, and, in high enough doses, causes significant noise-induced hearing loss (NIHL). Although roughly 25% of all Americans ages 65 and older suffer hearing loss, hearing loss is not part of the natural aging process. Much hearing loss in older Americans is due to preventable, noise-induced wear and tear on the auditory system.

**Mechanisms of NIHL**

The ear is injured by noise in 2 different ways, depending on the type of exposure. High-level, short duration exposures exceeding 140 dB can stretch the delicate inner ear tissues beyond their elastic limits, then rip or tear them apart. This type of damage—acoustic trauma—occurs rapidly and results in an immediate, permanent hearing loss. The organ of Corti becomes detached from the basilar membrane, deteriorates, and is replaced by scar tissue. Because the ear is damaged mechanically by impulsive sounds, the maximum sound pressure level (SPL) is more important than the duration of the exposure. Noises in the environment capable of producing acoustic trauma usually come from explosive events, such as a firecracker detonating near the head (170 dB SPL), a toy cap gun fired near the ear (155 dB SPL), or a shotgun, high-powered rifle, or pistol shot (160-170 dB SPL).

Exposure to noise between 90 and 140 dB (dB, denotes a decibel measure with a filter that adjusts for human auditory sensitivity) damages the cochlea metabolically rather than mechanically and causes damage relative to the level and duration of exposure. Noise-induced hearing loss, in contrast to acoustic trauma, develops slowly over years, is caused by any exposure regularly exceeding a daily average of 90 dB, and proceeds in 3 stages.

In the first stage, sensory cells within the cochlea are killed by excessive exposure. These cells do not regenerate; they are replaced by scar tissue. In the second stage, after weeks to years of excessive exposure, hearing loss can be detected audiometrically. Early loss occurs in the high-frequency range, around the highest C note played on a piano. Speech comprehension is not significantly affected; therefore, this loss is seldom noticed unless hearing is tested for some other reason.

With continued exposure, the loss spreads to the lower pitches necessary for understanding speech. At this point, the third stage, the patient usually becomes aware of the problem and may seek medical attention. Unfortunately, much of the damage has already occurred (FIGURE).

Noise exposure in the workplace has been known for centuries to produce hearing loss. The US Department of Labor promulgated regulations in the 1970s and 1980s to protect the hearing of millions of Americans working in noisy environments. Current regulations require workers to be enrolled in a hearing conservation program if their daily exposure exceeds an average level of 85 dB for an 8-hour day.

**Recreational Noise**

Recreational activities are also significant sources of noise. Clinical reports since the 1800s have documented hearing loss after exposure to shooting. Americans collectively own more than 230 million guns, and over half of men in the American industrial workforce occasionally use guns. Because guns are so prevalent in our culture, shooting firearms is the most important source of excessive noise outside the workplace.

The logarithmic nature of the decibel scale makes it difficult to grasp the amount of acoustic energy in a single gunshot. The energy in a single report from a high-powered rifle or shotgun is equivalent to almost 40 hours of continuous exposure at 90 dB. In other words, 1 bullet equals 1 week of hazardous occupational noise exposure. An avid target shooter can produce 1 year’s worth of hazardous occupational noise exposure in just a few minutes on the target range.

A large body of research details the noise exposure resulting from attendance at rock music concerts. One meta-analysis found that the average sound level at rock concerts was 103.4 dB. Studies of temporary threshold shifts (TTS), which are indices of the ear’s acclimatization to noise, have shown that after exposures to rock music most listeners sustain TTs of up to 30 dB but recover within hours to days. Although the risk of sustaining permanent hearing loss from attending rock concerts is limited to those who frequent such events, rock concerts remain an important contributor to cumulative noise for certain individuals.

The increased use of personal stereos and CD players has led to concern about hazardous noise exposures, particularly for young listeners. The risk of hearing loss resulting from the use of headphones depends on several variables. These include the volume level selected, the time spent listening, the susceptibility of the individual’s ear, and the extent of other noisy exposures. Although some stereos can exceed 120 dB, relatively few individuals exhibit patterns of use that significantly increase their risk of hearing loss.

**Preventing NIHL**

It has been suggested that prevention of excessive noise exposure would be more easily accomplished if the ear were to show its injury by bleeding after significantly damaging
events. Instead, by the time functional hearing impairment is detected, injury to the auditory system is usually at an advanced stage. The key to prevention is therefore education.

Several organizations have provided educational curricula to science or health teachers to encourage healthy hearing habits for young ears. Axelsson and Clark have suggested that schools invite hearing professionals who can relate real life experiences that will help deliver the message to children.

In addition, federal law requires education programs for employees exposed to high noise levels. Such programs are limited, however, in that they generally address workplace noise exclusively and are often available only to employees in high noise environments.

Physicians can help patients at risk for hearing loss by teaching them to avoid exposure to unwanted noise and to become judicious consumers of desired sounds. For example, physicians can recommend that patients avoid other noisy activities on the day of a rock concert. Research has shown that rest periods interspersed with an otherwise hazardous exposure can reduce auditory damage. Also, physicians can encourage patients to select events that are most enjoyable to them and then advise them to consider foregoing other noisy activities.

In situations where noise cannot be eliminated, patients should be advised to wear hearing protection. The 2 most commonly used types of protection are earplugs or earmuffs. Earplugs come in a variety of styles and sizes. Among their advantages are their small size, low cost, and relative comfort. The other type of hearing protector is a muff that fits over the ear. Heavier and more protective than earplugs, muffs are also reusable and, when kept in good condition, can be considerably cheaper than disposable earplugs. However, a seal must be made between the earmuff cushion and the side of the head; any break in the seal renders the muff useless.

Individuals should wear hearing protection whenever they are exposed to loud sound and remember that the most effective type of plug or muff is the one that is actually used. Most individuals will find foam earplugs the protection of choice, because they are cheap, comfortable, disposable, and readily commercially available.

Conclusion

Noise-induced hearing loss is usually undetected until damage to the inner ear is advanced. Much is known about the deleterious effects of noise, but few efforts have been made to reduce noises at their source, to protect hearing in noisy environments, and to educate individuals on the importance of preserving hearing into old age. Hearing professionals can help patients understand the importance of preserving hearing into later life and the steps that can be taken to prevent NIHL.

REFERENCES


Figure. Photomicrographs of the 4-kHz Region of the Organ of Corti in a Non–noise-Exposed Control and a Noise-Exposed Animal

Left, This view shows the organ of Corti (OC) from above as it is attached to the basilar membrane (BM). Its sensory cells are innervated by the peripheral processes (MNF) of the primary auditory neurons; Right, After excessive exposure to noise, a portion (up arrow) of the organ of Corti (OC) has degenerated. The nerve fibers (MNF) that originally innervated the degenerated region have also disappeared (down arrow). There is additional loss of sensory cells in the organ of Corti on either side of the central lesions. Bars equal 50 µm.