Effect of noise on the ear

Valerie E Newton
Professor Emerita in Audiological Medicine, University of Manchester, United Kingdom

Dolores Umapathy
Retired consultant and trainer in Audiovestibular Medicine, Bolton, United Kingdom

To understand the effect of a damaging noise on the ear, it is helpful to have a basic knowledge of the hearing process, particularly what happens in the inner ear. The ear is composed of the outer ear, middle ear and inner ear. The **outer ear** (pinna and ear canal) funnels sound waves into the middle ear. Inside the **middle ear** are three small bones called the 'ossicles'. The movement of ossicles converts sound waves into vibrations. These set up a travelling wave in the fluid in the **inner ear**, which results in a neural signal that can be interpreted by the brain.

What happens in the inner ear

The inner ear is composed of three compartments (Figure 1). In the central compartment (scala media) lies the organ of hearing, the Organ of Corti. It is composed of inner hair cells (IHCs), outer hair cells (OHCs), and supporting cells. When stimulated by the travelling wave of fluid in the inner ear, the OHCs act as an amplifier increasing the intensity (loudness) of quieter sounds to excite the IHCs. Stimulation of the IHCs results in the nerve endings at the base of the cells sending electrical signals along the auditory pathways to the brain, where they are decoded: the original sound is identified and its location is recognised.

Effect of a damaging noise on the ear

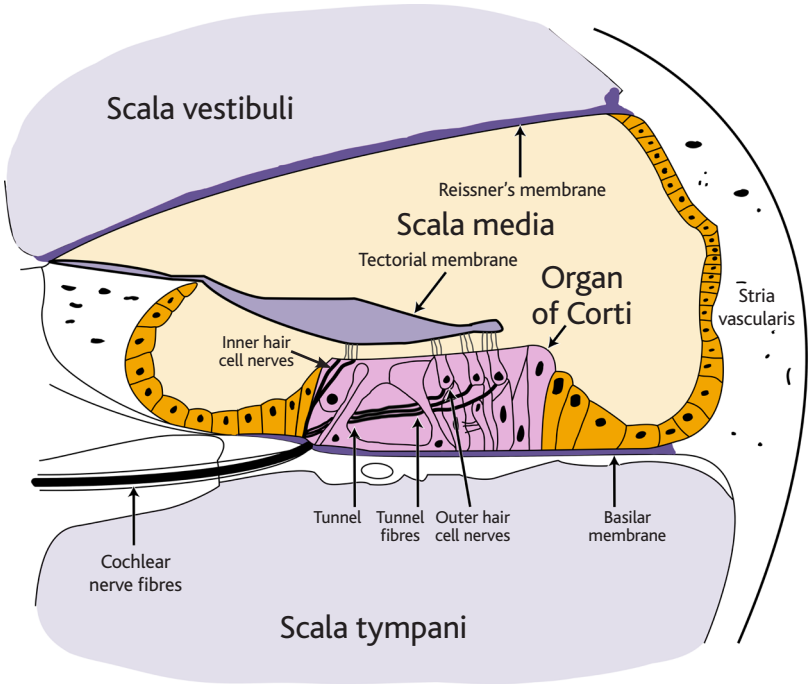
Acoustic trauma and noise-induced hearing loss

The effect of excessive noise upon the ear depends on the type of noise encountered:

A very loud sudden noise, perhaps resulting from an explosion or gunfire, causes what is known as 'acoustic trauma'. It can cause marked damage to structures within the ear, which can include:

- Perforation of the tympanic membrane (eardrum)
- Fracture and disruption of the ossicles
- Damage to hair cells in the inner ear
- Vestibular sensory organs may also be damaged.

FIGURE 1 CROSS SECTION OF THE COCHLEA



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Firecrackers can generate unsafe levels of noise. SPAIN

The resulting hearing loss can be conductive, sensorineural or mixed, depending upon the structures damaged. The extent of the damage depends upon the loudness of the sound. Acoustic trauma is usually bilateral, but it can also be unilateral.

A loud continuous noise experienced over a period of time, e.g. in a factory, particularly affects the inner ear. It causes what is known as noise-induced hearing loss (NIHL). NIHL is a sensorineural hearing loss and affects both ears. It may be temporary or permanent (see below).

Effect of a loud noise on the inner ear

Noise particularly damages the OHCs in the cochlea, which have an important function in hearing.

Initially, a loud noise damages the connections between hair cells, then subsequently it damages the hair cells themselves (see Figure 2 on page 9 of this issue). The overstimulation of the hair cells can lead to swelling of the nerve endings at the base of the hair cells, which impedes neural activity[1] and so causes a hearing loss. If the noise exposure is of short duration, then the damage can be repaired and the hearing loss is temporary. It is known as a Temporary Threshold Shift or TTS.

If the exposure is prolonged, or repeated over time, the damage to hair cells becomes permanent, leading eventually to cell death[1] and causing what is called Permanent Threshold Shift or PTS.

The hearing loss is reported to stop progressing when the noise exposure ceases.

Additional factors affecting the effect of noise on the ear

- Genetic susceptibility: it is recognised that some people may be genetically more susceptible to developing NIHL than others,[2] and will develop a more severe hearing loss.
- Synergistic effect of organic solvents: organic solvents have been shown to enhance the effects of noise upon the ear. Toluene is one such substance which enhances the damaging effects of noise; these two damaging factors target different areas within the cochlea, noise mainly affecting the sensory epithelium and toluene the supporting cells.[3] Other industrial chemicals can also exacerbate the effects of noise-induced hearing loss.[4]

Symptoms of loud, continuous noise exposure

Tinnitus

Initial exposure can lead to tinnitus, often described as a ringing sound in the ears. This may be only temporary, and be the only initial symptom, or it can be associated with a temporary loss of hearing.

Hearing loss

Loss of hearing is usually seen first on pure tone audiometry as a notch in the threshold at 4kHz (see Figure 2). With time other high frequencies are affected, and then lower frequencies. The hearing loss can eventually be very severe. It is mainly described as bilateral and symmetrical.[5]

Initially, TTS may occur. Recently it has been shown that although hearing tests may show normal hearing there may be residual damage not detectable by pure tone audiometry. After several episodes of TTS, hearing loss tends to progress and become permanent.

Communication is affected early on as high frequencies are important for discriminating the consonants in speech and, therefore, its intelligibility. As more lower frequencies are affected, perception of the loudness of speech is also affected. This will also have implications for safety at **work** and in **leisure** pursuits unless effective hearing devices are available.

Noise-induced hearing loss develops at a greater rate in the first two years of exposure. After this, hearing loss develops at a slower rate.

Dizziness

The vestibular system is also affected by loud noise exposure and dizziness has been described as a result of acoustic trauma and chronic noise exposure.[5,6,7]

Understanding noise exposure and protecting the ear

What is a 'damaging' noise?

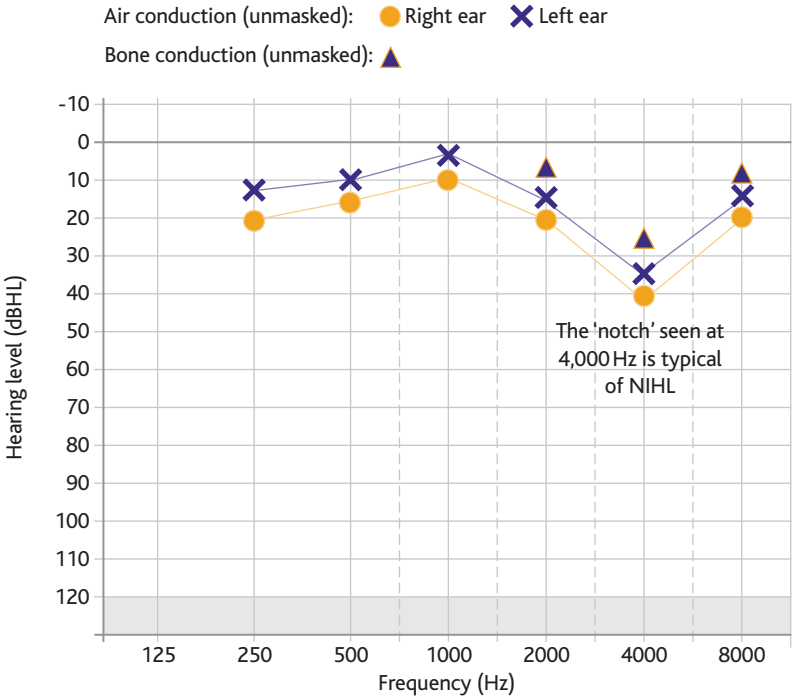
The risk of noise damage occurring depends on the intensity of the noise, distance from the noise source and the duration of exposure.

The 'intensity' of a noise is measured in decibels (e.g. with a sound level meter or with an app). It is an objective measure that is different from the loudness of a sound perceived by each person. (We can get 'used to' loud noises and no longer perceive them as loud, but they will still damage our ears). Generally, 85 dB(A) is accepted as the threshold for noise damage: protecting your hearing when exposed to noise that is equal to or higher than 85 dB(A) is good practice.

There are tables showing the intensity of noise produced by machinery or various activities (see page 8), which can be helpful as a guideline. However, it should be noted that these tables often do not take into account a person's distance from the source of noise. Intensity, duration and distance from the ear determine the effects on hearing.

For each noise intensity, damage occurs after a certain duration of exposure. The higher the intensity, the quicker the noise will cause damage. Noise levels in excess of 85 dB(A) over a period of 8 hours are considered excessive and potentially damaging. Several expert bodies, e.g. the World Health Organization, have defined the permissible daily 'dose' of sound (after which damage occurs) for different intensities (see page 11).[8]

FIGURE 2 PURE TONE AUDIOGRAM OF A PERSON WITH NIHL



Once the damage is severe enough to cause the death of OHCs, it is permanent. This means that over time, as more cell death occurs, noise damage is cumulative. Noise exposure early in life has also been shown to exacerbate age-related hearing loss.

Protecting the ear

It is important to use earmuffs or earplugs when exposure to loud sound is anticipated, whether in an occupational or recreational context. For example, hearing protection may need to be worn by musicians during rehearsals or when performing, by people attending loud concerts, by armed forces using loud firearms, or when motorcycling.

Various substances have been found to be protective to a certain extent. Steroids, such as dexamethasone, given before or after exposure to loud noise have been shown to reduce the effects of acoustic trauma. Magnesium can reduce the incidence of developing a temporary or permanent hearing loss after excessive noise exposure. Research has also indicated that antioxidant substances and anti-inflammatories can be oto-protective, as well as some vitamins, such as vitamin B12. Another possibility is that agents which target intrinsic cell-death processes can be protective.

However, avoiding or reducing exposure to noise is the best way to prevent hearing loss. Primary health personnel can contribute to preventing noise damage in the community by:

- Explaining noise damage and the risk of irreversible damage to hearing
- Explaining the importance of controlling noise exposure (the louder the noise and the closer the source of noise, the shorter the exposure should be)
- Explaining early signs of noise-induced hearing loss
- Giving tips on how to spot if a sound is too loud.

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