



High levels of noise, notably from traffic, are an integral part of city life. GHANA

PHOTO: JOZUADOUGLAS/PIXABAY

Noise-induced hearing loss



Shelly Chadha
Technical Officer, WHO
Programme on Ear and
Hearing Care, World
Health Organization,
Geneva, Switzerland

Loud sounds, loud music and noise have become an integral part of modern-day society. Seeping into every aspect of our everyday life, noise is one of the most important environmental risks to health today.¹ In Western Europe alone, over one million healthy 'life years' are lost daily due to environmental noise.² High levels of occupational noise continue to pose a problem in all regions of the world.³ The rise of personal audio devices and smartphones poses an additional challenge, because they are often used at loud volumes for long periods.⁴

The impact of loud sounds on hearing is indisputable. Exposure to loud sounds, especially when prolonged and regular, causes permanent damage to sensory cells and other structures within our ears, resulting in irreversible hearing loss, often accompanied by troublesome tinnitus. Noise exposure has also been shown to have an impact on other aspects of health. It has been associated with cardiovascular diseases (such as high blood pressure and ischaemic heart disease, including myocardial infarction), sleep disturbance, cognitive impairment (in children) and annoyance.

Cause for concern

The World Health Organization (WHO) estimates that over 460 million people worldwide currently experience moderate or higher levels of hearing

loss.⁵ Projections suggest that this number will continue to rise and could double by 2050, unless action is taken. While this growth is largely attributed to ongoing demographic changes, the persistence of risk factors such as noise exposure contributes to this upward trend.

Noise is a challenge in the workplace, with as many as 25–33% of the workforce in Europe being exposed to high-level noise.⁶ While similar data is

not available from some parts of the world, there is good reason to believe that the problem is widely prevalent especially in low- and middle-income countries where the regulatory environment is less likely to support hearing conservation efforts and the informal sector remains largely unregulated.⁷

Non-occupational noise has also emerged as a problem, particularly with the current easy access to technology. As the sales of smartphones continues to soar globally (1.5 billion devices sold in 2016 alone), the risk of hearing loss to the young listener is real. The World Health Organization estimates that 50% of those between 12 and 35 years of age listen to unsafe levels of sound through personal audio devices (such as smartphones or portable

Continues overleaf ➤

“Exposure to loud sounds, especially when prolonged and regular, causes permanent damage”

IN THIS ISSUE

- 1 Noise-induced hearing loss**
Shelly Chadha

- 4 Effect of noise on the ear**
Valerie E Newton and Dolores Umapathy

- 6 Occupational noise-induced hearing loss**
Catalina Valencia-Mayer and Diego J Santana-Hernández

- 8 Environmental and recreational noise-induced hearing loss**
Suneela Garg and Palak Goel

- 11 Challenging ideas about noise and hearing**
Paddy Ricard

- 12 Is it too loud?**

music/video players), and approximately 40% are exposed to potentially damaging sound levels in nightclubs, music venue and bars. Overall, 1.1 billion young people face the risk of hearing loss simply due to their recreational habits.⁴

The omnipresence of noise, its high potential for damage to hearing and health and the permanence of its auditory impact are all reasons why this hazard needs to be targeted as a public health priority. Addressing it and mitigating its impact requires a comprehensive effort that is a combination of:

- Policies, legislation and enforcement
- Awareness
- Technological advancements.

Policy development and implementation

The implementation of hearing conservation programmes has played a key role in controlling occupational noise and many countries have effectively enacted relevant policies bringing significant benefits to the affected population.⁸ However, in many parts of the world, such policies are either not developed or not well implemented. Legislation is also required to limit exposure to environmental noise (e.g. traffic and aircraft noise) and recreational sounds.² The WHO Environmental Noise Guidelines for the European Region provide a strong basis for policy development in the environmental context.¹ In all cases, legislation needs to be enforced in order to have a positive impact.

Recently, WHO, in collaboration with the International Telecommunications Union (ITU) launched the Global Standard for Safe Listening Devices and Systems.⁹ Developed through a consultative process with participation of key stakeholders in this field, this Standard provides a series of evidence-based recommendations to limit noise exposure through these devices. Currently, WHO is also working on formalising a regulatory framework for recreational places in order to minimise the risk of hearing loss to people who visit this type of venue.



Wearing hearing protectors can reduce the risk of noise-induced hearing loss.

Creating awareness

It is essential to the prevention of noise-induced hearing loss that people be aware of the risks posed by loud sounds and take concrete steps to protect themselves from this. Simple steps can go a long way in mitigating risk posed by exposure to loud sounds in occupational and recreational settings, such as:

- Using hearing protectors like earplugs
- Listening to music at lower volumes
- Limiting time spent in noisy activities
- Staying away from sources of noise
- Taking regular listening breaks.

The adoption of such safety measures can only occur through heightened awareness and behaviour change.

WHO's Make Listening Safe initiative, launched in 2015, aims to raise awareness of recreational noise exposure. It focuses mainly on safe listening through personal audio devices and at entertainment venues. World Hearing Day, celebrated every year on 3rd March, is another opportunity to organise events to raise awareness.

Technological advancements

It is essential that, as awareness rises among target groups, safe listening and protective options be made available to them. Technology



Editor
Dr Paddy Ricard

Editorial committee
Dr Diego J Santana-Hernández (Chair)
Dr Ian Mackenzie
Professor Valerie E Newton
Dr Tony Sirimanna
Professor Andrew Smith

Regional consultant
Professor Jose M Acuin (Philippines)

Editorial assistant
Joanna Jeremy

Design
Lance Bellers

Printing
Newman Thomson

Online edition (free)
View and download issues for free by clicking on the 'CEHH Journal' tab on <http://disabilitycentre.lshtm.ac.uk>

How to subscribe
The paper version of the journal is sent free of charge to readers working in low- and middle-income countries. To subscribe, please send your

name, occupation, postal address, phone number and email address to: Joanna Jeremy, Community Ear and Hearing Health, International Centre for Eye Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, United Kingdom. Email: Joanna.Jeremy@lshtm.ac.uk

For the paper version, may we suggest that readers in high-income countries make an annual donation of UK £10.

Please contact Joanna Jeremy (as above).

Correspondence
Please send all enquiries to: Joanna Jeremy (for contact details, see left).

Copyright
Articles may be photocopied, reproduced or translated, provided they are not used for commercial or personal profit. Acknowledgements should be made to the author(s) and to *Community Ear and Hearing Health*.

can play a key role both in limiting occupational and environmental exposure and in reducing unsafe listening. Some examples of beneficial technologies are:

- Effective and comfortable hearing protectors.
- Efficient headphones or earphones that can cancel or reduce external noise.
- Accurate and easy-to-use apps that can monitor outside noise or calculate noise exposure through one's personal audio systems (player and headphones). For example, the NIOSH SLM app is an accurate tool for external noise measurement and the 'HearAngel' app is useful for monitoring sound exposure through headphones.
- Simple tools for hearing testing that can be used by people to assess and monitor their own hearing status, as well as tools that can be used for checking hearing within the community. One free option is WHO's recently launched 'hearWHO' app.
- The availability of smart devices (smartphones, MP3 players and ear/headphones) with safe listening features.

The availability of safe listening features on smartphones is important because it will help reduce exposure to recreational noise. The WHO-ITU Global Standard recommends that⁹:

- Every device shall measure the listener's use of their 'sound allowance', based on a choice of two modes of reference exposure (one for adult listeners, one for children). (Sound allowance is estimated on the basis of a reference exposure, which in this case is 80 dB for 40 hours a week).

WHO/ITU RECOMMENDATIONS FOR SAFE LISTENING

Safe 'sound dose' at work

85 dB for a maximum of 40 hours per calendar week, for the duration of one's work life*

Safe 'sound dose' outside work

80 dB for a maximum of 40 hours per calendar week, during one's lifetime*

*If noise levels (dB) are above the limit, then duration of exposure needs to be reduced (see articles on pages 4, 8 and 11)

- Each device should include options for volume limiting and parental volume control.
- Each device shall provide the user with personal usage information, personalised messages and cues for action, and general information on safe listening.

The implementation of these recommendations in smartphones and MP3 players will empower their users to make safe listening choices and protect their hearing. Governments should mandate these features by developing suitable policies and regulations. Manufacturers can implement these voluntarily, while civil society can play a key role through advocacy for their adoption.

Conclusion

Protecting our ears from loud sounds is a key strategy to check the current trend of rapidly rising prevalence of hearing loss. A start has already been made, but strong action involving multiple stakeholders is still required. This will positively impact the hearing health of people across the world.

References

- ¹ Environmental Noise Guidelines for the European Region. Geneva: WHO, 2018. www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf?ua=1
- ² Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. Geneva: WHO, 2011. www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf
- ³ Occupational noise. Assessing the burden of disease from work-related hearing impairment at national and local levels. Geneva: WHO, 2004. www.who.int/quantifying_ehimpacts/publications/en/ebd9.pdf
- ⁴ Make Listening Safe. Geneva: WHO, 2019. www.who.int/pbd/deafness/activities/MLS/en/
- ⁵ Estimates. Geneva: WHO, 2019. www.who.int/deafness/estimates/en/
- ⁶ Risk Observatory Thematic Report. Belgium: European Agency for Safety and Health at Work, 2005. <https://osha.europa.eu/en/tools-and-publications/publications/reports/6905723>
- ⁷ Quiet please: reducing occupational exposure to harmful noise. Report by Humphreys G. Bull World Health Organ 2019;97: 650–651.
- ⁸ Stocks SJ et al. Trends in incidence of occupational asthma, contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb musculoskeletal disorders in European countries from 2000 to 2012. Occup Environ Med. 2015 Jan 9;72: 294–303.
- ⁹ Safe Listening Devices and Systems. A WHO-ITU standard. Geneva: WHO, 2019. <https://apps.who.int/iris/bitstream/handle/10665/280085/9789241515276-eng.pdf?ua=1>



HANNAH AYUKAWA

Hearing protection should be worn not just at work but also during noisy activities, such as ice sculpting. CANADA

Effect of noise on the ear



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



Dolores Umopathy
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

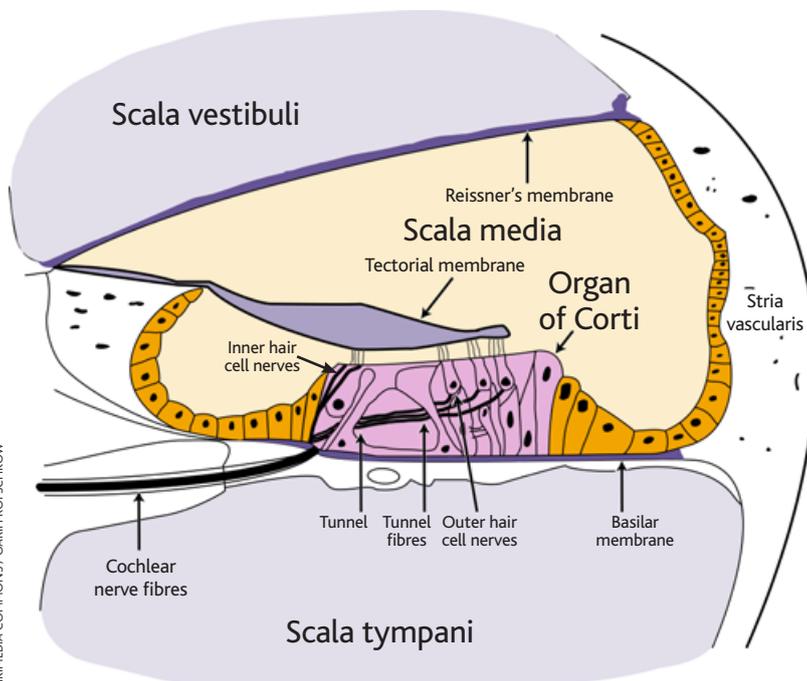
Acoustic trauma and noise-induced hearing loss

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

FIGURE 1 CROSS SECTION OF THE COCHLEA



Firecrackers can generate unsafe levels of noise. SPAIN

- Damage to hair cells in the inner ear
- Vestibular sensory organs may also be damaged.

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 activity¹ 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 death¹ 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?

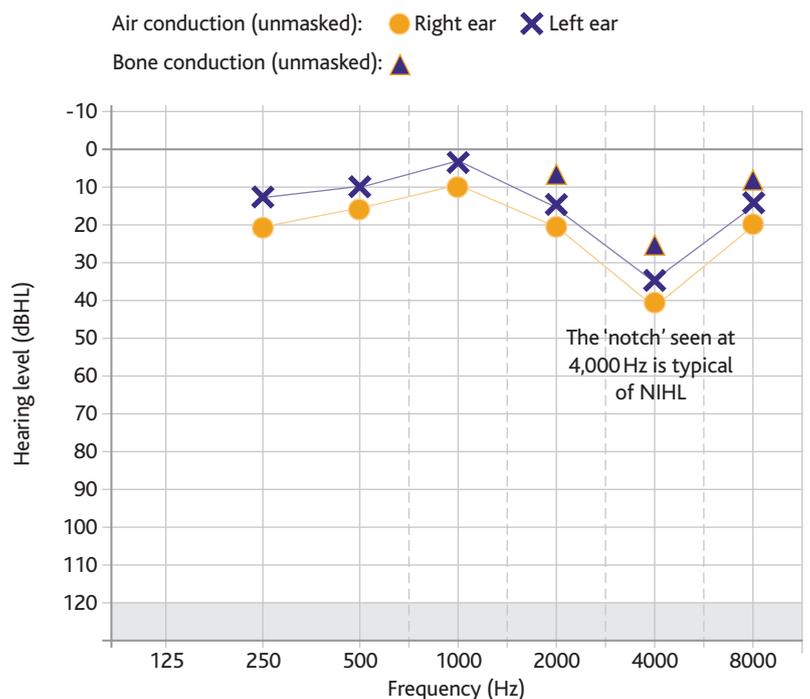
The risk of noise damage occurring depends on the intensity of the noise, distance from the noise source and the duration of exposure.

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

FIGURE 2 PURE TONE AUDIOGRAM OF A PERSON WITH NIHL



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

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.

References

- 1 Forge A. Mechanisms of hearing loss of cochlear origin. In: Newton VE, Alberti P, Smith A, (Eds) Prevention of Hearing Loss. New York: Nova Science Publishers, 2012, 51–78.
- 2 Zhang X et al. Screening of noise-induced hearing loss (NIHL)-associated SNPs and the assessment of its genetic susceptibility. *Environ Health* 2019; 18(1): 30.
- 3 Fetoni AR et al. Styrene enhances the noise induced oxidative stress in the cochlea and affects differently mechanosensory and supporting cells. *Free Radic Biol Med* 2016, 101:211.
- 4 Sliwiska M et al. Exacerbation of noise-induced hearing loss by co-exposure to workplace chemicals. *Environ Toxicol Pharmacol* 2005, 19(3): 547–53.
- 5 Le TN et al. Current insights in noise-induced hearing loss: a literature review of the underlying mechanism, pathophysiology, asymmetry, and management options. *J Otolaryngol Head Neck Surg* 2017, 46(1): 41.
- 6 Shupak A et al. Vestibular findings associated with chronic noise induced hearing impairment. *Acta Otolaryngol* 1994 Nov; 114(6): 579–85.
- 7 Hain TC. Noise-induced vestibular disturbances. 2016. www.dizziness-and-balance.com/disorders/hearing/noise_vestibular.html
- 8 WHO. Make Listening Safe. Geneva: WHO, 2019. Page 2.

Occupational noise-induced hearing loss



Catalina Valencia-Mayer
Assistant Professor,
School of Medicine,
Universidad El Bosque,
Bogota, Colombia



Diego J Santana-Hernández
ENT Surgeon, CBM's
Senior Global Advisor for
Ear and Hearing Care,
Santa Cruz de Tenerife,
Spain

Occupational noise-induced hearing loss (ONIHL) is described as an acquired hearing deficiency directly attributable to excessive workplace noise exposure.¹ This occurs when a worker is regularly exposed to more than 85 dB of sound during an eight-hour period. This exposure damages hair cells in the inner ear and over time leads to permanent hearing loss (see page 3).

Risk factors for ONIHL include:

- Frequent and long-term exposure to noise, usually ≥ 80 dB. The effect of noise exposure is cumulative over time. Also, the louder the noise and the more continuous the exposure, the sooner permanent damage will occur.
- Single or repetitive exposure to impulse or gunfire noises, usually > 90 dB.
- Males and older people are at higher risk of NIHL.²
- Lack of appropriate hearing protection.²
- Combined exposure to noise and solvents.²
- A working environment that amplifies noises, whether indoors (e.g. underground mines), or outdoors (e.g. quarries).³
- Occupations that by their nature put workers at higher risk of developing ONIHL: e.g. mining, woodworking, farming, manufacturing, heavy construction, aviation and the military, as well as music performance.²

An important public health problem

ONIHL is one of the leading causes of hearing loss worldwide, accounting for nearly 16% of it and, its frequency of distribution ranges between 7 to 21% worldwide among working-age adults.¹ It is, however, a highly preventable occupational hazard and this article will highlight key elements in the fight against ONIHL.

Measures to reduce occupational exposure to noise

The measures below all contribute to preventing ONIHL.

Technical measures⁴

- **Reducing noise at the source** by implementing engineering measures to reduce the noise made by machines: e.g. replacing them for quieter ones, installing mufflers or installing vibration mounts.
- **Reducing noise propagation** by considering acoustics at the factory design stage, by building an acoustic enclosure or barrier or by covering walls

with sound-absorbing materials. This can be a good solution, particularly in low- and middle-income countries (LMICs) where lack of resources limits the chances of replacing equipment.

- **Creating specific locations where noise exposure is reduced:** e.g. building soundproof cabins where workers can operate a piece of equipment.

Personal hearing protection

The most effective way to reduce the risk of ONIHL is to remove the source of noise or to remove workers from the source of noise, by ensuring they avoid noisy areas as much as possible. When neither option is possible, workers should be encouraged to wear hearing protection when exposed to ≥ 80 dB.

There are two main types of hearing protection devices (HPDs):

- **Earplugs** are smaller devices meant to fit into the outer ear canal, so it can be completely blocked. They can be found in different sizes, shapes and materials. Custom-moulded earplugs tend to better adhere and block the ear.
- **Earmuffs** completely cover the outer ear to form an air seal and are usually held in place by an adjustable band.

Earplugs or earmuffs can reduce noise by 15 dB to 30 dB separately. If the noise is higher than 105 dB, workers should wear both earplugs and earmuffs.⁴

Although they may be difficult to procure in some LMICs, HPDs are low-cost preventive measures. To optimise their use in the prevention of ONIHL, there are a few points to consider:

- HPDs are only effective when they are well fitted. Therefore, it is advisable to provide proper training to workers on how to fit them.
- HPDs should be cleaned regularly and replaced annually. Where resources are scarce and annual replacement may not be possible, hygiene and care measures are even more important.
- The quality of HPDs should be checked, as in some LMICs they can be of poor quality due to the absence of manufacturing standards.
- HPDs are only protective if worn regularly, so it is important to provide training to encourage compliance. HPDs may be worn intermittently because they create an occlusion effect that hampers communication, because they feel uncomfortable or because workers are not sufficiently aware of the risk of noise damage.⁵

Legislation

Efforts to develop legislation protecting the rights of workers are key in the development of public health programmes to prevent ONIHL.⁶ This is particularly important in LMICs, where due to the lack of resources and awareness about multiple hazards, the risk of developing preventable conditions tends to be higher.

The new World Health Assembly Resolution on the Prevention of Deafness and Hearing Loss (WHA70.13), adopted in 2017, urges countries to prevent hearing loss by enforcing noise exposure regulations in occupational settings, among others. This new resolution can be used to initiate advocacy efforts among policy makers.



Measuring sound levels
in a factory. BOLIVIA

DIEGO J SANTANA-HERNÁNDEZ

Essential elements of a programme to prevent ONIHL

In response to growing awareness of ONIHL and under pressure from legislation, programmes have been established in the workplace to prevent ONIHL by applying the measures mentioned above. Studies show that the effectiveness of these programmes until now has been mitigated by external factors such as:

- Low compliance from workers
- Poor management
- Lack of supportive climate and culture towards the prevention of ONIHL
- Insufficient training
- Insufficient monitoring of the programme (including by local authorities).

These barriers can be overcome by considering the following essential elements:

Increasing awareness

Raising awareness of hearing protection amongst front-line workers and individuals at the management level is a feasible and cost-effective intervention for behaviour change. It does not require a lot of resources, but commitment and perseverance.⁸ These interventions to increase awareness are an essential aspect of reducing ONIHL because in their absence:

- Workers may accept noise as an inevitable part of their work and adopt a fatalistic attitude.
- Workers may be unaware of noise hazards and their cumulative effect over time and may unnecessarily expose themselves to noise.
- Workers may be reluctant to use HPDs because they increase their level of discomfort, e.g. when worn with other safety equipment (such as helmet and goggles) or because their preferred type of HPD is not available (earplugs vs earmuffs).⁷
- Workers may use HPDs incorrectly.
- Managers may be unaware of existing legislation and quality regulations, the effect of noise on their employees' hearing and the measures that can be adopted.

There is evidence that health promotion strategies are more effective when coupled with **positive health drivers** rather than punishment or scare tactics. For example, the enjoyment of life with friends and family has been described as a powerful driver to use HPDs.⁷

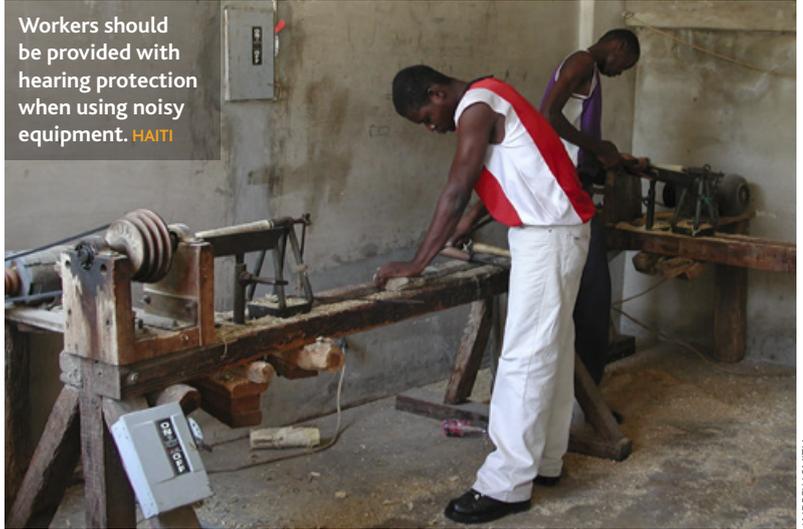
These strategies should also be **tailored to the needs and specificities of the target population**. For example, a study has shown the importance of appropriate role modelling to encourage the use of HPDs among women farm operators, particularly through peers and advertising.⁹

The World Health Organization (WHO) has also developed important initiatives, along with advocacy materials, that can be used to support efforts to increase awareness: World Hearing Day, the Make Listening Safe initiative, as well as the hearWHO smartphone app (which allows users to informally screen their hearing).

Monitoring noise levels and noise exposure

As part of the normal guidelines for the prevention of ONIHL, workplaces should measure their noise levels to know the risk presented by their environment. In

Workers should be provided with hearing protection when using noisy equipment. HAITI



ANDREW SMITH

the absence of measuring equipment, a practical way to determine whether the workplace is exceeding normal sound levels is to assess how difficult it is for employees to hear and understand other colleagues' commands within a distance of three feet. It can also be helpful to use standard tables showing how 'loud' various machines are on average.

Monitoring personal noise exposure has been shown to have a significant effect on ONIHL in the short and medium term.¹⁰ Giving workers the means to measure their exposure can be a novel component of programmes, which can help maximise the effectiveness of the reduction in ONIHL.

Regular audiometric testing in the workplace is also important to monitor hearing, in order to:

- Identify and refer workers with NIHL
- Raise awareness of the effect of occupational noise exposure
- Motivate workers to use protective equipment
- Monitor the effectiveness of preventive measures.

Involving a multidisciplinary set of stakeholders

Effective prevention of ONIHL requires the involvement of professionals who all need to actively interact and collaborate with each other. These stakeholders include:

- Audiologists
- Line managers
- Policy makers
- Technical advisors
- Frontline employees.

It is also very important to involve primary ear and hearing care personnel, as this can help to:

- Increase early prevention and treatment of ONIHL so that affected workers are identified at their earliest stage.
- Reduce the clinical and economic burden that advanced stages of disease and comorbidities can have on people and the health system.

Adopting a dual approach to prevention

It is desirable to involve both the community at grassroots level, in order to change personal and societal attitudes, as well as decision-makers, in order to include ONIHL programmes within national plans and systems for ear and hearing care.

References

- ¹ Nelson DI et al. The global burden of occupational noise-induced hearing loss. *Am J Ind Med.* 2005;48(6):446-458.
- ² Lie A et al. Occupational noise exposure and hearing: a systematic review. *Int Arch Occup Environ Health.* 2016;89(3):351-372.
- ³ Musiba Z. The prevalence of noise-induced hearing loss among Tanzanian miners. *Occup Med (Chic Ill).* 2015;65(5): 386-390.
- ⁴ CDC. NIOSH. Occupational Noise Exposure Revised Criteria. Cincinnati, Ohio: USDHHS, 1998.
- ⁵ Suter AH. Construction noise: exposure, effects, and the potential for remediation; a review and analysis. *AIHA J (Fairfax, Va).* 63(6):768-789.
- ⁶ Joy GJ, Middendorf PJ. Noise Exposure and Hearing Conservation in U.S. Coal Mines – A Surveillance Report. *J Occup Environ Hyg.* 2007;4(1):26-35.
- ⁷ Reddy R et al. Hearing protection use in manufacturing workers: A qualitative study. *Noise Health* 2012;14(59):202.
- ⁸ Tikka C et al. Interventions to prevent occupational noise-induced hearing loss. *Cochrane Database Syst Rev* 2017 Jul 7; 7.
- ⁹ McCullagh MC et al. Gender differences in use of hearing protection devices among farm operators. *Noise Health.* 18(85):368-375.
- ¹⁰ Rabinowitz PM et al. Effect of daily noise exposure monitoring on annual rates of hearing loss in industrial workers. *Occup Environ Med.* 2011;68(6):414-418.

Environmental and recreational noise-induced hearing loss



Suneela Garg
 Director Professor,
 Department of Community
 Medicine, Maulana Azad
 Medical College &
 Associated Hospitals,
 New Delhi, India



Palak Goel
 Senior Resident,
 Department of Community
 Medicine, Maulana Azad
 Medical College &
 Associated Hospitals,
 New Delhi, India

Background

Noise-induced hearing loss (NIHL) is emerging as a significant social and public health problem.

Initially, NIHL was mainly due to occupational exposure, e.g. it was prevalent in people working in mining, construction, manufacturing, etc.

However, non-occupational noise has now emerged as a threat to hearing. In a survey conducted by the United States' Centers for Disease Control and Prevention (CDC), it was reported that almost 50% of the participants who had hearing loss were not exposed to loud sounds at their workplace, showing the damage caused by exposure to noise at home and during everyday activities.¹

Non-occupational exposures to noise result in a similar amount of NIHL as occupational exposures of a similar duration and level. In addition, all age groups are affected by non-occupational noise (not just the working-age population) and individuals are exposed to it over a lifetime, not just throughout their professional life. Young people are particularly vulnerable: more than 1 billion young people globally are at risk of developing hearing loss through exposure to loud music through personal audio devices.² The consequences of hearing loss are profound. Difficulties in access to spoken communication are common and, in children, can lead to communication problems and poor literacy outcomes.

Sources of non-occupational noise-induced hearing loss

Home setting

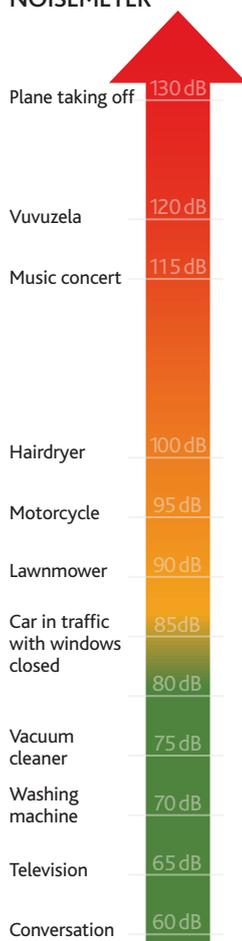
- Toys: some common children's toys, such as rattles, toy phones and guns, are capable of generating unsafe intensities ranging from 110 to 150 dB. Moreover, the danger is probably underestimated as children have a tendency to hold such toys closer to their ears, which increases the intensity.
- Gadgets and tools: electronic gadgets such as mixer-grinders, washing machines, vacuum cleaners, etc. produce harmful sounds which on prolonged exposure may lead to disabling hearing loss. Certain tools used in the garden, such as leaf blowers and lawn mowers, also produce harmful levels of noise. This is



Motorbike riders are exposed to dangerous noise levels. SRI LANKA

ANDREW SMITH

FIGURE 1
 NOISEMETER*



The effects on hearing will depend upon distance from the source and the duration of the sound.

*Extracted from: World Health Organization. Make Listening Safe. Geneva: WHO, 2019: 2–3.

particularly relevant in low- and middle-income countries (LMICs) where there is no regulatory legislation on the noise level generated by this home equipment (such as there is in the EU or the USA), both for local manufacturing and for imports into the country.

Transport

- Roads: due to the exponential increase in the number of vehicles on the road, traffic jams are a regular issue. This in turn leads to continuous honking causing a great deal of noise pollution.
- Public transport: commuters experience peak noise intensity not only on trains but on buses as well which may lead to detrimental effects.

Hospitals

Hospital noises are often a deafening mix of sounds. Conversations, televisions, paging systems,



Poster used to raise awareness about traffic noise. INDIA

SOUND HEARING 2030

and equipment noises from ventilation systems, alarms, and automatic doors create the majority of the sounds. Infant incubators can also generate unsafe levels of noise, if they do not comply with international safety standards. Alarms in the hospitals not only contribute to the overall noise, but also pose their own challenges: hospital codes and standards require that alarms on pumps and monitors are loud enough to be heard above the background noise.³ Other episodic sounds are also prevalent that induce spikes in noise levels leading to patient dissatisfaction (and to a stressful work environment for medical staff).

Sports and entertainment events

Unsafe levels of sound are frequently experienced in nightclubs, discotheques, pubs, bars, cinemas, concerts, live sporting events and even fitness classes. WHO estimates that around 40% of teenagers and young adults (12- to 35-year-olds) are exposed to potentially damaging sound levels at nightclubs, discotheques and bars.²

Ceremonies

In various functions and ceremonies, especially in LMICs, there is a trend of using loudspeakers and burning firecrackers. Firecrackers not only lead to air pollution, but also emit loud sounds which may even lead to disabling hearing loss.

Personal audio devices

Over recent years, there has been an increase in the use of recreational devices such as personal audio players (portable devices used for listening to audio/audiovisual material, such as smartphones) and video game consoles that emit sounds. These devices are commonly operated at unsafe volumes (generally while wearing headphones or earbuds) and for long durations. This has led to an increase in NIHL in youth.^{4,5} Nearly 50% of teenagers and young adults (12- to 35-year-olds) use their personal audio devices at unsafe levels.² The use of media players at loud volume while driving, cycling or walking has also risen, resulting in safety concerns for pedestrians, motorists and cyclists.

Prevention of NIHL

Although NIHL leads to permanent and irreversible damage, it is completely preventable. The impact of loud sounds on hearing depends on three main factors:

- Sound intensity (volume)
- Duration of exposure
- Distance from the sound source.

Prevention measures tend to focus on one or all of these variables.

Reducing sound intensity

The recommended safe volume level is below 85 dB (see Figure 1 for some of the common noise levels associated with daily activities).

Below are measures that can be taken to prevent NIHL by reducing sound intensity:



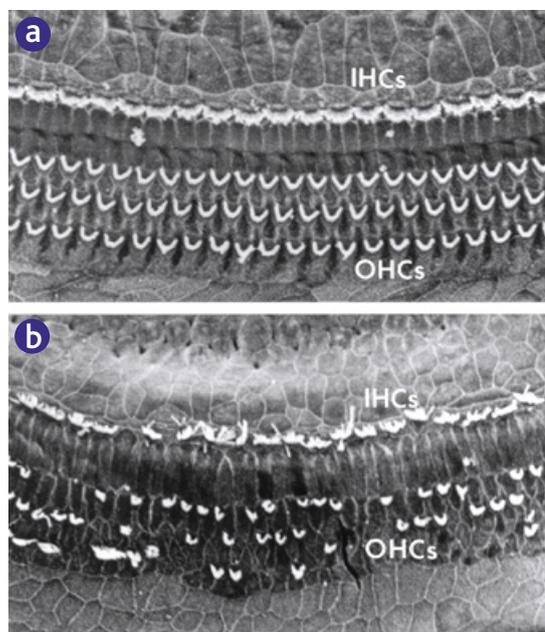
Unsafe levels of sound are often experienced in music venues. UNITED KINGDOM

- Identify the safe listening level on equipment and turn the volume down. Smartphone apps can be used to monitor sound levels as well as output levels of personal audio devices, and can help users ensure that they are within recommended levels.
- Wear earplugs: when visiting discotheques, bars, sporting events and other noisy places, or when participating in rifle shooting, use hearing protection to avoid damage to hearing.
- Use carefully fitted earbuds, which allow music to be heard clearly at lower volumes.
- Use noise-cancelling earphones or headphones, which can reduce the need to raise the volume on listening devices.
- When possible, move away from the loud sound source: at a noisy venue, it is better to stay as far away as possible from sources such as loudspeakers and to take listening breaks by going outside.

Continues overleaf ➤

“ Nearly 50% of teenagers and young adults use their personal audio devices at unsafe volumes ”

FIGURE 2 HAIR CELL DAMAGE LEADS TO HEARING LOSS



These scanning electron micrographs show inner hair cells (IHCs) and outer hair cells (OHCs) in a normal (a) and damaged (b) cochlear sensory epithelium.

This is a reproduction of Figure 1 in: Allen F Ryan, Protection of auditory receptors and neurons: evidence for interactive damage, PNAS June 20, 2000 97 (13): 6939-6940. (Micrographs courtesy of Elizabeth M Keithley) Copyright (2000) National Academy of Sciences, USA

Limiting the duration of exposure

Exposure to sound above a level of around 85 dB initially manifests as a temporary hearing loss or dullness of hearing that is known as temporary threshold shift (TTS), which may resolve within the first 10–15 days of exposure.⁶ However, a repeated or sustained exposure to noise of the hair cells and associated nerve fibres causes degenerative changes (see Figure 2) leading to TTS becoming a permanent threshold shift (PTS). Limiting the duration of exposure to loud sounds is an effective way to prevent NIHL:

- Monitor noise exposure: smartphone technology can be used to measure noise exposure levels and inform users about their risk for noise-induced hearing loss. Be aware of the dangers associated with certain activities and try to limit the duration of exposure accordingly. Safe daily 'doses' of sound have been calculated and translated into estimates of how much time one can be exposed to a certain intensity before permanent damage to hearing occurs. Even though these estimates do not always mention distance from the source, which is an important factor, they can help motivate users to monitor their duration of exposure.
- Be alert to the warning signs of hearing loss and seek help from a hearing health care professional if they do occur: ringing in the ears (tinnitus); difficulty understanding speech, especially over the telephone; difficulty in following conversations in noisy environments, such as in restaurants or at social gatherings.

Legislation and manufacturing standards

A number of legislative measures relating to environmental noise and occupational exposure are in place in many countries and they need to be strengthened. Few countries have legislative measures pertaining specifically to recreational noise exposure.

Although the use to smartphones is self-regulated, manufacturers, governments and other stakeholders can contribute to creating an environment that encourages safe listening practices. To this end, as part of WHO's Make Listening Safe initiative, WHO and the International Telecommunication Union (ITU) have published a Global Standard for Safe Listening



Users tend to increase the volume on their personal devices when background noise is louder. UNITED KINGDOM

FIGURE 3 EXAMPLES OF INFORMATION PROVIDED ON A SMARTPHONE VISUAL INTERFACE FOR SAFE LISTENING



REPRODUCED WITH KIND PERMISSION FROM ITU H4870

Devices and Systems. The Standard recommends that devices should include a system to track a user's level and duration of exposure to sound as a percentage of a weekly sound allowance (see Figure 3). It also recommends that devices should include options for limiting volume (and for parental control).⁷ ITU have also issued complementary technical guidelines for smartphone manufacturers.

The role of primary health workers at community level

Primary health workers have an important role to play in the prevention of hearing loss associated with non-occupational noise, because unlike exposure to occupational noise, exposure to non-occupational noise is largely self-regulated and requires awareness of noise damage.

At community level, health personnel can help increase awareness of:

- The damaging effect of noise (especially among at-risk populations such as young people).
- Noise levels in everyday life and safe listening behaviours: correct information about safe listening levels and durations is empowering and should be available to all.
- The first signs of hearing loss and the need to consult a health professional when they occur.

Primary health workers can also offer regular hearing checks, which can help identify the onset of hearing loss. High-risk populations (such as secondary school pupils or college students) should be encouraged to have regular check-ups. Schools, offices and communities should be encouraged to organise hearing screening. WHO has developed an app (hearWHO) which can be used by adults to check and track their hearing regularly.⁸ It can also be used by health workers to screen people in the community with a view to referring them for hearing testing, when indicated.

Conclusion

Hearing loss has negative consequences not just on the individual but on society as well. With its continued rise in prevalence, hearing impairment has emerged as an important public health issue requiring continued attention. Awareness of the impact of loud sounds and its mitigation should be raised at all levels: policy-makers, programme managers, health professionals, teachers and the community.

References

- 1 CDC Research on Non-Occupational NIHL. The Hearing Loss. 2017;70(4): 40.
- 2 World Health Organization. Make Listening Safe. Geneva: WHO, 2019. www.who.int/pbd/deafness/activities/MLS/en/
- 3 Solet JM & Barach PR. Managing alarm fatigue in cardiac care. *Progr Pediatr Cardiol* 2012;33(1), 85–90.
- 4 Shargorodsky J et al. Change in prevalence of hearing loss in US adolescents. *JAMA* 2010;304(7): 772–8.
- 5 Henderson E et al. Prevalence of noise-induced hearing-threshold shifts and hearing loss among US youths. *Pediatrics* 2011;127(1): e39–46.
- 6 Taneja MK. Noise-induced hearing loss. *Indian J Otol* 2014;20:151–4.
- 7 WHO-ITU Global Standard for Safe Listening Devices and Systems. www.who.int/deafness/make-listening-safe/standard-for-safe-listening/en/
- 8 WHO. hearWHO app. www.who.int/deafness/hearWHO/en/

Challenging ideas about noise and hearing



Paddy Ricard
Editor, *Community Ear & Hearing Health*, London, UK

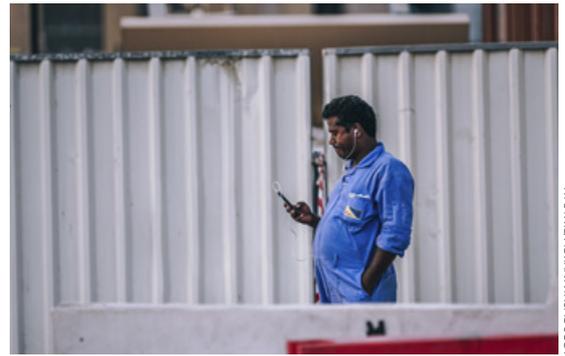
Noise can damage your hearing: this will be the first message primary health workers need to deliver to the community. However, in order to persuade community members to protect their hearing and adopt healthy listening habits, they may need to counter preconceived ideas:

Noise damage does not just concern people with noisy jobs. Some people do indeed work in environments that seem noisy to most of us: factories, building sites, and mines, for example. However, many of us are exposed to dangerous levels of noise in our daily life without realising it. One study even found that half of noise-induced hearing loss occurred in people who did not have noisy jobs.¹

Noise damage is permanent, but it is cumulative so it may be imperceptible for a long time. Noise-induced hearing loss is not an 'injury' we experience straight away. Noise damages sensory hearing cells, temporarily at first, then permanently, but we have many of these cells to start with. It is only when damage is extensive enough that we will perceive it as a problem. By then, it will be much too late.

When your hearing is affected by noise, it may not feel like a hearing 'loss' to begin with. Noise damage may manifest itself as temporary tinnitus (a ringing in your ears), or it may affect sound frequencies that are not 'essential' to your daily life. It may even manifest as a loss of balance.

You cannot always trust your ears to tell you how loud a noise is. You may be unaware of ambient noise because you are focusing on the sound coming out of your personal player through your headphones, or you are focusing on the conversation inside a moving vehicle. You may also have already lost the ability to hear certain frequencies. In all cases,



Worker listening to his phone near a construction site. UAE

noise still damages your hearing even when you are not aware of it.

Safe listening times diminish very sharply as volume increases. Safe listening times, i.e. the duration before which damage to your hearing occurs, decrease very quickly even if you perceive the noise as being just a bit louder (see Table 1).

Many people use smartphones and personal audio devices at unsafe volumes. Portable devices such as smartphones and tablets are increasingly common. They are often used for long periods of time at unsafe volumes,² e.g. during an already noisy commute to work or while exercising in a noisy gym. They may even be used by young people to fall asleep to music. It is estimated that 1.1 billion young people are at risk of hearing loss from recreational noise.²

Volume, distance and duration: these are the three factors you can act on to protect your ears. You can turn the volume down or turn your device off. You can walk away and increase the distance between you and the source of noise. Finally, you can limit the time you are exposed to noise, particularly during your leisure time.

References

- ¹ CDC Research on Non-Occupational NIHL. *The Hearing Loss* 2017;70(4): 40.
- ² WHO. *Make Listening Safe*. Geneva: WHO, 2019. www.who.int/pbd/deafness/activities/MLS/en/

TABLE 1 THE WORLD HEALTH ORGANIZATION'S MAKE LISTENING SAFE INITIATIVE: PERMISSIBLE DAILY NOISE EXPOSURES*

Permissible levels of daily exposure to noise have been identified by WHO, taking into account the total permissible 'dose' of sound that we can safely receive. Eighty decibels for a maximum of 40 hours a week is the permissible duration for safe listening in a non-occupational setting.

Activity	60 dB	65 dB	70 dB	75 dB	80 dB	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB	125 dB	130 dB
Conversation															
Watching television															
Standing by a washing machine															
Using a vacuum cleaner															
Alarm clock (ringing)															
Inside a car in traffic with windows closed															
Using a lawnmower															
Riding a motorcycle															
Using a hair dryer (any type)															
Driving an excavator															
Using a chainsaw															
Being at a music concert															
Using a vuvuzela															
Being very close to thunder															
Standing close to a plane at takeoff															
Decibels	60 dB	65 dB	70 dB	75 dB	80 dB	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB	125 dB	130 dB
Permissible daily noise exposure**	Unlimited				8 hours	2 hours and 30 mins	47 minutes	15 minutes	4 minutes	30 seconds	28 seconds	9 seconds	3 seconds	Less than one second	

**These are only estimates. Effects on hearing will depend on distance from the noise source and duration of exposure.

IMPORTANT! Listening to personal audio devices with earphones can also be unsafe: the output of these devices may range from 75 dB to as high as 136 dB and users typically choose to set the volume between 75 to 105 dB.²

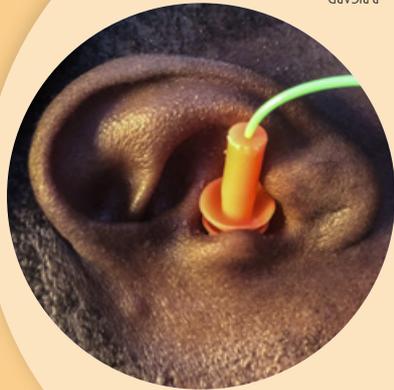
*This table has been extracted from: World Health Organization. *Make Listening Safe*. Geneva: WHO, 2019: 2–3. <https://www.who.int/pbd/deafness/activities/MLS/en/>

Is it too loud?

Noise can permanently damage your hearing
You should limit your exposure to any sound above 80 dB

These signs may alert you to dangerous noise levels in your daily life:

- You cannot hear someone who is standing at an arm's length, or have to raise your voice to be heard by them
- You have to increase the volume on your personal audio device to hear at the usual level (e.g. on public transport or on a plane)
- When you leave a 'noisy' area, speech around you sounds muffled or there is a ringing in your ear
- The sound-measuring app on your phone indicates 80 dB or more



P RICARD

Use earplugs or earmuffs to protect your hearing

Well-fitted and noise-cancelling earphones allow you to hear clearly at lower volumes

Walk away from the noise or take listening breaks



UVEK/PIXABAY

Limit your daily use of personal audio devices (and do not use them to fall asleep to music)

Turn the volume down!

Noise damage accumulates over time, eventually leading to irreversible hearing loss