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due to recreational exposure to loud sounds

A review

World Health Organization

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Hearing loss due to recreational exposure to loud sounds: a review.

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Introduction

Excessive noise is increasingly encountered in many aspects of day-to-day life. Among the many people exposed to noise at their place of work, occupational hearing loss is common, and the cost of compensation is extremely high (*1*). Environmental noise from non-occupational sources such as traffic is also increasing and is responsible for an estimated 1–1.6 million DALYs (disability-adjusted life years) in western European countries, implying an annual loss of 1 million life years in that part of the world (*2*).

Additionally, concern is growing about the ever-greater exposure to noise in recreational settings: unsafe levels of sound are frequently experienced in a variety of non-occupational settings such as nightclubs, discotheques, pubs, bars, cinemas, concerts, live sporting events and even fitness classes (*3*–*7*). Moreover, recreational devices such as personal music players and video game consoles that emit sounds are commonly operated at unsafe volumes. Hearing can be damaged by regular participation in these loud activities (*8*–*11*).

Cause for concern

WHO estimates that 1.1 billion young people worldwide could be at risk of hearing loss due to unsafe listening practices. Nearly half of all teenagers and young adults (12–35 years old) in middle- and high-income countries are exposed to unsafe levels of sound from the use of personal audio devices and some 40% of them are exposed to potentially damaging sound levels at clubs, discotheques and bars.

Analysis of data from the National Health and Nutrition Examination Survey in the United States suggests that, between 1994 and 2006, the prevalence of hearing loss[1] among teenagers (12–19 years old) rose from 3.5% to 5.3% (*12*). Another study from the USA indicates that the number of individuals listening to music through headphones and earphones increased by 75% between 1990 and 2005 (*13*). A 2008 European Commission report noted that personal audio devices are being used by an increasing proportion of the population; from 2004 to 2007, unit sales within the European Union are estimated to have been between 184 and 246 million (*14*). In recent years, music players have been increasingly replaced by smartphones. Worldwide sales of smartphones in 2011 amounted to 470 million units, and this figure is rising (*15*).

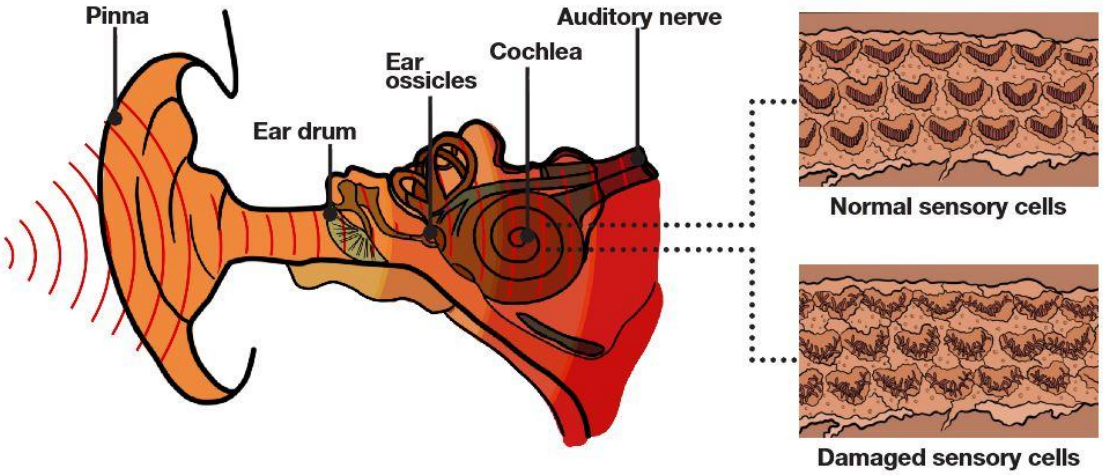
With the increased availability and use of personal audio devices for listening to music and the risky behaviour pattern of their use at high volume over long periods (*16*–*18*), the threat of hearing loss due to recreational exposure to noise is a real one.

How we hear

Ears are the organs that process sounds, enabling the brain to interpret what the individual is hearing. The ear is divided into three parts – outer ear, middle ear, inner ear – each of which has a unique function in the process of hearing. In simple terms, the outer and middle ears amplify the sound signal (vibration) and the inner ear converts this sound signal into an

[1] A person who is not able to hear as well as someone with normal hearing (hearing thresholds of 25dB or better in both ears) is said to have hearing loss.

electrical impulse that is transmitted to the brain. This process also produces a frequency (or pitch) and intensity (or loudness) analysis of the sound signal.



Sounds are complex mixtures of pressure variations and travel in invisible waves through air. When these sound waves reach the ear, the pinna (ear flap) funnels the sound waves into the ear canal. Sound waves travel down the canal to the eardrum, causing it to vibrate. The vibrations are transmitted by the ossicles (three small bones) within the ear to the cochlea, causing movement of the fluid and the sensory cells (hair cells) within the cochlea. The sensory cells convert the vibrations into electrical nerve signals that travel along the auditory nerve to the brain. The brain then interprets these signals as sounds that can be recognized and understood.

There are two types of sensory cells within the cochlea: inner and outer hair cells. The inner hair cells generate the electrical signals that are sent to the brain, while the outer hair cells act as amplifiers, increasing the stimulus delivered to the inner hair cells (*19*). It is important to note that a fixed number of these cochlea sensory cells is present at birth: in humans and other mammalian species, these sensory cells do not regenerate once they have been damaged (*20*).

How noise affects our ears

Excessive exposure to noise – both long-term, repeated exposure to noise and a single exposure to an extremely intense sound – causes damage to the auditory system and results in hearing loss, termed noise-induced hearing loss (*21*–*24*). The hearing loss is usually slow in onset but progresses relentlessly for as long as the exposure continues (*25*). Indeed, the harmful effects may continue long after noise exposure has ceased (*26*); they are irreversible (*20*, *23*).

The damage caused to the cochlea by loud sounds occurs by two means:

- Mechanical destruction (*20*, *27*, *28*). Regular exposure to loud sounds causes the hair cells to lose their rigidity and thus their ability to work effectively. This change occurs

over time until the sensory cells are eventually destroyed and are no longer able to carry out their function (*14*, *20*, *29*).

- Intense metabolic activity at cellular level (*20*, *27*, *28*, *30*, *31*). A higher level of energy is required by hair cells during periods of intense exposure to loud sounds. The consequent increased consumption of oxygen generates raised levels of free radicals in the cochlea. The ear's antioxidant defence mechanism is unable to cope with these levels and the free radicals cause cell death.

The physiological changes to the ear are reflected in a change in hearing sensitivity and/or the development of tinnitus (*2*, *14*, *29*, *32)*. Hearing loss can be temporary or permanent (*29*) and is usually bilateral (*33*).

Temporary or permanent threshold shift

Exposure to loud sounds for any length of time causes fatigue of the ear's sensory cells, resulting in temporary hearing loss or tinnitus (a ringing sensation in the ear). This is termed a temporary threshold shift (temporary loss of hearing). For example, a person who attends a loud concert may come out feeling slightly deaf or experiencing tinnitus (*20*). Hearing usually recovers within a few hours or a day (*34*). Temporary threshold shifts have been reported and measured following attendance at discotheques, rock concerts and sporting events (*35–40*).

Regular or prolonged noise exposure can cause gradual, irreversible damage to the sensory cells and other structures, leading to a permanent threshold shift (permanent hearing loss) (*7*, *9*, *20*, *41*, *42*). Noise-induced hearing loss initially involves the sensory cells that respond to high-frequency (high-pitched) sounds, specifically 4 kHz (*10*, *19*, *32*, *34*, *39*, *40*, *43*). This initial hearing loss may remain unnoticed by the affected individual, since speech comprehension is largely unaffected (*11*). However, continued exposure leads to increasing damage in other frequencies and progression of hearing loss, which begins to interfere with the individual's day-to-day activities (*19*, *20*, *29*, *32*, *42*, *44*). Noise-induced hearing loss adversely affects conversation and communication, especially in the presence of background noise (*14*, *20*, *32*). It also creates difficulty in distinguishing between speech consonant sounds, such as "fish" and "fist" (*32*).

While temporary threshold shift gives no indication of the magnitude of permanent threshold shift, it is a good predictor of the early development of irreversible hearing loss (*41*). For individuals who consistently listen to personal audio devices at high intensities with earbuds, the risk of developing a temporary or permanent threshold shift is a significant concern, particularly when such listening habits persist for a number of years (*45*, *46*). It has been demonstrated that persistent use of personal audio devices for more than five years can lead to changes in high-frequency hearing (4 kHz) (*46*). This hearing loss can be detected on audiological testing through pure tone audiometry (*32*). The audiogram displays a sharp reduction in hearing at frequencies between 3 and 6 kHz. With continued exposure the hearing loss extends to higher and lower frequencies; it is generally bilateral and symmetrical.

Tinnitus

The sensation of sound (e.g. roaring, hissing, or ringing) in the absence of an external sound source is known as tinnitus (*2*, *23*, *47–49*). Often the result of acute or chronic noise exposure, tinnitus can also be the result of other underlying pathologies or be associated with a variety of illnesses (*47*).

Researchers have demonstrated a strong correlation between recreational noise exposure and tinnitus (*50*, *51*). In general, noise-induced tinnitus, like other forms of tinnitus, can be acute or chronic. Acute or temporary tinnitus lasts for relatively short periods (a few seconds to a few days) and usually occurs immediately following exposure to loud sounds. Chronic tinnitus can last for months to years and suggests cochlear injury (*20*). It can be unilateral or bilateral (*47*) and can occur concurrently with hearing loss or in the absence of measureable hearing loss (*2*).

Noise-induced tinnitus due to recreational exposure usually occurs immediately, is transient and can be an indication of early hearing damage (*52*, *53*). Attendance at recreational activities, such as discotheques, clubs, sporting events or music concerts, has been known to result in temporary tinnitus (*6*, *35–38*, *53*). Temporary tinnitus has also been shown to occur in regular users of personal audio devices, although this is less prevalent (*37*, *50*).

Chronic tinnitus following recreational noise exposure is comparatively less frequent than acute tinnitus (*55*). Like hearing loss, chronic tinnitus can lead to sleep disturbance, anxiety, depression, and impaired concentration and communication and thus has a significant impact on quality of life (*2*, *23*, *52*).

Effect of noise-induced hearing loss on presbyacusis (age-related hearing loss)

Inadequate hearing protection during activities like shooting firearms and listening to loud music in adolescence may significantly contribute to communication difficulties in later life. Presbyacusis refers to the progressive and irreversible hearing loss that is common among individuals aged 60–65 years or more (*11*, *56*, *57*). The process of age-related hearing loss in an ear that has not been exposed to noise differs from the pattern of loss that follows regular exposure to noise (*26*, *58*, *59*). Research suggests that exposure to noise, particularly loud noise, is more harmful to the cochlea than the natural process of ageing (*60*). The effect of noise is cumulative and can increase susceptibility and accelerate hearing deterioration in later life, even after the exposure has ceased (*23*, *59*, *61–63*). Hence, cochlear degeneration from early noise exposure can render the ears more vulnerable to the effects of ageing (*58*, *60*, *62*, *64*). However, this association is a complex one as noise-induced hearing loss and presbyacusis frequently co-exist and it is difficult to distinguish between them (*59*, *65*).

Predisposing factors

Certain people may be more susceptible to noise-induced hearing loss than others, meaning that individuals who experience identical noise exposure may develop different degrees of hearing damage (*32*). Genetic predisposition, age, chronic conditions such as diabetes and hypertension, and exposure to cigarette smoke can increase the risk of acquiring noise-induced hearing loss. Pre-existing sensorineural hearing loss, use of ototoxic medications

and exposure to solvents also predispose to the development of hearing loss (*32*, *59*, *66*). However, since it is impossible to identify the most susceptible individuals, and since noise-induced hearing loss is irreversible, prevention is the most effective strategy.

How can noise-induced hearing loss be treated?

There is no medical or surgical cure for noise-induced hearing loss: damaged hair cells cannot regenerate (*20*, *32*, *67*). Once hearing loss begins, however, its progression can be halted by avoiding further exposure to loud sounds (*19*).

Current treatment methods for noise-induced hearing loss focus on people in severely noisy environments such as the military. Approaches such as placement in a quiet room or hyperbaric oxygen therapy immediately following exposure to the loud sound aim to prevent further damage (*67*, *68*). Post-exposure antioxidant and pharmacological therapy have also been shown to be partially effective and to prevent further sensory cell damage (*27*, *68*–*72*).

Currently, no pharmacological agents are available for prevention or reversal of noise-induced hearing loss. Nevertheless, there have been recent advances in this area and it is claimed that preventive medications are likely to be available in the near future (*73*). Other areas of scientific research are focusing on gene and stem-cell therapies (*74*, *75*). At present, there are only limited management options – such as hearing aids and counselling – for individuals with even a low degree of noise-induced hearing loss (*19*, *49*, *76*).

Other negative impacts of loud sounds

Noise-induced hearing loss can affect many aspects of life. In young children, it impairs language acquisition (*20*, *30*, *77*, *78*). Learning disabilities, anxiety and attention-seeking behaviours are also common in children exposed to loud sounds (*11*). The impact of chronic noise exposure in children is reflected in lowered academic performance and outcomes as well as reduced motivation and concentration (*23*, *38*, *79*–*89*).

The use of personal audio devices is becoming commonplace in educational institutions in developed and developing countries alike. These portable devices often make distribution of educational material easier, particularly to students in remote locations (*90*–*92*). They offer flexibility, allowing students to access information (e.g. lecture material) at any time and while participating in other activities, such as commuting, exercising or doing housework (*93*–*96*). They have been particularly beneficial in learning languages and music (*94*, *97*–*100*).

Using personal audio devices in the educational setting also appeals to students, who are familiar and comfortable with the technology. Students benefit from being able to record lectures, listen to podcasts and download books (*98*, *101*, *102*). However, some schools and universities prohibit the use of personal audio devices because of concerns about reduced communication and social isolation (*103*, *104*). Studies suggest that misuse or overuse of these devices will lead to cognitive overload and result in impaired performance (*86*, *105*).

Road safety

Exposure to loud sound is also of concern with respect to road safety for pedestrians, motorists and cyclists. The number of people using media players while driving, cycling or walking has risen, resulting in less safe road-use behaviour (*106–108*). These devices are a source of distraction and can affect the individual's responses and compromise road safety (*106*, *107*, *109*). It is reported that listening to music, particularly when earbuds are used, worsens auditory perception *107*, *110–112*). College students also do often listen to personal audio devices with earbuds while engaged in activities that require auditory attention in order to avoid danger, such as walking, jogging, cycling and driving (*45*). Use of noise-cancelling headphones can also pose a risk to safety (*113*).

Cyclists who listen to music on a portable music device are more likely to exhibit unsafe behaviours than those who do not use such devices (*114*). A study focused on teenage cyclists revealed that they tend to listen to music while cycling and are more likely than younger or older individuals to be involved in crashes when using personal audio devices (*115*). Listening to music does not appear to have an influence on cyclists' speed but it does impair their ability to respond to other auditory stimuli (*107*, *110*, *116*).

Pedestrians using personal audio devices receive less auditory information from their surroundings and are thus are less aware of important alerting signals, e.g. car horns (*106*, *117–119*). Young pedestrians who are distracted by music from personal audio devices while crossing the street have a higher risk of being hit by a vehicle (*112*). Some authors indicate mixed results, with some pedestrians exhibiting over-cautious behaviour and others unsafe behaviour (*118–120*). The risk is greater for elderly pedestrians who are more vulnerable than younger people to the hazards of crossing roads while listening to music (*105*, *121*)

As portable audio technologies become ever more commonplace and widely used, it is likely that safety problems related to inattention and distraction will increase (*122*).

What is safe listening?

Ears are designed to process the moderate levels of sound that exist in our normal environment (e.g. quiet conversation). Common recreational activities (e.g. rock concerts, listening to personal music players), however, often involve exposure to much higher sound levels for extended periods (*8*), and scientific evidence is accumulating to demonstrate that these recreational noise activities are potentially harmful to hearing (*4*, *123*). The factors that determine the level of risk are the intensity and duration of noise exposure.

The human ear is capable of detecting a large range of sound intensities (loudness levels) from extremely soft to extremely loud. The unit of measurement used to express the intensity of a sound is the decibel (dB). Measurement of sound intensity in decibels is based on a logarithmic scale, which allows the extreme range of sound intensities audible to humans to be quantified in manageable numbers. Thus, 10 dB is 10 times more intense than 1 dB and 20 dB is 100 times more intense than 1 dB.

The healthy hearing threshold is generally taken as 0 dB (11); a whisper is around 30 dB and normal conversation approximately 60 dB (124). Some common sounds and their intensities (dB) are indicated below.[1]

Device/situation	dB (approximate)
Ticking watch	20
Soft whisper	30
Refrigerator hum	40
Normal conversation	60
Air-conditioner hum	65
Washing machine	70
Vacuum cleaner	75
Alarm clock 60 cm away	80
Heavy city traffic (inside the car)	85
Lawn mower (gasoline)	90
Motorcycle (average)	95
Hairdryer, subway train, car horn at 5 m	100
MP3 player at maximum volume, chainsaw	105
Shouting into the ear	110
Loud rock concerts	115
Spectator trumpet (*vuvuzela*) 1 m from trumpet opening, sirens	120
Jackhammer, jet plane 30 m away	130
Firecrackers, firearms	150

Safe listening levels depend on the intensity (loudness) and duration of exposure (*19*, *32*). These two factors are interrelated (*19*, *32*, *128*) and contribute to the overall sound energy level to which the individual is exposed. Effectively, the total amount of sound energy to which an individual can safely be exposed remains constant: the sound energy of lower volumes listened to over long periods of time is the same as that louder sounds heard for over a short period. Permissible levels of daily exposure to noise have been defined on this basis, taking into account the daily permissible dose of sound; they have been calculated for occupational settings and are extrapolated for application in recreational settings.

[1] Sources: references *24*, *125*–*127*.

Daily permissible noise level exposure[a]	
Time per day	**Sound level (L_{Aeq}), dB**
25 hours	80
8 hours	85
2 hours 30 minutes	90
47 minutes	95
15 minutes	100
4 minutes	105
1 minute 30 seconds	110
28 seconds	115
9 seconds	120

[a] http://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf : p. 2.

The highest safe exposure level is considered to be 85 dB for up to a maximum of 8 hours (*33*, *129–132*). The permissible time for safe listening decreases as sound levels increase. Thus, the safe duration of exposure to a sound level of 100 dB — the level produced by a subway train – is only 15 minutes a day. The output of personal audio devices may range from 75 dB to as much as 136 dB (*11*); maximum output levels vary with the regulations and legislation in different parts of the world. Typically, users of personal audio devices set the volume between 75 and 105 dB (*34*).

At discotheques, bars and clubs, mean sound levels can range from 104 to 112 dB. Noise levels at pop concerts may be even higher (*34*), and 15 minutes of music at 100 dB may represent the same noise level exposure as that experienced by an industrial worker in an 8-hour day at 85 dB (*11*).

High sound levels are also encountered at popular sporting events, which are frequented by adolescents and young adults (*54*, *127*, *133–136*). Noise levels at sporting venues have been found to range from 80 to 117 dB (*40*, *54*, *127*, *136*, *137*). The average noise exposure for spectators during the FIFA World Cup in 2010 was as high as 100.5 dB (*127*).

Adults and adolescents are not the only age groups exposed to louder sounds. Some common children's toys, such as rattles, toy phones and guns, are capable of generating unsafe intensities ranging from 110 to 150 dB (*30*, *138*). Moreover, the danger is probably underestimated as children have a tendency to hold such toys closer to their ears, which increases the intensity (*30*).

The sound intensity levels involved in various common pastimes and activities have been reported as summarized below:

Recreational activity	Intensity of sound (dB)	Average time of activity	Reference
Rattles and squeaky toys	110 (max.)		*30*
Musical toys, drums and horns	120 (max.)		*30*
Toy phones	Range 123–129		*30*
Toy guns	150 (max.)		*30*
Ice hockey game	Range 103.1–110.7	>3 hours	*54*
Ice hockey game	Range 81–97, peak 105–117		*136*
Soccer match	92.7	90 minutes	*137*
Soccer match	100.5		*127*
Basketball game	84.64	2 hours	*40*
Sporting event	Range 85–100		*3*
Sporting event	Mean 93	2.5 hours	*139*
Aerobics class	89.6		*140*
Fitness class	Range 73–96		*141*
Fitness class	Mean 87.1, range 83.4–90.7		*142*
Fitness class	Range 78–106	60 minutes	*143*
Fitness class	Mean 98.8	52.8 minutes	*144*
Fitness class	Range 74–97		*3*
Fitness class	Mean 86	Mean 1.4 hours	*139*
Nightclub	Average 110.2, range 107.8–112.2	4 hours a week	*9*
Entertainment venue	Mean exceeded 95	5 hours per session	*145*
Concert, live music venue	Range 82–105		*3*
Concert, live music venue	Mean 92	Mean 3 hours	*139*
Nightclub	Mean estimated sound pressure level is 101, range 85–10 5	Mean 4.3 hours/week	*37*
Clubs	Average 97.9	5 hours per week	*5*
Discotheque	Ranged 104.3–112.4		*34*

Club	Range 94.9–106.7		*7*
Nightclub	Exceeded 87		*146*
Nightclub	Range 89–106		*3*
Nightclub	Mean 97	3.3 hours	*139*
Pub bar, registered club	Range 71–96		*3*
Pub or registered club	Mean 84	2.7 hours/visit	*139*

Even a brief exposure to high decibel levels can be harmful. For young people particularly, noise exposure is often not from a single recreational source (*18*). Environmental and occupational noise exposure also contributes to the overall risk of an individual.

While habitual exposure can certainly lead to hearing loss over time, noise-induced hearing loss can be *prevented* by following safe listening practices.

Preventing noise-induced hearing loss

The effect on the auditory system of exposure to loud sounds or noise is cumulative and irreversible, and effective treatment is limited (*11*, *32*, *61*). However, noise-induced hearing loss is completely avoidable: prevention is thus paramount, and efforts to preserve hearing and prevent tinnitus should be made wherever hazardous noise is present (*7*, *23*, *32*, *49*, *67*, *147–151*). Special mention should be made of developing countries, where preventive programmes and access to health services are limited and legislation may be inadequately enforced, even in occupational settings (*152*), .

A number of prevention strategies can be employed to preserve hearing. The chosen approach will depend on the source of loud sound (e.g. personal audio device or rock concert) and the motivation of the individual. Motivation, in turn, often depends on the individual's perception of the health threat; understanding this is important for the development of effective prevention strategies (*153*).

In general, people are less tolerant of noise and more motivated to take protective action if they have experienced symptoms such as tinnitus or have a positive attitude towards hearing health (*44*, *154–158*). If noise-induced hearing loss is perceived as of lesser priority than other health issues, the level of motivation is likely to be lower (*36*, *159*, *160*). The attitude that noise is enjoyable and that its enjoyment is a part of the individual's "image" is likely to hinder the practice of safe listening (*35*, *154*, *161*).

Prevention

The impact of loud sounds on hearing depends on three main factors: sound intensity (volume), duration of exposure and distance from the sound source. By regulating all or one of these variables, it is possible to protect the ears (*11*, *29*, *30*, *35*, *61*, *162–171*).

Knowing which loud sounds have the potential to cause harm to the auditory system is the first step towards prevention (*172*). Avoiding these loud sounds is one of the easiest ways to prevent damage. In recreational settings this is not always achievable or practical (*11*, *19*, *30*,

162): individuals usually seek out these sound sources for pleasure, and so practical strategies, other than avoidance, need to be implemented.

Strategies for prevention of harm from exposure to loud sounds are the responsibility of individuals, communities and governments. Preventive action at each of these levels is imperative. Individuals can take responsibility for their own hearing health by following a number of basic and practical steps as suggested by experts in the field. These are outlined below.

Strategies

- **Keeping the volume down.** The recommended safe volume level is below 85 dB. Sounds could be too loud if:
  - other people must raise their voice to make themselves understood;
  - it is difficult to understand someone an arm's length away;
  - listeners develop pain or a ringing sensation in the ear.

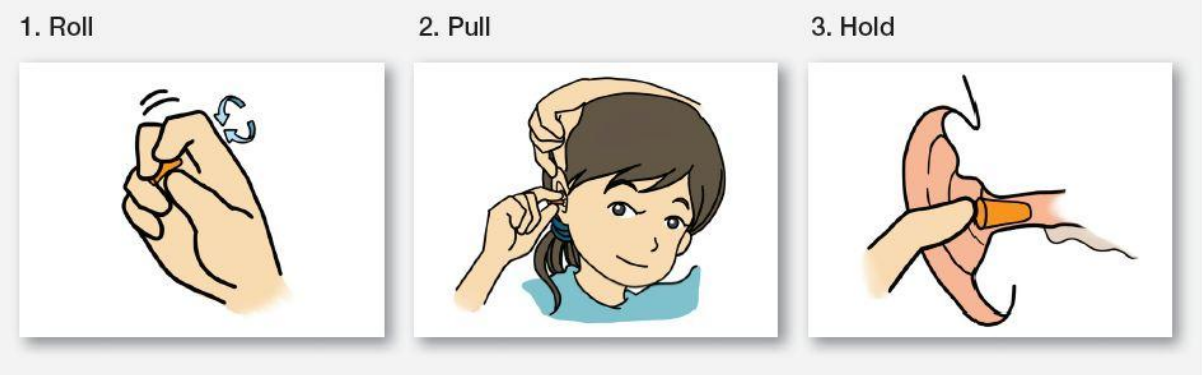
  Even a small reduction in volume can offer significant protection.
- **Using carefully fitted earbuds,** which allow music to be heard clearly at lower volumes.
- **Using noise-cancelling earphones or headphones, which can reduce the need to raise the volume on listening devices.** Personal audio devices can be turned up to harmful levels (*164*, *173*) although the majority of listeners do not always listen to these devices at such high volumes (*174–177*). Preferred volumes for listening often depend on the level of background noise: in places with high ambient noise levels (e.g. subways, trains, aircraft), there is a tendency to increase the volume. Use of noise-cancelling earphones or headphones can reduce the need to raise the volume in such surroundings. By cutting down background noise, these headphones/earphones allow personal audio devices to be used at lower volumes than would otherwise be needed (*147*, *167*, *168*, *170*).
- **Monitoring noise exposure.** Smartphone technology can be used to measure noise exposure levels and inform users about their risk for noise-induced hearing loss. Independently-developed applications ("apps") are currently available for many devices. Many of these apps display noise intensity in decibels and can inform the user of whether the level of exposure is a risk for hearing loss, often using a colour-coded scale or reference to activities that involve similar risk. Any individual who wishes to estimate his or her noise exposure levels could easily download one of these apps to a smartphone and use it to collect information about their environment and risk for hearing loss (*30*, *178–181*).

  It should be noted, however, that the accuracy of these apps is not completely reliable and caution is needed when using them to evaluate and assess potential risk. An analysis of 50 different apps indicated that only one was accurate to within 5 dB. Nevertheless, this type of app can act as a complementary educational tool, raising awareness among young people of the risk of noise-induced hearing loss (*181*, *182*).
- **Limiting the time spent engaged in noisy activities**
  - Small listening breaks can help to reduce exposure.
  - Limiting headphones/earphones use to less than one hour a day is ideal.

- The time spent in noisy environments should be limited.

- **Moving away from loud sounds.** At a noisy venue, it is better to stay as far away as possible from sources such as loudspeakers (*30*). If the individual has to raise his or her voice to be heard above the noise by someone at arm's length (1 m away), this is a good indicator that the sound is too loud (*147*, *183*). Moving to quieter locations within venues can reduce the level of exposure.

- **Wearing earplugs.** When visiting discotheques, bars, sporting events and other noisy places or participating in rifle shooting, use of hearing protection helps to avoid damage to hearing (*29*, *35*, *144*, *165*, *166*). Many countries have legislated, to a varying degree, on the use of personal hearing protection in the occupational setting. However, there is little in the way of legislation, guidelines or recommendations for use of hearing protection for recreational noise exposure (*184*).



Hearing protection devices can be broadly classified as either earplugs, which are inserted at the entrance of the ear canal, or earmuffs, which cover the outside of ear (*185*). Although neither will completely block out all sound (*147*), measurements of efficacy suggest that such devices can reduce exposure to loud sound by 5–45 dB if they are correctly used (*147*, *165*, *186*, *187*). There is no significant difference between earplugs and earmuffs: both block sounds similarly and have the same long-term effects on the auditory system (*185*, *186*, *188*).

The effectiveness of hearing protection depends on its correct and consistent use. Consistent use of properly inserted earplugs, throughout the entire period of exposure can significantly reduce the level of exposure and is important to preserving hearing and reducing the risk of tinnitus (*11*, *29*, *30*, *35*, *41*, *49*, *53*, *144*, *147*, *163*, *165*, *166*, *186*, *189–192*). Using a lower attenuating earplug or earmuff correctly and consistently can be more effective than using a higher-rated product incorrectly and sporadically (*147*).

- **Respecting safe listening levels**. All users of personal audio devices should identify the safe listening level for their particular equipment and not exceed that level (*6*, *11*, *30*, *174*, *193*):

- Set the volume to a comfortable level in a quiet environment and avoid raising it in noisy environments; the volume should be no more than 60% of maximum.
- Smartphone apps can be used to monitor the output levels of personal audio devices and ensure that they are below 85 dB.

It is important to be alert to the following warning signs of hearing loss and seek help from a hearing health care professional if the signs appear (*23*, *49*, *76*):

- ringing in the ears (tinnitus);
- difficulty in hearing high-pitched sounds (birds singing, doorbell, telephone, alarm clock);
- difficulty understanding speech, especially over the telephone;
- difficulty in following conversations in noisy environments, such as in restaurants or at social gatherings.

- **Regular hearing check-ups**. Regular check-ups can help to identify the onset of hearing loss. High-risk populations (secondary school pupils or college students) should be encouraged to have regular hearing checks. Schools, offices and communities should be encouraged to organize hearing screening.
- **Being aware.** Correct information about safe listening levels and times is empowering and should be available to all. It is important for users of MP3 players, ear- and headphones, etc. to learn more about these products and their safety features. If earbuds are used with these devices they should fit well and be worn correctly. Use of noise-cancelling earphones or headphones should be considered if music devices are used frequently in noisy environments, such as on trains or aircraft, .

Because noise-induced hearing loss is irreversible, prevention is the most effective strategy. If tinnitus or some loss of hearing loss is already apparent, caution should be exercised and exposure to loud sounds limited.

What is being done?

Awareness is growing of the risk associated with recreational noise exposure as a contributing factor to hearing loss. Several strategies have been implemented at community and government levels around the world, but their scope varies by country.

Legislation

A number of legislative measures relating to environmental noise and occupational exposure are in place in many countries although they vary in scope and sophistication (*194*). Fewer countries have legislative measures pertaining specifically to recreational noise exposure.

For instance countries of the European Union, China and New Zealand have legislation in place to protect employees who work in the entertainment/recreational sector (bars, concerts, discotheques, nightclubs) from exposure to unsafe noise (*33*, *195–199*). Legislation addresses the criteria for acceptable noise levels, acceptable control procedures and monitoring procedures to ensure that legislative requirements are met (*33*).

From the available data and a review of English-language legislation, it is evident that most countries of the world still have no legislation to control recreational noise exposure, either for recreational venues or with respect to the maximum output levels of personal audio devices.

There are a few examples of legislation that targets recreational noise exposures. In 2009, the European Commission issued a directive that output levels of new audio devices should be set to a standard of 85 dBA, allowing users to increase the volume to a maximum of 100 dBA. According to the directive, raising the volume to maximum level must prompt a warning message stating that hearing loss can occur at this level (*200*).

In April 2014, the Minneapolis City Council passed an ordinance making it compulsory for bars and clubs to offer free earplugs to patrons. Such a directive can have far-reaching impact, reducing the risk of noise exposure for those who frequent these entertainment venues (*201*).

Legal interventions have proved effective for many sentinel public health achievements (*202*, *203*). Hence, it is important for legislation to address public health issues such as exposure to noise, in order to bring about a sustained behavioural change.

Other interventions are also possible. For example, a leading manufacturer of personal audio devices has developed software that allows customers easily to set their own customized maximum volume limit. It also gives parents the ability to set a maximum volume limit on a child's device, locking it with a combination code (*204*). Another device displays an on-screen message warning that the user has reached dangerous listening levels and may want to turn the volume down (*205*). Such measures help raise awareness of the harmful effects of loud sounds.

Messages about the potential harm from recreational noise exposure can also be transmitted through education conservation programmes or campaigns. This approach has been widely used in a number of countries to raise awareness about safe listening practices, even in the absence of legislation.

Key target populations for prevention campaigns at the community level are children, teenagers and their parents (*6*, *10*, *13*, *44*, *53*, *55*, *206*–*210*). Children and teenagers appear to be most at risk from exposure to loud sounds associated with recreational activities (*158*). The effectiveness of such programmes and campaigns in improving knowledge, establishing attitudes to loud sounds and encouraging appropriate behaviours has been demonstrated, particularly among young people (*11*, *123*, *151*, *211*–*218*).

The following are examples of preventive campaigns:

- Listen To Your Buds (*219*) – a public education campaign launched by the American Speech and Hearing Association (ASHA) to educate children and parents about practising safe listening habits when using personal audio devices. It does this through a variety of bilingual media and public outreach tactics, partnerships with companies and organizations, "safe listening concerts" in schools, and dissemination of information throughout the school system.
- Dangerous Decibels (*220*) – a public health campaign that aims to reduce the incidence and prevalence of noise-induced hearing loss by changing knowledge, attitudes and behaviours of school-aged children. Through education and the use of exhibits, the

programme has been successful in producing long-term improvements in students' knowledge of noise and its effects.

- It's a Noisy Planet: Protect their Hearing (*221*) – a programme of the National Institute on Deafness and Other Communication Disorders (NIDCD) that uses social media, school presentations, awareness materials, conferences and exhibits to promote healthy hearing habits among parents and pre-teens.
- Don't Lose the Music (*222*) – a campaign by Action on Hearing Loss, a nongovernmental organization based in the United Kingdom, that aims to increase awareness and promote safe listening habits among music lovers through innovative messages.
- Cheers for Ears campaign – a school health programme designed by the Ear Science Institute of Australia to educate young people and encourage healthy behaviours to prevent noise-induced hearing loss.
- NOISE (Non-occupational Incidents, Situations and Events) database (Beach, 2013b): – the National Acoustic Laboratories in Australia maintains a detailed and standardized record of sound levels at non-occupational leisure events. It provides researchers and health professionals with realistic estimates of the noise exposure involved in various non-work activities.

What can be done

What can parents do?

Parents need to play an active role in educating their children about safe listening and monitoring their exposure to loud noise; they also need to be role models of safe listening for their children (6, 11, 123, 139, 151, 153, 193, 206, 223, 224).

What can teachers do?

Children and adolescents must be educated about the possible dangers of exposure to loud sounds from the misuse of personal audio devices and encouraged to develop safe listening habits. Such information should be part of the health education curriculum and also be taught as part of music and dance classes (6, 11, 23, 139, 151, 153, 193, 206, 224, 225, 226, 227).

What can physicians do?

Physicians have a significant opportunity to educate and counsel adolescents and young adults regarding hearing protection (36, 159). Physicians, nurses, audiologists and speech-language pathologists can convey appropriate messages about the risks and promote healthy listening habits among users (226).

What can managers do?

Managers of venues in which noise levels are high – nightclubs, discotheques, bars, pubs, cinemas, concerts, sporting events and even fitness classes – have an important role to play in ensuring the personal safety of people who frequent such venues. To make listening safe, they can: monitor and apply the safe noise limit set by the establishment itself ; make use of sound limiters to control noise levels in such settings ; provide free earplugs to all patrons along with information about their proper use as well as “chill out” rooms, where volume levels are monitored and safe; and prominently display messages about the risk of hearing loss during moments when the volume goes beyond safe levels (3, 139, 154, 215, 228, 229, 230).

What can manufacturers do?

Manufacturers of personal audio devices possess the technical knowhow to design these devices with appropriate safety features, and a number have already taken steps to put in place these features. For example, software developed by a leading manufacturer of personal audio devices allows customers to easily set their own customized maximum volume limit. It also gives parents the ability to set a maximum volume limit on their child’s device and lock it with a combination code. Another device displays an on-screen message displaying the average dB level at different volume settings, along with a warning to keep the output below 85 dB (3, 231). Such measures offer protection and help raise awareness about the harmful effects of loud music and other noise. Manufacturers can also provide prominent warning labels on the products themselves, as well as on the external packaging and accompanying information materials (231).

What can governments do?

For their part, governments are encouraged to develop stricter laws and rigorously enforce already existing legislation regarding non-occupational noise (38, 112, 159). Governments can raise awareness about the issue through targeted public information campaigns highlighting the potential consequences of hearing loss (45, 112, 115, 119, 232). Creative use of those means of communication which are most often used by teenagers and young adults, including various social media platforms, would help to disseminate messages on the importance of safe listening (36, 38, 44, 139).

References

1. Noise and hearing loss prevention. Atlanta, GA: Centers for Disease Control and Prevention; 2014 (http://www.cdc.gov/niosh/topics/noise/, accessed 21 November 2014).
2. Fritschi L, Brown AL, Kim R, Schwela D, Kephalopoulos S, editors. Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. Copenhagen: WHO Regional Office for Europe; 2011 (http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf, accessed 21 November 2014).
3. Beach E, Williams W, Gilliver M. Estimating young Australian adults' risk of hearing damage from selected leisure activities. Ear Hear. 2013b;34(1):75–82.
4. Carter L, Williams W, Black D, Bundy A. The leisure-noise dilemma: hearing loss or hearsay? What does the literature tell us? Ear Hear. 2014;35(5):491–505.
5. Williams W, Beach EF, Gilliver M. Clubbing: the cumulative effect of noise exposure from attendance at dance clubs and night clubs on whole-of-life noise exposure. Noise Health. 2010;12(48):155–8.
6. Gilliver M, Beach EF, Williams W. Noise with attitude: influences on young people's decisions to protect their hearing. Int J Audiol. 2013:52(Suppl. 1):S26–32.
7. Gunderson E, Moline J, Catalano P. Risks of developing noise-induced hearing loss in employees of urban music clubs. Am J Ind Med. 1997;31(1):75–9.
8. Zhao F, Manchaiah VK, French D, Price SM. Music exposure and hearing disorders: an overview. Int J Audiol. 2010;49(1):54–64.
9. Serra MR, Biassoni EC, Hinalaf M, Abraham M, Pavlik M, Villalobo JP et al. Hearing and loud music exposure in 14–15 years old adolescents. Noise Health. 2014;16(72):320–30.
10. Biassoni EC, Serra MR, Hinalaf M, Abraham M, Paylik M, Villalobo JP et al. Hearing and loud music exposure in a group of adolescents at the ages of 14–15 and retested at 1718. Noise Health. 2014;16(72):331–41.
11. Daniel E. Noise and hearing loss: a review. J Sch Health. 2007;77(5):225–31.
12. Shargorodsky J, Curhan SG, Curhan GC,Eavey R. Change in prevalence of hearing loss in US adolescents. JAMA. 2010;304(7): 772–8.
13. Henderson E, Testa MA, Hartnick C. Prevalence of noise-induced hearing-threshold shifts and hearing loss among US youths. Pediatrics. 2011;127(1):e39–46.
14. Potential health risks of exposure to noise from personal music players and mobile phones including a music playing function. Brussels: European Commission, Scientific Committee on Emerging and Newly Identified Health Risks: 2008.
15. Minges M. Key trends in the development of the mobile sector. In: 2012 Information and cmmunications for development: maximizing mobile. Washington, DC: World Bank; 2012:115–34.

16. Vogel I, Verschuure H, van der Ploeg CP, Brug J, Raat H. Estimating adolescent risk for hearing loss based on data from a large school-based survey. Am J Public Health. 2010;100(6):1095–100.

17. Vogel I, van de Looij-Jansen PM, Mieloo CL, Burdorf A, de Waart F. Risky music-listening behaviors and associated health-risk behaviors. Pediatrics 2012;129(6):1097–103.

18. Portnuff CD, Fligor BJ, Arehart KH. Teenage use of portable listening devices: a hazard to hearing? J Am Acad Audiol. 2011;22(10):663–77.

19. Prevention of noise-induced hearing loss. Report of an informal consultation. Geneva: World Health Organization; 1997 (http://www.who.int/pbd/deafness/en/noise.pdf, accessed 10 October 2014).

20. Harrison RV. Noise-induced hearing loss in children: a 'less than silent' environmental danger. Paediatr Child Health. 2008;13(5):377–82.

21. Babisch W. Noise and health. Environ Health Perspect. 2005;113(1):A14–5.

22. Punch JL, Elfenbein JL, James RR. Targetinghearing health messages for users of personal listening devices. Am. J Audiol. 2011;20(1):69–82.

23. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S et al. Auditory and non-auditory effects of noise on health. Lancet. 2014;383:1325–32.

24. Noise-induced hearing loss. Bethesda, MD: National Institute on Deafness and Other Communication Disorders; 2014 (NIDCD Fact Sheet; NIH Pub. No. 14-4233; http://www.nidcd.nih.gov/staticresources/health/hearing/NIDCD-Noise-Induced-Hearing-Loss.pdf, accessed 22 October 2014).

25. Forge A. Mechanisms of hearing loss of cochlear origin. In: Newton V, Alberti P, Smith A, editors. Prevention of hearing loss. New York: Nova Science Publishers; 2012:63–5.

26. Gates GA, Schmid P, Kujawa SG, Nam B, D'Agostino R. Longitudinal threshold changes in older men with audiometric notches. Hear Res. 2000;141(1–2):220–8.

27. Le Prell CG, Yamashita D, Minami SB, Yamasoba T, Miller JM. Mechanisms of noise-induced hearing loss indicate multiple methods of prevention. Hear Res. 2007;226(1–2):22–43.

28. Kopke RD, Coleman JKM, Liu J, Jackson RL, Van De Water TR. Mechanisms of noise-induced hearing loss and otoprotective strategies. In: Van De Water TR, Staecker H, editors. Otolaryngology: basic science and clinical review. New York: Thieme; 2006:395–408.

29. Sliwinska-Kowalska M, Davis A. Noise-induced hearing loss. Noise Health. 2012;14(61):274–80.

30. Levey S, Fligor BJ, Ginocchi C, Kagimbi L. The effects of noise-induced hearing loss on children and young adults. Contemp Issues Commun Sci Disord. 2012;39:76–83.

31. Henderson D, Bielefeld EC, Harris KC, Hu BH. The role of oxidative stress in noise-induced hearing loss. Ear Hear. 2006;27(1):1–19.

32. Hong O, Kerr MJ, Poling GL, Dhar S. Understanding and preventing noise-induced hearing loss. Dis Mon. 2013;59(4):110–8.

33. Thorne PR. Noise induced hearing loss. Report. Auckland: Auckland UniService Ltd; 2008 (http://www.acc.co.nz/PRD_EXT_CSMP/groups/external_ip/documents/reports_results/wim2_065096.pdf, accessed 21 November 2014).

34. Serra MR, Biassoni EC, Richter U, Minoldo G, Franco G, Abraham S et al. Recreational noise exposure and its effects on the hearing of adolescents. Part I: an interdisciplinary long-term study. Int J Audiol. 2005;44(2):65–73.

35. Bogoch I, House RA, Kudla I. Perceptions about hearing protection and noise-induced hearing loss of attendees at rock concerts. Can J Public Health. 2005;96(1)69–72.

36. Chung JH, Des Roches CM, Meunier J, Eavey RD. Evaluation of noise-induced hearing loss in young people using a web-based survey technique. Pediatrics. 2005;115(4):861–7.

37. Smith PA, Davis A, Ferguson M, Lutman ME. The prevalence and type of social noise exposure in young adults in England. Noise Health. 2000;2(6):41–56.

38. Bistrup ML, Keiding L, editors. Children and noise – prevention of adverse effects. Copenhagen: National Institute of Public Health; 2002 (http://www.si-folkesundhed.dk/upload/noiseprevention.pdf, accessed 21 November 2014).

39. Holland NV III. Sound pressure levels measured in a university concert band. Appl Res Music Educ. 2008:27(1):3–8.

40. England B, Larsen JB. Noise levels among spectators at an intercollegiate sporting event. Am J Audiol. 2014:23(1):71–8.

41. Noise and hearing loss. NIH Consensus Statement. 1990;8(1):1–24 (http://consensus.nih.gov/1990/1990NoiseHearingLoss076html.htm, accessed 22 October 2014).

42. Clark WW, Bohne BA. Effects of noise on hearing. JAMA. 1999;281(17):1658–9.

43. Yassi A, Pollock N, Tran N, Cheang M. Risks to hearing from a rock concert. Can Fam Physician. 1993;39:1045–50.

44. Gilles A, Van Hal G, De Ridder D, Wouters K, Van de Heyning P. Epidemiology of noise-induced tinnitus and the attitudes and beliefs towards noise and hearing protection in adolescents. PLoS One. 2013;8(7):e70297.

45. Danhauer JL, Johnson CE, Byrd A, DeGood L, Meuel C, Pecile A et al. Survey of college students on iPod use and hearing health. J Am Acad Audiol. 2009;20(1):5–27.

46. Kim MG, Hong SM, Shim HJ, Kim YD, Cha CI, Yeo SG. Hearing thresholds of Korean adolescents associated with the use of personal music players. Yonsei Med J. 2009;50(6):771–6.

47. Langguth B, Kreuzer PM, Kleinjung T, De Ridder D. Tinnitus: causes and clinical management. Lancet Neorol. 2013;12(9):920–30.

48. Mollasadeghi A, Mirmohammadi SJ, Mehrparvar AH, Davari MH, Shokouh P, Mostaghaci M et al. Efficacy of low-level laser therapy in the management of tinnitus due to noise-induced hearing loss: a double-blind randomized clinical trial. Scientific World Journal. 2013;2013:596076.

49. Rabinowitz PM. Noise-induced hearing loss. Am Fam Physician. 2000;61(9):2749–56, 2759–60.

50. Figueiredo RR, Azevedo AA, Oliveira PM, Amorim SP, Rios AG, Baptista V. Incidence of tinnitus in MP3 player users. Braz J Otorhinolaryngol. 2011;77(3):293–8.

51. Davis AC, Lovell EA, Smith PA, Ferguson MA. The contribution of social noise to tinnitus in young people – a preliminary report. Noise Health.1998;1(1):40–6.

52. Axelsson A, Prasher D. Tinnitus induced by occupational and leisure noise. Noise Health. 2000;2(8):47–54.

53. Degeest S, Corthals P, Vinck B, Keppler H. Prevalence and characteristics of tinnitus after leisure noise exposure in young adults. Noise Health. 2014;16(68):26–33.

54. Hodgetts WE, Liu R. Can hockey playoffs harm your hearing? CMAJ. 2006;175(12):1541–2.

55. Widén SE, Erlandsson SI. Self-reported tinnitus and noise sensitivity among adolescents in Sweden. Noise Health, 2004;7(25):29–40.

56. Weston TET. Presbyacusis: a study. J Coll Gen Pract. 1964;7:191–8.

57. Skelton D. Hearing impairment in the elderly. Can Fam Physician. 1984;30:611–5.

58. Rosenhall U. The influence of ageing on noise-induced hearing loss. Noise Health. 2003;5(20):47–53.

59. Kujawa SG, Liberman MC. Acceleration of age-related hearing loss by early noise exposure: evidence of a misspent youth. J Neurosci. 2006;26(7):2115–23.

60. Gonçalves CGO, Mota PHM, Marques JM. Noise and age: influence on the hearing of individuals with ages between 50–70 years. Pró-Fono Revista de Atualização Científica. 2009;21(4):57–61.

61. Harrison RV. The prevention of noise-induced hearing loss in children. Int J Pediatr. 2012; 2012: 473541.

62. Gates GA, Mills JH. Presbyacusis. Lancet. 2005;366:1111–20.

63. Toppila E, Pyykkö, Starck J. Age and noise-induced hearing loss. Scand Audiol. 2001;30(4):236–44.

64. Bielefeld EC, Tanaka C, Chen G, Henderson D. Age-related hearing loss: is it a preventable condition? Hear Res. 2010;264(1–2):98–107.

65. Liu XZ, Yan D. Ageing and hearing loss. J Pathol. 2007;211(2):188–97.

66. Pyykkö I, Toppila E, Zou J, Kentala E. Individual susceptibility to noise-induced hearing loss. Audiol Med. 2007;5(1):41–53.

67. Zhou Y, Zheng G, Zheng H, Zhou R, Zhu X, Zhang Q. Primary observation of early transtympanic steroid injection in patients with delayed treatment of noise-induced hearing loss. Audiol Neurotol. 2013;18(2):89–94.

68. Rajguru R. Noise-induced hearing loss: recent advances in pharmacological management. Indian J Otol. 2012;18(4):174–8.

69. Shim HJ, Kang HH, Ahn JH, Chung JW. Retinoic acid applied after noise exposure can recover the noise-induced hearing loss in mice. Acta Otolaryngol. 2009;129(3):233–8.

70. Le Prell CG, Dolan DF, Bennett DC, Boxer PA. Nutrient plasma levels achieved during treatment that reduces noise-induced hearing loss. Transl Res. 2011;158(1):54–70.

71. Mora R, Mora E, Salzano FA, Guastini L. Audiometric characteristics in patients with noise-induced hearing loss after sodium enoxaparin treatment. Ann Otol Rhinol Laryngol. 2012;121(2):85–90.

72. Park SY, Back SA, Kim HL, Kim DK, Yeo SW, Park SN. Renexin as a rescue regimen for noise-induced hearing loss. Noise Health. 2014;16(72):257–64.

73. Oishi N, Schacht J. Emerging treatments for noise-induced hearing loss. Expert Opin Emerg Drugs. 2011;16(2);235–45.

74. Sun H, Huang A, Cao S. Current status and prospects of gene therapy for the inner ear. Hum Gene Ther. 2011;22(11):1311–22.

75. Li H, Corrales CE, Edge A, Heller S. Stem cells as therapy for hearing loss. Trends Mol Med. 2004;10(7):309–15.

76. Giordano C, Garzaro M, Nadalin J, Pecorari G, Boggero R, Argentero P et al. Noise-induced hearing loss and hearing aid requirement. Acta Otorhinolaryngol Ital. 2008;28(4):200–5.

77. Lieu JE, Tye-Murray N, Karzon RK, Piccirillo JF. Unilateral hearing loss is associated with worse speech-language scores in children. Pediatrics. 2010;125(6):e1348–55.

78. Borg E, Risberg A, McAllister B, Undemar B, Edquist G, Reinholdson A et al. Language development in hearing-impaired children. Establishment of a reference material for a 'Language test for hearing-impaired children', LATHIC. Int J Pediatr Otorhinolaryngol. 2002;65(1):15–26.

79. Shield BM, Dockrell JE. The effects of environmental and classroom noise on the academic attainments of primary school children. J Acoust Soc Am. 2008;123(1):133–44.

80. Stansfeld A, Berglund B, Clark C, Lopez-Barrio I, Fischer P, Öhrström E et al. Aircraft and road traffic noise and children's cognition and health: a cross-national study. Lancet 2005;365:1942–9.

81. Ljung R, Sörqvist P, Hygge S. Effects of road traffic noise and irrelevant speech on children's reading and mathematical performance. Noise Health. 2009;11(45):194–8.

82. Haines MM, Stansfeld SA, Job RFS, Berglund B, Head J. A follow-up study of effects of chronic aircraft noise exposure on child stress responses and cognition. Int J Epidemiol. 2001;30(4):839–45.

83. Hygge S, Evans GW, Bullinger M. A prospective study of some effects of aircraft noise on cognitive performance in schoolchildren. Psychol Sci. 2002;13(5):469–74.

84. K awada T. The effect of noise on the health of children. J Nippon Med Sch. 2004;71(1):5–10.

85. Klatte M, Bergström K, Lachmann T. Does noise affect learning? A short review on noise effects on cognitive performance in children. Front Psychol. 2013;4:1–6.

86. Szalma JL, Hancock PA. Noise effects on human performance: a meta-analytic synthesis. Psychol Bull. 2011;137(4):682–707.

87. Evans GW, Hygge S, Bullinger M. Chronic noise and psychological stress. Psychol Sci. 1995;6(6):333–8.

88. Berglund B, Lindvall T, Schwela DH. Guidelines for community noise. Geneva: World Health Organization; 1999.

89. Trimmel M, Atzlsdorfer J, Tupy N, Trimmel K. Effects of low intensity noise from aircraft or from neighbourhood on cognitive learning and electrophysiological stress responses. Int J Hyg Environ Health. 2012;215(6):547–54.

90. Aqib JM, Asim M. M-learning education trends are popular in students through iPod. Int J Eng Technol. 2012;4(1):8–10.

91. Greenfield S. Podcasting: a new tool for student retention? J Nurs Educ. 2011;50(2):112–4.

92. Davis MR. Devices deliver learning in Africa. Technology Counts. 2010;29(26):32–3.

93. Donnelly KM, Berge ZL. Podcasting: co-opting MP3 players for education and training purposes. Online Journal of Distance Learning Administration. 2006;9(3):1–7 (http://www.westga.edu/~distance/ojdla/fall93/donnelly93.htm, accessed 23 October 2014).

94. Wang M, Shen R, Novak D, Pan X. The impact of mobile learning on students' learning behaviours and performance: report from a large blended classroom. Br J Educ Technol. 2009;40(4):673–95.

95. Chute PM. Music, MP3 players and hearing health. Hearing Loss Magazine. 2009;May/June:26 (http://www.hearingloss.org/sites/default/files/mags/MusicMP3HearingHealth_MayJune2009_HLM.pdf, accessed 24 October 2014).

96. Belenger Y, Menzies D. Duke University iPod first year experience: final evaluation report. Durham, NC: Duke University; 2005 (http://cit.duke.edu/pdf/reports/ipod_initiative_04_05.pdf, accessed 23 October 2014).

97. Roach RB. Duke to streamline iPod program. Black Issues High Educ. 2005; 22(6)

98. Fraga L, Harmon JM, Wood KD, Buckelew-Martin E. Digital word walls and vocabulary learning: the use of iPods to facilitate vocabulary instruction with ESL students. J Res Centre Educ Technol. 2011;7(2):38–57.

99. Demouy V, Kukulska-Hulme A. On the spot: using mobile devices for listening and speaking practice on a French language programme. Open Learning: The Journal of Open and Distance Learning. 2010;25(3):217–32.

100. Beseda J, Machat Z, Palecek L. M-Learning as a trend. Technology Transfers and Innovation International Conference 5–November 2012. PRADEC Interdisciplinary Conference Proceedings. 2012;1(1):32–8 (http://academicpublishingplatforms.com/downloads/pdfs/picp/volume1/201304032014_04_PICP_Vol1_Issue1_2012_Beseda_et_al_m_learning_trend_pp.32-38.pdf, accessed 23 October 2014).

101. Read B. Duke U assesses iPod experiment and finds it worked – in some courses. Chron High Educ. 2005;51(43):28.

102. Olney I, Herrington J, Verenikina I. Digital story telling using iPods. In: Herrington J, Herrington A, Mantei J, Olney I, Ferry B, editors. New technologies, new pedagogies: mobile learning in higher education. Woolongong, NSW: University of Wollongong; 2009:36–44.

103. Dybwad B. iPods banned in Sydney school for breeding 'social isolation'. Engadget. 2005 (http://www.engadget.com/2005/03/22/ipods-banned-in-sydney-school-for-breeding-social-isolation/, accessed 22 October 2014).

104. Sarrab M, Elgamel L, Aldabbas H. Mobile learning (M-learning) and educational environments. Int J Distributed Parallel Systems. 2012;3(4):31–8.

105. Weksler ME, Weksler BB. The epidemic of distraction. Gerontology. 2012;58(5):385–90.

106. Hoover A, Krishnamurti S. Survey of college students' MP3 listening: habits, safety issues, attitudes, and education. Am J Audiol. 2010;19(1):73–83.

107. SWOV Factsheet. Use of media devices by cyclists and pedestrians. Leidschendam, Netherlands: Institute for Road safety and Research; 2013.

108. Turner ML, Fernandez JE, Nelson K. The effect of music amplitude on the reaction to unexpected visual events. J Gen Psychol. 1996;123(1):51–62.

109. Young KL, Salmon PM. Examining the relationship between driver distraction and driving errors: a discussion of theory, studies and methods. Safety Sci. 2012;50(2):165–74.

110. De Waard D, Edlinger K, Brookhuis K. Effects of listening to music, and of using a handheld and handsfree telephone on cycling behaviour. Transportation Research Part F: Traffic Psychology and Behaviour. 2011;14(6):626–37 (http://www.sciencedirect.com/science/article/pii/S1369847811000684, accessed 28 October 2014).

111. Brodsky W, The effects of music tempo on simulated driving performance and vehicular control. Transportation Research Part F: Traffic Psychology and Behaviour. 2001;4(4):219–41.

112. Schwebel DC, Stavrinos D, Byington KW, Davis T, O'Neal EE, de Jong D. Distraction and pedestrian safety: how talking on the phone, texting, and listening to music impact crossing the street. Accid Anal Preven. 2012;45: 266–71.

113. Horie Y, Toriizuka T. A study on the influence of headphones in auditory perceptual function. Work. 2012;41(Suppl. 1):5417–8.

114. Terzano K. Bicycling safety and distracted behavior in The Hague, the Netherlands. Accid Anal Preven. 2013;57:87–90.

115. Goldenbeld C, Houtenbos M, Ehlers, De Waard D. The use and risk of portable electronic devices while cycling among different age groups. J Safety Res. 2012;43(1):1–8.

116. De Waard D, Schepers P, Ormel W, Brookhuis K. Mobile phone use while cycling: incidence and effects on behaviour and safety. Ergonomics. 2010;53(1):30–42.

117. Zellar T Jr. Can common sense be legislated? New York Times, 12 February 2007 (http://www.nytimes.com/2007/02/12/technology/12link.html?_r=0, accessed 7 October 2014).

118. Nasar J, Hecht P, Wener R. Mobile telephones, distracted attention, and pedestrian safety. Accid Anal Prev. 2008;40(1):69–75.

119. Walker EJ, Lanthier SN, Risko EF, Kingstone A. The effects of personal music devices on pedestrian behaviour. Safety Sci. 2012;50(1):123–8.

120. Bungum TJ, Day C, Henry LJ. The association of distraction and caution displayed by pedestrians at a lighted crosswalk. J Community Health. 2005;30(4):269–79.

121. Neider MB, Gasper JG, McCarley JS, Crowell JA, Kaczmarski H, Kramer AF. Walking and talking: dual-task effects on street crossing behavior in older adults. Psychol Aging. 2011;26(2):260–8.

122. Stutts JC, Reinfurt DW, Staplin L, Rodgman EA. The role of driver distraction in traffic crashes. Washington, DC: AAA Foundation for Traffic Safety; 2001 (https://www.aaafoundation.org/sites/default/files/distraction%20%281%29.pdf, accessed 7 October 2014).

123. Dell SM, Holmes AF. The effect of a hearing conservation program on adolescents' attitudes towards noise. Noise Health. 2012;14(56):39–44.

124. Healy B. Stop the decibel damage. US News & World Report. 2007;143(2):58–85 (http://web.b.ebscohost.com/ehost/detail/detail?sid=c8a2b95b-8b85-4a00-abd7-2770f6bce805%40sessionmgr114&vid=0&hid=101&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#db=aph&AN=25682029, accessed 21 January 2014).

125. It's a noisy world we live in: how loud is too loud? Portland, OR: American Tinnitus Association; 2014 (http://www.ata.org/for-patients/how-loud-too-loud , accessed 21 January 2014)

126. Common environmental noise levels. New York: Center for Hearing and Communication; 2014: (http://chchearing.org/noise/common-environmental-noise-levels/#, accessed 21 January 2015).

127. Swanepoel DW, Hall JW. Football match spectator sound exposure and effect on hearing: a pretest–post-test study. S Afr Med J. 2010;100(4):239–42.

128. Robinson DW. Noise exposure and hearing: a new look at the experimental data. London: Health and Safety Executive; 1987 (HSE Contract Research Report, No. 1/1987).

129. Goelzer B, Hansen CH, Sehrndt GA, editors. Occupational exposure to noise: evaluation, prevention and control. Dortmund: Federal Institute for Occupational Safety and Health on behalf of World Health Organization; 2001:95 (http://www.who.int/occupational_health/publications/occupnoise/en/, accessed 21 January 2015).

130. Noise and hearing loss prevention. Atlanta, GA: Centers for Disease Control and Prevention; 1998 (http://www.cdc.gov/niosh/topics/noise/stats.html, accessed 21 January 2015)

131. Regulations. London: Health and Safety Executive; 2005 (http://www.hse.gov.uk/noise/regulations.htm, accessed 21 January 2015).)

132. Foster JR, Hall DA, Summerfield AQ, Palmer AR, Bowtell RW. Sound-level measurements and calculations of safe noise dosage during EPI at 3 T. J Magn Reson Imaging. 2000;12(1):157–63.

133. Jokitulppo J, Toivonen M, Bjork E. Estimated leisure-time noise exposure, hearing thresholds, and hearing symptoms of Finnish conscripts. Mil Med. 2006;171(2):112–6.

134. Zocoli AM, MorataTC, Marques JM, Corteletti LJ. Brazilian young adults and noise: attitudes, habits, and audiological characteristics. Int J Audiol. 2009;48(10):692–9.

135. Marlenga B, Berg RL, Linneman JG, Wood DJ, Kirkhorn SR, Pickett W. Determinants of early-stage hearing loss among a cohort of young workers with 16 year follow-up. Occup Environ Med. 2012;69(7):479–84.

136. Cranston CJ, Brazile WJ, Sandfort DR, Gotshall RW. Occupational and recreational noise exposure from indoor arena hockey games. J Occup Environ Hyg. 2013;10(1):11–6.

137. Ramma L, Petersen L, Singh S. Vuvuzelas at South African soccer matches: risks for spectators' hearing. Noise Health. 2011;13(50):71–5.

138. Axelsson A, Jerson T. Noisy toys: a possible source of sensorineural hearing loss. Pediatrics. 1985;76(4):574–8.

139. Beach EF, Gilliver M, Williams W. Leisure noise exposure: participation trends, symptoms of hearing damage, and perception of risk. Int J Audiol. 2013;52(Suppl. 1):S20–5.

140. Nassar G. The human temporary threshold shift after exposure to 60 minutes' noise in an aerobics class. Br J Audiol. 2001;35(1):99–101.

141. Mirbod SM, Lanphere C, Fujita S, Komura Y, Inaba R, Iwata H. Noise in aerobic facilities. Ind Health. 1994;32:49–55.

142. Torre P, Howell JC. Noise levels during aerobics and the potential effects on distortion product otoacoustic emissions. J Commun Disord. 2008;41(6):501–11.

143. Yaremchuk KL, Kaczor JC. Noise levels in the health club setting. Ear Nose Throat J. 1999;78(1):54–7.

144. Beach EF, Nie V. Noise levels in fitness classes are still too high: evidence from 1997–1998 and 2009–2011. Arch Environ Occup Health. 2014;69(4):224–30.

145. Goggin LS, Eikelboom RH, Edwards GS, Maric V, Anderson JR, Sander PB et al. Noise levels, hearing disturbances, and use of hearing protection at entertainment venues. Australian and New Zealand J Audiol. 2008;30(1):50–8.

146. Kelly AC, Boyd SM, Henehan GT, Chambers G. Occupational noise exposure of nightclub bar employees in Ireland. Noise Health. 2012;14(59):148–54.

147. Berger EH. Hearing protection for the critical listener. Soundscape. 2005;6(1):7–10 (http://wfae.proscenia.net/journal/scape_10.pdf, accessed 15 October 2014).

148. Ferrite S, Santana, V. Joint effects of smoking, noise exposure and age on hearing loss. Occup Med (Lond). 2005;55(1):48–53.

149. Levey S, Levey T, Fligor BJ. Noise exposure estimates of urban MP3 player users. J Speech Lang Hear Res. 2011;54(1):263–77.

150. Ivory R, Kane R, Diaz RC. Noise-induced hearing loss: a recreational noise perspective. Curr Opin Otolaryngol Head Neck Surg. 2014;22(5):394–8.

151. Griest SE, Folmer RL, Martin WH. Effectiveness of “Dangerous Decibels,” a school-based hearing loss prevention program. Am J Audiol. 2007;16(2):S165–81.

152. Fuente A, Hickson L. Noise-induced hearing loss in Asia. Int J Audiol. 2011;50(Suppl. 1):S3–10.

153. Stephenson CM, Stephenson MR. Hearing loss prevention for carpenters. Part I: Using health communication and health promotion models to develop training that works. Noise Health. 2011a;13(51):113–21.

154. Beach EF, Williams W, Gilliver M. A qualitative study of earplug use as health behavior: the role of noise injury symptoms, self-efficacy and an affinity for music. J Health Psychol. 2012;17(2):237–46.

155. Bohlin MC, Erlandsson SI. Risk behaviour and noise exposure among adolescents. Noise Health. 2007;9(36):55–63.

156. Landälv D, Malmström L, Widén SE. Adolescents’ reported hearing symptoms and attitudes toward loud music. Noise Health. 2013;15(66):347–54.

157. Reed DB, Browning SR, Westneat SC, Kidd PS. Personal protective equipment use and safety behaviors among farm adolescents: gender differences and predictors of work practices. J Rural Health. 2006;22(4):314–20.

158. Widén SE, Erlandsson SI. The influence of socio-economic status on adolescent attitude to social noise and hearing protection. Noise Health. 2004b;7(25):59–70.

159. Quintanilla-Dieck MDL, Artunduaga MA, Eavey RD. Intentional exposure to loud music: the second MTV.com survey reveals an opportunity to educate. J Pediatr. 2009;155(4):550–5.

160. Ansari H, Mohammadpoorasl A, Rostami F, Maleki A, Sahebihagh MH, Naieni KH. Pattern of use of earphone and music player devices among Iranian adolescents. Int J Prev Med. 2014; 5(6):776–81.

161. Zhu X, Bihi A, Hu X, Abbas A, Zhu X2, Mo L, Peng X. Chinese-adapted youth attitude to noise scale: evaluation of validity and reliability. Noise Health. 2014;16(71):218–22.

162. McCullagh M. When hearing becomes part of healing. Orthop Nurs. 2002;21(4):64–8.

163. Toppila E, Koskinen H, Pyykkö I. Hearing loss among classical-orchestra musicians. Noise Health. 2011;13(50):45–50.

164. Fligor BJ, Cox LC. Output levels of commercially available portable compact disc players and the potential risk to hearing. Ear Hear. 2004;25(2):513–27.

165. Kim DK, Park Y, Back SA, Kim SL, Park HE, Park KH et al. Protective effect of unilateral and bilateral ear plugs on noise-induced hearing loss: functional and morphological evaluation in animal model. Noise Health. 2014;16(70):149–56.

166. Williamson A. In praise of ear plugs. Hearing Health. 2010;26(3):28.

167. Manuel J. Clamoring for quiet: new ways to mitigate noise. Environ Health Perspect. 2005;113(1):A46–9.

168. Na WS, Kim KW, Jung SD, Lee JW, Jung JY, Suh MW. Effect of active noise cancelling earphones on preferred listening level when listening to portable music players in noisy environments. Korean J Otorhinolaryngol Head Neck Surg. 2012;55(7):415–21.

169. Voix J, Le Cocq C, Hager LD. The healthy benefits of isolating earphones. Proc Meet Acoust. 2008;4:1–6.

170. Henry P, Foots A. Comparison of user volume control settings for portable music players with three earphone configurations in quiet and noisy environments. J Am Acad Audiol. 2012;23(3):182–91.

171. Noise. Rockville, MD: American Speech-Language-Hearing Association; 2014 (http://www.asha.org/public/hearing/Noise/, accessed 21 January 2015).

172. Crank it down. Bethesda, MD: National Institute on Deafness and Other Communication Disorders; 2011 (http://www.nidcd.nih.gov/health/inside/sum06/pages/pg1.aspx, accessed 21 January 2015).

173. Keith SE, Michaud DS, Chiu V. Evaluating the maximum playback sound levels from portable digital audio players. J Acoust Soc Am. 2008,123(6):4227–37.

174. Williams W. Noise exposure levels from personal stereo use. Int J Audiol. 2005;44(4):231–6.

175. Keith SE, Michaud DS, Feder K, Haider I, Marro L, Thompson E et al. MP3 player listening sound pressure levels among 10 to 17 year old students. J Acoust Soc Am. 2011;130(5):2756–64. HNO, 2006, 54:573-581.

176. Hodgetts WE, Rieger JM, Szarko RA. The effects of listening environment and earphone style on preferred listening levels of normal hearing adults using an MP3 player. Ear Hear. 2007;28(3):290–7.

177. Lee GJ, Lim MY, Kuan AY, Teo JH, Tan HG, Low WK. The music listening preferences and habits of youths in Singapore and its relation to leisure noise-induced hearing loss. Singapore Med J. 2014;55(2):72–7.

178. Kardous CA, Shaw PB. Evaluation of smartphone sound measurement applications. J Acoust Soc Am. 2014;135(4):E186–92 (http://tinyurl.com/oxol3hh, accessed on 19 August 2014).

179. Kardous CA, Shaw PB. So how accurate are these smartphone sound measurement apps? NIOSH Science Blog. April 9 2014 (http://blogs.cdc.gov/niosh-science-blog/2014/04/09/sound-apps/#comment-286534, accessed on 19 August 2014).

180. Huth ME, Popelka GR, Blevins NH. Comprehensive measures of sound exposures in cinemas using smart phones. Ear Hear. 2014;35(6):680–6.

181. Nast DR, Speer WS, Le Prell CG. Sound level measurements using smartphone "apps": useful or inaccurate? Noise Health. 2014;16(72):251–6.

182. Galster JA. Apps for audiology. Audiol Practices. 2012;4(3):16–9.

183. Operation BANG (Be Aware of Noise Generation). Location?: Military Audiology Association; 2014 (http://militaryaudiology.org/site/resources/be-aware-of-noise-generation/1/, accessed 21 January 2015).

184. Levey S, Fligor BJ, Cutler C, Harushimana I. Portable music player users: cultural differences and potential dangers. Noise Health. 2013;15(66):296–300.

185. Berger EH, Kieper RW, Gauger D. Hearing protection: surpassing the limits to attenuation imposed by the bone-conduction pathways. J Acoust Soc Am. 2003:114(4):1955–67.

186. Verbeek JH, Kateman E, Morata TC, Dreschler WA, Mischke C. Interventions to prevent occupational noise-induced hearing loss. Cochrane Database Syst Rev. 2012;10:CD006396.

187. Tabachnick B. Hearing protection devices for consumers. Consumers Research Magazine. 1994;77(12).

188. Noise and hearing loss prevention. Choose the hearing protection that's right for you. Atlanta, GA: enters for Disease Control and Prevention; 2014 (http://www.cdc.gov/niosh/topics/noise/choose.html, accessed 21 January 2015).

189. Peters RJ. The role of hearing protectors in leisure noise. Noise Health. 2003;5(18):47–55.

190. Arezes PM, Miguel AS. Hearing protectors acceptability in noisy environments. Ann Occup Hyg. 2001;46(6):531–6.

191. Groenewold MR, Masterson EA, Themann CL, Davis RR. Do hearing protectors protect hearing? Am J Ind Med. 2014;57(9):1001–10.

192. Beach E, Williams W, Gilliver M. Hearing protection for clubbers is music to their ears. Health Promot J Austr. 2010;21(3):215–21.

193. Folmer RL, Griest SE, Martin WH. Hearing conservation education programs for children: a review. J Sch Health. 2002;72(2):51–7.

194. Arenas JP, Suter AH. Comparison of occupational noise legislation in the Americas: an overview and analysis. Noise Health. 2014;16(72):306–19.

195. European Union. Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). Official Journal of the European Union. 2003;L42/38 (http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32003L0010&qid=1401884162436&from=EN, accessed 22 October 2014).

196. The Control of Noise at Work Regulations 2005. London: The Stationery Office; 2005 (http://www.legislation.gov.uk/uksi/2005/1643/pdfs/uksi_20051643_en.pdf, accessed 22 October 2014).

197. The noise of music: sound advice for the music and entertainment sectors. Guidance on how to comply with the Safety, Health and Welfare at Work (General Application) Regulations 2007. Dublin: Health and Safety Authority; 2009 (http://www.hsa.ie/eng/Publications_and_Forms/Publications/Occupational_Health/The_Noise_of_Music.pdf, accessed 22 October 2014).

198. Safety, Health and Welfare at Work (Control of Noise at Work) Regulations 2006, SI Ireland 371/2006. (http://www.irishstatutebook.ie/2006/en/si/0371.html, accessed 22 October 2014).

199. Law of the People's Republic of China on Prevention and Control of Pollution From Environmental Noise. Beijing: Government of China; 1996 (adopted at the 22nd Meeting of the Standing Committee of the Eighth National People's Congress on October 29, promulgated by Order No. 77 of the President of the People's Republic of China on October 29, and effective as of March 1, 1997; http://www.china.org.cn/english/environment/34448.htm#, accessed 21 January 2015).

200. Commission Decision of 23 June 2009 on the safety requirements to be met by European standards for personal music players pursuant to Directive 2001/95/EC of the European Parliament and of the Council (Text with EEA relevance)(2009/490/EC). Official Journal of the European Union, 2009, L 161/38-39 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:161:0038:0039:EN:PDF, accessed 21 January 2015).

201. Gilbert C. Free earplugs at Minneapolis nightclubs now mandatory. MPR News. 11 April 2014 (http://www.mprnews.org/story/2014/04/11/free-earplugs-minneapolis, accessed 21 January 2015).

202. Callinan JE, Clarke A, Doherty K, Kelleher C. Legislative smoking bans for reducing secondhand smoke exposure, smoking prevalence and tobacco consumption. Cochrane Database Syst Rev. 2010;Apr 14(4):CD005992.

203. Mello MM, Wood J, Burris S, Wagenaar AC, Ibrahim JK, Swanson JW. Critical opportunities for public health law: a call for action. Am J Public Health. 2013;103(11):1979–88.

204. Apple provides volume limit setting for iPod. Cupertino, CA: Apple Press Info; 2006 (http://www.apple.com/pr/library/2006/03/29Apple-Provides-Volume-Limit-Setting-for-iPod.html, accessed 21 January 2015).

205. Ward C. Why do I get a volume warning on Android and can it be disabled? Clove Online Blog; (http://blog.clove.co.uk/2013/06/14/why-do-i-get-a-volume-warning-on-android-and-can-it-be-disabled/, accessed 21 January 2015).

206. Sekhar DL, Clark SJ, Davis MM, Singer DC, Paul IM. Parental perspectives on adolescent hearing loss risk and prevention. JAMA Otolaryngol Head Neck Surg. 2014;140(1):22–8.

207. Knobel KA , Lima MC. Knowledge, habits, preferences, and protective behavior in relation to loud sound exposures among Brazilian children. Int J Audiol. 2012;51(Suppl. 1):S12–9.

208. Vogel I, Brug J, Hosli EJ, van der Ploeg CP, Raat H. MP3 players and hearing loss: adolescents' perceptions of loud music and hearing conservation. J Pediatr. 2008;152(3):400–4.

209. Vogel I, Brug J, van der Ploeg CP, Raat H. Young people: taking few precautions against hearing loss in discotheques. J Adolesc Health. 2010;46(5):499–502.

210. Vogel I, Burg J, van der Ploeg CP, Raat H. Younge people's exposure to loud music: a summary of the literature. Am J Prev Med. 2007;33(2)124–33.

211. Gilles A, Van de Heyning P. Effectiveness of a preventive campaign for noise-induced hearing damage in adolescents. Int J Pediatr Otorhinolaryngol. 2014;78(4):604–9.

212. Fausti SA, Wilmington DJ, Helt PV, Helt WJ, Konrad-Martin D. Hearing health and care: the need for improved hearing loss prevention and hearing conservation practices. J Rehabil Res Dev. 2005;42(4):45–62.

213. Martin WH, Griest SE, Sobel JL, Howarth LC. Randomized trial of four noise-induced hearing loss and tinnitus prevention interventions for children. Int J Audiol. 2013;52(Suppl. 1):S41–9.

214. Chermak GD, Peters-McCarthy E. The effectiveness of an educational hearing conservation program for elementary school children. Language, Speech, and Hearing Services in Schools. 1991;22(1):308–12.

215. El Dib RP, Mathew JL, Martins RH. Interventions to promote the wearing of hearing protection. Cochrane Database Syst Rev. 2011;9:CD005234.

216. Widén SE, Holmes AE, Erlandsson SI. Reported hearing protection use in young adults from Sweden and the USA: effects of attitude and gender. Int J Audiol. 2006;45(5):273–80.

217. Becker T, Martin W, Lambert W, Griest S, Sobel J. Community based noise induced hearing loss prevention for tribal children. J Epidemiol Community Health. 2011;65(Suppl. 1):A176.

218. Taljaard DS, Leishman NF, Eikelboom RH. Personal listening devices and the prevention of noise induced hearing loss in children: the Cheers for Ears Pilot Program. Noise Health. 2013;15(65):261–8.

219. Listen to your buds. Rockville, MD: American Speech-Language-Hearing Association; 2012 (http://www.asha.org/buds/, accessed 21 January 2015).

220. Noise induced hearing loss can be prevented. Greeley, CO: Dangerous Decibels; 2014 (http://www.dangerousdecibels.org/, accessed 21 January 2015).

221. It's a noisy planet: protect their hearing. Bethesda, MD: National Institute on Deafness and Other Communication Disorders; 1999 (http://www.nidcd.nih.gov/health/wise/Pages/Default.aspx , accessed 21 January 2015).

222. Protecting your hearing. London: Action on Hearing Loss; 2011 (http://www.actiononhearingloss.org.uk/get-involved/campaign/protecting-your-hearing/the-campaign.aspx, accessed 21 January 2015).

223. Widén S, Bohlin M, Johansson I. Gender perspectives in psychometrics related to leisure time noise exposure and use of hearing protection. Noise Health. 2011;13(55):407–14.

224. Rosenstock IM. Why people use health services. Milbank Q. 1999 ;83(4):1–32.

225. Chesky K, Pair M, Lanford S, Yoshimura E. Attitudes of college music students towards noise in youth culture. Noise Health. 2009;11(42):49–53.

226. Fligor BJ, Levey S, Levey T. Cultural and demographic factors influencing noise exposure estimates from use of portable listening devices in an urban environment. J Speech Lang Hear Res. 2014;57(4):1537–47.

227. Wising up about noise-induced hearing loss: an evaluation of Wise Ears! A national campaign to prevent noise-induced hearing loss. Bethesda, MD: National Institute on Deafness and other Communication Disorders; 2006 (http://www.noisyplanet.nidcd.nih.gov/press/pages/journal_patricia.aspx, accessed 21 January 2015).

228. Weichbold V, Zorowka P. Effects of a hearing protection campaign on the discotheque attendance habits of high-school students. Int J Audiol. 2003;42(8):489–93.

229. Axelsson A, Prasher D. Tinnitus: a warning signal to teenagers attending discotheques? Noise Health. 1999;1(2):1–2.

230. Guide to noise control in the music & entertainment industry. Singapore: Ministry of Manpower; 2011 (http://www.mom.gov.sg/Documents/safety-health/factsheets-circulars/Guide%20to%20Noise%20Control%20in%20Music%20and%20Entertainment%20Industry.pdf, accessed 21 January 2015).

231. Kim J. Analysis of factors affecting output levels and frequencies of MP3 players. Korean J Audiol. 2013;17(2):59–64.

232. Beach EF, Williams W, Gilliver M. The objective–subjective assessment of noise: young adults can estimate loudness of events and lifestyle noise. Int J Audiol. 2012;51(6):444–9.

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