Recreational Noise and Its Potential Risk to Hearing
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A practical review of some of the most-common threats to people's hearing

Do you sometimes wonder what you *really* should be warning your patients about relative to noise-induced hearing loss and their hobbies—without sounding like a complete kill-joy? Here's the "short list" along with some basics about hearing conservation.

Editor's Note: *This article is an excerpt from Dr Fligor's chapter[1] in the new book,* **The Consumer Handbook on Hearing Loss and Noise***, edited by Marshall Chasin, AuD, and published this spring by Auricle Ink Publishers. It appears here with permission and* HR *thanks Auricle Ink Publisher Richard Carmen, AuD, for his assistance with the article. For more information about the book, visit www.hearingproblems.com.*

Many people engage in noisy recreational activities. Most of them do not have hearing loss. There is a world of difference in the wear-and-tear on the ear caused by shooting a single round on a .22 caliber rifle compared to weekly target shooting with a large caliber firearm. The most important aspect of understanding recreational noise sources is that "how long" and "how often" is much easier to measure (and moderate) than "how loud." The intent of identifying the following recreational noise sources is to educate the reader who in turn can make good and informed decisions; the intent is not to suggest the reader stop having fun!

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Firearms

There's little question among the scientific community that shooting firearms is the most common cause of recreational noise-induced hearing loss (NIHL). Sound levels exceeding 132 dB can cause an acoustic trauma—immediate loss of hearing after a single exposure. The discharge of a round from most firearms easily exceeds 132 dB, and so it's reasonable to expect that after a person fires a single shot without using any kind of hearing protection, some permanent hearing loss has occurred.

The sound levels from firearms are difficult to measure, because the levels are higher than most sound recording equipment can manage. However, those measures that have been reported show some trends. Generally, the larger the bore of the firearm, the more intense is the peak sound level. Table 1 shows the general range of the sound levels generated by different firearms. A shortened barrel, a muzzle break, and shooting in an enclosure all increase the sound levels relative to those reported in Table 1, since these are levels recorded in an open field. The number of rounds that are fired matters as well, as the greater the number of rounds fired, the greater the risk for NIHL.

Firearm Type	Peak Sound Level (dB SPL)
Small Rifle	140-145
Medium Rifle	157-160
Large Rifle	160-174
Shotgun	152-166
Small Pistol	150-157
Large Pistol	158-174

Table 1. Sound levels for different firearms.

As an illustration of how common hearing loss is in people who shoot firearms, consider a study conducted by audiologists at Central Michigan University in the early 2000s.[2] The researchers approached people as they entered a large northern Michigan sporting good store the weekend before deer hunting season, and asked them to participate in the study. A total of 232 people (187 men and 45 women) were included in the study. All had shot firearms in the past year, with the average number of shots fired without using earplugs or other hearing protection being 241 rounds per person. The degree of hearing loss varied by age (the older the subject, the worse the hearing) and by gender (men had worse hearing than women), and in all, 177 of the 232 people had hearing loss. Half of the people had been taught to use hearing protection in their hunter safety course, and yet 76% of them had hearing loss.

Woodworking

Power tools are a potential source of noise that, if used often enough, can lead to NIHL. Many woodworking tools do produce high sound levels, while others produce levels that are quite low. Table 2 shows a list of common tools used in hobby woodworking shops, and the sound levels at the user's ear. Consider that NIHL risk begins at levels around 80-85 dBA, depending on how long and how often the tool is used. For instance, it would be relatively safe to use the 6" jointer and 10" cabinet table saw for a couple of hours per week, while using the circular saw or chain saw (with levels around 110 dBA) for more than a minute could pose significant risk to hearing.

Woodworking Tools	A-weighted Decibels (dBA) at User's Ear
Minilathe with spindle	60
Drill Press	66
Spindle Sander	70
Brad Nailer	74
1-hp Dust Collector	76
6" Jointer	83
10" Cabinet Table Saw	88
5" Random Orbit Sander	90
2-hp Air Compressor	94
14" Band Saw	95
Biscuit Joiner	98
Router	100
Shop Vacuum	101
Miter Saw	103
Bench Top Planer	105
Circular Saw	109
Chain Saw	111

Table 2. Woodworking tools and their noise levels.

How potentially harmful is hobby woodworking to a person's hearing? As noted, that depends on how often a person does this, and whether or not they use hearing protection (discussed in detail later in this chapter). A study of 3,500 participants in Beaver Dam, Wis, suggested that, on average, woodworking poses a greater threat to hearing than most other leisure time activities.[3] The researchers were looking at age-related hearing loss in this population, but also looked at leisure time activities to try to account for NIHL that was unrelated to the participants' occupation. They looked at how many people did woodworking and metalworking, rode recreational

vehicles, used power tools in yardwork, used a chain saw, played a musical instrument, used noisy kitchen appliances, and used a vacuum cleaner and hair dryer. Considering how often people reported engaging in each of these activities, and taking into account the people who used firearms, the only leisure activity in the list above that had a clear impact on hearing was woodworking: people who did woodworking were 30% more likely to have hearing loss than those people who did not. While other activities (such as using a chain saw) can damage hearing, in this group of 3,500 people, they did not engage in those other activities often enough or for long enough to predictably have an effect on hearing.

Motor Sports and Sporting Events

Whether riding a motorcycle or an all-terrain vehicle (ATV) or attending a NASCAR event, being around large engines can be exciting—and can take a toll on hearing. Jet skis, motorcycles, and snowmobiles all generate sound levels in excess of 100 dBA. The occasional use on the weekends for a total of a few hours per week will likely have limited impact on a person's hearing, but, nonetheless, does contribute to the lifetime wear-and-tear on the ear. For those people who ride a four-wheeler daily, for instance, the total sound exposure may be significant. Some reports suggest that levels as high as 110 dBA are not uncommon in recreational vehicles, and in people living in rural areas, it is typical to use them for hours at a time. By some standards, 110 dBA is relatively safe to hear for only about 90 seconds; this means that spending 3 hours on an ATV on a weekend gives over 15 times the allowable noise dose for that week. Attending a monster truck rally, truck pull, motocross, or NASCAR event may be a special, once-a-year event. Barring other noisy leisure time activities, very occasional attendance at a very loud sporting event will likely have little impact on a person's hearing.

However, awareness should be paid to prevention and protection, given the significant exposures that are possible; it's not inconceivable that a permanent hearing loss could occur after a single event. A recent study reported levels at a series of NASCAR events to be high enough to be of concern for people who attend regularly.[4] At 150 feet from the racetrack, levels were on average close to 101 dBA (range 96.5-104 dBA). At 20 feet from the racetrack (the front row of seating), average levels were over 106 dBA (range 99-109 dBA). The races typically lasted 4 hours, which means someone sitting at 150 feet from the racetrack would have over 20 times the allowable noise dose on that day (close to 3 times the allowable noise dose for the week, after that one race). For the person sitting in the front row, the spectator would have 64 times the allowable noise dose on that day (which equates to over 9 times the allowable noise dose for that week). In laboratory studies using sound to experimentally induce acoustic trauma, a noise dose between 25 and 45 times the allowable noise dose consistently resulted in

permanent damage to the ear.[5] It is not unreasonable to think that some people with natural susceptibility to NIHL who happen to get really good seats at a NASCAR event might leave with permanent hearing loss if they don't use hearing protection. Such overexposures are not limited to motorized sports. Reported exposures at professional football games can be 5 times the allowable noise dose, and an attendee at a Colorado Rockies baseball game wearing a pocket noise dosimeter (to record her total noise dose for that game) was nearly 800% (8 times the allowable noise dose).

Noisy Toys

There's understandable concern that children might be inadvertently exposed to damagingly loud sound from their toys, given their inability to anticipate risk. A toy fire truck with a siren and flashing lights might be intended to be used at arm's length, except a child could hold the truck up to his or her ear and engage the alarm, bringing the sound source from roughly 10 inches away to less than an inch away.

The American Society for Testing and Materials (ASTM) proposed a standard in 2003 for the maximum sound levels for toys.[6] This standard is considered voluntary, but toy manufacturers are encouraged to follow it. This standard states that the maximum sound level for a toy should be no more than 90 dBA at 25 cm (which is considered at arm's length), and for toys used "close to the ear," the maximum sound level should be no more than 70 dBA. High peak sound levels (impulse or impact sound) should be no more than 120-138 dB peak sound level depending on the type of sound burst. This standard does not apply to toys that require muscular activity or blowing through the toy to create the sound.
Parents are advised to think judiciously about how their child will use a toy and consider doing an Internet search to see if the toy they are looking to purchase meets the ASTM (2003) sound level standard. One recent study of toys produced since this standard was established showed that, of 20 toys evaluated, 13 exceeded the ASTM (2003) standard.[7] Some noisy toys are more obviously sound generating than others, but the levels produced might be surprising. Toy cap guns and fireworks can produce peak sound levels that are not so far off from firearms. Gupta and Vishwakarma[8] reported peak sound levels from fireworks at a distance of 3 meters were 126-156 dB, and children ages 9 to 15 years old were more likely to have permanent hearing loss from fireworks than adults.
Clinically, it is not uncommon for a child or teenager in the United States to come to this author's clinic after an accident on our Independence Day (July 4th) where he or she (but, in truth, much more likely "he") lit a handheld firecracker with the intent to throw it, but mistimed the speed of the fuse and the firecracker exploded within arm's length of the child's head. Notwithstanding the burn injuries and the

potential permanent damage to the hand, such an accident often leaves the individual with a unilateral (one-sided) or asymmetrical hearing loss (hearing loss in both ears, but worse in the ear closer to the explosion).

Music as a Source of Recreational Noise Exposure

Considerable popular media attention has been given to music as a potential source of hazardous sound exposure, particularly from listening to music on headphones. As with essentially all sound exposures, whether or not hearing is damaged depends on the level and on the duration of use and how often a person listens to headphones or attends a concert.

Music is no more, and no less, risky to hearing than are the other sources of high-level sound described previously in this chapter. While less obviously damaging to hearing, the popularity of listening to music with headphones may be a more universal source of high level sound compared to woodworking or shooting firearms. It is the universality of music exposures that has some hearing health care providers concerned. By sheer number of people using the devices, the number of individuals at risk for NIHL is not inconsequential, given that a small but significant percentage uses them inappropriately.

The rise of Personal Listening Devices (PLDs). Reports of headphone use vary with age, as illustrated by the data from the *Listen Up!*research exhibit that is a feature of the Oregon Museum of Science and Industry (OMSI): 78% to 83% of young people compared to 56% to 59% of adults used headphones in the past year in that group visiting OMSI (for more detailed information on the OMSI study, see the full chapter in *The Consumer Handbook on Hearing Loss and Noise*[1]). A survey of over 1,000 college students at a university in California revealed that over 90% of participants owned a personal listening device (PLD) with headphones.[9] In a 2006 Zogby telephone survey of 1,000 adults and over 300 teenagers, roughly half of adults and nearly all teenagers owned a PLD.[10] Of those who owned a PLD, 52% of adults and 31% of teenagers reported listening for 1 to 4 hours per day. Media reports indicate that over 100 million Apple iPods® have been sold since the device was first introduced in 2001, and sales of all PLDs are projected to be 275 million by 2011.[11]

A study conducted in the late 1980s very conservatively estimated that only about 1 in 1,500 cassette tape player users were at risk for substantial hearing loss.[12] The definition of substantial hearing loss was hearing that has decreased enough that it was necessary to use hearing aids. Even with this extremely conservative estimate of hearing loss risk, if 100 million people regularly use PLDs now, that still means 65,000 people would have NIHL sufficient to require being fitted with hearing aids from using headphones alone.

Despite the media's attention to "headphones and hearing loss," there are in fact little data to prove that abusive use of PLDs is widespread and will be responsible for an epidemic of NIHL in young people. There is no doubt that PLDs can produce sound levels capable of doing damage to hearing, but whether or not people use PLDs at such high levels for a sufficiently long enough time is a matter of ongoing debate. There have been developed rules-of-thumb to help guide consumers in making better listening-level decisions, and some factors have also been identified that contribute to a person listening too loud.

The "60-60 Rule." Since the Sony Walkman® cassette tape player was introduced in the early 1970s, concerns for hearing loss were raised. Maximum output levels were reported to be 110-128 dBA[13] with risk for hearing loss starting at a volume control setting of only 30% (that is, level "3" where "10" is the highest volume control setting). The reports of hearing loss risk continued with compact disc (CD) players. Fligor and Cox[14] reported sound levels exceeding 120 dBA in some CD player-headphone combinations. The highest selling CD player leading up to the publication of the study, the Sony CD Walkman®, produced 87 dBA with the volume control set to half-maximum, and 107 dBA at maximum, using the on-the-ear headphones that were included in the purchase of the device. Using a somewhat conservative guideline for reducing risk for NIHL from using these headphones, the authors suggested limiting listening level to 60% of the maximum volume control if listening for 1 hour or less per day.
This guideline has since been termed the "60-60 rule" to reflect that it was considered relatively safe to use the CD player set to 60% of the maximum for 60 minutes per day. A caveat to this rule of thumb suggested by Fligor and Cox had quite an impact in the popular media: using after-market accessory earbud earphones could result in 7-9 dB increase in sound level, relative to levels from on-the-ear headphones. Therefore, the suggested guideline would need to be modified to listen either lower than 60% or shorter than 60 minutes if the consumer preferred earbuds. The popular media took this higher level from using earbuds to mean that earbuds were in fact more dangerous (they are not, read on), and this study happened to be published just as the Apple iPod (which includes earbuds as the standard earphone that comes with the device) jumped in popularity and sales at the end of 2004.

As an aside, the Fligor and Cox[14] study was prompted by a clinical encounter in which a 15-year-old boy came to the audiology clinic at an inner city hospital in Boston, complaining of difficulty hearing in the right ear. The cause of this hearing problem was because he had impacted earwax in that right ear. After the wax was removed, we tested his hearing and, by accident, found he had a mild hearing loss in the left ear, and the pattern was classic for NIHL. He reported no noise

exposure, with the exception of regular use of a CD player at near maximum volume control setting. It seems that the plug of wax in the right ear was actually acting like an earplug, protecting that ear, while the left ear was fully exposed to the high levels of music. When counseled to lower the listening levels, the teenager appropriately responded, "If I can't listen all the way up, how loud can I listen?" This was a reasonable question, and likely not uncommon, but up to that point, there were no answers to be found in the scientific literature. So the work of Fligor and Cox was an attempt to provide an answer, and arrived at the "60-60 rule."

Revising the 60-60 Rule to the 80-90 Rule. There has since been an update to the "60-60" rule of thumb, because that guideline is specific to CD players. Contrary to popular belief, the newer MP3 players do not produce sound levels higher than CD players and cassette tape players. In fact, the levels are generally lower.

A paper published by Keith, Michaud, and Chiu[15] showed that the maximum output levels by current MP3 players are 85-107 dBA, depending on the type of earphone. Preliminary findings from ongoing studies of output levels from MP3 players[16] are in good agreement with those of Keith, Michaud, and Chiu, and suggest that the rule of thumb for present day MP3 players is to limit the volume control to 80% of the maximum and listen no longer than 90 minutes per day, if using the headphones (the earbud) that come with the MP3 player (an "80-90" rule of thumb for MP3 players).

Legislating hearing safety. One approach European lawmakers have taken is to impose output level limits on manufacturers. French law mandates a maximum level of "100 dB" from personal stereo systems with headphones and specifies a maximum output voltage to headphones not exceed 150 millivolts.[17]

It is unclear whether or not different PLDs are manufactured for sale in Europe than the rest of the world that does not have such a legislative mandate. Of additional concern to this author is that this maximum level mandate of "100 dB" is certainly not safe. A PLD meeting the requirements of French law will exceed recommended exposure limits after 15 minutes of use at the maximum "limited" level. Some PLDs, such as the iPod, have a volume control limiter in the software controlling the device, and include a password to lock this maximum limit. A limitation of this software is that no guidance is provided to the user on what levels to limit, and it considers only level, not duration of use. The "80-90" guideline might address this limitation.

Listening duration and environment still prime considerations in MP3 usage. Despite the fact the recommended level-and-time limit appear more lenient for MP3 players than the older technology, the risk for hearing loss may be no less. In fact, the risk may be greater, given the capacity to carry several days' worth of music and other audio content and battery life that far exceeds that of CD and

cassette players. The greater portability of MP3 players allows the user to routinely use the device daily during activities that do not require their immediate awareness of the sounds in their environment.

A frequent time for people to use headphones is during commutes to and from work or school and while doing office work or homework. In a quiet setting (such as working in a quiet office or while doing homework in a quiet bedroom), the majority of people listen at moderate levels, regardless of the type of earphone they use. This has been confirmed by preliminary findings of Fligor and Ives[18] that have been presented at scientific meetings and are currently in review for publication in a scientific journal. In quiet settings, Fligor and Ives showed that regardless of the type of earphone used (earbud, on-the-ear, or in-the-ear earphones), people set music to the same relatively quiet level. A few people set the music too loud when the background noise levels are quiet, also regardless of the type of headphone. In a noisier environment (such as a typical commute in a car, bus, or subway), the majority of people turn up the sound level to be able to hear their music over the background noise.

How much higher they turn it depends on the level of background noise. Two earlier studies independently showed that the average chosen listening level above background noise is 13 dB higher than the noise.[19,20] In a quiet bedroom, the background noise may be 50 dBA, and so the average chosen listening level would be roughly 63 dBA. This level is perfectly safe for any duration of time, and is similar to the level of normal conversation. On a noisy bus that is 75-80 dBA, the chosen listening level would be 88-93 dBA (similar to some of the louder power tools in Table 2) and is not safe if used for a few hours per day. This is irrespective of whether the person uses an earbud or on-the-ear headphone, because it's the background noise that causes a person to increase the volume control, not the type of earphone.

Sound-isolating earphones. The Fligor and Ives study further indicated that using sound-isolating earphones allows people to moderate the level of their headphones in a noisy environment, compared to their chosen listening levels using earbud and on-the-ear headphones that don't block out background noise. Even in very noisy conditions, such as while flying on a commercial flight, the majority of people who turn their music up too loud using on-the-ear earphones set the music much lower using sound-isolating in-the-canal earphones.

Myth: "I know the music is too loud when I can hear their music!" This is an all too common misconception this author has heard from parents, nurses, and even some well-meaning audiologists. Conversely, one might ask, *"So, if you can't hear the music, does that mean it's OK?"*

Weiner, Kreisman, and Fligor[21] conducted a study to debunk this urban myth. They asked subjects to set the music to the level where they liked it, varying the level of

background noise from very quiet to moderately loud background noise, and an observer judged whether or not she could hear the music from the headphones. In quieter environments, the music was detectable whenever the headphone user set the music to 85 dBA or higher (considered "risky"), but it was also detectable most of the time when the music was set less than 85 dBA (considered "not risky"). In louder background noise, music that was set less than 85 dBA was less often detectable, but so was music set to 85 dBA and higher. In the end, this screening measure of hearing loss risk ("If I can hear it, that means it's too loud") correctly identified whether or not there was NIHL risk only 9% of the time in quiet, 12% of the time in low-level background noise, 16% of the time in moderate background noise, and 42% of the time in high background noise. Essentially, in all situations, "If I can hear it, that means it's too loud" got it wrong most of the time.

Music Concerts and Dance Clubs

As with NASCAR events and other loud entertainment activities, whether or not attending a rock concert or dance club causes hearing loss depends on how often a person engages in that activity. With very few exceptions, a single rock concert or outing to a dance club will not result in permanent hearing loss. Weekly (or even more frequent) attendance could contribute to the wear-and-tear on one's hearing if proper precautions are not taken.

Musicians and their audiences. There's little doubt that professional musicians are at risk for hearing loss from their work, as they are exposed to high-level crowd noise and the sound reinforcement on stage several times per week. Pete Townshend, from the rock band *The Who*, famously acknowledged his NIHL and tinnitus in 1989, and helped fund a non-profit organization dedicated to the prevention of hearing loss from music: Hearing Education and Awareness for Rockers (**www.hearnet.com**).

According to a report in the scientific literature in the early 1990s, the average level of rock concerts was 103.4 dBA.[22] At a typical concert venue (both outdoor and indoor), crowd noise alone tends to be around 100 dBA. In order for musicians to hear themselves on stage, they need to either set the level of the loudspeakers on stage (called "wedge monitors") higher than the crowd noise, or use an in-ear monitoring system that can (if the correct devices are selected) block the crowd noise and allow the monitoring mix to be audible to the musician at a moderate level. The sound engineer who sets the level of the main loudspeakers (called the "house mains") that amplify the music to the audience must set the levels sufficiently higher than the crowd noise.

In this author's experience working at rock concerts, the sound engineer typically targets a level of 104 dBA at his or her location. An unprotected exposure at this level exceeds allowable limits within about 6 minutes' time. After a 45 minute set,

the audience and the engineer would have a 750% noise dose (7.5 times the allowable exposure). If this is a rare event for the concert attendee, it's unlikely this moderate overexposure will permanently damage hearing. The sound engineer, however, is at risk for NIHL due to this overexposure occurring every day.

Single-event exposures leading to NIHL. It is possible to sustain permanent hearing damage after a single, very high exposure during a rock concert. There are two separate cases this author has reviewed for civil litigation where permanent auditory injuries were claimed to have been suffered because of attendance at a single rock concert. In one case, the plaintiff claimed to suffer loss of hearing and chronic tinnitus after attending a show where he had very good seats at an outdoor amphitheater-style venue. Reconstructing the sound levels based on sound monitoring conducted at the sound engineer's location and his proximity to the house main speakers, this plaintiff was exposed to 105-108 dBA for at least 2 hours, and possibly as long as 3.5 hours. The resultant noise dose would have been 44 to 85 times the allowable exposure, which is sufficient to cause an acoustic trauma.[5]

The other case involved an attendee who claimed chronic tinnitus and hyperacusis following attendance at a rock concert in a medium-sized indoor venue where the levels were as high as 107.4 dBA and she was present between 1 and 2 hours (for a resulting noise dose of 22 to 44 times the allowable). Both cases settled out of court, with reasonable damages awarded to the plaintiffs. It should be noted that these cases of civil litigation against concert venues involved noise exposures quite similar to sitting in the front row of a NASCAR event, as described earlier in this chapter. Thus, risk for acoustic trauma would be similar.

Dance clubs. A longitudinal study of hearing in teenagers 14-17 years old in Argentina identified attendance at dance clubs to be the most significant source of noise exposure in this group (more significant than use of PLDs). Typical sound levels in the dance clubs were 104.3 to 112.4 dBA, with noise routinely exceeding 16 times the allowable doses.[23] Dance club attendance was in part responsible for slightly poorer hearing in those who frequented this entertainment activity.

Preventive Measures

From these reports, it's reasonable to consider those who regularly attend dance clubs, rock concerts, or NASCAR events and the like should investigate preventive measures to limit the unnecessary wear-and-tear on their hearing. NIHL develops insidiously, so significant hearing loss often exists before it becomes obvious. This type of hearing loss is permanent and cannot be "cured" by medication or surgery.

Hearing aids have come a long way since microchips and digital signal processing were first introduced in their circuits, but they don't "fix" the hearing loss. The

hearing abilities of a person with NIHL cannot be restored to “normal.” Thus, prevention is the key.

Hearing loss prevention programs implemented in the workforce can teach us much about protecting our hearing off the job. Occupational hearing loss prevention programs are generally comprised of assessing the risk, identifying technical controls to limit or eliminate the risk, conducting annual evaluation of the workers’ hearing, educating workers about NIHL and motivating them to take personal responsibility for hearing loss prevention, and using hearing protection devices when a hearing hazard persists.

Very similar steps can be taken in preventing hearing loss from recreational noise. Parents often ask me what they can do to protect their child’s hearing. The response usually includes they take their child to see an audiologist to have the child’s hearing tested, and have their own hearing tested as well.

How many readers have had their hearing tested in the last year? In the last 5 years? Parents lead by example, and children are very sensitive to hypocritical behavior. How is a child supposed to listen to parents’ urging them to turn their MP3 players down when the parent uses power tools and shoots firearms without hearing protection? It may be unreasonable to assess the risk for NIHL for many recreational activities, given that hearing loss prevention professionals undergo extensive training to learn how to use sound level meters and dosimeters, and interpret the findings.

Consumers can choose to “buy quiet,” since many appliances and electronic devices are manufactured with noise control in mind. Purchase toys that meet the ASTM (2003) standard. Use earphones that are designed to block out background noise. And see a hearing care professional for routine hearing evaluations.

ADDITIONAL READING:

"**Earmuffs: A Primer**," by Brad Witt, MA, in March 2007 issue of *HR*.
"**Uniform Attenuation Hearing Protection Devices**," by Patricia A. Niquette, MA, in March 2007 issue of *HR*.
Hearing screenings in school are helpful at identifying significant hearing loss, but often are inadequate to identify early NIHL. Hearing screenings in primary care offices as well are not intended to detect subtle changes in hearing that may be the harbinger of worse things to come. Most physicians still do not screen for hearing loss. An audiologist is uniquely qualified to obtain a full history pertinent to the

individual's hearing health and risk factors and conduct measures to detect early changes to the hearing mechanism.

For the consumer reading this chapter, clearly you are already highly motivated to minimize your risk for NIHL. The key now is to be educated about hearing loss risk and translate this education into behavior that takes responsibility for NIHL prevention. It's not necessary to avoid all forms of recreational noise. Rather, take high-level sound in moderation, give hearing a break between loud exposures, and use hearing protection devices (HPDs) when the levels are going to be high for a long duration.

HPDs come in many forms, from foam earplugs to over-the-ear earmuffs to custom molded level-dependent hearing protection. The appropriate style of HPD is best recommended by a hearing care professional based on the recreational activity and how long and how often you'll be engaged in it.

A few general recommendations follow. Avid target shooters should consider using both earplugs and earmuffs (double protection). While the sound reduction provided by both is only a few decibels more than that provided by one or the other, maximum sound isolation is necessary due to the number of rounds one may fire. Earmuffs shield a portion of the skull (at the temples) behind and within which sit the cochlear structures at risk. Furthermore, target shooters should strongly consider investing in custom-fitted hearing protection.

Custom-fitted hearing protection can be obtained from a hearing care professional, and involves custom earmold impressions being taken of your ears and sent to a laboratory for fabrication of the device. This ensures a consistently good fit and custom-fitted HPDs are often considerably more comfortable than over-the-counter HPDs.

Level-dependent HPDs are a viable alternative to solid earplugs for hunters, as they provide little sound attenuation until the sound level becomes excessively high (that is, the firearm is discharged). Passive level-dependent HPDs do not work perfectly to prevent NIHL, but are much better than shooting unprotected.

Hunters who wish to have extremely good auditory awareness, such as being able to detect game at a distance, can invest in electronic HPDs. These devices are similar to hearing aids in that they may provide mild amplification for soft sounds (or at least pass through soft and moderate sound without attenuation, as though there were nothing in the ear), and compress or clip the level of high sound. These are a more expensive option, but relative to the cost of a firearm, they are not exorbitant. Compared to the cost of NIHL, they're a trivial expense.

Sometimes foam earplugs or earmuffs provide too much sound isolation, particularly when the recreational activity involves music appreciation. Earplugs and earmuffs attenuate high-pitch sound more than low-pitch sound, so music sounds muffled and distorted. Additionally, earplugs and earmuffs provide more sound isolation than is needed (more is not always better).

An excellent alternative is to invest in Musicians Earplugs™ (also called the ER-series of earplugs), which are custom molded HPDs that attenuate all pitches relatively evenly. The result is music sounds nearly unchanged, just a little softer. Musicians Earplugs™ can even provide varying levels of attenuation: 9 dB when levels or duration will not be extreme, 15 dB for most live-music shows, or 25 dB when the level and/or duration of exposure is extensive.

Musicians Earplugs™ should be obtained through a hearing care professional who assesses your hearing, recommends an appropriate level of attenuation, counsels you on the proper use and care of these devices, and verifies that the devices do, in fact, attenuate the frequencies uniformly. A poorly fitted Musicians Earplug™ can sound worse than a foam earplug, and result in the consumer rejecting their use. A well-fitted Musicians Earplug™ is an absolute pleasure; live music that is just a little too loud is brought into a loud but comfortable range.

An intermediate alternative to foam earplugs for people who are not yet ready for Musicians Earplugs™ is ER-20 high fidelity earplugs. While not as uniform in attenuation as the Musicians Earplugs™, they're considerably better (much less high frequency roll-off) than foam earplugs.

People who invest considerable time and money into their MP3s and downloads should look into upgrading their headphones. Why spend hundreds of dollars on a device and hundreds more on music and then listen with $10 headphones? Research has shown that, in moderate to high levels of background noise, people tend to set the music at a level that, for some, can pose a risk for NIHL.[18] Using earphones that act like an earplug to outside sound (that is, block out ambient noise) allows people to keep their listening levels moderately high and still hear everything. There are a few headphone manufacturers who design headphones to block out background noise.

The ER-6i earphones, produced by Etymotic Research Inc, provide considerable sound isolation to most people. The benefit to custom sleeves is a consistent, comfortable fit and excellent sound isolation, which is quite helpful for those people who have never been able to get standard headphones to fit in their ears. Custom headphone sleeves are obtained by an hearing care professional, and should be made of a soft material that completely blocks the ear canal. Custom sleeves that have venting (or slide onto earphones with vents in the back of the

earphone) allow ambient sound to pass through to the ear and provide essentially no sound isolation. This somewhat defeats the purpose of a custom sleeve: to block out background noise and allow a person to listen at moderate levels, even when the ambient sound is very high.

Active noise-canceling (ANC) headphones that employ phase-cancellation technology can provide good control of ambient sound. This phase-cancellation works better on low frequency sound, and requires a power supply (a battery) that could run out during use.

By contrast, passive sound-isolating earphones provide sound isolation across frequencies and do not require a battery. Care should be taken when using any sound-isolating earphones: a person should not use these devices when there's a need to monitor the auditory environment, such as running through Central Park at night, or crossing a busy city street. Blocking the ear and listening to music will very effectively block out ambient sound, including car horns and ambulance sirens.

Conclusions

Can we legislate common sense? Likely not. Should we try? This might be a matter of debate, but perhaps efforts would be better spent working to educate people so that hearing loss prevention becomes common sense.

ADDITIONAL READING:

"**Firearms and Hearing Protection**," by William J. Murphy, PhD; David C. Byrne, MS; and John R. Franks, PhD, in March 2007 issue of *HR*.
"**'Portable' Music and Its Risk to Hearing Health**," by by Brian J. Fligor, ScD, in March 2006 issue of*HR*.
"**Hearing Conservation in Schools of Music: The UNT Model**," by Kris Chesky, PhD, in March 2006 issue of *HR*.
"**Please Welcome On Stage...Personal In-the-Ear Monitoring**," by Michael Santucci, MS, in March 2006 issue of *HR*.
Legislative efforts to increase funding for NIHL education, particularly for school age children, would be considerably more effective than mandating sound output limits on PLDs. Personal choice is highly valued in many societies, and so personal responsibility ought to receive appropriate attention to allow personal choice to continue without resulting in detrimental effects.

Recreational activities are vital to one's happiness and should not be avoided out of fear of NIHL. Moderating high recreational sound exposures, taking responsibility for one's NIHL prevention, and serving as role models to our children would allow us, as a society, to enjoy our leisure time without suffering the ill effects of a completely preventable disorder.

It is a noisy world, but we have a *choice* whether or not we allow it to "prematurely age" our ears.

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