Preventing Music-Induced Hearing Loss

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By Kris Chesky

A small investment in hearing safety education can prevent damage to your students' hearing.

When people are repeatedly exposed to loud sounds, the common result is noise-induced hearing loss (NIHL). In addition to not being able to perceive music normally, those who experience this irreversible disease often encounter difficulties with communication and problems with academic and cognitive performance, and can even be prone to hypertension as they struggle to understand others' words.[1]

Physicians and scientists who study hearing believe that loud music heard over extended periods is contributing to increasing rates of NIHL. Based on national data from 1988 to 1994, researchers estimate that NIHL affects 12.5 percent of children in the United States ages six to nineteen.[2] These rates are now allegedly rising even higher among these and older populations because of the high output levels and use rates of iPod and other sound-producing technologies (whose earbuds bring the sound very near both eardrums).[3] In April 2007, Apple announced that it had sold its 100 millionth iPod, making the system the fastest-selling music player in history.

The belief that repeated exposure to loud music can lead to hearing damage is reinforced by reports of hearing problems among musicians[4] and the potential intensity levels of sound that musicians are capable of producing—even within the context of music education. A 2005 report based on a survey of young people averaging 19.2 years old concluded that 61 percent experienced tinnitus or hearing loss as a result of attending music concerts.[5] Another recent report demonstrated that college music students in a marching or pep band were exposed to levels up to 17,000 percent of allowable exposure (dose) for one day.[6] Data for this 2007 study were derived and analyzed using standards developed by the National Institutes of Occupational Safety and Health (NIOSH). One hundred percent of the allowable dose for a day is equivalent to an average sound of 85 decibels (dB) for eight hours. (For reference, 85 dB is the volume of a common household blender.) A succession of studies conducted through the University of North Carolina–Greensboro revealed similar concerns for the health of some public school music students and teachers.[7]

The evidence is sufficient to prompt music educators to be aware of and concerned about the role of music in the prevalence of NIHL. There are obvious reasons to respond. In addition to knowing that music-related NIHL is preventable and prevention is possible through education, the music education

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community needs to realize that children in the United States are not learning about NIHL as part of the public school curriculum. According to a recent issue of the Journal of School Health, the lack of effective hearing-conservation instruction in our public schools is one of the most challenging obstacles to effective implementation of a national hearing loss prevention strategy.8 The problem is generally traced to the lack of public policy, public awareness, and effective dissemination methods of existing lesson plans and other teaching materials. Basically, there are no public school disciplines under which this education naturally falls.

It would be inappropriate to expect music teachers to tackle public health issues like bicycle helmet or seat belt use, smoking, recreational drug use, or teen pregnancy. On the other hand, it seems responsible to call on music teachers to educate students about the relationships between music and NIHL. Hearing health is essential to the music experience, and music is often implicated as a causal factor in hearing loss. Audiologists and hearing conservationists are now using the term *music-induced hearing loss* in response to the increased clinical and research-based evidence of this relationship.

Music teachers working in general music education and in music ensemble settings should learn about basic strategies and resources available to them. Implementation of these and other actions requires the concern, interest, and commitment of music teachers at all levels. The field of music education, particularly at the college level, needs to embrace this urgent challenge.

Catch Them Early!

Hearing conservationists have long advocated hearing-health education as part of public school education. Because the majority of public school teachers are not formally trained in this area, a number of professional nonprofit organizations have developed, tested, and now offer teaching resources specifically for the nonexpert. Music teachers at all levels can access these materials, use them as provided, or modify them to suit a specific musical context.

Dangerous Decibels, a public-private partnership launched in Oregon, is a good example of such a resource. A public health campaign, Dangerous Decibels is designed to reduce the incidence and prevalence of NIHL by changing knowledge, attitudes, and behaviors of school-age children. The campaign offers a curriculum and teacher's guide that are posted online (see the resources sidebar for more information on this program and others).

Photo by Mark Regan

Average sound levels produced within certain music ensembles can be very high, but the director can moderate sound levels by focusing on musical dynamics.

Hearing Loss Factors

A typical assumption is that the threat to hearing from sound is directly related to the intensity level—loudness—of the sound. This is not completely accurate. The risk from overexposure to sound emanates from a combination of the average sound pressure (decibel level) and the length of time the ear is exposed to the sound. The more intense the average sound is, the shorter the amount of time a person can be exposed to it without incurring damage. For instance, exposure to an average sound intensity of 85 dB for eight hours produces the same risk as an average sound intensity of 88 dB for four hours, 91 dB for two hours, or 94 dB for one hour, and so on. The allowable time of exposure is cut in half with every 3-dB increase in average intensity. Risk from sound exposure depends both on the average intensity level of the

sound *and* on the amount of time (duration) of exposure.

The cumulative nature of exposure to sound is another important and often misunderstood concept. Exposure level, especially in music, is often applied to or reflective of one specific and independent event. This view can be misleading. To establish whether someone is at risk, you need to know and consider exposure levels for an entire day. This perspective is critical for musicians and music students who are diligently and fervently involved with music.

Imagine for a moment a percussionist who practices for two hours at an average intensity level of 88 dB. This specific event represents 50 percent of allowable exposure for a day. By itself, the practice session does not represent a harmful activity. The same student practices on the same day with a drumline for one hour at an average intensity level of 91 dB. This additional event also represents 50 percent of allowable exposure for a day. Individually, neither event is considered risky, but together they represent 100 percent of allowable exposure for a day. But what if the same student participates in a large marching band rehearsal on the same day for an hour at an average intensity level of 94 dB? At this intensity level, the marching band rehearsal represents 100 percent of allowable exposure. Considering all three events, this music student is exposed to 200 percent of allowable exposure for one day.

Repercussions for Students

Because motivated music students spend more time exposed to music, music teachers must assume a potential association between wanting to make music and an elevated risk for music-induced hearing loss. A recent study of college piano majors reported an average of twenty hours per week of individual practice time, with some students reporting more than forty hours per week.[9] College music majors are typically and routinely involved with multiple ensembles and other sound-producing events on a daily basis.

Logically, some events involve sound pressure levels that are higher than others, but the emphasis here is that *all* events contribute to the total amount of exposure. Music teachers should recognize this fact and help educate music students accordingly.

The College of Music at the University of North Texas is one music school that has recently instituted a policy stating that every music ensemble director is responsible for providing appropriate information about hearing loss at the beginning of each semester. Recognizing that the vast majority of music majors participate in the ensemble program, the policy is designed to ensure that all students routinely receive appropriate educational messages directly from ensemble instructors.

The music school's policy is based on the work of the Music-Induced Hearing Loss Task Force of the National Hearing Conservation Association, a group that helped develop the educational goals and talking points to be used by ensemble teachers. The involvement and consensus of these experts was critical to ensure credibility and consistency with the National Institute for Occupational Safety and Health Publication No. 98–126. A description of this project, along with the names and affiliations of contributors, was published in the March 2006 issue of *Hearing Review*,[10] and the goals listed here were outlined in that article.

Music educators who work in ensemble settings need to consider ideas for teaching all students about hearing loss. To ensure that all music students receive some education about hearing health in the context of music making, every ensemble director, regardless of educational level or genre, should provide at least one lesson on hearing health at the beginning of each school year or semester. The materials presented here should be used as resource material, not as a script to be read to students. Although originally developed for college music students, these goals are appropriate for middle school and high school music students with slight modifications—particularly in reference to school resources. I recommend that they be used in all music education ensemble classes, including band, orchestra, and choir.

Goal 1: Promote Hearing Health

The first goal is to promote an awareness of and concern for hearing loss that could result from participating in music ensembles. Tell your students that, under certain conditions, participation in music ensembles represents a risk for hearing loss, and that music-induced hearing loss can be prevented. Instructions to teachers and faculty should provide the information that follows.

Characterize Noise-Induced Hearing Loss. When an individual is overexposed to excessive sound levels, sensitive structures of the inner ear can be damaged. This damage can result in permanent hearing loss. These structures can be injured by exposure to a brief but intense sound, such as an explosion, or from regular exposure to loud sound levels over time. Risk for this type of hearing loss can be minimized through routine annual audiologic evaluation, moderation of exposure levels and exposure durations, resting between excessive exposures, and proper use of hearing protection devices such as earplugs.

Describe Measurements That Determine Risk for Hearing Loss. Sound pitch or frequency is measured in hertz (Hz). Although the human ear collects sounds up to 20 kHz (1 kilohertz = 1000 hertz), the 2–5 kHz frequency range is where most of the spectral cues (the frequency of the sound) for speech are found. Sound pressure levels are measured in decibels (dB). Normal conversation is measured at a moderate sound level of 50–70 dB, while the sound level within a music ensemble might be measured at 100–120 dB. Prolonged exposure to sounds above 85 dB can cause permanent hearing loss.

Describe the Effects of Hearing Loss. Overexposure to sound is the leading cause of damage to sensory hair cells, called cilia, in the inner ear. When damage first occurs, it usually affects the part of the ear corresponding to the midfrequency range of 3–6 kHz. On an audiogram, this type of hearing loss configuration is commonly referred to as a "noise-notch." These frequencies are particularly important for understanding speech, because they contain the consonant

information needed for distinguishing speech sounds.

Hearing loss in this range of sound makes speech sound muffled. Conversing is difficult, especially when there is background noise present. For instance, the phrase "take the fast car" may be misheard as "rake the backyard." It is common for individuals with this type of hearing loss to report, "I can hear you; I just can't understand you." This is because the louder, lower-frequency vowels are audible, but the softer, higher-frequency consonants are difficult to hear due to reduced hearing sensitivity in that spectral region.

Hearing loss may or may not be accompanied by tinnitus—ringing, buzzing, or a fluttering sound in one or both ears. While people with normal hearing may also have tinnitus, it is especially common in people with NIHL.

Sometimes, short-duration exposure to sound may cause temporary hearing loss called a *temporary threshold shift*. This temporary loss usually vanishes within fourteen to sixteen hours after overexposure to loud sounds, and hearing gradually returns to preexposure levels. Cumulative overexposure to loud sounds eventually results in permanent hearing loss that will not recover over time.

Goal 2: Prevent Hearing Loss

The second goal is to promote hearing-loss prevention and risk-reduction practices among students, faculty, and staff. For most students, information about risk to hearing will be new, unusual, and challenging. If the information you share is to be effective, students must believe they are at risk and they must believe that the benefits of recommended protective behavior outweigh the costs of risk-taking behavior. Following are steps to take in fulfilling this goal.

Underscore the Importance of Hearing. Address the importance and sophistication of the sense of hearing for musicians: speech understanding, pitch perception, localization (pinpointing where a sound is coming from). Hearing loss permanently changes a musician's capacity to hear and can diminish the capacity to perceive changes in timbre, pitch, dynamics, and localization.

Give Students the Facts about Risk. Share information about prevalence rates for problems with hearing loss among musicians, and assert that the risk occurs across all music genres and is not restricted to particular types of music, instruments, or venues. Experts agree that 30–50 percent of musicians have some degree of hearing loss. Proportions are related to many factors, including the instrument played, the genre of music performed, and the performance venue.

Risk from sound exposure depends both on average intensity level of sound and on the amount of time of exposure.

Describe and Demonstrate Safe Sound Levels. Risk for injury is based on both sound intensity and duration. The exposure limit is 85 dB TWA (time-weighted average) for eight hours in a single day. Even brief exposures to extremely loud sounds have the same potential for hearing damage as longer exposures to lower intensity sound sources. Remember that for every 3-dB increase in sound level, you need to decrease the maximum time of exposure by half.

The average sound levels produced within certain music ensembles can be very high; they depend on factors such as an individual's location within the ensemble, size and kind of ensemble, the selected literature, choices about dynamic levels, the acoustical environment, and individual playing styles.

Goal 3: Teach Risk Reduction

The third goal is to teach students how to reduce risk and prevent hearing loss. Experts agree that proactive strategies can contribute significantly to the prevention of hearing loss due to overexposure. To fully realize these benefits, students should be continuously encouraged to take individual responsibility, including making use of free opportunities and resources such as clinics available at their schools.

To fulfill this goal, music educators should encourage students to take the following steps.

Learn the Warning Signs. Describe to your classes the warning signs of overexposure, such as temporary threshold shifts, ear discomfort during or after exposure, ringing and buzzing sensations in the ears, and difficulty hearing in noisy environments.

If Possible, Obtain an Objective Baseline Audiogram. Encourage students to get a baseline audiological evaluation regardless of their age and to have subsequent annual checkups. For the college student, evaluations on many campuses are free through the Department of Speech and Hearing. Annual test results should be compared to the baseline test and monitored for change. Students should understand their baseline results. Instruct students to learn about the audiogram from an audiologist (if possible), and about the importance of maintaining a baseline audiogram for future comparison.

Have Access to a Sound-Level Meter, and Keep It in Your Gig Bag. Encourage the use of a sound-level meter and/or a personal dosimeter at the high school and college level for estimating the amount of sound generated in a particular ensemble or for an entire day through a readout for a certain period, including out-of-school sound exposures.

In turn, teachers should be able to do the following for their students.

Supply Solid Advice. Provide tips for reducing risk. In particular, encourage students to moderate loudness levels of the music they listen to and play, reduce exposure time to sounds greater than 85 dB, and reduce repeated or cumulative exposure to very loud sounds.

Sound Safety Tips

To prevent hearing loss, encourage students to:

- Moderate loudness levels of the music they listen to and play.
- Reduce exposure time to sounds greater than 85 dB.
- Reduce repeated or cumulative exposure to very loud sounds.
- Avoid hazardous sound environments, such as very loud music ensembles or iPods turned to "10."
- Give ears a periodic rest after exposure to loud sounds.

Students also need to rest their ears after exposure to loud sounds (see Sound Safety Tips sidebar).

When using the materials described here, try innovative and varied approaches for engendering positive attitudes toward hearing-loss prevention among students. This may involve some thinking about students' beliefs, values, habits, and educational culture. And don't forget to continually model the behavior you want to teach, since your actions make a greater impression than any lecture you give.

Is Your Ensemble Too Loud?

As the professional directly responsible for the production of sound from a school-based ensemble, and therefore for the risk levels that affect students' hearing, every ensemble director should seek to understand the levels produced and should act accordingly. To get a general idea of intensity levels, an ensemble director can use a standard sound pressure level (SPL) meter, available for under $50 at retail electronics stores, to observe the sound pressure levels reflected on the meter. This information can be helpful, but a formal quantitative assessment requires a dosimeter that measures accumulated noise exposure and determines percent of allowable exposure (dose), time-weighted averages, exposure times, and so on. Consult a local audiologist to assist in acquiring and interpreting dosimeter data.

Students who participate in ensembles should be notified in the event that dosimeter data show that exposure levels have exceeded 100 percent of allowable dose. If students are minors, parents or guardians should be notified with a written statement disclosing the average exposure levels for the event and the risk associated with these levels. The form should include a place for a parent/guardian signature indicating acknowledgment of the risk and consent to participate in the ensemble. Again, a hearing conservationist or audiologist can help interpret the dosimeter data and present it to both students and their parents.

The next step is for the ensemble director to embrace the challenge of producing music that retains all the desired musical energy and excitement, but without the risk to hearing. Some directors may choose to provide a box of hearing protectors for students to use. This action may be helpful, but without any research on the impact of hearing protectors with musicians, these devices are an undocumented attempt to reduce the negative impact of exposure to dangerous intensity levels. Students may not comply because of discomfort or perceptual changes. Hearing protectors may actually increase the intensity levels produced; that is, students wearing earplugs or headphones may play louder. The primary response should focus on changing the music so that it is not risky to participants.

When approaching this problem from a musical perspective, remember the "3-dB rule" that exposure to an average sound of 85 dB for eight hours is the same as being exposed to an average sound of 88 dB for four hours, 91 dB for two hours, or 94 dB for one hour. This rule is vital; it dictates that the allowable exposure time is reduced by half for every 3-dB increase in average sound. To reduce risk, an ensemble director can apply this rule in reverse and recognize that the allowable time of exposure doubles for every 3-dB decrease in average sound.

Most dosimeters offer an output chart of the percentage of time spent at half-dB increments across the full range of sound intensity levels used and the time frame that data was collected. This function lets an ensemble director know exactly how much time is being spent at each discrete intensity level. This objective evaluation of sound intensities produced by an ensemble can be applied to one piece of music, an entire rehearsal, or even a series of rehearsals. Dosimeters should become required technology, especially for directors of large ensembles. A dosimeter can also be used as a training device in teacher education programs at the college level.

The easiest way to reduce average sound levels is to focus on musical dynamics. If an ensemble rehearsal produces average intensity levels above allowable exposure levels, it's very likely that a large percentage of time is spent producing high intensity levels, and little or no time is spent producing music at low levels. Based on personal experience evaluating ensembles using dosimeters, I believe that the amount of time spent in the production of high "average" sound levels (high-risk) is much higher than that spent producing sounds at low and medium intensity levels. One way to reduce the "average" sound level without specifically lowering the high sound levels is to increase the times spent at medium and low levels—playing with more dynamics. The ensemble director can produce safe intensity levels through literature selection, musical programming, greater attention to dynamics, and modifications to conducting technique.

This musical approach to reducing risk allows an ensemble director to retain and perhaps increase the excitement associated with performing intense passages. By incorporating a balanced percentage-of-time approach, an ensemble director can successfully reduce high average sound levels while, at the same time, the ensemble becomes more musical.

Be a Good Role Model

In addition to focusing on the hearing health of music students, music educators need to be concerned about their own hearing. After reading this

article, music educators should recognize that teaching music is a potentially hazardous occupation because of the extended exposure to high-intensity sound. The primary line of defense is to have your hearing evaluated annually by an audiologist and to limit your exposure to loudness in any form.

Your students need to be informed and empowered, but you are the one who needs to be aware of the sound levels of your ensembles and the potential for noise-induced hearing loss. You must be honest in your disclosure of any problems to your students and the community. The ability to make changes and the responsibility for doing so belong to the person who holds the baton.

Notes

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6. Vanessa Miller, Michael Stewart, and Mark Lehman, "Noise Exposure Levels for Musicians," research poster presentation at the annual meeting of the National Hearing Conservation Association, Savannah, GA (February 2007).

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Online Resources for Hearing Conservation

Web Sites

- **Dangerous Decibels** maintains a Web site sponsored by the University of Oregon and a consortium of other institutions. A teacher's guide includes background information, classroom activities, and various appendixes with glossary, diagrams, scales, pictures, and at-home activity supplements. Adaptable for grade levels K–8, but designed and tested with specific age ranges and developmental stages in mind. Clear and accessible to the nonspecialist. www.dangerousdecibels.org/teachers_guide.cfm
- **National Hearing Conservation Association** seeks to prevent hearing loss due to noise and other environmental factors in all sectors of society. A newly enhanced Web site is intended to provide information to anyone interested in learning more about hearing loss prevention. www.hearingconservation.org

Videos from the University of North Texas Center for Music and Medicine

- **Interactive Lesson Plan for Fifth Graders.** Carla Moreno, a public school music teacher from W. S. Ryan Elementary in Denton, Texas, reviewed the Dangerous Decibels Web site and developed a lesson plan for her fifth-grade general music class. The lesson plan includes instruction on normal auditory mechanisms, the effects of noise on hearing, types of hearing loss and their causes, warning signs of noise-induced hearing loss, and specific recommendations for hearing-loss prevention. The video, showing that a public school teacher with no prior experience in hearing conservation can effectively teach this information, can be viewed at http://media.unt.edu:8080/ramgen/cdl/MUAG1500/video/Hearing_Loss_5thgrade.rm
- **Visit to an Audiologist.** Like other professional groups in health care, audiologists are continually improving their diagnostic and clinical approaches. This video shows a student's visit to an audiologist to get a basic hearing test and ear protectors. http://media.unt.edu:8080/ramgen/cdl/MUAG1500/video/hearing_exam.rm