

WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Reducing the Risk of Hearing Disorders among Musicians

Summary

Musicians and others involved in the music industry are at risk of developing permanent hearing loss, tinnitus (ringing in the ears), and other hearing disorders from exposure to loud sounds. The National Institute for Occupational Safety and Health (NIOSH) examines the risks associated with music exposure and provides recommendations to protect their hearing.

NIOSH Recommended Exposure Limit

In the United States, occupational regulations and standards were established to protect workers against the health effects of exposure to hazardous substances and agents when certain values (or limits) are reached. NIOSH establishes recommended exposure limits (REL) for various hazards on the basis of the best available science and practice. The NIOSH REL for noise is 85 decibels, using the A-weighting frequency response (often written as dB(A) or dBA) over an 8-hour average, usually referred to as time-weighted average (TWA). The A-weighting of sound levels is thought to provide a rating that

indicates the injurious effects of noise on human hearing. Exposures at or above this level are considered hazardous [NIOSH 1998].

The NIOSH REL was developed to assess the risk of hearing loss among industrial workers exposed to steady broadband noise over 8-hour work shifts for up to a 40-year working lifetime and thus may not be completely applicable to assessing the risk to musicians and other music professionals who have irregular and unpredictable sound exposures. Musicians' work schedules vary considerably—they typically play less than 4 hours per day, and sometimes just 2 or 3 sessions or work shifts per week. The REL specifies a maximum allowable daily noise dose, expressed in percentages. The noise dose is based on both the sound exposure level and how long it lasts (duration), so for each 3-dB increase in noise exposure levels, the duration of the exposure should be cut in half (this is what's referred to as exchange rates in standards). For example, a person exposed to average sound levels of 85 dBA will reach 100% of their daily noise dose over their typical 8-hour work shift, but for a musician who is practicing or performing around 60 minutes a day, they will reach their maximum daily dose of 100% only if the sound

levels average around 94 dBA. The relationship between exposure duration and levels is shown in Table 1.

Table 1. The relationship between exposure duration and levels

Time to reach 100% noise dose	Exposure level per NIOSH REL
8 hours	85 dBA
4 hours	88 dBA
2 hours	91 dBA
60 minutes	94 dBA
30 minutes	97 dBA
15 minutes	100 dBA

Description of Risk

Hearing loss is one of the most common work-related illnesses in the United States. NIOSH estimates that 22 million U.S. workers encounter noise exposures loud enough to be hazardous. The American Tinnitus Association estimates that 50 million Americans suffer from prolonged tinnitus. As of 2012, the Bureau of Labor Statistics estimates that 167,400 people work as musicians and singers, and 77,600 as music directors and composers [BLS 2012]. For professional musicians, hearing loss or tinnitus can significantly impair not

only their communication and quality of life, but also their career and ability to obtain or maintain a job.

Although this document is aimed at professional musicians (members of an orchestra or a band, or music teachers) many of the recommendations also apply to the wide range of occupations in the music profession such as audio engineers, producers, crew members, music students, and nightclub disc jockeys (DJs). Professional musicians work and practice in a variety of venues ranging from large music halls, theatres, and arenas; to smaller clubs and school and university music rooms. Musicians are often overlooked in terms of occupational safety and health practices. Music-induced hearing loss occurs slowly and over a long period of time, and most musicians do not seek help until they start to experience secondary symptoms such as tinnitus (buzzing or ringing in the ears), distortion of sounds, diplacusis (hearing same notes at different pitches), and hyperacusis (extreme sensitivity to everyday sounds) [Santucci 2010].

In addition, negative health consequences are associated with producing high musical sound levels. Musicians are at increased risk for both musculoskeletal and vocal health problems when producing high sound levels on musical instruments like the piano, trumpet, guitar, or drums. Increased biomechanical demands, whether at the hands, embouchure, or vocal cords, elevates the risks for occupational health problems like tendonitis, carpal tunnel, rupture of facial muscles, and vocal cord malfunction [Hoppmann 2010].

Description of Exposure

Measurements of sound levels on stage of rock-and-roll concerts range from 105–120 dB SPL (90 – 110 dBA) [Speaks et al. 1970]. A study of sound exposure levels among orchestral members during individual or group rehearsals and during live performances showed sound levels reaching as high as 100 dBA. The highest sound exposure levels among orchestra members were found in percussionists, 95 dBA; flute/piccolo players, 95 dBA; and brass players, 92–94 dBA [Laitinen et al. 2003]. A study of noise exposure associated with marching bands found average sound levels of 95–122 dBA for brass drums, 106–118 dBA for cymbals, and 95–113 dBA for snare drums [Keefe et al. 2004]. Studies of sound exposure during college wind band performances and rehearsals found average levels of concert and symphonic bands were 89–90 dBA [Chesky 2010], and 52% of subjects had a daily noise dose that exceeded the NIOSH REL [Stewart 2009]. A questionnaire from the Stewart study found the use of hearing protection to be almost nonexistent during “instrument-playing activities.” Even employees of music clubs are at risk of developing hearing loss; average sound levels at eight different music clubs during performances ranged from 95 to 107 dBA [Gunderson et al. 1998].



Figure 1. An image of the volume and other knobs on a speaker amp.

Although great strides are being made in research on music-induced hearing loss, overall hearing conservation efforts have been minimal and left to the individual. A few countries (Australia, UK, Switzerland, Italy, Austria, Finland, and Sweden) have specific recommendations for occupational exposure limits for music or noise in the entertainment industry. Two excellent resources are the Control of Noise in the Music Entertainment Industry from the Worksafe Western Australia Commission and the Control of noise at work in music and entertainment from the United Kingdom Health and Safety Executive.

NIOSH Investigation

NIOSH conducted a Health Hazard Evaluation during middle and high school music classes and marching band rehearsals [NIOSH 2012]. Music instruction and rehearsals took place in a band room and in a cafeteria. NIOSH researchers measured the instructor’s personal noise exposure using a noise dosimeter. Researchers measured sound levels throughout the room and cafeteria areas. Sound levels during most band rehearsals ranged from 91–97 dBA, and exceeded 100 dBA numerous times. The band director’s personal exposure over 6 different classes and rehearsals (228 minutes) was 92 dBA (TWA), with a dose of 461% (both well above the NIOSH REL). Sound levels in the band room were much greater than in the cafeteria, mostly because the cafeteria was larger and had higher ceilings. NIOSH recommendations included treating the rooms with acoustical absorbent materials; providing appropriate space for practice based on the number of the students; improving faculty and students’ awareness of the risk of developing noise-induced hearing loss; increasing distances between students and band directors; lowering sound levels during rehearsals, if feasible; taking breaks in quiet areas; and providing teachers and students with custom-fitted musician earplugs.

Recommendations

NIOSH recommends hearing conservation programs for all workplaces with noise levels that exceed the REL of 85 dBA. However, because music is part of musicians' work and is the direct result of deliberate and desired actions, effective interventions must be behavioral and should rely primarily on awareness, knowledge, competency, and accountability of those producing musical sounds.

Employers, music venue operators, schools and colleges, and anyone responsible for music-related activities should consider the following recommendations:

1. Educate musicians and those involved in the industry about the importance of using increased distances between individuals and arrangements of instruments to reduce overall noise exposure during practice and performances. [For more specific recommendations, see Chasin 2010].
2. Develop a hearing conservation program that includes annual audiometric testing and training about protecting musicians' hearing.
3. Encourage participation in education and awareness campaigns of music-induced hearing loss, see a list of resources in the "more information" section below.
4. Since music levels fluctuate greatly from one practice or performance to another, conduct regular sound level assessments at a reference location and establish an average and a range of music levels during rehearsals and performances. Conduct personal exposure monitoring of performers and exposed staff. Assessments should be conducted, where practicable, by a certified industrial hygienist or an occupational safety and health specialist.
5. If sound level assessments show elevated levels (consistently exceeding the NIOSH limit of 85 dBA), consider reducing the amount of time musicians and staff are exposed through rotation or offering frequent breaks in quiet areas.
6. Work with musicians and affected workers to identify hearing protection solutions that work best for the individual. A variety of hearing protection options are available from inexpensive foam earplugs to potentially more costly products designed specifically for professional musicians and other entertainers.
7. Although more studies are needed to verify the effectiveness of general noise control solutions for musicians' workspaces, the following features may be effective in reducing the overall sound exposure levels among musicians and staff:

- Consult with architects, acousticians, and sound engineers to create the best desired and most effective musical workspace
- If the workspace for musicians or staff is very reverberant, treat certain sections of walls and ceilings with sound absorbent material to reduce reverberation time. Higher ceilings also help reduce reverberation for high energy instruments such as brass instruments and percussion
- For rehearsal and practice, consider using appropriate size rooms for the number of musicians
- Placement, spacing, and use of enclosures can help reduce overall sound levels from certain instruments
- If rooms or venues have hard reflective surfaces, position instruments and speakers to direct sound away from musicians

Musicians and workers in the music industry should consider the following recommendations:

1. When possible, play music at lower levels during individual and group rehearsals. If using amplified speakers in live performance, work with sound engineer to adjust the volume down to desired but acceptable levels.
2. If you use In-Ear monitors (IEM) to listen to vocals and stage instruments, work with your sound engineer and fitting audiologist to reduce sound output to workable levels, especially during practice and rehearsals.
3. Wear hearing protection when appropriate and ask your employer or audiologist about getting custom-fitted earplugs that work best for your environment.
4. Have your hearing evaluated annually by an experienced audiologist who understands noise exposures in the music industry.
5. Always be aware of your sound exposure level, an easy and practical way is to use your smartphone and a sound meter app (see NIOSH evaluation of smartphone sound measurement apps <http://blogs.cdc.gov/niosh-science-blog/2014/04/09/sound-apps/>).
6. Give your ears some rest; ears typically need about eighteen hours of quiet after exposures to loud sounds in order to return to normal hearing. Take advantage of breaks (in quiet areas) whenever possible.

Acknowledgments

The principal contributors to this publication were Chucri Kardous, Christa Themann, and Thais Morata from the NIOSH Division of Applied Research and Technology (DART); Jennifer Reynolds of the University of Florida College of Medicine; and Susan Afanuh from the NIOSH Education and Information Division (EID).

References

- BLS [2012]. Occupational outlook handbook. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics. <http://www.bls.gov/ooh/entertainment-and-sports/home.htm>
- Chasin M [2010]. Hear the music: hearing loss prevention for musicians. Toronto, Canada: Musicians Clinics of Canada. http://www.marshallchasinassociates.ca/pdf/Hear_the_Music_2010.pdf
- Chesky K [2010]. Measurement and prediction of sound exposure levels by university wind bands. *Med Problems Performing Artists* 25(1):29–34. <http://www.ncbi.nlm.nih.gov/pubmed/20795377>
- Gunderson E, Moline J, Catalano P [1997]. Risks of developing noise-induced hearing loss in employees of urban music clubs. *Am J Ind Med* 31(1):75–79. [http://onlinelibrary.wiley.com/doi/10.1002/\(SICI\)1097-0274\(199701\)31:1%3C75::AID-AJIM11%3E3.0.CO;2-4/abstract;jsessionid=5D6A3192FFE85F6FF1E8E2A1E14CB120.f04t03](http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1097-0274(199701)31:1%3C75::AID-AJIM11%3E3.0.CO;2-4/abstract;jsessionid=5D6A3192FFE85F6FF1E8E2A1E14CB120.f04t03)
- Hoppmann RA [2010]. Musculoskeletal Problems of Instrumental Musicians. *Performing Arts Medicine*, 3rd ed. Chapter 11. <http://www.sciandmed.com/tpam/journalviewer.aspx?issue=1188&article=1859>
- Keefe J. [2005]. Noise exposure associated with marching and pep bands. <http://acoustics.org/pressroom/httpdocs/150th/Keefe.html>
- Laitinen HM, Toppila EM, Olkinuora PS, Kuisma K [2003]. Sound exposure among the Finnish National Opera personnel. *Appl Occup Environ Hyg* 18(3):177–182. <http://lib.tkk.fi/Diss/2010/isbn9789526030746/article1.pdf>
- NIOSH [1998]. Criteria for a recommended standard: occupational noise exposure. DHHS (NIOSH) Publication No. 98-126. <http://www.cdc.gov/niosh/docs/98-126/>
- NIOSH [2012]. Health Hazard Evaluation report: noise evaluation of elementary and high school music classes and indoor marching band rehearsals—Alabama. By Chen L, Brueck S. NIOSH HETA No. 2011-0129-3160. <http://www.cdc.gov/niosh/hhe/reports/pdfs/2011-0129-3160.pdf>
- O'Brien I, Driscoll T, Ackermann B [2013]. Sound exposure of professional orchestral musicians during solitary practice. *J Acoustical Soc America* 134(4):2748–2754. <http://scitation.aip.org/content/asa/journal/jasa/134/4/10.1121/1.4820900>
- Santucci M [2010]. Saving the music industry from itself. *Hearing J* 63(6):10–14. http://journals.lww.com/thehearingjournal/Fulltext/2010/06000/Saving_the_music_industry_from_itself.3.aspx
- Speaks C, Nelson D, Ward WD [1970]. Hearing loss in rock-and-roll musicians. *J Occup Environ Med* 12(6):216–219. http://journals.lww.com/joem/Citation/1970/06000/Hearing_Loss_in_Rock_and_Roll_Musicians_.4.aspx
- Walter J [2009]. Sound exposure levels experienced by university wind band members. *Med Problems Performing Artists* 24(2):63–70. <https://www.questia.com/library/journal/1P3-2823067431/sound-exposure-levels-of-university-jazz-band-members>

Suggested Citation

NIOSH [2015]. Reducing the risk of hearing disorders among musicians. By Kardous C, Themann C, Morata T, Reynolds J, Afanuh S Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2015-184.

For More Information

More information about noise-induced hearing loss is available on the NIOSH Web site at <http://www.cdc.gov/niosh/topics/noise/about.html>

To receive documents or other information about occupational safety and health topics, contact NIOSH at

Phone: 1-800-CDC-INFO (1-800-232-4636)

TTY: 1-888-232-6348 ■ E-mail: cdcinfo@cdc.gov

or visit the NIOSH website at www.cdc.gov/niosh.

For a monthly update on news at NIOSH, subscribe to *NIOSH eNews* by visiting www.cdc.gov/niosh/eNews.

Mention of any company or product does not constitute endorsement by NIOSH. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites.

Examples of efforts to reach musicians and other professionals exposed to music can also be found from some of the Safe-in-Sound Excellence in Hearing Loss Prevention Award™ recipients, an award created by NIOSH in partnership with the National Hearing Conservation Association (NHCA) See <http://blogs.cdc.gov/niosh-science-blog/2011/01/25/music/> and <http://www.safeinsound.us/archive.html>

Reducing the Risk of Hearing Disorders among Musicians

Additional resources:

- H.E.A.R – Hearing Education and Awareness for Rockers
- Hear Tomorrow – Hearing Conservation Workshop
- Listen to Your Buds – American Speech-Language-Hearing Association
- Musicians' health and therapy – American Federation of Musicians
- For musicians and music lovers – American Tinnitus Association
- Basic Information on Hearing Health – National Association of Schools of Music
- Adopt-A-Band – Etymotic Research, Inc.
- Musicians' Clinics of Canada – Musicians Clinics of Canada

This document is in the public domain and may be freely copied or reprinted. NIOSH encourages all readers of the *Workplace Solutions* to make them available to all interested employers and workers.

As part of the Centers for Disease Control and Prevention, NIOSH is the Federal agency responsible for conducting research and making recommendations to prevent work-related illnesses and injuries. All *Workplace Solutions* are based on research studies that show how worker exposures to hazardous agents or activities can be significantly reduced.

DHHS (NIOSH) Publication No. 2015-184