Spring 3-31-2020

Sound Exposure Characterization for Faculty Musicians: A Hearing Loss Prevention Initiative

Hannah Mahon
Illinois State University, hlmahon@ilstu.edu

Antony Joseph
Illinois State University, arjosep@ilstu.edu

Sound Exposure Characterization for Faculty Musicians:

A Hearing Loss Prevention Initiative

Capstone Document

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Audiology (Au.D.)

in the Graduate School of Illinois State University

By

Hannah L Mahon, B.S.

Illinois State University

March 2020

Approved By

Antony Joseph, Au.D., Ph.D., CPS/A, F-NAP, Advisor ____________________________

ABSTRACT

The primary aim of this project was to characterize the sound exposure of faculty musicians at a university music department, specifically for hearing loss prevention purposes. Sound measurements were obtained as a major portion of the project to calculate the risk for over-exposure to hazardous sound intensities. Excessive sound exposure can cause permanent injury to the human auditory system. This type of injury is diagnostically classified as noise-induced hearing loss and tinnitus. To verify risk-exposure status, dosimeters were used to sample a variety of accessible musician training environments. Sound samples obtained from personal noise dosimetry instrumentation were used to obtain common noise metrics, such as A-weighted decibel (dBA) intensity level, time-weighted average, and peak sound pressure level. During group rehearsals and private lessons, our measurements indicated that faculty musicians were exposed to sound levels in excess of 85dBA (the damage-risk criterion level used by most countries, except the United States). At times, students and faculty were exposed to sound intensities in excess of 90dBA. These surveillance samples were plotted and interpreted to provide appropriate recommendations for faculty musicians. To deliver hearing-loss prevention to all workers affected by hazardous sound, our national policies, hearing conservation programs, and hearing-health wellness should be revised and mandated for professional musicians.

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Antony Joseph, my Advisor, for his insight, commitment, and support throughout this project. This project would not have existed without his devotion to the students of Illinois State University. I would also like to thank Dr. Stephen Parsons, Director of Illinois State University Music Department, for seeking consultation regarding hearing prevention for the faculty and staff of the music department. He provided motivational support throughout the entire process.

VITA

Education

B.S., Communication Disorders, 2016, Truman State University

Au.D., Audiology, 2020 (expected), Illinois State University

Experience

Graduate Assistant, Department of Audiology at Illinois State University, 2016-2018

Coordinator, Musician Hearing Wellness Program, HLP Laboratory, 2018-2020

Member, Student Academy of Audiology, Illinois State University, 2016-2019

Audiology Resident, Associated Audiologists, Inc. of Overland Park, KS, 2019-2020

TABLE OF CONTENTS

CHAPTER 1

Introduction

Occupational audiologists are responsible for hearing loss prevention in the workplace, which is rendered primarily by implementation of hearing conservation programs (HCPs). Federal regulations, such as the Occupational Safety and Health Administration (OSHA, 1983), require workers who are exposed to hazardous occupational noise to be enrolled in an HCP, which includes annual monitoring audiograms, annual hearing wellness education, and the availability of free hearing-protection products. This federal policy should be updated (e.g., written in1983) and does not mention music exposure. More recently, a position statement on hearing conservation and preventing work-related occupational hearing loss was written by an American Academy of Audiology task force (AAA, 2003) but does not consider musicians and their excessive sound-exposure levels. Nevertheless, for many years, professional musicians have been exposed to excessive sound-intensity levels, placing them at risk for music-induced hearing loss (MIHL).

Reports on MIHL are provided by the National Association of Schools of Music (NASM), which has a hearing-health education requirement for student and faculty musicians due to the high-intensity sound produced by their musical instruments. Conventional occupational HCPs may not be optimal for academic musicians; therefore, we designed this project in order to quantify the sound-exposure levels of faculty musicians to increase our understanding of MIHL risk at the School of Music.

Literature Review

Long-duration, high-intensity sound exposure places musicians at risk for MIHL. Gopal et al. (2013) conducted a study that revealed musician exposure levels ranging from 95-105.8

dBA during 50-minute practice sessions, exceeding the daily exposure limit suggested by the National Institutes for Occupational Safety and Health (NIOSH, 1998). Orchestra, jazz ensemble, and rock musicians may be at risk for MIHL and should be educated about strategies for hearing-loss prevention. Phillips et al. (2010) reported that the prevalence of hearing loss in adult musicians is 38 to 50%, which is significantly higher than the national rate of hearing loss in the population, approximately 10%. One factor that may contribute to the higher rate of hearing loss in musicians is poor compliance with hearing protection use.

Many musicians report that earplug use is bothersome, so they wear a protector in only one ear to minimize its effect on performance (Laitenen et al., 2008). For this reason, hearing-health professionals should provide the musician population with direct access to hearing screenings and assessments, hearing-loss prevention education, and appropriate hearing protection devices. Traditional, off-the-shelf hearing protection products may not be appropriate for musicians and concert goers because of the way they attenuate sound and alter sound perception. So, products need to be developed that are less bothersome to musicians and individuals that attend loud music performances.

Professional musicians may have a wide range of sound exposures due to their fluctuating schedules. The HCPs for musicians should address their needs across different settings (Halevi-Katz et al., 2015), especially in university-campus environments. Accredited Schools of Music (ASOM) around the United States have recognized the value of hearing-wellness education. The ASOM encourages music education programs to follow hearing health policies determined by the National Association of Schools of Music (NASM) and the Performing Arts Medicine Association (PAMA). The extent to which this is being administered in music education programs was not revealed in the literature.

The NASM and PAMA have set the standard for music students and faculty to have access to basic information about hearing health and injury prevention, suitable choices of equipment, and acoustic conditions that reflect the health and safety of musicians in various environments. Methods for addressing these policies are the responsibility of each academic institution (NASM Handbook, 2018). It may be advantageous for music departments to seek guidance from audiologists who specialize in hearing loss prevention and HCP implementation. As partnerships between audiologists and musicians are formed, the importance of hearing health and wellness should be emphasized so that the art of sound is not diminished (Laitenen, 2008).

Conventional industrial HCPs deliver five programmatic components (Hutchison and Schulz, 2014; Amlani and Chesky, 2014), including (1) noise monitoring, (2) engineering controls, (3) audiometric monitoring, (4) hearing conservation education, and (5) hearing protective devices. Such a program should satisfy ASOM requirements, and promote hearing wellness for students and faculty, but relevant sound-exposure information must be included.

Sound exposure with musicians

Overexposure to loud sound affects musicians and music educators of all ages in our society. More recent reports indicate that sound-exposure hazards exist in music-education facilities around the world (Gopal et al., 2013; Phillips, 2008; Zhao et al., 2010). Regarding occupational exposure, NIOSH (1998) states that sound intensity at or above 85 dBA for more than 8 hours is hazardous. Furthermore, for every 3-dB increase in intensity of the exposure above 85 dBA, the exposure-duration allowance is reduced by 50%. For example, sound exposure of 88 dBA will reach the maximum daily noise allowance in just four hours. **Table 1** shows the permissible sound-exposure levels according to length of time exposed (from the Council for Accreditation in Occupational Hearing Conservation, CAOHC by Hutchison and

Schulz, 2014). Because musicians have fluctuating sound exposures during their daily activities at work, it is important to apply an 8-hour time-weighted average (TWA) when determining noise exposure levels, but to still consider the absolute intensity levels that comprise any TWA estimate. This may be done with a noise dosimeter or sound-level meter (SLM).

A personal noise dosimeter is an instrument used to monitor sound-intensity levels, calculate TWAs, collect peak sound pressure levels (SPL), and estimate noise dose. Noise dose is important because it identifies the permissible noise exposure (in percent) of the monitored individual. For example, if a musician has a noise-dosimeter measurement of 94 dBA for a 4-hour rehearsal, this is 400% of the allowable noise dose (Hutchison and Schulz, 2014) and hazardous. Kahari et al. (2003) reported that sound exposure from rock concerts exceeded 100 dBA on average, including peak intensities of 120-130 dBA. Mean sound levels of orchestral rehearsals were identified by Zhao et al. (2010) as 83-112 dBA. Noise dosimeters may be deployed in these environments, particularly for musicians who function in a variety of settings and activities during a day of work.

Individual instruments provide intense sound levels, so music professions who instruct multiple private lessons per day may be at-risk for hearing injury. For example, a cello produces an average sound exposure of 88.6 dBA while drum rolls are 106 dBA. Readers may refer to Darling (2016), which reports sound-level measurements for various instruments that exceed NIOSH exposure recommendations (≥85 dBA). The average college jazz practice session loudness level ranged from 95.0-105.8 dBA for 50-minute practice sessions, (Gopal et al., 2013). Each day, music educators typically lead several practice sessions, as well as public performances. Some participate in Drum Corps International (DCI), an elite marching band organization. Members of DCI practice up to 14 hours each day, including a full tour schedule.

According to Bondurant and Smaldino (2012), noise-dose measurements for a 16-hour day snare drummer can reach 8900%, which is 89 times higher than the daily allowable exposure. Dose results from a 16-hour day for a cymbal player reached 3000%; 30 times the permitted amount. During their free time, DCI musicians listened to music, recreationally. Zhao et al. (2010) reported that personal MP3 players and similar devices typically exceed 85 dBA with a peak output of 110 dBA. These work-related and recreational intensity levels are unsafe and raise concerns about the collective daily exposures of music students, coaches, and conductors.

Professional musicians play 5.5 hours each day on average, but this may vary, based on career specialty (Laitinen et al., 2003). Halevi-Katz (2015) investigated music exposure and hearing loss in pop, rock, and jazz musicians. The professional qualifications determined for the participants of this study included at least four years of musical experience and five hours of practice per week. Their data indicated a positive correlation between the amount of exposure to amplified music and audiometric thresholds at 3000-6000 Hz. The authors reported no correlation between experience, number of years in music, and use of hearing protection and concluded that hours per week was most predictive of hearing loss (Halevi-Katz, 2015). At the time of this literature review, no data on music educator hours per week of high-intensity exposure had been published, but educators have expressed concerns (Gopal et al., 2013). High-intensity sound (music) exposure may lead to auditory disorders, such as hearing loss, tinnitus, hyperacusis, sound distortion, and diplacusis.

Hearing loss may be determined by behavioral or objective testing; however, some auditory problems are self-reported, such as tinnitus, hyperacusis, distortion, and diplacusis. Tinnitus is a patient report of ringing, chirping, or other self-perceived noises that are bothersome. Hyperacusis is the sensitivity to loud noises, distortion causes music to sound out of tune, and diplacusis is a disorder that makes one sound match two sounds that may differ in frequency and time. Zhao et al. (2010) reported that high-intensity, long-duration music exposure can cause temporary threshold shift, tinnitus, hyperacusis, recruitment, distortion, and abnormal pitch perception. In addition, 74% of the musicians had hearing problems that were correlated with overexposure to sound and these disorders negatively impacted their careers (Kahari, 2003).

Awareness of MIHL

It is important to provide hearing wellness training for music educators because they, in turn, can impart pertinent hearing-loss prevention knowledge to their students. Chesky (2008), a musician educator and advocate, reported a lack of public-school guidelines for prevention of MIHL, reportedly resulting from a lack of policies, public awareness, and resources. School districts could use hearing conservation initiatives such as *Dangerous Decibels*, a partnership that provides teaching materials to mitigate MIHL and shape the attitudes of school age children. Unfortunately, university musician educators and students rarely have access to HCP services (Bondurant et al., 2012).

The awareness of MIHL has improved with college music students and faculty (Zhao et al., 2010; Gopal et al., 2013); however, these students and faculty do not consistently practice preventive health. Some musicians wear hearing protection in one ear only. Factors associated with these poor substitutions of hearing protection may include limitations and discomfort of standard earplugs, inaccurate perception of sound levels, perceived interference of musical abilities, limited understanding of flat-attenuating earplug benefits, and limited earplug counseling and training strategies, (Halevi-Katz, 2015; O'Brien et al., 2014).

Musicians may be aware of risks to their hearing but still need more direct access to information. Some lack awareness of hearing conservation information that was designed to meet their needs (O'Brien et al., 2015). The Music-Induced Hearing Disorders Task Force of the National Hearing Conservation Association was charged to promote risk reduction for MIHL in musicians, music-industry professionals, and music listeners and to ensure that music programs provide appropriate education about the risks of noise and high-intensity sound exposure. Appropriate education on MIHL has been shown to be successful in increasing hearing protection usage and other hearing loss prevention elements, (Laitinen et al., 2008; O'Brien et al., 2014).

Santucci and Hall (1995) suggested an educational approach for musician hearing loss prevention programming. In the past, hearing conservation was misunderstood by the music industry. More recently, increased education has helped musicians, as well as audiologists, recognize the value of these programs. Studies have demonstrated an increase in hearing protection usage when musician hearing loss prevention education is delivered (Laitinen and Poulsen, 2008; O'Brien et al., 2015). When informed about the negative impacts of auditory injury, musicians respond favorably (Santucci and Hall, 1995), and hearing loss prevention strategies are more frequently implemented, especially when the risks, initial symptoms, and ways to protect hearing are included (Laitinen et al., 2008).

Recommended Hearing Loss Prevention Program Model

Education methods used with other occupational specialties must be revised to address the needs of musicians. Amlani and Chesky (2014) suggested that the primary objective of the hearing loss prevention program is to decrease overstimulation of the musician's auditory system throughout their lifetime. This objective may be accomplished by revealing the individual's daily noise exposure level through an exposure-monitoring program. Gopal et. al (2013) also recommended that the personal sound-exposure levels of musician educators should be identified and discussed, and affected students should be informed as well. Chesky et al. (2008) identified three goals for a musician education program: (1) promote hearing health, (2) prevent hearing loss, and (3) provide risk-reduction training.

As part of a 5-year occupational health study, the Queensland Symphony Orchestra (QSO) redesigned a conventional HCP to meet the needs of their musicians (O'Brien et al., 2015). The strategy was developed through surveying, literature reviews, and industrial experience. Elements of the QSO-HCP included the following:

1. Exposure monitoring
2. Annual audiological assessment
3. Weekly education sessions on risk
4. Annual education sessions
5. Engineering controls (absorptive acoustical materials and treatments)
6. Administrative controls (seat rotations and scheduling)
7. Personal controls (hearing protection)

The QSO-HCP was implemented by a noise committee, which included several people who held various roles and responsibilities for delivery of the program. The musicians of QSO expressed mostly positive feedback about the program.

Current Standards for Accredited Schools of Music

There are approximately 1,795 institutions in higher education that have degree-granting music programs. United States ASOMs have recognized the value of hearing-health education and follow the NASM and PAMA hearing health policies. According to the NASM Handbook (2018), music majors and faculty must be provided basic information regarding the maintenance of hearing health and injury prevention. The ASOM may provide this material to students and faculty in written form, lectures, or partnerships with audiologists. ASOM institutions must also provide suitable choices of equipment, and appropriate acoustic conditions that reflect the health and safety in all musical environments. The method of addressing these policies is the responsibility of each academic institution, so some schools have partnered with campus speech and hearing clinics to improve the level of programming for musicians (Phillips et al., 2010).

Although NASM and PAMA have written policies to support the prevention of hearing loss, at the time this manuscript was completed, there were no regulations for schools on sound monitoring, audiometric monitoring, or hearing protection counseling. This may be due to variability of sound level measurements between musicians, lack of personnel to administer the programs, and decreased funding for ancillary programs (O'Brien et al., 2015). As mentioned, the 4-month QSO-HCP was rated favorably by its musicians; however, there were questions about sustainability of the HCP due to lack of funding (O'Brien et al., 2015). Clearly, funding will be needed to support all elements of an ASOM-qualified program.

Despite these limitations, there are examples of ASOM HCPs that have partnered with campus Audiology clinics. Phillips (2010) reported that music students at University of North Carolina were required to have annual hearing tests as part of their HCP. Students completed a case history prior to the test that requested information about their sound exposures, such as:

1. Year in school
2. Instrument
3. Ensemble participation
4. Hours of practice and exposure
5. Medical history

The medical intake included otologic history, family history, noise exposure from outside sources, tobacco usage, and chemical exposure. Doctoral Audiology students reviewed the case history and performed a hearing examination. The hearing evaluation was comprised of an audiometric pure-tone air-conduction test from 1000-8000 Hz with inter-octave frequencies 3000 and 6000 Hz. According to the university website, HCP services have been delivered annually. In addition, the University of Wisconsin HCP is provided by the campus speech and hearing clinic. Services for student and faculty musicians include comprehensive hearing evaluations with pure-tone air-conduction hearing testing and otoacoustic emissions, as well as counseling about risk behaviors and musician hearing protection.

CHAPTER 2

Methodology

Subjects

Four music professors at the Illinois State University School of Music participated in this project. Each faculty member specialized in different musical instrumentation including percussion, brass, and woodwinds and had more than five years of professional musical experience.

Instrumentation/Equipment

Educators donned an Extech SL-355 Personal Noise Dosimeter™ (FLIR Commercial Systems Inc., Nashua, New Hampshire) for six to nine hours during 2-3 different days at work. This dosimeter met OSHA (1983) specifications for threshold measurement range (70-140dB), slow response time, exchange rate (5 dB), A-weighted filter, threshold level (80 dB), and a criterion level (84 dB). Pre- and post-calibration was performed with a standard 114 dB pistonphone. The dosimeter microphone was placed in the pistonphone cavity and a 1000-Hz calibration signal was selected. Adjustments were made to the dosimeter to match the 114dB output level. The sound survey was logged in 10-second increments, which was approximately 3000-4000 logs entries for each sound survey.

The dosimeter was clipped to the collar of each professor, and instructions to keep the microphone of the device at approximately ear level were provided. Educators could remove the dosimeter during lunch breaks, if needed. The dosimeter was retrieved at the end of the day. When removing the dosimeter, we observed that the device appeared to have remained in the preferred position for the sampling period.

Environment

Sound measurements were collected in locations where the professor spent their time. These locations were at campus music facilities, including offices, recital halls, and rehearsal classrooms. The music professor offices were located between two university buildings that lacked acoustic treatment. The two recital halls were treated by professional acoustic engineers for optimal sound quality and evenly dispersed transmission of sounds for live performances. The rehearsal classrooms were not acoustically treated.

Procedures

Arrangements were made with four music conductors to collect sound measurements. Undergraduate students were trained how to properly perform dosimetry, and participated in collecting measurements with a graduate (AuD) student (H.L.M). The Extech SL-355 Personal Dosimeter was given to each educator at the beginning of their shift and they were counseled on the importance of maintaining the appropriate ear-level placement of the microphone. The participants were asked to proceed with their day as planned. The dosimeter was retrieved by the AuD student at the end of the day, and the professors were asked to provide a summary of their schedule. Three professors wore the dosimeter for one day, and one wore the instrument for two days.

Sound samples were classified into three categories: rehearsal, private lessons, and office hours. These categories were chosen from the schedule provided by the educators and verbal description of each day. Professors confirmed their days were consistent with the rehearsal schedule, with additional 30-minute or 60-minute private lessons in the office setting. Other work activities included grading, meetings, and administrative tasks (meetings with students).

When the dosimetry data were collected, the results were downloaded as DOSI files to a personal computer with the Extech SL-355 software installed. Each DOSI file was converted into a TXT file for Microsoft Excel compatibility. The four educators had separate Excel files created to store their individual sound measurements. Data were extracted from each sampling of sound measurements, graphed, and analyzed using Microsoft Excel software.

Results were discussed with each of the music professors and they were counseled about the risks of MIHL, strategies to prevent hearing loss, musician hearing protection, and the permanent nature of MIHL. Annual hearing evaluations to monitor hearing thresholds were recommended for all professors.

CHAPTER 3

Results

Personal dosimetry samples were obtained from four music conductors over a total of five days. **Figures 1-4** represent the sound intensity data collected for four of the five samples including ensemble genre. The sound-intensity levels ranged from 58.1 to 115.1 dBA. Each faculty member was exposed to hazardous levels of sound (e.g., above 85 dB) at some point during the sampling period, sometimes for short durations. **Figure 1** shows 3,740 data points with an exposure range from 61.5 to 105.2 dBA. **Figure 2** is a display of 2,003 data points with an exposure range of 58.2 to 106.7 dBA. **Figure 3** shows 2,628 data points with an exposure range of 58.2 to 115.1 dBA. **Figure 4** is a display of 3,246 data points with an intensity range of 58.1 to 107 dBA. The most hazardous sound intensities were sampled during music rehearsals, private practice sessions, and small ensembles, with lowest risk of exposure occurring during office hours.

A comparison of the personal dosimetry data revealed that routine (daily) sound exposure varied between and within each educator. **Table 2** captures the time weighted average (TWA) and noise dose of each day. Music Conductor 2 (jazz) demonstrated excessive sound exposure for both samples. The TWA was 85.4 dBA for the first sample and 87.5 dBA for the second sample, and noise-dose estimates were 121.5% and 163.5%, respectively. The TWAs for the other musicians ranged from 78 to 84.5 dB, with noise-dose estimates ranging from 19.1 to 47.1%.

While reviewing the sound-measurement data and associated activities, Music Conductors 1, 2, and 4 each verified individual activities associated with measured sound levels. We observed that excessive noise peaks were either related to private lessons or music rehearsals of the day. **Figure 5** is a summary of the average percentage of time dedicated to music rehearsals, private practice sessions and small ensembles, and office work during the sound samples. These percentages were based on the music rehearsal schedule and verbal confirmation of activities for three of the four professors. We learned that private practice sessions were sometimes scheduled as two to three consecutive appointments each day. Those lessons are organized by the student and music professor, therefore are not reflected in the template schedule. The schedule of Music Conductor 3 is unknown.

When results were reviewed, counseling on the benefits of musician plugs and engineering controls were provided. Music Conductor 1 reported frequent use of custom musician plugs or Etymotic standard ER-15 musician plugs. This musician reported intermittent use of custom musician plugs with 25-dB filters. Music Conductor 2 expressed concerns about the dosimetry data results and reported frequent use of commercial off-the-shelf earplugs. Music Conductor 4 confirmed use of Etymotic standard ER-15 musician plugs during all music rehearsals and private lessons. The benefits of custom earplugs were discussed with Music Conductor 4 (percussionist). Each musician reported concerns about the acoustics in rehearsal rooms but recognized the limitations of funding for engineering controls.

CHAPTER 4

Discussion

According to the National Institute on Deafness and Other Communication Disorders (NIDCD Information Clearinghouse, updated 2017), continuous or repeated exposure to sound-intensity levels at or above 85 dB may result in hearing loss. Schulz (2014) reported that individual susceptibility is a critical variable that must be recognized because some workers may demonstrate no loss of hearing after years of high-level noise exposure, while others will show hearing loss following exposure to lower intensities.

Music professors monitored for this project were routinely over-exposed to hazardous sound (e.g., 85 dBA). Even more alarmingly, students and faculty were exposed to excessive sound intensity levels during rehearsals (e.g., over 90 dBA). The sound surveillance from this project revealed that music faculty were at risk for auditory injury, especially when educators reported no use of hearing protection.

To mitigate the risk for individuals exposed to high intensities in the music department, a hearing loss prevention program should be designed and administered. At a minimum, hearing screenings should be offered to music professors. Hearing screenings should consist of otoscopy, otoacoustic emissions, and pure tone audiometry from 500-8000 Hz. Further testing (i.e. speech in noise testing, high frequency audiometry, acoustic reflexes) should be recommended if referred from the screening. They should wear adequate hearing protection devices during rehearsals, and, when possible, faculty should use protection when conducting large groups of students. Training could be incorporated into a class lecture; however, acoustical treatment of rehearsal spaces would be the preferred method of intervention. As defined by the policies of NASM and PAMA, appropriate acoustic conditions reflect the health and safety in all musical environments. The music director reported that acoustical treatments would occur when funding was available and during the construction of updated music rehearsal rooms (Waller et al., 2018).

Future Research

This project was administered to determine if the sound exposures of faculty musicians warrant an occupational hearing conservation program. Dosimetry sound monitoring indicated that exposure levels for various musicians were hazardous at times and exceeded damage risk criterion as well. Based on these data, the following program is suggested: (1) periodic personal and area sound monitoring surveillance with dosimetry and SLMs, (2) hearing wellness screening of faculty by audiometric threshold testing from 500-8000 Hz accompanied by distortion product otoacoustic emissions testing, and (3) education and training sessions to improve hearing loss prevention and awareness. Future service projects in the Hearing Loss Prevention Laboratory should build from this project to identify specific aspects of a hearing-loss prevention program, including administrative and engineering controls, and hearing protection devices. Furthermore, future research might include investigation of the motivational factors for use of musician hearing protection devices, risk of hearing loss in music conductors, and development of a pragmatic screening methodology for musicians. Finally, from a perspective of advocacy and leadership, the American Academy of Audiology should draft an updated position statement on hearing conservation and hearing loss prevention that specifically addresses musicians and other unregulated specialties and professionals and their hazardous sound exposures.

REFERENCES

Amlani, A. M., & Chesky, K. (2014). Hearing Preservation in Musicians. American Music Teacher, 64(3), 19-21.

American Academy of Audiology. [October 5, 2011] Position statement: Preventing noise-induced occupational hearing loss. 2003. From https://www.audiology.org/publications-resources/document-library/hearing-conservation

Beach, Elizabeth, W. Williams, and M. Gilliver (2011). "A Qualitative Study of Earplug Use as a Health Behavior: The Role of Noise Injury Symptoms, Self-efficacy and an Affinity for Music." Journal of Health Psychology 17.2 (2011): 237-46. Journal of Health Psychology. Sage Publications, Inc. Web. 19 Oct. 2015.

Bondurant, Lindsay, and Joseph Smaldino (2012). "Hearing Conservation Programs for Drum and Bugle Corps: Implications for Educational Audiologists." *Journal of Educational Audiology* 25. Web. http://www.edaud.org/journal/2013/3-article-13.pdf 15 Oct. 2015

Chesky, K. (2008). Preventing Music-Induced Hearing Loss. Music Educators Journal, 94(3), 36-41.

Darling, D. (2016). Decibel. Retrieved from http://www.daviddarling.info/encyclopedia_of_music/D/decibel.html

Gopal, K., Chesky, K., Beschoner, E., Nelson, P., & Stewart, B. (2013). Auditory risk assessment of college music students in jazz band-based instructional activity. Noise & Health, 15(65), 246-252.

Halevi-Katz, D., Yaakobi, E., & Putter-Katz, H. (2015). Exposure to music and noise-induced hearing loss (NIHL) among professional pop/rock/jazz musicians. Noise & Health, 17(76), 158-164.

Hearing Health. (2018). Mead Witter School of Music. Retrieved from https://www.music.wisc.edu/hearing-health/

Hutchison, T. L., & Schulz, T. Y. (2014). Hearing conservation manual. 5th edition. Council for Accreditation in Occupational Hearing Conservation; CAOHC. Milwaukee, WI: 2014.

Kahari, K., Zachau, G., Eklof, M., Sandsjo, L., & Moller, C. (2003). Assessment of hearing and hearing disorders in rock/jazz musicians. International Journal of Audiology, 42(5), 279-288.

Killion, Mead. "Factors Influencing Use of Hearing Protection by Trumpet Players." *Trends in Hearing* 16.3 (2012): 173-78. Sage Publications, Inc. Web. 19 Oct. 2015. http://www.etymotic.com/media/publications/erl-0145-2012.pdf

Laitinen, H., & Poulsen, T. (2008). Questionnaire investigation of musicians' use of hearing protectors, self-reported hearing disorders, and their experience of their working environment. International Journal of Audiology, 47(4), 160-168.

NASM Handbook 2017-2018. (2017). Retrieved from https://nasm.arts-accredit.org/

National Institute for Occupational Safety and Health. Criteria for a recommended standard: Occupational noise exposure: Revised criteria 1998. Government Printing Office; Cincinnati, OH: 1998. (DHHS [NIOSH] Publication No. 98-126).

Niquette, Patty. "Hearing Protection for Musicians." *Hearing Review* 1 Mar. 2006: 52-58. Web. http://www.etymotic.com/media/publications/erl-0105-2006.pdf

O'Brien, I., Ackermann, B., & Driscoll, T. (2014). Hearing and hearing conservation practices among Australias professional orchestral musicians. Noise & Health, 16(70), 189-195.

Occupational Safety and Health Administration. 1910.95 CFR Occupational Noise Exposure:Hearing Conservation Amendment (Final Rule). Federal Register. 1983:9738–9785.

Santucci, M., & Hall, J. (1995). Protecting the Professional Ear: Conservation Strategies and Devices. The Hearing Journal, 48(3).

Phillips, S. L., Henrich, V. C., & Mace, S. T. (2010). Prevalence of noise-induced hearing loss in student musicians. International Journal of Audiology, 49(4), 309-316.

Waller, E., Mahon, H., Maze, H., & Joseph, A. (2018, April). Hearing loss prevention (HLP) component: Sound surveillance for the School of Music. ISU Research Symposium, Normal, IL.

Zhao, F., Manchaiah, V. C., French, D., & Price, S. M. (2010). Music exposure and hearing disorders: An overview. International Journal of Audiology, 49(1), 54-64.

TABLES AND FIGURES

Table 1. National Institutes for Occupational Safety and Health suggested noise-exposure limits for a 3-dB exchange rate and 100% dose.

Level (dBA)	Duration	Dose %
85	8 hours	100
88	4 hours	100
91	2 hours	100
94	1 hour	100
97	30 min	100
100	15 min	100

Table 2. Time weighted average (TWA) and noise dose (%) for each recording of Music Conductors 1-4. TWA and noise doses were based on NIOSH recommendations. Sampled using the Extech SL-355^{TM} (FLIR Commercial Systems Inc., Nashua, New Hampshire) Personal Noise Dosimeter and analyzed using the Extech software.

Name	Weekday	Time Weighted Average (dB)	Noise Dose (%)
Music Conductor 1	Thursday	84.50	47.1
Music Conductor 2	Tuesday	85.40	121.46
Music Conductor 2	Tuesday	87.50	163.48
Music Conductor 3	Wednesday	78.00	19.1
Music Conductor 4	Wednesday	82.60	36.2

Figure 1. Sound level measurements (dB) of Music Conductor 1, a professor of the ISU Symphonic Bands, experienced throughout the day from 7:30 AM-5:43 PM. Sample obtained using Extech SL-355™ (FLIR Commercial Systems Inc., Nashua, New Hampshire) Personal Dosimeter.

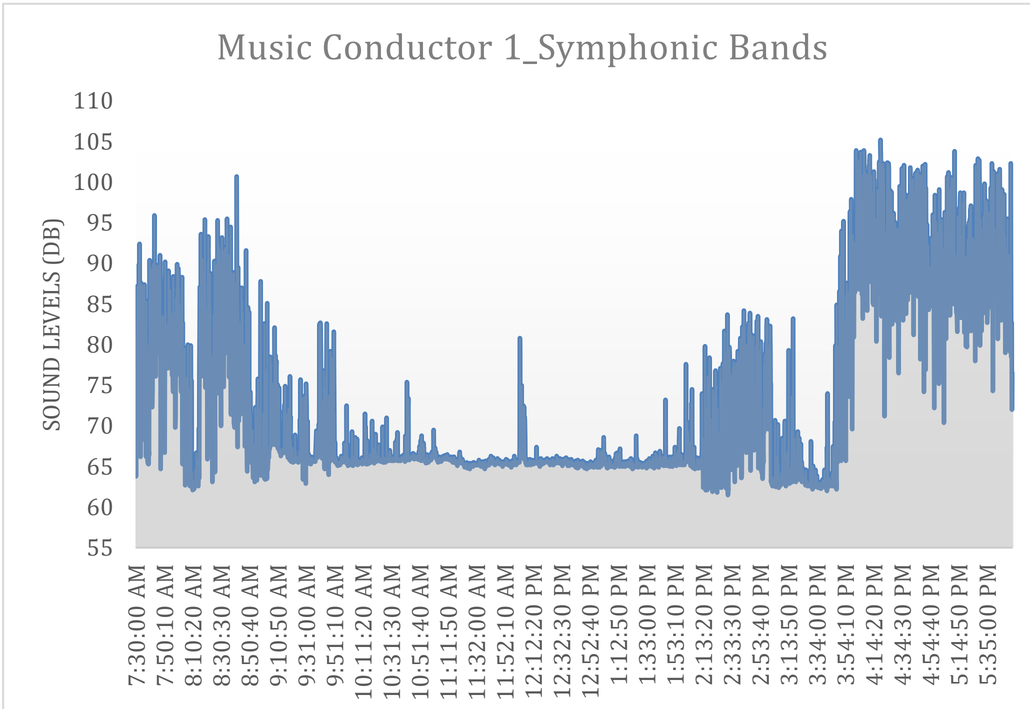

Figure 2. Sound level measurements (dB) of Music Conductor 2, a professor of the ISU Jazz Ensembles, experienced throughout the day from 9:30 AM-2:56 PM. Sample obtained using Extech SL-355™ (FLIR Commercial Systems Inc., Nashua, New Hampshire) Personal Dosimeter.

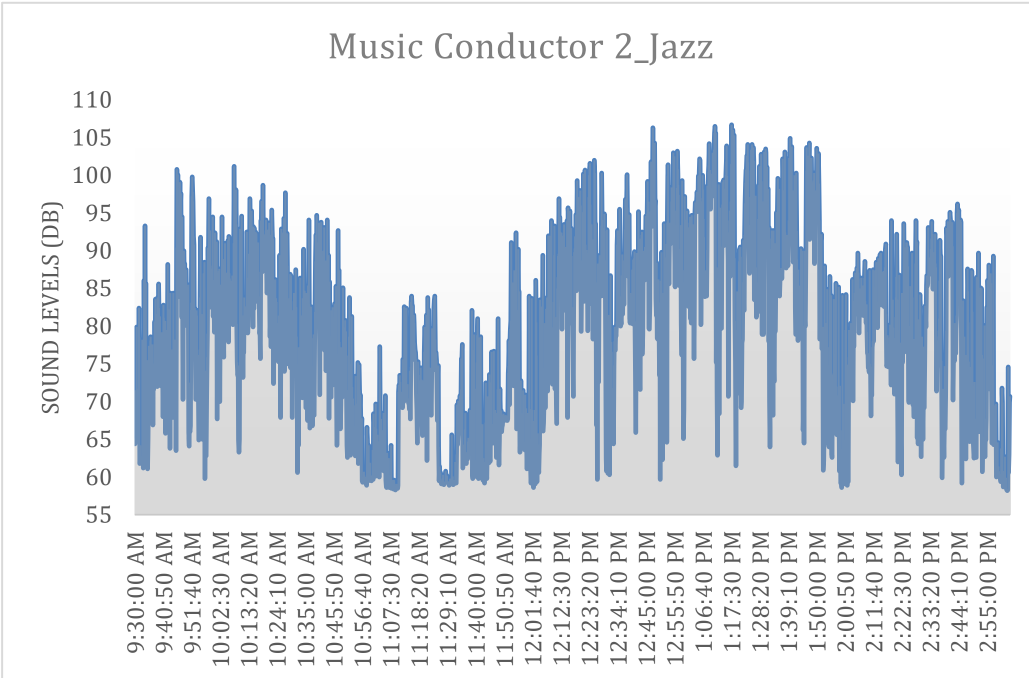

Figure 3. Sound level measurements (dB) of Music Conductor 3, a professor of the ISU Marching Bands, experienced throughout the day from 11:00 AM-6:15 PM. Sample obtained using Extech SL-355^{TM} (FLIR Commercial Systems Inc., Nashua, New Hampshire) Personal Dosimeter.

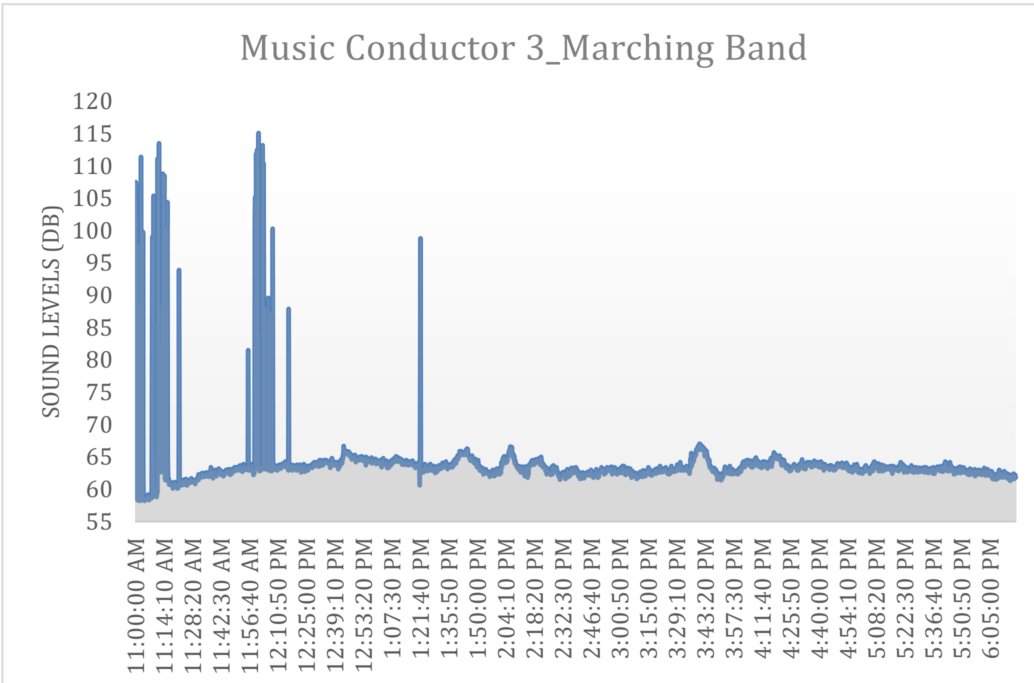

Figure 4. Sound level measurements (dB) of Music Conductor 4, a professor of the ISU Percussion Line, experienced throughout the day from 9:00 AM-5:45 PM. Sample obtained using Extech SL-355™ (FLIR Commercial Systems Inc., Nashua, New Hampshire) Personal Dosimeter.

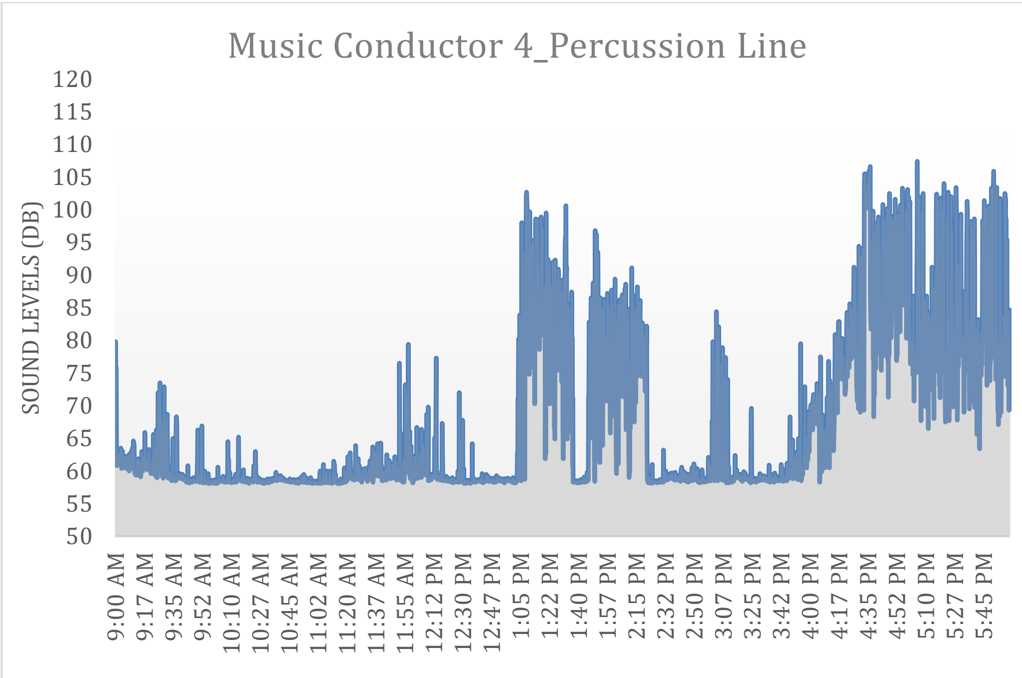

Figure 5. Percentage of time spent during “music rehearsals”, “private lessons/small ensembles”, and “office hours”.