NOISE
Not Just in the Workplace

By Ryan Cannady

NOISE IS AMONG THE MOST COMMON HAZARDS employees are exposed to in the workplace. OSHA (2020) states that millions of employees are exposed to excessive noise in their work environment. The agency reports that U.S. businesses paid more than $1.5 million in penalties for negligent protection from noise, and also that an estimated $242 million is spent annually on workers' compensation for hearing loss disability (OSHA, 2020).

Regulatory agencies and companies have aimed to reduce noise exposure and protect employees throughout the workplace through enforcement and mitigation measures. For example, a hearing conservation program is required when employees are exposed to noise levels that meet or exceed the permissible exposure limit in decibels (OSHA, 2008). However, the reach of these efforts does not extend outside the work environment. This article discusses the harmful effects of noise and several nonoccupational activities that generate excessive noise levels. Noise in recreational activities such as target shooting, exercise classes, sporting events, motorsports, landscaping, visiting bars or nightclubs, and playing a musical instrument can affect individual health. While noise remains prevalent throughout industry, it is critical to remain aware of nonoccupational noise exposure and its harmful effects.

Employer Risk

Hearing conservation programs aim to prevent an individual's hearing loss, preserve and protect remaining hearing, and equip workers with hearing protection devices to prevent further hearing damage (OSHA, 2020). Companies develop hearing conservation programs that establish requirements to monitor noise levels, perform annual audiometric testing, provide hearing protection and conduct training. The aim of hearing conservation programs is to protect employees, but this approach is often reactive to the noise hazard. Additionally, this approach provides surveillance and protection for individuals in the workplace but does not evaluate activities that pose issues outside of the work environment.

Hearing test results from 3,583 people (age 20 to 69) revealed hearing damage in one or both ears in 24% of adults (Carroll, Eichwald, Scinicariello, et al., 2017). Nearly 50% of individuals with hearing damage sustained their hearing loss as a result of exposure to excessive noise levels outside of work (CDC, 2017a). While it is important to establish safe working conditions, increasing evidence shows that the workplace is not the most damaging environment. Information from CDC (2017a) suggests that researchers believe exposure to loud noise comes from everyday activities in homes and communities. Annually administered workplace audiograms often cannot distinguish between occupational and nonoccupational noise damage; consequently, the employer must assume liability (Witt, 2006).

To be more effective, companies can include extracurricular activities in hearing conservation programs to reduce noise-induced hearing loss. Safety professionals can discuss nonoccupational activities and controls to minimize exposure. These discussions can occur during annual training or through take-home programs. Some companies have experienced a positive result from establishing their own magazine or computer-based training for employees that focuses on safety awareness outside of the workplace. While employers cannot enforce the hearing conservation program outside of the work environment, the safety professional can be a resource to raise awareness of the dangers associated with extracurricular activities.

Engineering controls may not be feasible in public places but if provided relevant information, employees can use administrative approaches and personal protective controls to reduce their exposures during recreational activities. Controls could include avoidance of loud areas, reducing exposure time, maintaining distance from the source, reducing the volume of the source, or replacing old equipment that is causing the noise levels (CDC, 2018). Although engineering controls may not be feasible, fit testing technologies can be used to determine the best level of hearing protection for individuals relying on PPE.

Through these programs, individuals can learn to recognize the causes of noise-induced hearing loss by understanding the limits and time-weighted averages at which noise begins to cause damage. Such programs can include providing facts about activities to show individual risk. For example, many may not understand that while momentary exposure to 90 dB will not cause adverse effects, exposure to a 160-dB gunshot without protection can cause instant, permanent hearing damage (Witt, 2006). Many may also not recognize that hearing loss due to nonoccupational excessive noise levels is a cumulative factor that results from multiple sources. By providing consistent awareness through annual training and take-home programs, employers can establish a culture that addresses safety outside of the work environment rather than only administering the required occupational hearing conservation program.

Harmful Effects of Noise

Safety professionals strive to anticipate, identify, evaluate and control hazards to protect employees. During the evaluation phase, it is important to recognize a hazard and determine exactly what is causing the exposure to be hazardous. While a safety professional's primary goal is to eliminate hazards, it may not be possible to completely rid the workplace of all dangers. Noise proves a particularly challenging foe, as exposure to excessive noise levels has been linked to various adverse health conditions. These conditions include stress, poor concentration, productivity losses in the workplace, communication difficulties, fatigue due to lack of sleep, cardiovascular disease, cognitive impairment, tinnitus and hearing loss (Housley & Burgess, 2017). While it is important to recognize that these conditions may be multifactorial, some evidence has shown harmful health effects of excessive noise exposure.

Poor Concentration

Noise can have significant effects on an individual's working memory including decreased task performance. Exam-

KEY TAKEAWAYS

- **Hearing loss is the third most common chronic health condition in the U.S.**
- **Occupational noise exposure is maintained, while recreational noise has been shown to exceed regulatory limits without proper controls.**
- **Annually administered workplace audiograms often cannot distinguish between occupational and nonoccupational noise damage and, consequently, the employer must assume liability.**
- **Safety professionals must establish more effective hearing conservation programs to reduce noise-induced hearing loss.**

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ples of decreased task performance include hindered serial recall, revision, mental arithmetic, reading comprehension, operation span tasks and knowledge acquisition (Monterio, Tomé, Neves, et al., 2018). The working memory performs complex tasks to solve problems throughout the day. When the working memory is affected, individuals begin to see a decline in performance during their daily tasks. Additionally, that noise intermittency has been shown to cause greater hindering effects than continuous sound. In the presence of intermittent sound, individuals show a decrease in work performance that involves completing cognitive tasks (Monterio, et al., 2018). Continually, Monterio, et al. (2018), performed a study dividing individuals into three distinct groups that experienced different decibel levels or alarms throughout a fast-food restaurant. The results of the study suggest that individuals are negatively affected under excessive noise environments and intermittent alarms. The results indicate slower reaction time, increased number of errors, decreased short-term memory function, and attention difficulty when sound pressure levels were about 68 dB. The data suggest errors increase and reaction time decreases as the sound levels increase in the work environment (Monterio, et al., 2018). While studies indicate that noise can affect an individual's performance, the intermittent distraction from noise can disrupt the ability to complete a difficult task throughout the day.

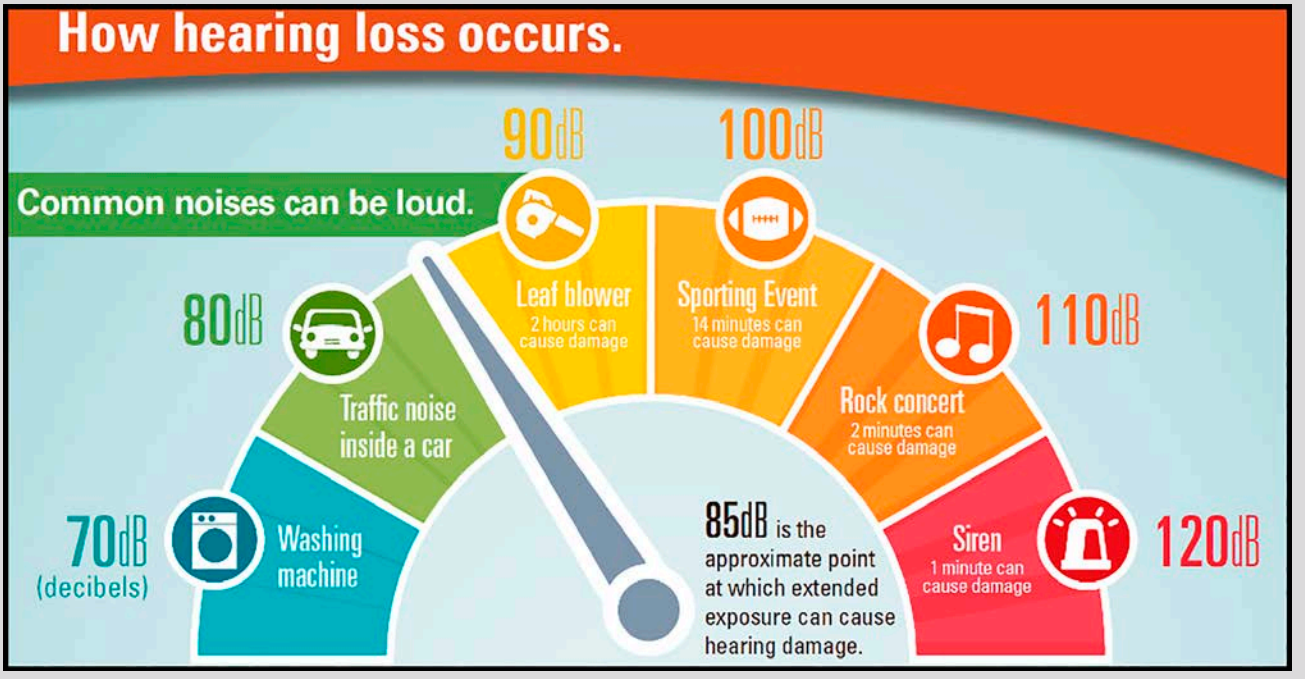
Reproductive System

Noise exposure has been shown to impact humans in various physiological ways. Although limited research has been conducted in this area, noise stressors have been shown to alter the immune system and potentially lead to birth defects in the fetus (Ristovska, Laszlo & Hansell, 2014). Ristovska, et al. (2014), conducted a literature review of published evidence supporting the association with noise and adverse reproductive issues. The authors evaluated 14 epidemiological studies related to occupational and environmental noise exposure (Ristovska, et al., 2014). While these epidemiological studies have limitations, some evidence indicates negative reproductive effects of noise exposure.

In one evaluated study, independent noise exposure did not show direct results affecting the reproductive system. However, the study compared exposed women with unexposed women and found increased effects on preterm labor and preterm birth (Croteau, Marcoux & Brisson, 2006). Four of the reviewed studies indicated moderate evidence of noise exposure negatively impacting the reproductive system. Noise exposure was associated with lower birth weight among women who worked in health and manufacturing sectors (McDonald, Armstrong, Cherry, et al., 1986). Hartikainen-Sorri, Sorri, Anttonen, et al. (1988), performed a case-control study of 299 women with lower birth weight babies and 284 women with preterm birth and matched controls. The study did not find a significant association with occupational noise, but a very small sample of 26 subjects showed difficulties during birth after being exposed to noise levels greater than 81 dB (Hartikainen-Sorri, et al., 1988). Furthermore, Hartikainen, Sorri, Anttonen, et al. (1994), performed a prospective cohort study evaluating environments that had noise levels exceeding 78 dBA. Results of this study indicated birth weight was on average 200 to 300 g lower in the group exposed to greater than 90 dBA (Hartikainen, et al., 1994).

FIGURE 1

COMMON ACTIVITIES THAT RISK EXCESSIVE NOISE LEVELS



Note. Reprinted from "Too Loud! For Too Long!", by CDC, 2017.

While these studies indicate low to moderate reliability in determining whether excessive noise levels result in adverse reproductive issues, some evidence shows that women working in areas with high noise levels have an increased risk for low birth weight, preterm labor and preterm birth. Additional reviews of epidemiological studies provide evidence of lower birth weight from noise exposure (Ristovska, et al., 2014). Throughout the studies collected by the authors, low birth weight was a recurring issue for women exposed to significant noise levels. Although the link between low birth weight and high noise levels was limited, evidence supports the associations (Ristovska, et al., 2014).

Cardiovascular System & Stress

According to CDC (2019), heart disease and stroke are among the leading causes of death. While various contributing factors exist, uncontrolled stress and hypertension can lead to heart disease and stroke. In a study by Dehghan, Bastami and Mahaki (2017), exposure to different noise levels including 75, 85 and 95 dB led to an increase in systolic and diastolic pressures. Another study found traffic noise (e.g., road, aircraft, railway noise) to be associated with increased risk of physiological responses that can lead to increased risk of heart disease or stroke (Münzel, Schmidt, Steven, et al., 2018). An increase in physiological response and stress could lead to individual health risk.

Nonoccupational Noise Exposures

Figure 1 shows common examples of activities that produce high noise levels (CDC, 2017a). Such nonoccupational settings are common throughout society and pose a risk of excessive noise levels. These activities often exceed recommended occupational limits and must be evaluated to identify ways to protect individuals. Exposures are not limited to such activities, but OSH professionals must recognize various sources that threaten an individual's health.

Firearms

Target shooting and the use of firearms is a popular hobby for recreational purposes. When using firearms, individuals can experience excessive levels of noise that could damage their hearing. While no regulations currently protect individuals from being exposed to excessive noise levels caused by firearms, World Health Organization (WHO) recommends that peak sound pressure levels (SPLs) stay below 140 dB for adults and 120 dB for youth (Meinke, Finan, Flamme, et al., 2017). OSHA and NIOSH incorporate an SPL peak limit of 140 dB for occupational exposures (Meinke, et al., 2017). These regulations and recommendations mandate occupational noise exposure, however, nearly all guns produce noise levels that exceed these values (Meinke, et al., 2017). Factors that influence the risk of noise-induced hearing loss include muzzle brakes, number of shots, shooting in enclosed areas, type of ammunition and firearm suppressors (Meinke, et al., 2017). Contemporary research has shown that unprotected noise exposure from firearms can lead to permanent noise-induced hearing loss.

Personal Audio Devices

Earbuds and headphones have been shown to contribute to hearing loss among heavy users. Today, hearing loss among teens is about 30% higher than it was during the 1980s and 1990s (James, 2015). Gopal, Mills, Phillips, et al. (2018), studied 40 adults to evaluate personal audio device volume levels resulting in hearing damage. Participants performed two rounds of studies listening to songs at 100%, 75%, 50% or 0% volume (no music). The authors found that listening to the playlist for 30 minutes through standard earbuds resulted in an average level of 97.0 dB at 100% volume, 83.3 dB at 75% volume, and 65.6 dB at 50% volume (Gopal, et al., 2018). The results show that listening to a personal audio device at 100% volume will lead to temporary threshold shifts and produce risk of permanent hearing damage (Gopal, et al., 2018). According to WHO (2015), more than 1 billion teenagers and young adults are at risk of hearing loss from various sources including personal audio devices. Additionally, WHO (2015) analyzed studies that found nearly 50% of teenagers and young adults are exposed to unsafe levels of sound from personal audio devices. Safe listening depends on duration, frequency and loudness of the personal audio device. Listening to personal audio devices for prolonged periods can cause damage and lead to irreversible hearing loss (WHO, 2015). Individuals can limit exposure time and frequency or reduce the volume to protect their hearing.

Exercise Classes

Fitness classes such as Zumba, high-intensity interval training, Body Pump and Pound are becoming more popular in the exercise world. Typical classes last about an hour. Instructors motivate participants to push their limits to become stronger. In the process, music is played at high sound levels, the instructor shouts over a microphone and hand instruments are used. Beach and Nie (2014), assessed noise levels during 35 low-intensity and 65 high-intensity fitness classes from 1997 to 1998, and from 2009 to 2011. The noise levels frequently exceeded 90 dBA and averaged 93.1 dBA in high-intensity classes (Beach & Nie, 2014). These results show an increasing risk of noise levels exist in exercise classes and today's instructors prefer louder music to motivate their classes. Furthermore, there is a concern that instructors who participate in multiple classes are at risk of noise-induced hearing loss. It is important to identify and evaluate these fitness classes to ensure that the instructors are aware of the risk involved with high noise levels. Once the risk has been evaluated and determined, solutions must be implemented to protect instructors and participants in wellness centers. Noise dampening material may be used in the exercise rooms to reduce levels and protect class participants.

A convenience sample was collected at a Murray State University Wellness Center to determine noise levels during eight scheduled exercise classes including Zumba (four) and Pound (four). Data were collected on four different dates surveying each class twice. Each class lasted 1 hour during which the dosimeters collected area noise samples to determine exposure among participants. Dosimeters were placed near the speakers, in the center of the room and in the back of the room. Results suggest noise exposure levels would exceed ACGIH recommended limits. Formal study would likely draw results similar to this anecdotal data.

Sporting Events

Sports remain among the highest attended social events in the world. People of various ages attend sporting events to

support their favorite teams and follow their idolized athletes. Such events include motorsports, soccer, basketball, football, hockey and baseball. A typical professional sporting arena exceeds a capacity of 20,000. While fans cheer and support their favorite teams, noise levels can easily exceed recommended doses.

Rose, Ebert, Prazma, et al. (2008), evaluated noise levels experienced by fans attending professional stock car races, one of the world's fastest growing spectator sports. They studied the National Association for Stock Car Auto Racing (NASCAR) Nextel Cup Series. The noise levels ranged from 96.5 dBA to 109 dBA depending on distance from the track. The peak sound level was 109 dBA from 6 m away from the track. Although this is below OSHA and NIOSH peak exposure limits, temporary threshold shifts could still occur (Rose, et al., 2008). The results show sound pressure levels above OSHA's limit of 105 dBA for 1 hour. Since NASCAR races typically last longer than an hour, these noise levels can induce significant damage to fans who attend without any hearing protection. Additionally, Van Campen, Morata, Kardous, et al. (2005), found that employees involved in stock car racing are routinely exposed to extreme levels of noise and auditory damage. In the pit area, SPLs average more than 100 dBA and peak levels reach 140 dBA (Van Campen, et al., 2005). While these events are entertaining and popular, such activities can begin to damage an individual's health outside of the work environment.

Walter (2013) analyzed two studies that examined sporting events that can cause noise-induced hearing loss. Noise surveys from a hockey arena suggested the sampled workers were not exposed above OSHA's permissible exposure limit. However, 40% of workers and 33% of fans at one venue, as well as 57% of workers and 91% of fans at a second venue, were exposed above the ACGIH action limit (Walter, 2013). Other sporting arenas may show similar results in risk of exposure to excessive noise levels.

Flamme and Williams (2012) evaluated how referees can suffer hearing loss and tinnitus from continuous whistle use throughout a game and from large crowds. Qualitative online surveys were completed by 321 officials and found that approximately 50% of sports officials reported experiencing tinnitus. Approximately one-eighth (13%) of sports officials reported ringing or roaring after officiating a game or match, and an additional 11% of sports officials reported post-officiating tinnitus (Flamme & Williams, 2012).

Other sporting events such as football and basketball have high noise levels that can cause hearing loss. Arrowhead Stadium is cited in the Guinness Book of World Records as having hosted the loudest crowd roar on Sept. 29, 2014, with the noise level recorded at 142.2 dBA (American Academy of Audiology, 2019). In a study by Engard, Sandfort, Gotshall, et al., (2010), 30 personal noise surveys were conducted at large- and medium-sized football stadiums. Noise levels were recorded at both collegiate and professional stadiums. Throughout the survey, none of the workers' results exceeded the OSHA permissible exposure limit. However, 11 out of 28 workers (39%) exceeded the OSHA action level of 85 dBA. Based on ACGIH and WHO recommendations for noise exposure limits, 27 out of 28 workers (96%) and 24 out of 25 fans (96%) would be considered overexposed (Engard, et al., 2010). Additionally, Morris, Atieh and Keller (2013) measured noise levels in a basketball arena that has a capacity of 8,700. Peak levels of noise reached 138 dBA at one game and exceeded 130 dBA at several sites of the arena during three games studied. Additionally, the study found that five of the 15 samples taken exceeded the 85-dBA OSHA action limit that would require entry into a workplace hearing conservation program (Morris, et al., 2013). These results show significant noise levels; further evaluation could raise additional concerns in arenas that have a capacity of more than 20,000.

Marching Bands

Marching bands typically perform at sporting events, which produce a significant noise risk of their own. Chen and Brueck (2012) evaluated a band director's noise exposure at an Alabama high school. NIOSH received an employee request for investigators to evaluate the sound levels during band rehearsal and music classes in two different locations. During the evaluations in the cafeteria and band room, the investigators found that the band director's exposure did not exceed OSHA's permissible exposure limit. However, the noise levels reached OSHA's action limit and NIOSH recommended exposure limit of 85 dBA. The marching band rehearsal recorded the loudest levels, reaching 110 dBA (Chen & Brueck, 2012). Additionally, reverberation times were calculated and considered appropriate for teaching the classes. However, the band room did not provide an adequate space for the number of students in marching band. NIOSH suggested that practices should take place outdoors or in a larger space with absorbent materials. Since the noise levels exceeded OSHA's action limit, a hearing conservation program must be implemented for the band director. As discussed, this program must include hearing protection, yearly audiometric testing and training on noise exposure. While it is important to protect the band director because of extended exposure to noise, members of the band must become aware of the potential risk associated with high noise levels. This resource provides necessary information to evaluate members of a high school band but these students may continue their education and extracurricular activity in college where exposure to excessive noise levels would continue.

Landscaping

Stadiums and arenas employ groundskeepers to take care of the fields for the players. Balanay, Kearney and Mannarino (2016) evaluated groundskeepers employed at a university to determine noise exposure. Groundskeepers typically perform various tasks that include the use of power tools and equipment that produce excessive noise levels. In that study, researchers evaluated the sound pressure levels of equipment and tools used by the groundskeepers in various locations throughout the university campus. These tools include chain saws, leaf blowers, lawn mowers, tractors and various types of heavy lifting equipment. Chain saws were the loudest equipment, measuring between 104.5 and 105 dBA at full throttle. All equipment and tools monitored except the backhoe, hook lift, front-end loaders and sweeper truck had SPLs at or above 85 dBA (Balanay, et al., 2016). Additionally, commonly used equipment such as riding mowers (92.1 to 95.9 dBA), push mowers (85.0 to 92.4 dBA), grass trimmer (97.8 to 98.0 dBA) and leaf blowers (94.4 to 102.5 dBA) showed excessive noise levels during the task (Balanay, et al., 2016).

While Balanay, et al. (2016), evaluated employees in a work setting, this equipment is commonly used in communities

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and homes to maintain yards. Prior to distribution, "manufacturers can implement engineering controls to reduce noise levels including new blade designs, improved mufflers, sound-absorptive materials around the engine housing, lining vibrating surfaces with sound-absorptive coatings and damping of body components to reduce rattling" (Mahoney, Mahoney & Spea, 2017). Rather than focusing on the occupational applications of these noise hazards, individuals can view their own use of such equipment and begin to protect themselves outside of the work environment.

Restaurants & Bars

Some individuals may view and experience sporting events outside of the premises of an arena. While these individuals may not experience the noise levels present at the sporting event, restaurants and bars pose their own risk. In a pilot study evaluating noise levels among restaurants and bars, Spira-Cohen, Caffarelli and Fung (2017) aimed to identify sound levels in various loud urban venues and compare exposure to regulations. In that study, researchers surveyed various restaurants, bars, clubs and lounges in New York, NY, to determine whether noise levels exceed guidelines. Results showed an average noise level of 92 dBA (Spira-Cohen, et al., 2017). Additionally, 80% of the venues visited had a noise level above 85 dBA, 44% above 94 dBA and 14% above 100 dBA. In 29 of the 59 venues, the employees wearing dosimeters received more than 100% of the daily allowable dose during the time of the visit based on the NIOSH recommended exposure limit (Spira-Cohen, et al., 2017). Based on this information, individuals who frequently visit these venues multiple times a week for extended periods can develop hearing damage from this type of entertainment.

Conclusion

Hearing loss is the third most common chronic health condition in the U.S. Nearly twice as many people report hearing loss as report diabetes or cancer (CDC, 2020). While control processes can manage occupational noise exposure, increasing evidence shows that recreational noise exposure can cause significant damage to individual health and inevitably lead to workplace hearing loss claims. Safety professionals maintain work environments to protect employees against noise-induced hearing loss. However, safety professionals must establish programs that evaluate recreational activities and protect employees from excessive noise exposure. By addressing nonoccupational noise exposure, safety professionals can help create a culture that more effectively addresses problems outside of the work environment. **PSJ**

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Acknowledgments

The author thanks all who reviewed and offered editorial recommendations to improve this manuscript, and is honored to have such great mentorship and support from these individuals. The author also acknowledges those who participated in Murray State University's 2018-2019 ASSP research committee. Finally, the author thanks Murray State University's Wellness Center for allowing the convenience noise survey to be completed in its exercise classes.