AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 31:75–79 (1997)

Risks of Developing Noise-Induced Hearing Loss in Employees of Urban Music Clubs

Erik Gunderson, BA,[1] Jacqueline Moline, MD, MSc,[2]* and Peter Catalano, MD[3]

Noise-induced hearing loss has previously been reported among rock musicians. This study sought to determine whether a hazard of noise-induced hearing loss exists for music club employees other than musicians themselves. Sound levels at eight live-music clubs were measured and symptoms of noise exposure in 31 music club employees were assessed by questionnaire. The average sound level at the various clubs during performances ranged from 94.9 to 106.7 dBA. The overall sound level average, including both performance and ambient levels, ranged from 91.9 to 99.8 dBA. Symptoms of noise exposure, such as tinnitus and subjective hearing loss, correlated with sound intensity. Only 16% reported regular use of hearing protection. We conclude that employees of music clubs are at substantial risk of developing Noise-Induced Hearing Loss, due to chronic noise exposure which consistently exceeded safe levels. Hearing protection is used much too infrequently. The development of hearing conservation programs for this large group of workers is essential. Am. J. Ind. Med. 31:75–79 © 1997 Wiley-Liss, Inc.

KEY WORDS: noise-induced hearing loss; occupational; music sound levels

INTRODUCTION

Hearing loss afflicts 28 million people in the United States, 10 million of whom became impaired at least in part from exposure to loud sounds [Consensus Conference, 1990]. Hearing impairment has a major impact on an individual's ability to communicate. Even a mild hearing impairment can adversely affect quality of life.

Noise injures the hearing apparatus in the ear by two distinct mechanisms. An intense noise peak exceeding 140 decibels (dB) can cause immediate and usually permanent hearing loss. This is termed *acoustic trauma,* whereby the elastic inner ear compartments are stretched beyond their limits and are physically torn by the impact of the noise peak. In contrast to this mechanical type of injury, chronic exposure to noise between 90 and 140 dB results in permanent metabolic cochlear damage, called *noise-induced hearing loss* (NIHL) [Clark, 1992]. The extent to which NIHL progresses depends on both the intensity and duration of noise exposure, as well as differences in individual susceptibility [Consensus Conference, 1990; Clark, 1992].

Initial exposures to sound levels within the 90 to 140-dB range result in a temporary threshold shift (TTS), a transient hearing impairment in which there is an increase in the hearing ''threshold,'' the quietest sound that can be detected. Repeated TTS over the course of a few weeks to a few years may lead to accumulated cellular damage, causing a permanent threshold shift (PTS) [Consensus Conference, 1990; Clark, 1992]. Although TTS alone cannot predict the magnitude of PTS, it is believed to be an early indicator of permanent damage [Luz et al., 1973].

The development of permanent hearing loss through chronic exposure to excessive noise levels is of great importance, because an estimated 20 million Americans are exposed to hazardous noise levels on a regular basis [Consensus Conference, 1990]. Of these persons, 11 million

[1]Department of Community Medicine, Division of Occupational and Environmental Medicine, Mt. Sinai Medical Center, Medical Student, New York, NY.
[2]Department of Community Medicine, Division of Occupational and Environmental Medicine, Mt. Sinai Medical Center, New York, NY.
[3]Department of Otolaryngology, Mt. Sinai Medical Center, New York, NY.
Sponsored by NIEHS; CDC/NIOSH, grant number T42.CCT210425-02.
*Correspondence to: Dr. Jacqueline Moline, Mt. Sinai Medical Center, Department of Community Medicine, Box 1057, 1 Gustave L. Levy Place, New York, NY, 10029.

Accepted for publication 30 April 1996.

are exposed in the workplace [Bahadori and Bohne, 1993], making occupational noise exposure the most common cause of NIHL [Consensus Conference, 1990]. Standards set by the Occupational Safety and Health Administration (OSHA) limit the maximum allowable exposure in the workplace without the use of hearing protection to a time-weighted average (TWA) of 90 dB in the A scale (dBA) for an 8-hr period, with a 5-dBA trading ratio (i.e., a 5-dBA increase or decrease in volume results in the halving or doubling, respectively, of permissible exposure time) [Department of Labor Occupational Noise Standard, 1983]. Further interpretation of OSHA standards indicates that exposure to sound levels above 115 dBA are not permissible for any length of time [Department of Labor Occupational Noise Standard, 1983].

Many studies in the past have examined the sound levels of live music and their corresponding effects on hearing among musicians and patrons. A review of all published data found the geometric mean of sound levels in concert halls and arenas to be 103.4 dBA [Clark, 1991; Flugrath, 1969; Dey, 1970]. In several occupational studies of sound level exposure of rock and roll musicians, noise levels have ranged between 90 and 130 dBA [Speaks et al., 1970; Jerger and Jerger, 1970; Axelsson and Lindgren, 1978]. Other workers in addition to musicians are exposed to loud music in music halls and rock clubs. There are more than 300,000 bartenders and 1.4 million waiters and waitresses in the United States, many of whom work in music clubs [U.S. Bureau of the Census. Statistical Abstract of the United States, 1994]. The exposure of these individuals varies from that of employees of concert halls or the patrons of live music venues, because it is continuous and lacks periods of time for recovery. However, no published studies have measured the noise intensity in bars and clubs which feature live music and examined the effect of such exposure on bartenders, waiters and waitresses, or sound and lighting personnel.

To determine whether music club employees are at risk of developing NIHL, this study assessed the noise exposure of these workers. Such information is essential for making recommendations on the use of hearing protection and could aid in the prevention of hearing loss in this large group of workers.

METHODS

Eight New York City music clubs that feature live bands comprised the study sites. Venues were chosen to include various club sizes as well as different genres of music, such as jazz, blues, hip-hop, rock, hard-rock, and amplified-acoustic rock. Each club was visited three to four times between 9 PM and 2 AM during the time when the bands were playing, and sound levels were measured with a calibrated TK-3 portable dosimeter (A-weighted). To approximate the bartenders' exposure, the dosimeter was worn by an investigator standing near the midpoint of the bar. With the dosimeter microphone clipped to a shirt collar, noise exposure was measured for a minimum of 30 min while the band played, and for at least 10 min during intermissions or before the start of the performance, to determine ambient noise levels. To validate the testing protocol, a bartender wore the dosimeter on one occasion. These data were used for comparison with data collected by an investigator on a different night while the same band performed at the same venue.

The dosimeter automatically calculated the average sound level during the exposure time (L_{avg}) and determined the peak sound pulse of 0.1-sec duration. The distance between the midpoint of the bar and the stage speakers was estimated by counting the number of paces between the two points. Sixteen paces corresponded approximately to 10 m.

When working conditions were not busy, all available employees were asked to complete a questionnaire. Thirty-one of 32 responded (24 bartenders, 4 waiters or waitresses, 3 sound or lighting personnel), giving a participation rate of 97%. Information obtained from the questionnaire included the total length of all previous nightclub employment, the typical daily and weekly work hours, the use of hearing protection, and the degree to which the employees experienced symptoms of noise exposure.

Statistical analysis of dosimetry data was carried out using the JMP® statistical package (SAS Institute, JMP® User's Guide, Version 2, 1989). analysis involving ordinal questionnaire data was performed using the Mantel-Haenszel test of the SAS® statistical package (SAS Institute, SAS/SAT® User's Guide, Version 6, 1989).

RESULTS

Dosimetry Data

Three to four sound level measurements made during band performances as well as during intermissions were averaged. In addition, an overall sound level average for each club was determined by averaging all performance and ambient levels. These results are depicted in Figure 1 with a generalized classification of the music genre played during the nights of data collection: jazz, hip-hop, blues, rock, hard rock, and amplified-acoustic rock. The overall average sound level at all clubs exceeded the OSHA standard of 90 dBA and ranged from 91.9 to 99.8 dBA (jazz 92.7; hip-hop 95.0; blues 99.2; rock 98.3, 91.9, 97.8; hard rock 99.8; and amplified acoustic rock 92.7). The average performance sound levels ranged from 94.9 to 106.7 dBA. Performance sound levels at all venues were greater than the average ambient sound levels, which ranged from 83.7 to 97.1 dBA.

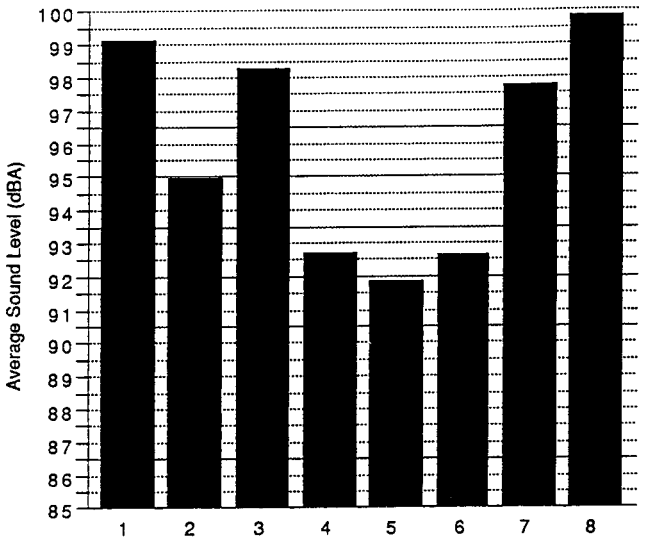

FIGURE 1. Average sound levels measured at New York City 1994 survey of music clubs with different genres of music. (1) blues, (2) hip-hop, (3) rock, (4) amplified acoustic rock, (5) rock, (6) jazz, (7) rock, (8) hard rock.

Peak sound levels exceeded 115 dBA, the OSHA maximum allowable exposure limit without protection, during 2 of 3 (67%) of hard rock performance measurements, 3 of 9 (33%) of rock, and 1 of 4 (25%) of blues measurements. Peaks did not exceed 115 dBA at jazz, hip-hop, or amplified-acoustic rock performances, nor did they exceed 115 dBA during any ambient sound level measurements.

The clubs varied in size and had maximum occupancies ranging from approximately 150 to 2,000 people. The distance from the midpoint of the bar to the stage speakers ranged from 6 to 52 paces (3.8 to 32.5 m). There was no relationship between distance from the noise source and noise level among clubs ($r = 0.54$, $p = 0.4069$).

Noise exposure of a bartender who wore the dosimeter was comparable to that of an investigator on a different occasion during a performance by the same band at the same venue. The investigator stood at the midpoint of the bar. Sound levels measured by the bartender and investigator, respectively, were as follows: ambient levels (94.3 and 95.6 dBA), performance levels (98.8 and 96.6 dBA), peak levels (116.3 and 113.5 dBA).

Questionnaire Data

The degree to which employees experienced tinnitus (ringing) and the perception of hearing deficit immediately after work were grouped into three categories: never/rarely (0–25%), sometimes (25–75%), often/always (75–100%). The Mantel-Haenszel test was used to compare these criteria to the average volume of the clubs: low (<93 dBA), medium (93–98 dBA), high (>98 dBA), and to the duration of employment: recent (<3 years), intermediate (3–10 years), and long-term (>10 years).

Employees who worked in louder clubs were found to experience more symptoms of noise exposure (tinnitus) after work ($p = 0.01$) and were more likely to perceive a hearing deficit after work ($p = 0.04$) (Fig. 2).

Recent employees perceived more hearing loss after work than did employees of longer duration ($p = 0.04$). The relationship between tinnitus after work and employment duration approached statistical significance ($p = 0.11$).

Fifty-five percent (17/31) of employees felt that they could not hear as well in general since becoming employed at a music club. Hearing difficulty was not associated with club sound level ($p = 0.95$), duration of employment ($p = 0.70$), or the use of hearing protection ($p = 0.842$). Fifty-five percent (17/31) of employees reported the use of hearing protection never/rarely (0–25%), 29% (9/31) reported hearing protection use sometimes (25–75%), and 16% (5/31) reported hearing protection use often/always (75%–100%). No employees were observed wearing hearing protection during data collection.

DISCUSSION

This study demonstrates that employees of urban music clubs which feature live bands are exposed to noise levels that consistently exceed safe levels. The average performance sound levels ranged from 94.9 to 106.7 dBA. Using the 5-dBA trading ratio of OSHA standards for permissible exposure time above 90 dBA, the allowable exposure times during performances would range from approximately 4 hr to <1 hr at the loudest venue [Department of Labor Occupational Noise Standard, 1983]. In addition, ambient sound levels ranged from 83.7 to 97.1, showing that substantial noise exposure may occur even when the band is not performing. This finding suggests that noise exposure may also be excessive in music clubs that do not feature live bands, thus further increasing the numbers of workers in the bar and restaurant industry at potential risk of NIHL.

Overall sound levels ranged from 91.9 to 99.8 dBA, exceeding the 90-dBA limit set by OSHA for the maximum allowable noise exposure in the workplace without the use of hearing protection. The average sound levels of the different clubs were not related to distance of the bar from the stage speakers. This suggests that club size is not a risk factor for NIHL. Sound levels were more dependent on the genre of music. Sound levels of jazz, hip-hop, and amplified-acoustic rock performances were lower than levels for blues, rock, and hard rock. Furthermore, performances of these louder genres were the only instances where peak levels exceeded 115 dBA.

It is important to note that the sound levels reported here were measured by an investigator standing at the midpoint of the bar. Comparison of investigator exposure to that of a

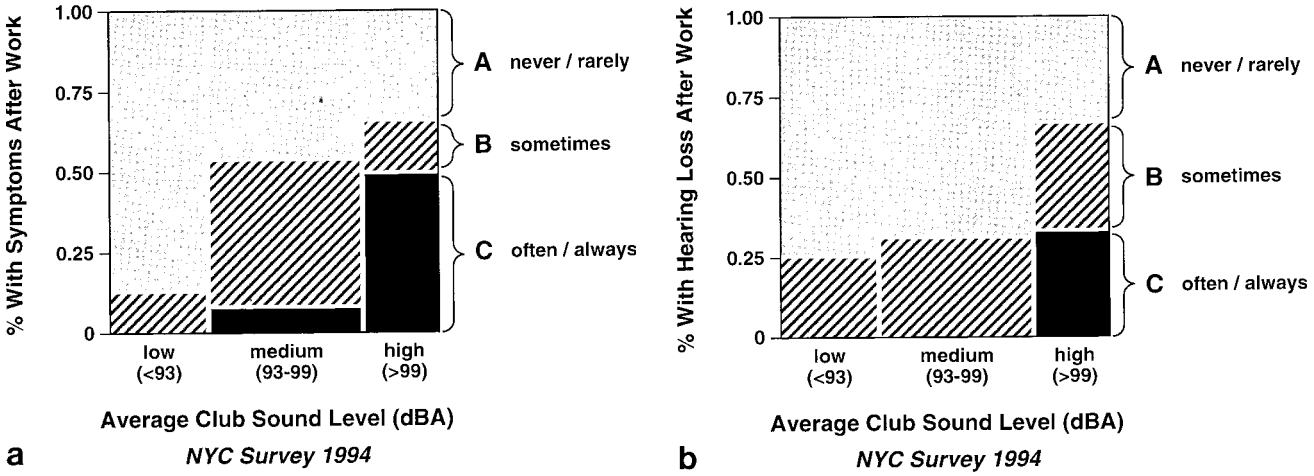

FIGURE 2. **a:** Percentage of employees with symptoms of noise exposure after work. **b:** Percentage of employees experiencing hearing loss after work.

bartender who wore the dosimeter under similar conditions suggests that this method of data collection is representative of bartender exposure. The noise exposure of waiters and waitresses, and of sound and lighting personnel, may vary from bartender exposure, because these workers usually spend more time near the stage where sound levels are higher.

Immediately after their work shifts, employees of louder clubs experienced more symptoms of excessive noise exposure, such as tinnitus and the perception of a temporary hearing deficit. This finding suggests that their occupational noise exposure has an adverse physiological effect on hearing, and that the degree of this effect is related to sound intensity [Mollar, 1977; Okada et al., 1991].

Recently employed workers were more likely to perceive a temporary hearing deficit after work. Similar trends existed with tinnitus and duration of employment that might reach significance in a study with greater statistical power. This is consistent with the findings of Taylor et al. [1965], who demonstrated that more recent employees with industrial noise exposure experienced the most tinnitus. Long-term employees may have become desensitized to perceptions of hearing deficit or tinnitus after work, or these employees may have experienced permanent threshold shift (PTS).

Fifty-five percent of employees surveyed felt that they generally could not hear as well as previously since becoming employed at a music club. The finding that this general hearing deficit was not related to club sound levels might be attributable to the fact that even the ''low''-level clubs had average sound levels that exceeded 90 dBA. It is unclear why the perception of hearing deficit was not related to duration of employment. It is possible that newer employees perceive the temporary threshold shift (TTS) after work as a general deficit. Temporary threshold shifts generally last 24 hr or more after cessation of excessive noise exposure [Sataloff and Sataloff, 1987]. For employees who work regularly, it is possible that there is insufficient time between work shifts for the temporary deficit to improve. Although the damage is not permanent, employees might perceive such a continuous deficit as general hearing loss.

Hearing protection is used much too infrequently by bartenders and waitpersons; only 16% use hearing protection regularly, while 55% reported never or rarely using protection. This finding might explain why the use of hearing protection was not related to the perception of a general hearing deficit. Hearing protectors must be worn for a very high proportion of the exposure time for them to afford worthwhile protection [Else, 1973]. A larger sample size may be useful for further examination of this relationship.

Future projects should include audiograms to determine the prevalence of permanent damage. By screening employees for a 4,000-Hz audiometric notch, the common initial finding during the progression of NIHL [Sataloff and Sataloff, 1987], more extensive hearing loss could be prevented. In addition, audiometric examination after employee work shifts would be useful to detect the presence of a TTS. Employees with normal hearing who are at risk for future permanent damage would be identified. Hearing protection could be implemented even before permanent deficit occurs.

CONCLUSION

Noise-induced hearing loss is one of the 10 leading work-related disorders [CDC, 1983]. This disorder, which greatly interferes with an individual's sense of well being and ability to communicate, is entirely preventable.

Employees of music clubs that feature live and/or recorded music experience chronic noise exposure ranging from 91.9 to 99.8 dBA during their work shifts. At time-weighted exposure levels of >90 dBA, OSHA requires that employees wear hearing protection. However, OSHA does not regulate these establishments with regard to employee noise exposure. Unfortunately, routine inspections by OSHA are virtually nonexistent in industry and are even rarer for small businesses such as the music facilities in this study. Consequently, hearing protection is used infrequently by the workers of these establishments, and symptoms of excessive noise exposure are common. More than 50% surveyed felt that they generally could not hear as well since becoming employed at a music club. Hearing conservation programs need to be developed for the employees of music clubs. Providing education about the risks of NIHL and the necessity of regular use of hearing protection is essential for the prevention of hearing loss in this large group of workers.

ACKNOWLEDGMENTS

We acknowledge the valuable assistance of Philip Landrigan, M.D., M.Sc.; Mark Goldberg, Ph.D., CIH; John Doucette, Ph.D.; Nancy Clark, M.S., CIH; Jairo Munoz, B.S., and Katherine Gleaton in the preparation of this manuscript. This research was supported in part by summer student grant-NIEHS, ''Short-Term Training Students in Environmental Health Sciences,'' and by CDC/NIOSH grant ''Educational Resource Center: Occupational Medicine, Safety & Health Professionals'' T42.CCT210425-02.

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