Prevalence of Hearing Loss Among Noise-Exposed Workers Within the Health Care and Social Assistance Sector, 2003 to 2012

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Objective: The purpose was to estimate the prevalence of hearing loss for noise-exposed U.S. workers within the Health Care and Social Assistance (HSA) sector. **Methods:** Audiograms for 1.4 million workers (8702 within HSA) from 2003 to 2012 were examined. Prevalences and adjusted risks for hearing loss as compared with a reference industry were estimated for the HSA sector and all industries combined. **Results:** While the overall HSA sector prevalence for hearing loss was 19%, the prevalences in the Medical Laboratories subsector and the Offices of All Other Miscellaneous Health Practitioners subsector were 31% and 24%, respectively. The Child Day Care Services subsector had a 52% higher risk than the reference industry. **Conclusion:** High-risk industries for hearing loss exist within the HSA sector. Further work is needed to identify the sources of noise exposure and protect worker hearing.

Hearing loss is the third most common chronic physical condition in the United States.[1] Among currently employed workers, 11% have hearing loss, about one quarter of which is due to occupational exposures.[2] Occupational exposures that cause hearing loss include hazardous noise (≥85 dBA) and ototoxic chemicals.[3–5] Approximately 17% of U.S. workers are exposed to hazardous noise overall,[6] but the prevalence of noise exposure and occupational hearing loss (OHL) varies widely across industries and occupations. Less is known about which industries and occupations are exposed to ototoxic chemicals.

Industries such as Mining, Manufacturing, and Construction are recognized as having high prevalences of hazardous noise exposure,[6] hearing loss,[2,7] and hearing threshold shifts.[8,9] Hearing threshold shifts are measurable losses in hearing sensitivity that an individual may experience over time. However, recent analyses of noise-exposed workers have found higher than expected prevalences of hearing loss and hearing threshold shifts in industries with typically low prevalences of noise exposure.[7,8] The Health Care and Social Assistance (HSA) sector was among these ''low-exposure'' industries with a higher than expected prevalence of hearing threshold shift (24%),[8] incidence of hearing loss (7%) and increasing trends over time among its noise-exposed workers.[10] The overall prevalence of hearing loss among noise-exposed workers within the HSA sector was found to be 18%; the same as for all industries combined.[7] The overall prevalence of hearing difficulty among all HSA workers (noise-exposed and non-noise-exposed) was 9% in Hospitals, 9% in Health Services, Except Hospitals and 10% in Social Services, Religious, and Membership Organizations, fairly close to the prevalence for all industries combined (11%).[2] However, none of these studies examined the subsectors within HSA to identify high-risk groups.

Noise exposure information within this sector is limited, making it difficult to identify which workers are most at risk for hearing loss. The available research includes a paper from Holmes et al,[11] which reported that the noise levels of some orthopedic instruments such as cast cutters ranged from 95 to 106 dBA, and found a small sample of cast technicians had hearing loss that increased with years of exposure. Noise levels of dental instruments have raised frequent concern.[12,13] A study of noise levels in a hospital emergency department found peak levels in excess of 85 dBA occurring at least once per minute from sources such as monitor alarms, overhead speakers, and slamming doors.[14] High noise levels have also been reported in operating rooms,[15,16] hospital kitchens,[17] intensive care units (ICUs),[18] hospital laundry facilities,[19] and around helicopter emergency medical crews.[20]

The purpose of this study was to further investigate the prevalence of hearing loss among noise-exposed U.S. workers in the HSA sector using audiograms collected through the National Institute for Occupational Safety and Health (NIOSH) OHL Surveillance Project. Prevalence and adjusted risk as compared with a reference industry were estimated. This analysis identified HSA subsectors that need further attention to prevent hearing loss.

METHODS

Study Design and Population

This was a cross-sectional study that estimated and compared the prevalence and adjusted risk of worker hearing loss within the U.S. HSA sector. NIOSH OHL Surveillance Project worker audiograms and related information were used and are described in detail in Masterson et al.[7] Briefly, audiometric service providers, occupational health clinics, hospitals, and others (hereafter denoted as providers) who conduct audiometric testing for workers exposed to high noise (≥85 dBA) were recruited to share de-identified audiograms with NIOSH. The total number of U.S. providers is unknown, as are the proportion of providers servicing the HSA sector. No comprehensive lists of these entities exist. As such, the NIOSH OHL Surveillance Project dataset contains noise-exposed worker audiograms from a convenience sample of providers.

Electronic audiograms and associated information were securely transmitted to NIOSH. The collected audiograms were assigned arbitrary employee IDs. Male and female workers aged 18 to 75 years with at least one audiogram during 2003 to 2012 who met study quality standards (described below) were included. We chose this time period because 2012 was the latest year of data available and multiple years were needed to increase sample size for smaller groups within the HSA sector. Only the last quality audiogram for each worker was retained for the analyses and was used to determine worker age and hearing status. This ensured we only counted each worker once and used their most recent results. In all,

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TABLE 1. Audiograms Excluded From Analysis

Reason for Exclusion	Number With Characteristic	Total Excluded in Grouping*
Missing value for independent variable†	284,064	1,098,361
Missing value for dependent variable‡	5,064	
Unlikely threshold values for left ear§	3,893	
Unlikely threshold values for right ear§	4,338	
Large inter-aural difference‖	510,766	
Negative slope¶	415,595	
Not the most recent valid audiogram in time period#		3,145,992
All Exclusions		4,244,353

*Some audiograms were eliminated for more than one reason within groupings.
†Industry [North American Industry Classification System (NAICS) code].
‡Hearing threshold values. Includes eliminations of affected ear results due to ''no response at maximum value'' threshold values.
§Affected ear results suggesting the presence of testing errors.
‖Large (≥40 dB) inter-aural differences indicating possible medical etiology.
¶Negative slope in either ear indicating possible threshold contamination by background noise during testing.
#Only the last quality audiogram for each worker within the study period was retained for analysis.

1,491,729 workers were included with 8702 from the HSA sector. This Project was determined by the NIOSH Institutional Review Board to be research not involving human subjects, as all audiograms were de-identified.

Materials

Hearing loss was identified using the results of worker audiograms, which included gender, date of birth, threshold values at frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz, and North American Industry Classification System (NAICS) codes.[21,22] Occupation and date of hire were not available for most cases, and education, race, income, smoking status, and ototoxic chemical exposure information were also not available. Specific noise exposure levels were not available; however, exposures at or above 85 dBA can be presumed for all or nearly all workers, as the data were collected as part of U.S. regulatory audiometric testing requirements for noise-exposed workers.

Audiogram Inclusion and Exclusion Criteria

Originally, the study audiograms were collected for non-research purposes and could contain inaccurate or incomplete information.[23] If the gender, year of birth, geographical region, or NAICS code was missing and this information could not be imputed from another audiogram for the same worker, the entire audiogram was excluded. Missing birth months and days were imputed as July and 15, respectively. July 1 was imputed if both month and day were missing. Audiograms with unlikely birth years were excluded by restricting the age range to 18 to 75. If thresholds were missing at frequencies necessary for calculations of hearing loss or evaluations of quality, audiometric results for the affected ear were excluded.

Audiograms that did not meet additional quality standards or displayed attributes indicating that hearing loss may be due to nonoccupational factors or pathology were excluded utilizing methods developed by senior NIOSH audiologists [described in Masterson et al].[7] Briefly, audiograms with threshold values depicting negative slope in either ear (indicating possible threshold contamination by background noise during testing), or with large (≥40 dB) inter-aural differences (indicating possible medical etiology), were excluded. Affected ear results were also excluded if the threshold values suggested the presence of testing errors (unlikely threshold values) or there was ''no response at maximum value.''

Beginning with 5,736,082 U.S. audiograms for 1,660,013 workers ages 18 to 75 during 2003 to 2012, 1,098,361 audiograms (19%) were eliminated from the analysis due to the quality deficiencies identified in Table 1. Next, only the last audiogram for each worker was retained (3,145,992 audiograms eliminated, no workers eliminated). Our final study sample contained 1,491,729 workers at 26,191 companies, including 8702 workers at 204 companies in the HSA sector.

Statistical Analysis

The independent variable was industry, based on the assigned NAICS code. The HSA sector included all audiograms with NAICS codes beginning with 62, or two-digit NAICS code specificity. Subsectors are identified at three, four, and five-digit NAICS code levels of specificity. Hearing loss was the outcome and determined using the NIOSH definition of material hearing impairment: a pure-tone average threshold across frequencies 1000, 2000, 3000, and 4000 Hz of 25 dB or more in either ear.[24] Six descriptive categories were used for worker age. U.S. states of worker employment were condensed into six geographical regions based on the U.S. Embassy region groupings.[25] Due to a small sample size (35) for HSA workers in the New England region, New England was combined with the Mid-Atlantic region and together denoted as the Northeast region. SAS version 9.3 statistical software was utilized for analyses (SAS Institute Inc., Cary, North Carolina).

Prevalence percentages were estimated for all industries combined, the HSA sector and its subsectors, and the reference industry (Couriers and Messengers). Hearing loss risk estimates in the form of prevalence ratios (PRs) and their 95% confidence intervals were estimated using the SAS genmod procedure for log-binomial regression.[26] PRs were calculated instead of odds ratios because 1) some prevalences were expected to exceed 10% and odds ratios should only be used for rare outcomes[27]; and 2) for ease of interpretation. The copy method was used to estimate PRs, as the log-binomial regression models did not converge.[27]

The PRs identify the risk as compared with the reference group (they are not estimates of absolute risk). Similar to previous analyses comparing risks among industries,[7,8] Couriers and Messengers (NAICS 492) was designated ''a priori'' as the PR reference group for the industry analyses. The rationale for this decision, which was based on an examination of the literature, preliminary analyses, and statistical considerations, is provided elsewhere.[7,8] The reference industry has a prevalence of hearing loss (9%), which is close to the prevalence of hearing difficulty among non-noise exposed workers (7%).[28] This allows comparisons to better approximate the difference in risk (if any) between workers in each industry and non-noise exposed workers, even though non-noise exposed workers are not available in the sample. Covariate reference groups were designated as female for gender, ages 18 to 25 for age group, and West for region.

PRs for the demographic variables were adjusted by age-group, gender, and region, as appropriate. PRs for the HSA sector and subsectors were adjusted by gender and age group. A PR greater than 1 indicated that the risk was higher in that industry or demographic category than in the reference industry or reference demographic category. A PR less than 1 indicated that the risk was lower than in the reference industry or reference demographic category.

Prevalence and adjusted risk as compared with the reference industry could not be accurately estimated for the following subsectors due to insufficient or zero sample size (insufficient number of cases and noncases per cell): Nursing and Residential Care Facilities (NAICS 623), Offices of Dentists (NAICS 6212), Home Health Care Services (6216), Psychiatric and Substance Abuse Hospitals (NAICS 6222), and Individual and Family Services (NAICS 6241).

TABLE 2. Health Care and Social Assistance Sector Demographics for Noise-Exposed Workers, With Estimated Prevalence and Adjusted Prevalence Ratios (PRs) for Hearing Loss (HL), 2003–2012 ($N = 8,702$)

Demographic	*n*	(%)	Prevalence of HL (%)	Prevalence 95% CI	PR*	95% CI
HL (outcome)						
Yes	7,086	81.43				
No	1,616	18.57				
Missing	0					
Gender						
Male	7,094	81.78	21.47	20.52–22.43	3.52	2.88–4.30
Female (ref)	1,580	18.22	5.70	4.56–6.84	Ref	
Missing	28					
Age group, years						
18–25 (ref)	1,135	13.04	3.35	2.30–4.40	Ref	
26–35	1,941	22.31	5.56	4.54–6.58	1.67	1.17–2.39
36–45	2,234	25.67	12.85	11.46–14.24	3.89	2.81–5.39
46–55	2,205	25.34	26.76	24.91–28.61	7.93	5.79–10.87
56–65	1,112	12.78	48.92	45.98–51.86	14.25	10.42–19.50
66–75	75	0.86	65.33	54.56–76.10	16.82	11.87–23.84
Missing	0					
Geographical region						
Midwest	5,744	66.09	19.20	18.18–20.22	1.02	0.89–1.17
Northeast	567	6.52	18.17	15.00–21.34	0.97	0.79–1.19
South	1,330	15.30	17.22	15.19–19.25	1.01	0.85–1.19
Southwest	183	2.11	22.95	16.86–29.04	0.82	0.63–1.08
West (ref)	867	9.98	15.92	13.49–18.36	Ref	
Missing	11					

95% CI, 95% confidence interval; PR, prevalence ratio.
*PRs were adjusted for gender, age group, and geographical region, as appropriate.

RESULTS

Most noise-exposed HSA workers were male (82%) and employed in the Midwest (66%) (see Table 2), as compared with 78% male and 46% employed in the Midwest for all industries combined (data not shown). The distribution of the age groups for HSA was similar to all industries combined, although there were 5% more workers in older age groups (aged 36 to 65) and 5% fewer workers in younger age groups (aged 18 to 35). Males were 3.5 times more likely to have hearing loss than females and the risk of hearing loss increased substantially as workers aged.

The prevalence of hearing loss for noise-exposed workers in the HSA sector was nearly identical to the prevalence for all industries combined (19%) [not shown] and very close to the prevalence of all industries combined except Couriers and Messengers (20%) (see Table 3). All of the HSA subsector prevalences at three-digit NAICS specificity were below the overall HSA prevalence except for Hospitals (NAICS 622) (25%). All subsectors but the Hospitals subsector had adjusted risks for hearing loss significantly higher than the reference industry, which had a hearing loss prevalence of 9%. The HSA subsector with the highest risk as compared with the reference industry was Ambulatory and Health Care Services (NAICS 621) [PR = 1.21; confidence interval (CI) = 1.16 to 1.27], but it had a lower risk than all industries combined except Couriers and Messengers (PR = 1.38; CI = 1.36 to 1.41).

Figure 1 depicts HSA subsector prevalences (at four-digit NAICS specificity) in order of magnitude. Most of the HSA subsector prevalence estimates ranged from 14% to 18%. Medical and Diagnostic Laboratories (NAICS 6215) stood out with a 31% prevalence of hearing loss and significantly higher risk (PR = 1.24; CI = 1.09 to 1.42) than the reference industry. Offices of Other Health Practitioners (NAICS 6213) also had a high prevalence (24%) and an even higher risk (PR = 1.38; CI = 1.28 to 1.49) as compared with the reference industry. Although Child Day Care Services (NAICS 6244) had a moderate prevalence of hearing loss (17%), it had the highest adjusted risk as compared with the reference industry (PR = 1.52; CI = 1.41 to 1.64). Community Food and Housing, and Emergency and Other Relief Services (NAICS 6242) also had an unremarkable prevalence of hearing loss (14%), but the second highest risk for hearing loss (PR = 1.41; CI = 1.14 to 1.74). General Medical and Surgical Hospitals (NAICS 6221) had a high prevalence (26%), but the adjusted risk was not significantly higher than the reference industry. Outpatient Care Centers (NAICS 6214) had a very low prevalence of hearing loss (6%) and nonsignificantly lower risk than the reference industry.

DISCUSSION

This is the first known study to estimate and compare the prevalence of worker hearing loss by subsector within the HSA sector, and used audiograms from hundreds of U.S. companies from this sector. Study results identified the subsectors within the HSA sector that have an elevated prevalence, and adjusted risk of hearing loss as compared with the reference industry. Results identifying the severity of hearing loss within the HSA sector have been published previously.[29] Our discussion focuses on these subsectors, all of which have statistically significantly higher adjusted risks than the reference industry: Medical and Diagnostic Laboratories; Child Day Care Services; Officers of Other Health Practitioners; and Community Food and Housing, Emergency and Other Relief Services. It is possible to have a higher prevalence of hearing loss and a nonsignificant risk estimate, or a lower prevalence of hearing loss and a statistically significant risk estimate. Risk estimates are adjusted for age group and gender, and a nonsignificant difference in risk from the reference industry may indicate that age or gender in a particular subsector is accounting for more (or less) of the hearing loss than noise or other risk factors. For example, General Medical and Surgical Hospitals (NAICS 6221) has a higher prevalence, but the adjusted risk is not statistically significantly different than

TABLE 3. Estimated Prevalence and Adjusted Prevalence Ratios (PRs) for Hearing Loss (HL) by Industry for Noise-Exposed Workers Within Health Care and Social Assistance, 2003–2012 ($N = 1{,}491{,}729$)

Industry (NAICS 2007 Code)	*n*	Prevalence of HL (%)	Prevalence 95% CI	PR*	95% CI
All industries EXCEPT Couriers and Messengers (492)	1,381,759	19.74	19.68–19.80	1.38	1.36–1.41
Health care and Social Assistance (62)	8,702	18.57	17.75–19.39	1.17	1.13–1.22
Ambulatory Health Care Services (621)	6,581	18.25	17.32–19.18	1.21	1.16–1.27
Offices of Physicians (6211)	2,161	17.72	16.11–19.33	1.30	1.21–1.41
Offices of Dentists (6212)	0	ISS		ISS	
Offices of Other Health Practitioners (6213)	1,259	23.91	21.55–26.27	1.38	1.28–1.49
Outpatient Care Centers (6214)	107	5.61	1.25–9.97	0.63	0.30–1.32
Medical and Diagnostic Laboratories (6215)	362	31.49	26.71–36.28	1.24	1.09–1.42
Home Health Care Services (6216)	1	ISS		ISS	
Other Ambulatory Health Care Services (6219)	2,691	14.72	13.38–16.06	1.03	0.95–1.12
Hospitals (622)	752	24.73	21.65–27.81	1.07	0.96–1.19
General Medical and Surgical Hospitals (6221)	682	25.81	22.53–29.09	1.09	0.97–1.22
Psychiatric and Substance Abuse Hospitals (6222)	1	ISS		ISS	
Specialty Hospitals [except Psychiatric and Substance Abuse] (6223)	69	14.49	6.18–22.80	0.79	0.47–1.34
Nursing and Residential Care Facilities (623)	8	ISS		ISS	
Social Assistance (624)	1,357	16.73	14.74–18.72	1.11	1.01–1.22
Individual and Family Services (6241)	19	ISS		ISS	
Community Food and Housing, and Emergency and Other Relief Services (6242)	346	14.16	10.49–17.83	1.41	1.14–1.74
Vocational Rehabilitation Services (6243)	881	17.59	15.08–20.10	1.03	0.91–1.16
Child Day Care Services (6244)	111	17.12	10.11–24.13	1.52	1.41–1.64
Couriers and Messengers (492) (ref)	109,970	9.08	8.91–9.25	Ref	

95% CI, 95% confidence interval; ISS, insufficient sample size; PR, prevalence ratio.
*PRs were adjusted for gender and age-group.

the reference industry, indicating that much of the elevation in prevalence can be explained by the covariates.

All of the workers in the Medical and Diagnostic Laboratories subsector (NAICS 6215) in this sample worked in Medical Laboratories (NAICS 621511). This subsector includes blood analysis, medical pathology, medical bacteriological, medical testing, and medical forensic laboratories. No noise studies were found targeting this subsector after the 1980s. Pragay[30] measured noise levels in various hospital laboratories, including urinalysis, hematology, and microbiology laboratories. Average background noise levels ranged from 60 to 68 dBA and average noise levels during work hours (and equipment operation) ranged from 60 to 75 dBA.[30] Laboratory noise is usually generated by the operation of equipment, including analyzers, incubators, biosafety cabinets, stirrer motors, and fume hoods.[31] Other noise sources in laboratories include refrigerators, centrifuges, fans, and freezers, and can elevate background noise levels. For example, a centrifuge can emit a 65 dBA level of noise.[31] While 65 dBA is below the hazardous level, increases in background noise lead workers to elevate voices and volumes on radios, phones, and other personal listening devices.

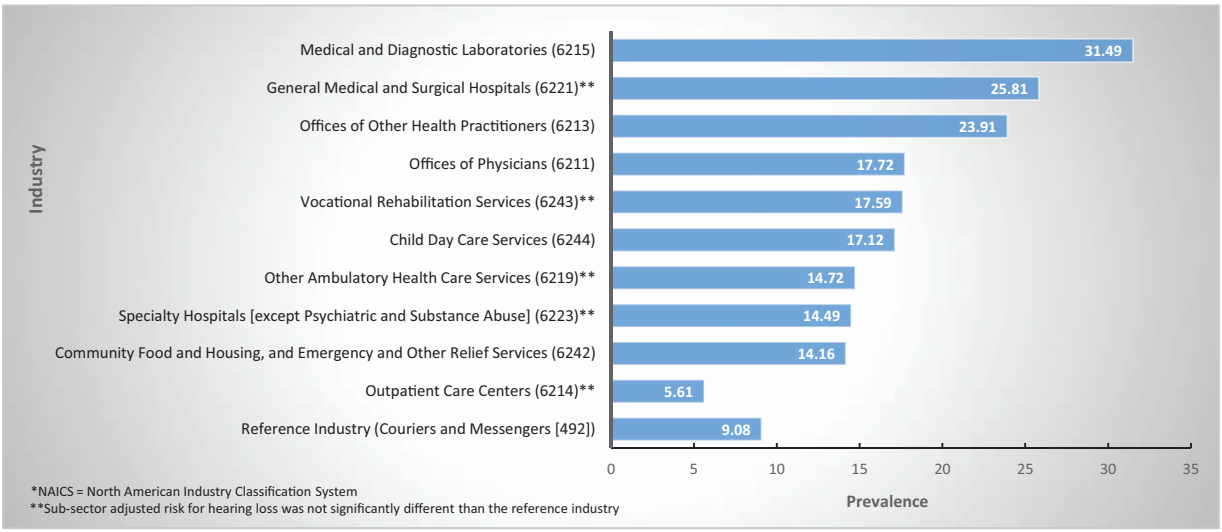

FIGURE 1. Prevalence of hearing loss by subsector (four-digit NAICS* specificity) for noise-exposed workers within Health Care and Social Assistance.

Research is needed to determine noise levels in medical laboratories that use modern equipment.

In this sample, workers in the Child Day Care Services subsector (NAICS 6244) all worked in Child Day Care Services (NAICS 624410). This subsector (NAICS 624410) includes child day care babysitting services, child or infant day care centers, nursery schools, and preschool centers. It is unlikely that these were mostly daycare workers, as 68% of the noise-exposed Child Day Care Services sample was male. This subsector had the highest percentage of workers in the 18 to 25 age group (32%), exceeded only by the reference industry, and these workers may have performed tasks very different than working with children. No studies were found related to hearing loss in child care. However, a study looking at vocal fatigue among preschool teachers did conduct noise measurements and found a high mean background noise level of 76 dBA.[32] Although it is below the hazardous level, it may influence behaviors contributing to hearing loss, such as increasing sound levels on personal equipment and raising voices. American Industrial Hygiene Association recommendations for background noise levels, depending on the function of the space, are all 50 dBA or less, and 40 to 45 dBA is recommended for an environment similar to one used for child day care.[33]

All of the workers in the Offices of Other Health Practitioners (NAICS 6213) subsector in this sample worked in Offices of All Other Miscellaneous Health Practitioners (NAICS 621399). This subsector (NAICS 621399) includes offices for a wide range of practitioners: acupuncturists (except MDs or DOs), hypnotherapists, dental hygienists, inhalation or respiratory therapists, denturists, midwives, dietitians, naturopaths, homeopaths, and registered/licensed practical nurses. There is limited study information available related to exposures in these health practitioner offices. Acupuncturists who work in large rehabilitation centers may be exposed to ''excessive noise'' being generated by instruments, equipment, and machines.[34] Sorainen and Rytkonen[12] measured noise levels of current dentistry equipment under controlled conditions and found that the average noise levels for most equipment ranged from 76 to 83 dBA. These types of equipment (eg, hand pieces, suction tubes, and ultrasonic scalers) would be used by both dental hygienists and dentists. Hearing loss has been documented elsewhere among dentists[35] and dental hygienists.[36] Studies specific to denturists were not found, but workers in this profession use some of the same tools (eg, hand pieces) as dentists and dental hygienists. A Chinese study did find that noise levels in a denture fabrication room at a dental laboratory ranged from 65 to 83 dBA.[37] Meyer et al[38] examined environmental conditions (including noise exposure) for patients in the respiratory ICU, where respiratory therapists at hospitals might spend some of their time. They found peak sound levels regularly surpassed 80 dBA.

A hospital study by Yassi et al[19] found that the dietetics areas had the most employees exposed to noise levels greater than 80 dBA (range <80–95 dB) and the second highest percentage of abnormal hearing cases (31%). However, ''dietetics'' in this study appears to include the main kitchen, bakery, and dishwashing areas. Continuing with practitioners in this subsector, noise exposures for registered and licensed practical nurses likely vary widely depending on location and setting. No relevant studies were found related to offices of hypnotherapists, midwives, naturopaths, and homeopaths. It is unknown whether our sample includes workers from these offices (only the subsector is known). In general, more recent targeted studies are needed to identify the higher risk groups within this subsector.

Workers in the Community Food and Housing, and Emergency and Other Relief Services subsector (NAICS 6242) in this sample all worked in Emergency and Other Relief Services (NAICS 624230). This includes establishments who primarily provide shelter, food, clothing, resettlement, medical relief, and counseling to victims of domestic or international disasters or conflicts. Exposures likely vary widely depending on the type of disaster and location (domestic or international) and limited research was available. One study looked at workers performing somewhat different functions during disaster relief operations for Hurricane Katrina, including building repair, animal shelter setup, and debris removal. This study found noise exposure levels exceeding 90 dBA.[39] It also raised the important point that some of these relief workers lived in the disaster zone during the aftermath and therefore had extended exposures.[39] It is likely that workers might cover extended shifts during emergency and relief efforts. Hearing protection may also be considered a lower priority in these situations.

Tak et al[6] reported that hearing protector use among noise-exposed workers varies inversely with the prevalence of noise exposure in a given industry, suggesting that industries in which fewer workers are exposed to noise may have less awareness of or experience in hearing loss prevention. The HSA sector had the lowest estimated prevalence of noise-exposed workers (4%) and the highest rate of failure to use hearing protection among workers exposed to noise (74%).[6] A study of worker awareness of job hazards by Behrens and Brackbill[40] found that health care workers ranked among the top five industries with the greatest difference between the proportion of workers exposed to a given hazard and the proportion aware that the exposure was hazardous. Among clinical laboratory technologists and technicians, the difference between those exposed to noise and those aware of the noise hazard was 70%.[40]

Exposure to ototoxic chemicals may also elevate the risk for workers in this sector, especially in hospitals and infusion centers where chemotherapy drugs are administered. Antineoplastic drugs can destroy sensory hair cells in the cochlea and cause tinnitus.[41] A study that queried 1339 oncology nurses working in ambulatory settings found that 17% had exposures to the skin or eyes in the past year.[42] Another study examining antineoplastic drug spills, drips, drops, and leaks in an academic center's infusion center found that workers had detectable levels of antineoplastic drugs in urine.[43] Workers who did not have spills also had detectable levels due to environmental contamination on surfaces in work areas. This study also found that nursing and pharmacy workers that reported spills scored significantly poorer for ''collegial relations with physicians'' than those who did not report spills, indicating work culture and teamwork may influence risk of exposure.[43]

In addition, when examining the results of workers in this sector, especially within the health care industries, one must be cognizant of workers whose workday extends beyond an 8-hour shift. Noise becomes hazardous at lower levels when the work day is longer (29 CFR 1910.95).[24] For example, 75% of hospital nurses work 12-hour shifts[44] and other professions likely work extended hours in these kinds of work environments.

This study had limitations. The data were part of a convenience sample that NIOSH obtained from providers willing to share their data. As such, the sample may not be representative of all noise-exposed workers in HSA, and there were some industries in this sector for which we had no representation (eg, Offices of Dentists). The work-relatedness of a hearing loss can only be inferred in the absence of additional information such as medical records. Audiograms with attributes unlikely to be related to OHL were excluded to strengthen this inference. Also, the industry coding was performed by the provider in some cases, with the potential for inconsistencies in the coding or misclassification. One audiogram (the last) was examined for each worker without a ''confirmation'' audiogram. It is possible that a few hearing losses were temporary shifts in hearing, although temporary threshold shift can be a sign that a worker is overexposed to noise. The risk estimates in this study represent the risk for worker hearing loss in an industry as compared with the risk in the reference

industry—not compared with the general population. The workers in this sample were all or nearly all exposed to noise, including workers in the reference industry, meaning that the risk estimates might be biased toward the null and the true risks might be higher than reported here. Finally, NAICS was designed as an economic classification system and may not group workers with similar exposures together.

CONCLUSIONS

OHL remains one of the most prevalent work-related conditions in the U.S.[9] Workers who develop hearing loss suffer from reduced auditory sensation, difficulty understanding speech in background noise, and the inability to localize sound sources.[45] These consequences often further manifest themselves psychosocially, as workers reduce their interactions with family, friends, and coworkers, withdraw from activities that require auditory attention (such as concerts, meetings, and social gatherings), and suffer reduced self-esteem.[3] However, OHL is entirely preventable,[3,4] and methods for controlling noise to safe levels, protecting employees through personal protective devices, and monitoring workers for changes in their hearing levels are well-established (29 CFR 1910.95).[24,46] Successful noise reduction measures have been documented in hospital settings, including training and changing procedures for hospital staff members; limiting visitor hours and numbers of visitors for each patient at a time; lowering volumes on alerting bells and phones; using floor mats; and modifying equipment.[47,48] Exposure to chemotherapy drugs can be better prevented by using closed-system transfer devices for administering drugs, using double gloves and single-use gowns, improving awareness of risks among staff, and fostering a ''blame-free'' environment for reporting spills.[43] OSHA also recommends using acoustical treatment on laboratory walls and ceilings, moving as much noise-producing equipment as possible out of the lab and into equipment rooms, and situating remotely the compressors for temperature-controlled rooms.[31]

This study highlights some of the industries within the HSA sector that need targeted hearing conservation efforts. Additional attention is needed to identify at-risk workers and protect their hearing. Prior noise studies need to be replicated in the current health care environment that uses new technology and employs new methods and practices—to both pinpoint and mitigate exposures. Ototoxic chemical exposures, alone and in combination with noise exposures, also need to be identified and the proper precautions taken to prevent these exposures.

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