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Risk assessment of recordable occupational hearing loss in the mining industry

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Abstract

Objective: To evaluate the hearing loss risk in different sectors and subunits in the mining industry and to identify associated occupations, in an attempt to locate gaps between hearing conservation efforts and hearing loss risks.

Design: Descriptive statistics and frequency tables were generated by commodity types, subunit operations, and/or occupations. Temporal trends of the incidences of hearing loss were reported by commodity types.

Study Sample: The MSHA Accident/Injury/Illness and MSHA Address/Employment databases from 2000 to 2014 were used.

Results: Incidence rate of OHL was reported highest in the coal sector compared to other commodity types. Those members of the workforce that entered the mining industry after the year 2000 accounted for 6.5% and 19.0% of the total hearing loss records for coal and non-coal, respectively. High-risk occupations found in all three commodity sectors (coal; stone, sand, and gravel; and metal/non-metal) were electrician/helper/wireman, mechanic/repairman/helper, bulldozer/tractor operator, and truck driver.

Conclusion: Hearing loss risks were not uniform across mining sectors, subunit operations, and occupations. In addition to the continuous efforts of implementing engineering controls to reduce machinery sound level exposure for operators, a multi-level approach may benefit those occupations with a more dynamic exposure profile – e.g., labour/utilityman/bullgang, electrician/helper/wireman, and mechanic/repairman/helper.

Keywords

Noise-induced hearing loss; mining industry; hearing conservation; hearing loss prevention; noise

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Disclosure statement
The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centres for Disease Control and Prevention.

Introduction

Occupational hearing loss (OHL) is one of the most common work-related illnesses in the United States (NIOSH 2016). According to the Bureau of Labour Statistics (BLS) in 2014, it is estimated that OHL accounted for 10.4% of all occupational illnesses in the United States. There are approximately 22 million workers in the United States exposed to hazardous levels of noise (Tak, Davis, and Calvert 2009). Of these workers, 18% have developed hearing impairment (Masterson et al. 2013). Many noise-exposed workers have developed hearing loss during their first 5 to 10 years of employment (Rosler 1994; Wards, Royster, and Royster 2000). The maximum hearing shift due to noise exposure was often seen within 10 to 12 years of repetitive exposure (Bartholomae and Redmond 1986).

High risk of hearing loss has often been reported in the mining industry (Rubak et al. 2006; Tak and Calvert 2008; Engdahl and Tambs 2010; Money et al. 2011, Kerns et al. 2018). Masterson et al. estimated the national burden of hearing impairment in all industries in the United States during 2000–2008, showing that the prevalence of hearing loss among workers in the mining industry was 27.3%, which was the highest among all industries surveyed (Masterson et al. 2013). Approximately 29% of workers in coal and non-metal mining and quarrying, and 25% of workers in metal ore mining and support activities of mining, had developed hearing impairment (Masterson et al. 2013). The BLS reported that the incidence rate (IR) of hearing loss in the mining industry (except oil and gas) was about 2 per 10,000 full-time workers from 2004 to 2010 (Martinez 2012). During this period of time, the IR in the mining industry remained constant. However, in the manufacturing and utility industries, the rates declined significantly (Martinez 2012).

The association between hearing loss and accumulated noise dose was found as early as 1958 (Rosenwinkel 1958). Mining operations have a long history of hazardous noise levels in operational areas (Federal Register, Department of Labor, Mine Safety and Health Administration 1999). A surveillance analysis of noise exposure across all types of mining still revealed excessive noise exposure of mine workers (Roberts, Sun, and Neitzel 2017). Many types of large mining equipment generate noise above 90 dBA or even 100 dBA (Bartholomae and Redmond 1986). Among the loudest machines in underground operations are jumbo-mounted percussion drills, continuous miners, roof bolters, diesel-powered load-haul-dump and haulage trucks, continuous haulage chain conveyors, and face ventilation systems (fans and blowers). In surface mining, the loudest equipment includes machine-mounted percussion drills, haulage trucks, front-end loaders, and crawler tractors. In facility mining (shops and yards, mill, or preparation plant), the primary noise sources are jaw and cone crushers, grinders and mills, car shake-outs, classifying screens, vacuum pumps, and chutes and hoppers (Bartholomae and Redmond 1986).

In 2000, the Mine Safety and Health Administration (MSHA) promulgated the revised noise regulation 30 CFR Part 62. This regulation requires implementing a continuous noise monitoring system and enrolment in a hearing conservation programme (HCP), with baseline and annual audiograms required for miners who are exposed to noise levels equal to or in excess of the Action Level (AL). Confirmed hearing loss cases from audiograms are required to be recorded and reported to MSHA. Moreover, a requirement for the use of hearing protection, as well as a noise criterion for the use of dual hearing protection, was defined. These requirements were not part of the previous noise requirements for mines and were intended to serve as steps to reduce the incident of occupation hearing loss in mining. These regulations are used in all operating mines within the United States and are similar to the Occupational Safety and Health Administration (OSHA) noise regulation requirements.

Implementing a hearing conservation programme is a widely used strategy for hearing loss prevention. A number of studies, including a recently published Cochrane review, have found that better implementation of HCPs can reduce hearing loss (Fonseca et al. 2014; Verbeek et al. 2014; Muhr et al. 2016). Among the key components in HCPs, Hearing Protection Devices (HPDs) are consistently shown to be effective in reducing hearing loss. Four studies in the Cochrane review have found that HPDs decrease the risk of OHL (Verbeek et al. 2014). Groenewold et al. reported a similar finding of increased risk of high-frequency threshold shift being associated with decreased use of hearing protection (Groenewold et al. 2014). A few studies have reported the positive impact of better quality in noise monitoring and audiometric testing on hearing loss prevention. As one example, Heyer et al. (2011) found a significant association between better noise monitoring and reduced hearing loss, but the authors believed the finding was inconclusive as these results were likely confounded by the studied plants/facilities. Pre-existing differences between job tasks were in place that may have led to the differences found in the study.

Due to the variability of past research in terms of study populations, methods and findings, questions still remain regarding whether implementing the required HCP is effective in reducing hearing loss. Surveillance data on OHL is useful to identify sectors, subunits, operations, and occupations with the highest risk in the mining industry. These data are a vital indicator of the effectiveness of HCPs and other hearing loss prevention efforts. MSHA datasets include information on employment and reported hearing loss in the mining industry. This study used these datasets to assess the OHL risk in the mining industry and to locate gaps between the hearing loss prevention efforts and the reduction of risk.

Methods

Data acquisition

The MSHA Accident/Injury/Illness and MSHA Address/Employment datasets were used in the study. In the US, mining accident/injury/illness data is reported separately from other industries. The collection of this information by companies about mining accident, injury/illness, and employment is required under Part 50 of the U.S. Code of Federal Regulations. Original accident/injury/illness data were reported on MSHA form 70001, and employment data were reported on MSHA form 7000–2. These two sets of data are available on the MSHA database website (http://arlweb.msha.gov/OpenGovernmentData/OGIMSHA.asp) in.txt format and are periodically updated. NIOSH converted the accident/injury/illness and address/employment data from 1983 to 2014 into IBM SPSS file format, and these two converted datasets were used in this study.

The total number of employees and the total working hours in each mine in a given year were reported in the MSHA employment dataset. In the MSHA accident/injury/illness dataset, reported hearing loss cases were listed by mine ID and year. A mine could have more than one reportable OHL case in a given year. A reportable hearing loss is a change in hearing sensitivity for the worse, relative to the miner's baseline or revised audiogram, of an average of 25 dB or more at 2000, 3000 and 4000 Hz in either ear. For each hearing loss case, the age, gender, mining experience, and occupation of the miner were reported.

OHL case selection

OHL illness data were extracted from the MSHA accident/injury/illness dataset through serial steps of selection (Supplementary Appendix 1). First, injury classified as hearing loss or impairment was selected, leaving 5027 OHL cases from 1983 to 2014. Secondly, permanent hearing loss, as opposed to injury from a sudden accident, was selected based on injury/illness class, event type, and degree of injury. Thirdly, the selected cases were further confirmed through reviewing the narrative of the accidents, by looking for any word indicating chronic exposure or the absence of a word indicating an explosion, a sudden accident/blast, or physical ear injury. Because contractors from the same company can work at different mines, which would complicate the analysis, only mine operator employees (but not contractors) with recordable hearing loss were selected. In total, there were 4864 OHL incidences reported during 1983–2014. Of these, the 1626 recordable incidences from January 2000 to December 2014 were selected (Supplementary Appendix 1).

Combining datasets

To combine the two datasets, first, the accident/injury/illness dataset was aggregated by mine ID and year, and the sum of OHL cases from all subunits and each individual subunit were computed. Secondly, the aggregated dataset was then merged with the MSHA employment dataset by matching on mine ID and year to form a master dataset.

Data selection and recoding on combined datasets

Permanently abandoned mines or an active mine with no personnel working and no production were removed (only the active mines at each given year were selected). Commodity types were recoded into three groups: coal; stone, sand, and gravel (SSG); and metal/non-metal. The latter two were further combined and referred to as non-coal given the similarity in the operations thereafter the nature of noise. Subunits of the mine operation were originally coded as underground operations, surface at underground, surface, auger, culm banks, dredge, other surface, independent shops and yards, mill or preparation plant, and office, then were regrouped as well. Categories called "Surface at underground", "surface", and "other surface" were combined into one category – "surface operations". Categories of independent shops and yards and mills or preparation plants were grouped into facility operations. All other subunit types remained the same. In the master dataset, a missing value of hearing loss injury means that there was no reported OHL injury for the mine in the given year; thereafter, the missing value was recoded as zero. Miners with reported OHL injury who entered the mining workforce after 2000 were selected based on the year a recordable OHL injury was reported and the total years of mining experience by the time the OHL injury occurred. If the total mining experience of a miner was less than the year difference between the time the OHL injury was reported and the year 2000, the injured miner was classified as "workforce post 2000," indicating that the miner started working in the mining industry after the effective year of the new MSHA noise rule when an HCP had been implemented.

Data analysis

Descriptive statistics on age and mining experience from OHL cases were generated based on the MSHA accident/injury/illness dataset. The frequency of age, gender, mining experience, and workforce after the year 2000 from all reported cases were computed and presented. In addition, the years of mining experience was presented for the workforce after the year 2000. The total number and the percentage of recordable cases by commodity types and occupations were also computed. Occupations were classified according to MSHA's simplified version of the occupational codes. One-way ANOVA tests to compare age and total mining experience among commodity categories were conducted. One-way ANOVA with Bonferroni adjustment on *p*-value (0.05 divided by the number of occupations in each commodity categories) was also conducted to compare age and mining experience among all occupations within each commodity type.

To calculate the mean and the standard deviation (SD) of the number of hearing loss cases during 2000–2014, first, the sum of MSHA-recordable injury cases by year, commodity, and subunit type were computed, and then the mean across all years was computed. The number reported in the resultant table was rounded to its nearest integer. To calculate the average incident rate, first, the total number of MSHA-recordable OHL cases and the total working hours from all employees were computed by commodity type and subunits for each given year, and then OHL incident rate (IR) per 10,000 fulltime (2000 hours per year) employees per year was calculated using the following equation:

$$IR = \frac{No.\ of\ MSHA\ Recordable\ HL\ Cases \times 20,000,000}{No.\ of\ Employee\ Labor\ Hours\ Worked}.$$

The mean and SD of IRs across all years during 2000–2014 was then calculated and reported. The average IRs for each 5-year bin were computed by commodity type and/or subunits, and a bar graph was generated.

Results

Demographic information for the miners with hearing impairment and/or significant threshold shift (STS) during 2000–2014 are summarised in Table 1. Almost all miners with OHL were male regardless of the type of commodity being mined, largely due to the predominance of male miners in the workforce. Both age and total mining experience were significantly different among commodity types. Coal miners with OHL tended to be older and had more mining experience than those from SSG or metal/non-metal mines. Nearly 90% of the coal miners with reported OHL had overall mining experience equal to or greater than 15 years, whereas only around 60% of OHL non-coal miners had this length of years of experience in mining. Most miners with reported OHL were in the age categories of 45–54 and 55–64. The percentage of hearing-impaired miners in these two age groups was higher in coal mining than other types of mining. A greater proportion of the workforce began after the year 2000 in SSG mining and metal/nonmetal than coal mining. Within this population, around one-fifth had been working in the mining industry for 1–3 years before a standard threshold shift (STS) was observed, and an average of 40% across commodity types had 5 to 10 years of mining experience. According to MSHA methods, a standard threshold shift is a change in hearing sensitivity for the worse relative to a miner's baseline or revised baseline of an average of 10 dB or more at 2000, 3000, and 4000Hz. In the coal commodity, it appears that no hearing loss was reported for miners with less than one year of mining experience, while, 8.6% and 10.0%, were reported in SSG and metal/non-metal mines for this category, respectively.

The top ten occupations with the highest amount of OHL cases during 2000–2014 are listed in Table 2. Age and mining experience were not significantly different by occupations in each commodity type (data not shown). Electrician/helper/wireman, mechanic/repairman/helper, bulldozer/tractor operator, and truck driver were listed as the high-risk occupations in all three commodity types. Occupations with a high-risk of noise over-exposure (based on past NIOSH research and MSHA data) included specialised occupations in coal mining were roof bolter, shuttle car/ram operators, belt/conveyor/crew, and continuous miner operators. Specialised occupations in non-coal mining that had greater recordable OHL incidences were sizing/washing/cleaning plant operator/worker and front-end loader/high lift operator.

Table 3 reports the average number of cases and incidence rate per year of MSHA-reported OHL during 2000–2014. The incidence rate was highest in coal mines, followed by metal/non-metal mines and SSG. In particular, OHL incidence rates were higher at underground operations in coal, surface, and facility operations in non-coal mining compared to other subunits nested within the same commodity type.

Temporal trends of incidence rate for MSHA-recordable OHL by commodity and/or subunits are presented in Figure 1. Overall, incidence rates in coal and metal/non-metal sectors decreased over time. There was a significant rebound since 2010. The reason behind the rebound was unknown, but it is possibly due to the emerging of more powerful mining machines and possible improvement in hearing loss reporting. By contrast, the incidence rate in the SSG sector showed a continuous increase since 2000, especially for underground and surface operations.

Discussion

The study focussed on MSHA-recordable OHL cases during 2000–2014 to estimate OHL risks among different sectors in the mining industry. The study also took advantage of MSHA data and combined MSHA accident/injury/illness and MSHA employment databases to adjust recordable OHL by employment size. The goal of the study was to understand high-risk fields in the mining industry and to explore potential early indicators of OHL, in order to better guide the prevention of irreversible OHL before it occurs.

Major findings

Our study found that among the types of mining investigated, the OHL incidence rate was highest in coal mines. This finding was consistent with a previous study on noise exposure in the mining industry, showing that the sound levels were highest in coal mines (Roberts, Sun, and Neitzel 2017). In underground mines, as opposed to surface mines, it is difficult to escape the noise source. Also, especially for underground coal mining, much of the equipment is not cabbed. Therefore operators are either outside of the machine or on it but without any type of enclosure or noise baffle. Greater noise exposure and in turn incident of hearing loss is a logical outcome of the noise situation in many underground coal mines. Our study also found a high risk of OHL at underground and surface operations in metal/non-metal mines, and at facility operations in SSG mines. Although the incidence rate was relatively low in SSG, given that SSG mines account for over 70% of all mines in the United States, the burden of OHL in terms of the number of reported cases was still high. Moreover, the incidence rate of OHL in SSG mines has continuously increased since 2000, even after the implementation of the new noise rule, implying a potential gap in implementing HCP in this sector.

In this study, we found that among all working populations between 2000 and 2014 nearly 90% of coal miners with recordable hearing loss had mining experience of more than 15 years, and more than 60% of non-coal miners with recordable hearing loss had mining experience at 10 years and above. Hearing impairment is a chronic illness. It requires long-term exposure to hazardous noise levels before a significant decline in hearing level can be noticed. According to ISO 1999:1999(E), 10% of the population has their hearing levels deteriorate by 11.3 dB after 10 years exposure to 90 dBA of noise (ISO 1990). This number increases to 35.3 dB when the exposure level is at 100 dBA and the exposure duration remains the same (ISO 1990). A 10-dB hearing shift after hearing sensitivity deteriorates to 25 dB or worse is considered to be recordable on the MSHA accident/injury/illness form; however, we observed that a notable proportion of miners with a recordable STS among the post-2000 workforce have mining experience of fewer than 3 years. This finding raises concerns about the effectiveness of HCPs in the mining industry, in that since 2000 all mines are required to implement an HCP. However, it is still unknown whether this finding reflects that the current HCP programmes are not fully effective at reducing noise exposure and the resultant OHL, or whether they are not effectively implemented – either due to missing components or due to those components only being executed at the lowest acceptable level. In addition to unknown effectiveness or implementation of HCPs, is the exposure to non-occupational noise that many of these workers experience. This demographic traditionally enjoys outdoor and sporting activities such as ATV and motorcycle riding, shooting, woodworking and use of tools and equipment such as chainsaws, drills, tractors and others that are known to produce hazardous levels of noise. In order to see improvements in the incidence of hearing loss on the job, one must recognise and address the plausibility of non-occupational noise exposure. By encouraging employees to follow the same noise exposure reduction techniques off the job, such as donning HPDs, moving away from noise sources when possible, and properly maintaining personal equipment, greater returns can be achieved from the HCP efforts.

Several occupations were identified with high OHL incidences which have been aligned with identified high-exposure occupations in other studies, such as longwall operators, bulldozer/tractor operator, roof bolter, continuous miner operator, front-end/loader/high lift operator, etc. (Camargo, Azman, and Peterson 2018; Peterson et al. 2016; Camargo, Azman, and Alcorn 2016; Yantek, Camargo, and Jurovcik 2010; Bauer, Babich, and Vipperman

2006; Bauer and Kohler 2000). To reduce sound level exposure among these occupations, the NIOSH mining research team has targeted roof bolters, continuous mining machine, haul trucks, and load-haul-dump (LHD) trucks and developed appropriate engineering controls – e.g. a drill bit isolator for a roof bolter, a polyurethane-coated chain flight on a continuous mining machine, and optimising the proper selection of the type and size of engine cooling fan for an LHD and haul truck (Carter 2003; Smith et al. 2009; Michael et al. 2011; Peterson et al. 2013; Azman, Camargo, and Alcorn 2014; Azman, Alcorn, and Li 2015). In addition, we have identified several occupations that were not recognised as high-risk occupations for hearing loss in the past – e.g. laborer/utilityman/bull gang, electrician/helper/wireman, mechanic/repairman/helper. These occupations, although different from machine operators, are also exposed to multiple noise sources and have ever-changing working tasks/environments. Therefore, it is challenging to characterise their exposure profiles due to the dynamic nature of their jobs. Development of engineering controls to reduce the overall sound levels at mining sites would benefit these occupations, but a multilevel approach beyond engineering controls, targeting administrative controls and improvement of individual awareness and self-empowerment efforts, may be more appropriate.

Limitations

The IR estimation in this study was much lower than what was reported by Masterson et al. in 2015. (Masterson et al. 2015). One major difference is that the other study directly used audiogram testing results obtained from audiometric service providers who performed the test in various industries across the country. Another difference between the two studies is that in the Masterson et al. study the oil and gas industries were combined with mining, while in the present study only the mining industry was included. In this study, the recordable OHL cases were identified according to the MSHA method allowing for age adjustment, instead of the NIOSH method (Rosenstock 1998) which does not allow for age adjustment. Nevertheless, our estimation was similar to the incidence rate reported by BLS, which also relied on data that MSHA provided (Martinez 2012). However, the discrepancy in reporting criteria and the definition of hearing impairment and STS cannot completely explain such significant disparity between the two data sources. Other unknown factors need to be explored and identified in the future.

One limitation of this study is that the IR for each occupation cannot be computed because MSHA data does not provide the number of employees by occupation. OHL incidence number is a combined effect from both risk and employment size. Another limitation is that a recordable OHL can be the deterioration of a miner’s hearing level that meets the MHSA hearing impairment criteria, or a work-related STS after a miner develops hearing impairment. From the MSHA accident/injury/illness database, we cannot tell if different miners working at the same mine developed hearing impairments or if the same hearing impaired miner had multiple hearing shifts over time. Therefore, the number of recordable OHL incidences is not an accurate reflection of the number of affected miners. In addition, information on mining experience is not available for the entire mining workforce, but only for those who have developed an STS. Frequency reported by categories in mining experience is not adjusted by the size of each category in the entire workforce, and thus is subject to bias. Lastly, only the indirect information – i.e. recordable OHL—was being used instead of audiograms. This indirect parameter relies on the accuracy of reporting/recording and is subject to variability among different recorders. Potential under-reporting is inevitable. To truly understand the relationship between hazardous noise conditions and hearing impairment, a comprehensive surveillance study is needed.

Conclusion

This study found that OHL incidence rate was highest in coal mines. We also found relatively high IR in surface and facility subunits in SSG and metal/non-metal mines. The incidence rate in SSG mines showed a trend of increase since 2000, whereas other sectors were decreasing. Several high-risk occupations were identified in this study. Besides operators exposed to loud, large mining machines, occupations with no fixed working station, a more dynamic work schedule, and a wider range of job tasks also experienced higher risk of OHL. Workers who entered the mining industry after 2000 (i.e. those affected by the implementation of HCPs required by the MSHA noise rule) were still at risk. A comprehensive evaluation of the effectiveness of HCPs is necessary especially for SSG and metal/non-metal mines. The underlying reasons for OHL cases should be identified and remediated – whether through improved audiometric methods, improved use of HPDs, or modified training methods. This investigation is currently being performed by the NIOSH Pittsburgh Mining Research Division, and recommendations to enhance current HCP practices are forthcoming.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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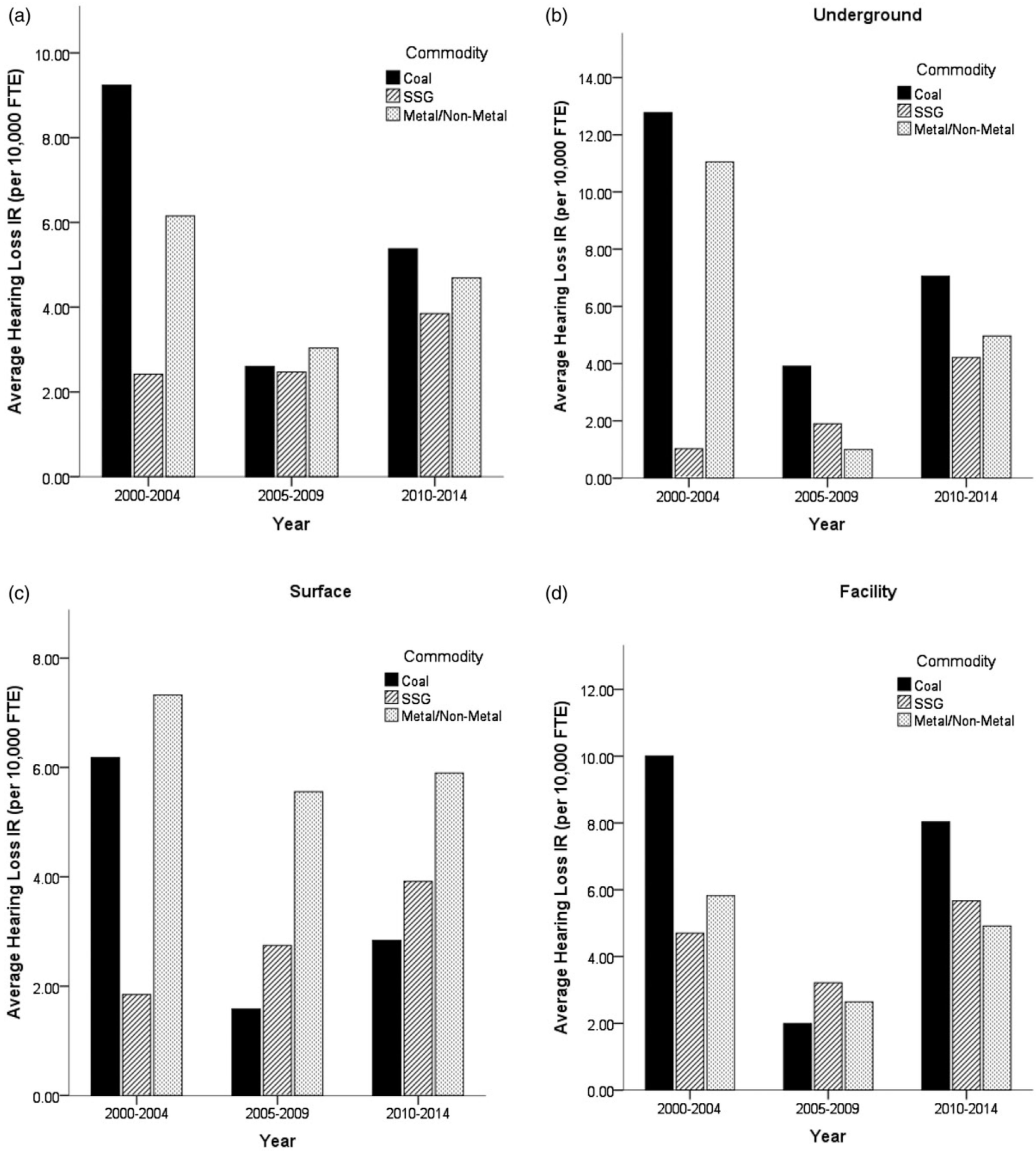

Figure 1.

Temporal trend of hearing loss IR by commodity type, 2000–2014.

Table 1.

Demographic information of mining operators with recordable OHL, 2000–2014

	Mean ±SD/Percentage (%)			
	Coal	**Stone, sand and gravel**	**Metal/non-metal**	**Non-coal**[c]
Age (year)[a]	54.2 ± 6.5	51.5 ±9.8	53.0 ±9.0	52.2 ± 9.4
18–24	0.1	1.3	0.5	0.9
25–34	0.7	4.7	3.6	4.1
35–44	5.5	14.6	11.7	13.2
45–54	43.2	35.9	36.9	36.4
55–64	46.4	36.6	41.4	38.9
65 and above	4.0	6.9	6.0	6.4
Sex				
Male	99.6	98.5	98.1	98.3
Total mining experience (year)[b]	26.6 ±8.6	20.3 ±11.6	21.2 ±11.4	20.7 ±11.5
≤1		1.9	1.9	1.9
>1 and ≤3	1.3	5.0	3.0	4.0
>3 and ≤5	0.6	2.4	5.1	3.6
>5 and ≤10	3.6	14.2	12.4	13.3
>10 and ≤15	6.5	14.4	10.5	12.6
>15	88.0	62.3	67.2	64.6
Workforce post year 2000 (%)	6.5	19.1	18.8	19.0
Mining experience	8.5 ± 4.0	5.7 ±3.6	5.2 ±3.1	5.5 ± 3.4
≤1	-	8.6	10.0	9.3
>1 and ≤3	20.5	23.5	15.7	19.9
>3 and ≤5	4.5	9.9	25.7	17.2
>5 and ≤10	36.4	45.7	40.0	43.0
>10 and ≤15	38.6	12.3	8.6	10.6

[a,b] Age and total mining experience are statistically significantly different among commodity categories, $p < 0.05$.

[c] Non-coal includes SSG and metal/non-metal.

Table 2.

Top ten occupations with the greatest number of recordable OHL incidences by commodity type, 2000–2014.

Commodity	Rank	Occupations (job title)[a]	Reported hearing loss No. (#)	Reported hearing loss Percentage (%)[b]
Coal	1	Laborer/utilityman/bull gang	108	19.5
	2	Mechanic/repairman/helper	67	12.1
	3	Supervisory/management/foreman/boss	45	8.2
	4	Bulldozer/tractor operator	43	7.8
	5	Electrician/helper/wireman	45	8.1
	6	Roof bolter (single head)	36	6.5
	7	Shuttle car/ram operator (standard side)	28	5.1
	8	Truck driver	21	3.8
	9	Belt/conveyor man/crew	19	3.4
	10	Continuous miner operator	17	2.3
Stone, sand and gravel	1	Mechanic/repairman/helper	80	20.8
	2	Sizing/washing/cleaning plant operator/worker	72	18.7
	3	Supervisory/management/foreman/boss	39	10.1
	4	Bulldozer/tractor operator	30	7.8
	5	Front-end loader/high lift operator	27	7.0
	5	Laborer/utility man/bull gang	27	7.0
	6	Truck driver	24	6.3
	7	Miner Not Else Classified (NEC)/Surface miner	19	4.9
	8	Electrician/helper/wireman	11	2.9
	9	Coal-metal/non-metal sampler/dust sampler/lab tech	9	2.3
	10	Oiler/greaser	7	1.8
Metal/non-metal	1	Mechanic/repairman/helper	111	31.6
	2	Sizing/washing/cleaning plant operator/worker	37	10.4
	3	Bulldozer/tractor operator	26	7.3
	3	Supervisory/management/foreman/boss	26	7.3
	4	Laborer/utility man/bull gang	22	6.2

Commodity	Rank	Occupations (job title)[a]	Reported hearing loss No. (#)	Reported hearing loss Percentage (%)[b]
	5	Miner NEC/Surface miner	20	5.6
	6	Miner NEC/Underground miner	18	5.1
	7	Electrician/helper/wireman	16	4.5
	8	Dragline/crane/backhoe operator	10	2.8
	9	Truck Driver	7	2.0
	9	Drill operator (coal/wagon/diamond)	7	2.0
	10	Engineer(elect/vent/mining)	6	1.7
Non-coal	1	Mechanic/repairman/helper	191	25.8
	2	Sizing/washing/cleaning plant operator/worker	109	14.7
	3	Supervisory/management/foreman/boss	65	8.8
	4	Bulldozer/tractor operator	56	7.6
	5	Laborer/utility man/bull gang	49	6.4
	6	Miner NEC/Surface miner	39	5.3
	7	Truck driver	31	4.2
	8	Front-end loader/high lift operator	29	3.9
	9	Electrician/helper/wireman	27	3.6
	10	Miner NEC/Underground miner	19	2.6

[a]After Bonferroni correction for multiple comparison in one-way ANOVA, age and mining experience for a particular job title are not significantly different among occupations under each commodity type.

[b] $Percentage(\%) = \frac{Number\ of\ ONIHL\ Cases\ in\ a\ Specific\ Occupation}{All\ ONIHL\ cases\ from\ all\ occupations} \times 100\%$

Table 3.

Recordable OHL and incidence rates by commodity type and mining subunit, 2000–2014.

	OHL No.[a] (per year)		OHL IR[b] (per 10,000 FTE per year)	
Commodity	**Mean**	**SD**	**Mean**	**SD**
Coal				
Underground	32	24	7.9	6.3
Surface	12	9	3.5	2.8
Facility	6	5	6.7	6.1
Total[c]	50	34	5.7	4.2
Stone, sand and gravel				
Underground	0	1	2.4	3.3
Surface	15	6	2.8	1.3
Facility	14	6	4.5	1.9
Total[c]	30	8	2.9	1.0
Metal/non-metal				
Underground	4	4	5.7	6.2
Surface	12	9	6.3	5.1
Facility	12	9	4.5	3.0
Total[c]	28	14	4.6	2.4
Non-coal				
Underground	5	4	4.9	4.6
Surface	26	10	3.6	1.5
Facility	26	11	4.5	1.7
Total[c]	58	18	3.5	1.1

[a]The total number of recordable OHL is calculated, and then the average number per year is computed, and then rounded.

[b]The IR in each year is calculated using equation $IR = \frac{No.\ of\ MSHA\ Recordable\ HL\ Cases \times 20,000,000}{No.\ of\ Employee\ Labor\ Hours\ Worked}$ per 10,000 FTE, and then the average IR across years is computed.

[c]This includes all subunits: underground, surface, facility, auger, culm banks, dredge, and office. The individual information from the last four subunits is not presented in this table.