THE NATIONAL OCCUPATIONAL HEALTH SURVEY OF MINING: MAGNITUDE OF POTENTIAL EXPOSURES TO MUSCULOSKELETAL OVERLOAD CONDITIONS

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The National Institute for Occupational Safety and Health conducted the National Occupational Health Survey of Mining (NOHSM) to characterize health-related agents, including musculoskeletal overload (MO) conditions, to which U.S. miners are potentially exposed (i.e., observed during on-site survey activity, but not quantified, measured, or evaluated). The percentage of miners potentially exposed to each separate MO condition was calculated, first for coal mining and then for metal/nonmetal (MNM) mining. The average percentage, over all twelve conditions, for coal mining (26.2%) was significantly larger than that for MNM mining (17.2%). Female miners comprised 1.6% of the total mining workforce, and were involved in 1.5% of the MO potential exposures. Full-time potential exposures accounted for 19.6% of the potential exposures in coal mining and 10.0% in MNM mining. The NOHSM data offer a unique body of information to musculoskeletal researchers, with ample opportunities for further analysis and comparison to other studies.

INTRODUCTION

Musculoskeletal disorders have been identified as a costly concern within the mining industry and analyses of these injuries have been examined by nature and body part, job title, and location on mine site. Pickett (1986) reviewed the problems of musculoskeletal injuries in coal miners but did not provide any statistics about body parts. Back injuries in underground mining have been described previously by a number of authors/investigators (Connelly, 1983; Peters, 1983; Stobbe, 1983; Stobbe, 1984; Leigh et al., 1991; Stobbe et al., 1986). Connelly (1984) reported that from 1978 to 1981, back injuries accounted for 21% of all injuries in coal mines, 15% of all injuries in metal mines, and 18% of all injuries in nonmetal mines. Stobbe et al. (1986) also provided specific body-part summary statistics for both coal and metal/nonmetal (MNM) musculoskeletal injuries. They reported that back injuries dominated both types of mining and accounted for about 55% of strains and sprains for coal mining and about 53% for MNM mining. In a safety manual by the National Mine Health and Safety Academy (1992), mechanics/electrician and laborers/cleanup were the most frequently involved with back injuries in 1990 in both coal and MNM mining. The annual informational reports on injury experience in mining by the Mine Safety and Health Administration (MSHA, 1986-1989) provide summaries of injury statistics. The numbers of strain and sprain injuries in coal mining in 1985, 1986, 1987, and 1988 were 3,599, 4,120, 6,564, and 6,568, respectively.

Although a large amount of research has been conducted on musculoskeletal disorders, little research has examined the etiological factors which are task-specific to musculoskeletal injuries. In order to better understand these etiological factors the National Institute for Occupational Safety and Health (NIOSH) conducted the National Occupational Health Survey of Mining (NOHSM). The goal of the survey was to inventory and characterize all health-related agents to which U.S. miners are potentially exposed. The terms "potentially exposed" or "potential exposures" are used in this paper because the surveyors observed health-related agents during on-site survey activity, but did not quantify, measure, or otherwise evaluate the conditions.

The NOHSM survey design, sample selection, and field protocol have been described previously

(Groce et al., 1986; NIOSH, 1995). Greskevitch et al. (1992) have reported the NOHSM potential exposure data which are related to the percentage of quartz measured in bulk dust samples. This paper presents the methodology which NOHSM surveyors followed for coding potential exposures to musculoskeletal overload (MO) conditions and a portion of the results from a systematic analysis of the MO potential exposure data obtained in the survey. The results are compared with previous literature of musculoskeletal injuries to provide additional insight to address injury problems in the mining industry.

METHODS
Overview of NOHSM

NIOSH conducted the NOHSM over a six-year period which began in May 1984 and ended in August 1989 (Groce, et al., 1986; NIOSH, 1995). The survey consisted of four segments in successive time periods, with each segment covering a different set of mineral commodities. Office workers were not included in the miner population being surveyed. NOHSM was conducted at the request of MSHA. NIOSH successfully surveyed 491 mines across the country during the NOHSM.

The NOHSM was a survey of the mining industry, with that industry consisting of commodities, which in turn were composed of specific mines and mills. The NOHSM actually was a series of one-year studies of selected commodities. Sample selection began with a population of mines actively mining specified commodities. The selection was then based on each mine's activity status, average yearly employment, mineral commodity, and geographical area. The 72 mineral commodities recognized by MSHA at the start of NOHSM were divided into geographic strata based on differences in mineral composition and mining methods. Geographic stratification produced 103 strata from the 72 commodities.

The selection of mine sites from each stratum was further divided into two categories: self-representing (SR) units and non-self-representing (NSR) units. The SR units were selected, according to objective criteria, due to their employment level relative to the rest of the commodity. Data from SR units applied only to the individual mine selected. A probability of selection of 1.0 was assigned to the data from SR units. The NSR units were selected from the remainder of the commodity on a systematic, random basis. Data from the NSR units applied to other mine sites within the same mineral commodity, and were used to create projected data. Each NSR unit had a probability of selection, greater than 0 and less than 1.0, depending on the percent of the workforce the site represented. This probability was obtained by dividing the total number of employees at a particular NSR mine site by the total number of employees in the entire commodity, and multiplying that fraction by the number of NSR sites to be surveyed within the commodity.

The NOHSM observations included industrial hygiene practices required and/or recommended by management, and information regarding chemicals, physical agents, and MO conditions found on mine property. The data have been entered into a computer-readable format and are available from NIOSH to interested parties.

Definitions and procedures

Twelve basic categories of activities were used in the survey as MO conditions; the categories are listed in Table 1 and have been defined elsewhere by NIOSH (1995).

Potential exposure to a MO condition was recorded when any miner was observed by NOHSM surveyors to engage in activity that required that muscular overload condition. If a single miner was observed to be involved with two or more MO conditions, two or more separate potential exposures were recorded. Similarly, if two or more miners were observed to be potentially exposed to a single MO condition, the number of potential exposures was recorded as equivalent to the number of miners observed. In the NOHSM survey, MO potential exposures were identified by the surveyors by observing a part of miners' tasks, by questioning the miners about the different operations the miners performed, or by questioning labor and management representatives.

For each job title within the mine, the surveyors recorded each MO condition present at the work site, the gender and number of miners that were associated with the MO condition, whether the potential exposure was part-time or full-time, operations the miners performed, and locations within the mine. The identification of musculoskeletal overload conditions also involved the following: a) observations of the miners' activities at their worksites; or b) observations of repetitive activities that appeared to occur on a continuous basis; or c) questioning miners on the amount of time spent performing the activity during an average workday. The surveyors recorded that the exposure was either part-time (if the miner spent 30 minutes to four hours per day at this particular activity) or full-time (if the miner spent more than four hours per day).

The surveyors observed miners with each job title long enough to comprehend the motions involved. They observed at least two full cycles if the work was repetitive. The surveyors analyzed the job for each of the twelve MO conditions and observed the positions the miner assumed and estimated the forces

involved. If necessary, the surveyors asked the miners questions, such as if they were pushing hard, how much an object weighed, or whether the activity made their muscles sore.

If more than one MO condition could be used to describe the same activity, only the more specific one was used. For example, if a miner was lifting while twisting, this was coded as awkward lifting, even though it might be also coded as neck and back. If, however, two aspects of a job were overloads, both codes were recorded. For example, if a miner was lifting 60 pounds, seven times a minute, both heavy lifting and frequent lifting were coded.

The surveyors observed miners at every work site on the shift that was being surveyed. If a given job title was not represented on the shift being surveyed, and if a knowledgeable person who had extensive work experience in that job title could not be questioned, then the surveyors had to survey that job title on the shift when at least one miner in the job title was available.

The accuracy of the data were dependent upon the surveyors' understanding of the MO conditions, the surveyors' powers of observation, and the surveyors' ability to faithfully record these observations within the coding system. Definitions, examples, and hypothetical sets of observations were provided to familiarize the surveyors with the survey strategy. The surveyors' professions included: mining engineer, geologist, chemical engineer, and industrial hygienist. All surveyors received identical orientation training which included specific instruction regarding MO observations. The surveyors' observations were further standardized as a result of occasional "quality control" checks by supervisory staff.

Magnitude of musculoskeletal overload potential exposures

The magnitude of projected MO potential exposures to each of the twelve conditions for a single commodity was determined by summing the MO observations found at the SR units and the MO observations found at the NSR units divided by their respective probabilities of selection. The projected total number of miners potentially exposed to each of the twelve MO conditions was then estimated for the entire mining industry by summing all the MO potential exposures for each commodity. The data were also analyzed by type of mining (i.e., coal and MNM), gender of miners, and exposure duration.

The number of MO potential exposures to each MO condition is equal to the number of miners potentially exposed to that particular MO condition. Thus, the percent of miner population potentially exposed to each separate MO condition can also be calculated to express the magnitude of MO potential exposures to that particular MO condition. The average number of miners or percentage, over all twelve conditions, can then be calculated to indicate the magnitude of MO potential exposures to all conditions for each type of mining or other descriptors. The magnitude of MO potential exposures can also be expressed in term of average number of MO potential exposures per miner, i.e., the summation of MO potential exposures to all twelve conditions divided by the miner population.

Statistical analysis

The NOHSM survey data were analyzed using the analysis of variance (ANOVA). Statistical analysis was performed using the Statistical Analysis System (SAS) software (SAS Institute, 1989). The SAS ANOVA procedure was used for analyzing the balanced data sets (without missing cell). Duncan's Multiple Range Test was performed to compare means and detect significant differences between means. A significant level of 5% was used in all cases.

RESULTS

Coal mining and metal/nonmetal mining

The projected number of miners potentially exposed to each of the twelve MO conditions was determined and summarized in Table 1 for coal mining, MNM mining, and both types of mining. The corresponding percentage of the total number of miners covered in this survey, i.e., miner population, was also calculated and shown in Table 1.

The miner populations, shown at the bottom of the table, were nearly equal for coal and MNM mining: 135,378 for coal mining, and 138,352 for MNM mining, for a total of 273,730 miners. The magnitude of potential exposures in coal mining (424,821) was greater than that in MNM mining (285,588). The average numbers of projected MO potential exposures per miner were 3.1 for coal mining and 2.1 for MNM mining.

The projected number of miners potentially exposed to each MO condition in coal mining appeared to be larger than that in MNM mining except for the standing condition. The projected number of miners ranged from 958 for standing to 69,842 for diminished light in coal mining and from 2,648 for standing to 51,152 for neck and/or back in MNM mining. The average projected number of miners, over all twelve conditions, for coal mining was 35,402 (i.e., 26.2% of coal miners) and for MNM mining it was 23,799 (i.e., 17.2% of MNM miners). This difference in average projected number of miners or percentage of miner population between coal mining and MNM mining was statistically significant. Therefore, all

subsequent analyses were performed separately for both types of mining (i.e., coal and MNM).

Table 1. Projected number of workers potentially exposed to each musculoskeletal overload condition and the corresponding percentage of miner population.

Musculoskeletal Overload Conditions		Coal		Metal/ Nonmetal		Both[1]	
Awkward Lifting	(AK)	29,386	21.7%	27,235	19.7%	56,621	20.7%
Arm and Shoulder	(AS)	58,916	43.5%	40,284	29.1%	99,199	36.2%
Diminished Light	(DL)	69,842	51.6%	19,343	14.0%	89,184	32.6%
Fingers and Hand	(FH)	31,905	23.6%	28,834	20.8%	60,739	22.2%
Frequent Lifting	(FQ)	12,792	9.4%	9,168	6.6%	21,960	8.0%
Heavy Lifting	(HV)	55,087	40.7%	40,555	29.3%	95,641	34.9%
Lower Limb	(LO)	41,545	30.7%	24,687	17.8%	66,232	24.2%
Neck and/or Back	(NB)	57,049	42.1%	51,152	37.0%	108,201	39.5%
Prone and Supine	(PS)	13,131	9.7%	6,068	4.4%	19,199	7.0%
Standing	(SD)	958	0.7%	2,648	1.9%	3,606	1.3%
Sitting	(SI)	25,681	19.0%	12,737	9.2%	38,418	14.0%
Wrist	(WR)	28,529	21.1%	22,878	16.5%	51,407	18.8%
Total[2]		424,821		285,588		710,409	
Average[3]		35,402	26.2%	23,799	17%	59,201	21.6%
Miner Populations[4]		135,378		138,352		273,730	

[1] Rounding process may prevent "Both" from equalling sum of "Coal" and "Metal/Nonmetal."
[2] The sum of MO potential exposures for all twelve conditions.
[3] The average number of workers or average percentage of miner population, over all twelve conditions.
[4] Miner populations did not include office workers.

Diminished light, arm and shoulder, neck and/or back, and heavy lifting were among the most common MO conditions in coal mining. As shown in Table 1, over 40% of the miners in coal mining were potentially exposed to these conditions. Arm and shoulder, neck and/or back, and heavy lifting were also the most common MO conditions in MNM mining. However, the percentages of miners potentially exposed to these MO conditions in MNM mining appeared to be smaller than those in coal mining.

Gender
Data regarding the association between gender and MO conditions are presented in Table 2. Females comprised 1.6% of the total mining workforce (4,334 out of 273,730). The 10,982 potential exposures associated with females ("Both", column (1), in Table 2) represent 1.5% of the 710,409 MO potential exposures summarized in Table 1.

Females were involved with 6,909 (1.6%) of the projected MO potential exposures in coal mining. The miner population in coal mining included 1,884 females. Thus, the average rate of projected MO potential exposures per female miner was 3.7 (6,909/1,884), which was higher than the rate of 3.1 for males in coal mining. The average number of females potentially exposed to MO, over all twelve conditions, for coal mining was 576 (i.e., 30.6% of female coal miners) and for males it was 34,826 (i.e., 26.1% of male coal miners). Statistical tests showed that there was no significant difference between the rate of MO condition potential exposures experienced by female coal miners as compared to that experienced by male coal miners. The most common MO conditions to which female coal miners were potentially exposed were diminished light and neck and/or back, with 1,224 and 1,017 female miners potentially exposed to these two conditions, respectively. Females accounted for 1.8% of the total number of coal miners potentially exposed to each of these two conditions.

Female miners were involved with 4,072 (1.4%) of the projected MO potential exposures in MNM mining. The miner population included 2,450 female miners in MNM mining. The average rate of projected MO potential exposures per female miner was 1.7 (4,072/2450), which was lower than the rate of 2.0 for males in MNM mining. The average number of female MNM miners potentially exposed to MO, over all twelve conditions, was 339 (i.e., 13.9% of female coal miners) and for males it was 23,460 (i.e., 17.3% of male MNM miners). Statistical tests showed that there was no significant difference between the rate of MO condition potential exposures experienced by female MNM miners as compared to that experienced by male MNM miners. In MNM mining, the most common MO conditions to which female miners were potentially exposed were neck and/or back and sitting, with 649 and 647 female miners potentially exposed to these two conditions, respectively. Female miners accounted for 1.3% and 5.1% of the total number of miners potentially exposed to neck and/or back and sitting conditions, respectively.

Table 2.   Female miners' potential exposures to musculoskeletal overloads.

Musculoskeletal Overload Conditions	Coal			MNM			Both[1]		
	(1)[2]	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
AK	768	40.7%	2.6%	302	12.3%	1.1%	1,070	24.7%	1.9%
AS	977	51.9%	1.7%	551	22.5%	1.4%	1,528	35.3%	1.5%
DL	1,224	64.9%	1.8%	202	8.3%	1.0%	1,426	32.9%	1.6%
FH	382	20.3%	1.2%	517	21.1%	1.8%	899	20.7%	1.5%
FQ	288	15.3%	2.3%	106	4.3%	1.2%	394	9.1%	1.8%
HV	904	48.0%	1.6%	372	15.2%	0.9%	1,276	29.4%	1.3%
LO	552	29.3%	1.3%	276	11.3%	1.1%	828	19.1%	1.2%
NB	1,017	54.0%	1.8%	649	26.5%	1.3%	1,665	38.4%	1.5%
PS	68	3.6%	0.5%	27	1.1%	0.4%	95	2.2%	0.5%
SD	0	0.0%	0.0%	76	3.1%	2.9%	76	1.8%	2.1%
SI	380	20.1%	1.5%	647	26.4%	5.1%	1,026	23.7%	2.7%
WR	351	18.6%	1.2%	347	14.2%	1.5%	698	16.1%	1.4%
Total[3]	6,909			4,072			10,982		
Average[4]	576	30.6%	1.5%	339	13.9%	1.6%	915	21.1%	1.6%
Miner Populations[5]	1,884			2,450			4,334		

[1] Rounding process may prevent "Both" from equalling sum of "Coal" and "MNM."
[2] Column (1) - number of female miners potentially exposed; column (2) - % of female miner population potentially exposed; column (3) - female % of total number of miners potentially exposed to the indicated MO condition.
[3] The sum of MO potential exposures to all twelve conditions.
[4] The average number of miners or average percentage of miner population, over all twelve conditions.
[5] Miner populations did not include office workers.

Potential exposure duration
   Table 3 presents the projected number of miners and percent of the miner population potentially exposed to each of the twelve MO conditions by type of mining and potential exposure duration.
   Most MO potential exposures were of part-time duration (30 minutes to four hours/day). Full-time MO potential exposures (more than four hours/day) accounted for 19.6% of the total number of exposures

(424,821) in coal mining. In MNM mining 10.0% of the total potential exposures (285,588) were full-time. The higher percentage of full-time MO potential exposures in coal mining was primarily due to the greater number of full-time potential exposures to diminished light (36.5% of miners in coal mining). The three most common full-time MO potential exposures were diminished light, sitting, and neck and/or back for both types of mining. However, the magnitudes were significantly different. The percentages of miners potentially exposed to diminished light and neck and/or back conditions for more than four hours per day were 36.5% and 6.3% in coal mining as compared to 5.3% and 2.2% in MNM mining.

The three most common part-time MO potential exposures in coal mining were arm and shoulder, heavy lifting and neck and/or back. These were also the three most common MO potential exposures in MNM mining that the neck and/or back was the most common followed by arm and shoulder, and heavy lifting.

The percentages of miner population potentially exposed to the part-time MO condition of neck and/or back for both types of mining were about the same (35.9% in coal mining vs. 34.8% in MNM mining). The percentages for the other two most common part-time MO conditions, "arm and shoulder" and heavy lifting, appeared to be higher in coal mining (42.2% and 40.4%) than those in MNM mining (27.7% and 28.3%). Another noticeable difference between these two types of mining was the percent of miner population potentially exposed to the part-time lower limb condition (27.6% in coal mining vs. 17.3% in MNM mining). The projected number of miners potentially exposed to the remaining part-time MO conditions in coal mining were larger than those in MNM mining except for the standing condition. The differences between those remaining percentages ranged from 2.0 to 7.8 percentage points. The magnitude of part-time exposure to diminished light condition was 15.1% of all coal miners. This was less than one-half of the full-time exposure (36.5% of all coal miners).

Table 3.   Projected number of workers potentially exposed to each musculoskeletal overload condition and the corresponding percentage of miner population by type of mining and exposure duration.

Musculoskeletal Overload Conditions	Coal				Metal/Nonmetal			
	Full-Time		Part-Time		Full-Time		Part-Time	
AK	564	0.4%	28,822	21.3%	722	0.5%	26,513	19.2%
AS	1,811	1.3%	57,105	42.2%	2,010	1.5%	38,273	27.7%
DL	49,386	36.5%	20,456	15.1%	7,337	5.3%	12,006	8.7%
FH	3,816	2.8%	28,090	20.7%	2,955	2.1%	25,879	18.7%
FQ	556	0.4%	12,236	9.0%	786	0.6%	8,383	6.1%
HV	347	0.3%	54,740	40.4%	1,434	1.0%	39,121	28.3%
LO	4,180	3.1%	37,365	27.6%	726	0.5%	23,961	17.3%
NB	8,490	6.3%	48,559	35.9%	3,046	2.2%	48,106	34.8%
PS	898	0.7%	12,233	9.0%	9	0.0%	6,059	4.4%
SD	1	0.0%	957	0.7%	650	0.5%	1,998	1.4%
SI	9,371	6.9%	16,310	12.0%	6,877	5.0%	5,859	4.2%
WR	3,678	2.7%	24,851	18.4%	1,884	1.4%	20,994	15.2%
Total[1]	83,098		341,724		28,436		257,152	

[1]   Total MO potential exposures, i.e., the sum of all twelve conditions.

DISCUSSION

Musculoskeletal injuries experienced by miners have been previously described in the literature, including those reports referenced in the Introduction. Stobbe et al. (1986) reported that the numbers of strain and sprain injuries in 1983 and 1984 were 2,475 and 2,776 for coal mining and 306 and 282 for MNM mining. These injuries in 1983 and 1984 accounted for 24.0% and 25.2% of all injuries for coal mining, and 19.4% and 20.4% of all injuries for MNM mining. These data showed that coal mining musculoskeletal injuries were more frequent than MNM mining musculoskeletal injuries. This is consistent with the pattern identified in the NOHSM survey, i.e., the magnitude of MO potential exposures for coal

mining was larger than that for MNM mining. The same source indicates that back injuries are the most common form of strain and sprain injury in both coal and MNM mining. Four MO conditions (awkward lifting, frequent lifting, heavy lifting, and neck and/or back) recorded in the NOHSM survey may contribute to back injuries. The number of potential exposures for these four MO conditions was 154,314 which accounted for about 44% of total number of MO potential exposures excluding diminished light for coal mining. The potential exposures to the same four MO conditions were 128,110 for MNM mining and accounted for about 48% of the total number of MO potential exposures excluding the diminished light condition. Thus, the four types of MO potential exposures related to back injury dominated both types of mining. This pattern in the NOHSM data is similar to the observation in Stobbe's study.

Three MO conditions (wrist, fingers and hand, and arm and shoulder) recorded in the NOHSM survey may contribute to hand/arm and shoulder injuries. The magnitude of MO potential exposures for these three MO conditions was 119,350 which accounted for about 34% of total MO potential exposures excluding the diminished light for coal mining. The potential exposures to the same three MO conditions were 91,996 for MNM mining and accounted for about 35% of the total MO potential exposures excluding the diminished light condition. However, Stobbe et al. (1986) reported that hand/arm and shoulder injuries accounted for about 8% of coal musculoskeletal injuries and 11% of MNM musculoskeletal injuries. Once again, the NOHSM data are in general agreement with that reported by Stobbe since the hand/arm and shoulder involvement in both studies is of a lesser magnitude than that of back involvement. Furthermore, both studies show the relative magnitudes for coal and MNM to be similar.

MSHA (1986-1989) has reported that the numbers of strain and sprain injuries in coal mining in 1985, 1986, 1987, and 1988 were 3,599, 4,120, 6,564, and 6,568, respectively. In MNM mining, the numbers of strain and sprain injuries in 1985, 1986, 1987, and 1988 were 2,102, 2,233, 3,280, and 4,345, respectively. The number of musculoskeletal injuries increased from 1985 to 1989 in both types of mining. The number of coal mining musculoskeletal injuries each year was larger than that in MNM mining. This is consistent with the pattern identified in the NOHSM survey and Stobbe's study. Back injuries accounted for about 54% of strains and sprains for coal mining and about 57% for MNM mining based on the pooled MSHA data from 1985 to 1989. Knee and ankle injuries were the next most common in both types of mining, with 12% and 6% in coal mining and 12% and 10% in MNM mining, respectively. One MO condition, i.e., lower limb, recorded in the NOHSM survey may contribute to knee and ankle injuries. The MO potential exposures to this MO condition accounted for about 12% of total MO potential exposures excluding the diminished light for coal mining and 9% in MNM mining. Thus, the NOHSM potential exposure data do offer a similar view of lower limb involvement, as compared to that offered by the MSHA injury data.

A review of all upper extremities cumulative trauma disorder (UECTD) injuries by Hudock and Keran (1992) for 1985 through 1989 showed that MNM mines accounted for 80% of UECTD injuries, while coal mines accounted for 20%. However, the NOHSM data showed that MNM mines accounted for only 43% of the two MO conditions related with hand and arm, "arm and shoulder" and "finger and hand", while coal mines accounted for 57%. The NOHSM data therefore seem to differ from that reported by Hudock and Keran.

SUMMARY AND CONCLUSIONS

This paper reports the magnitude of MO potential exposures in mining observed in the NOHSM survey. These observations spanned twelve muscular overload conditions in two major sectors of the mining industry.

The average projected number of miners, over all twelve conditions, for coal mining was 35,402 and for MNM mining it was 23,799. The average percentages of miner population, over all twelve MO conditions, were 26.2% in coal mining compared to 17.2% in MNM mining. This difference in average projected number of miners or percentage of miner population between coal mining and MNM mining was statistically significant.

Female miners comprised 1.6% of the total mining workforce, and were involved in 1.5% of the musculoskeletal potential exposures. Females were not found to be at higher risk of musculoskeletal injury than males, whether analyzed within coal and MNM separately or for all of mining.

Most MO potential exposures were of part-time duration. Full-time MO potential exposures accounted for 19.6% of the total number of MO potential exposures in coal mining, while 10.0% of the MO potential exposures in MNM mining were full-time. The higher percentage in coal mining was due to the greater number of full-time potential exposures to diminished light.

The NOHSM survey provided a new approach to the description of MO potential exposures. The NOHSM data offer a unique body of information to musculoskeletal researchers, with ample opportunities for further analysis and comparison to other studies. Interested parties may obtain the data from NIOSH.

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ADVANCES IN INDUSTRIAL ERGONOMICS AND SAFETY VII

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