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Identification of Work-Related Musculoskeletal Disorders in Mining

Eric Weston,

Graduate student in the Department of Integrated Systems Engineering at Ohio State University

Mahiyar F. Nasarwanji, Ph.D, and

Industrial Engineering Associate Service Fellow in the Workplace Health Branch at NIOSH's Pittsburgh Mining Research Division in Pittsburgh, PA

Jonisha P. Pollard, M.S

Musculoskeletal disorders prevention team leader in the Workplace Health Branch at NIOSH's Pittsburgh Mining Research Division in Pittsburgh, PA

Mahiyar F. Nasarwanji: MNasarwanji@cdc.gov

Abstract

Work-related musculoskeletal disorder (WMSD) prevention measures have been studied in great depth throughout various industries. While the nature and causes of these disorders have been characterized in many industries, WMSDs occurring in the U.S. mining sector have not been characterized for several years. In this report, MSHA accident/injury/illness data from 2009 to 2013 were characterized to determine the most frequently reported WMSDs in the U.S. mining sector. WMSDs were most frequently reported in workers with less than 5 years or more than 20 years of mining experience. The number of days lost from work was the highest for shoulder and knee injuries and was found to increase with worker age. Underground and surface coal, surface stone and stone processing plants experienced the greatest number of WMSDs over the period studied. WMSDs were most commonly caused by an employee suffering from an overexertion, falls or being struck by an object while performing materials handling, maintenance and repair tasks, getting on or off equipment or machines, and walking or running. The injury trends presented should be used to help determine the focus of future WMSD prevention research in mining.

Keywords

Musculoskeletal disorder; mining; occupational injury; overexertion; falls; materials handling

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Work-related musculoskeletal disorders (WMSDs) are a common type of occupational injuries and illnesses worldwide. In 2004, the U.S. healthcare system treated 16.3 million strains and sprains alone, with the estimated cost of all musculoskeletal injury treatments

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Correspondence to: Mahiyar F. Nasarwanji, MNasarwanji@cdc.gov.

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totaling $127.4 billion (U.S. Bone & Joint Initiative, 2014). Moreover, WMSDs involve longer recovery times as compared to other workplace injuries or illnesses, resulting in millions of lost workdays each year which can also have significant financial costs and impact workers' quality of life (U.S. Bone & Joint Initiative, 2014). In labor-intensive industries such as mining, workers are exposed to significant WMSD risk factors. In 1991, the U.S. Department of Labor (2001) classified mining as one of the most hazardous occupations in terms of ergonomic exposures. More recently, in 2013, Bureau of Labor Statistics (BLS, 2013) reported incidence rates for WMSDs in all mining sectors to be 42.5 per 10,000 full time employees. Common tasks contributing to mining-specific WMSDs across the globe have included handling heavy and awkward objects, jolting/jarring, forceful exertions, working in confined spaces or non-neutral posture, or repetitive operation of machinery (Dempsey & Hashemi, 1999; Wiehagen & Turin, 2004; Xu, Pang, Liu, et al., 2012).

Recent research has examined the types of WMSD injuries sustained and associated risk factors for specific commodities or job types within the U.S. mining sector (Heberger, 2013; Moore, Bauer & Steiner, 2008). Heberger (2013) examined common maintenance and repair activities and compared the ergonomic risk factors present during these tasks to the musculoskeletal injuries sustained by maintenance workers as reported to MSHA. Heberger (2013) noted several positive associations between tasks and specific injuries. Moore, et al. (2008) examined WMSDs in underground coal mining between 1983 and 1984, and 2003 and 2004 to determine the impact of technological advances on the prevalence of cumulative injuries. The authors noted a decrease in the number of WMSDs but also cited a significant decrease in the number of workers employed in underground coal mining. The authors found minimal decrease in the percentage of WMSDs with WMSDs consistently accounting for more than 30% of all injuries reported to MSHA.

While mining-specific WMSD prevention research is ongoing, no recent literature sources provide insight into the types of WMSDs currently plaguing the industry as a whole. To identify mining-specific WMSDs, this analysis uses MSHA accident/ injury/illness data for the 5-year span from 2009 to 2013. Methods were adapted from WMSD classification techniques developed by the Battelle Centers for Public Health Research and Evaluation (Seattle, WA) in 1999, a NIOSH work authorization that originally aimed to examine potential sources of error in the MSHA Form 7000-1 reporting system (Battelle, 1999). The current work describes a method that can be used to quickly identify WMSDs within MSHA accident/injury/illness reports to allow individual organizations to identify WMSDs in their own mines; it also aims to characterize the most recent WMSDs occurring in mining to provide areas in need of future mining-specific WMSD prevention efforts.

Methods

Data Acquisition

Data on mining accidents, injuries, fatalities, employment, production, etc., are collected by MSHA under Part 50 of the U.S. Code of Federal Regulations. Original raw data files are released periodically to the public on the MSHA website. As a convenience, NIOSH has converted MSHA data to SPSS (Statistical Package for Social Sciences; IBM SPSS

Statistics for Windows, 2010, Version 19.0, IBM Corp., Armonk, NY) file formats that include labeled and coded data. Accident/injury/ illness data reported to MSHA using Form 7000-1 were obtained from NIOSH for the most recent 5-year period available, 2009 through 2013. These data were imported into statistical analysis software for further analysis (IMB SPSS Statistics for Windows, 2010, Version 19.0, IBM Corp., Armonk, NY). This injury data and guidance associated with its usage, including the explanations of all coded fields, is available at www.cdc.gov/niosh/mining/data/default.html.

WMSD Selection

The data selection method including exclusion criteria is shown in Figure 1. Consistent with Battelle (1999), office employees (subunit[1] = 99) were excluded. To better characterize WMSDs, "degrees of injury/illness" (deginj) were filtered such that reportable no-injury accidents (deginj = 0), fatalities (deginj = 1), fatal and nonfatal injuries due to natural causes to employees on company business (deginj = 8), fatal and nonfatal cases involving nonemployees on or off mine property (deginj = 9), and cases characterized as "all other cases" (deginj = 10) were excluded. The final dataset included nonfatal cases involving days lost from work, nonfatal cases involving no days lost from work and occupational illness cases.

Consistent with Battelle (1999), the data were then filtered based on the nature of injury/ illness (natinj) classifications that have been shown to be the best identifiers for WMSDs. Cases classified as a hernia/rupture (natinj = 260); joint, tendon, or muscle inflammation or irritation (natinj = 270); sprain/strain (natinj = 330); multiple injuries (natinj = 370); occupational injuries, not elsewhere classified (natinj = 380); other injury, not elsewhere classified (natinj = 390); and unclassified, not determined (natinj = 400) were included. All other natures of injury/illness were excluded (Battelle, 1999; NIOSH, 2013).

Those cases with hernia/rupture, joint, tendon, or muscle inflammation or irritation and sprain/strain were assumed to represent an injury/illness report in which WMSD was present. For the remaining four nature of injury/illness codes, it was necessary to code the narrative field descriptions to determine: 1) whether there was any indication that a WMSD could have occurred; and 2) the cause of the WMSD described. Cases involving parts of the body above the neck (partbody < 200) and caught-in-under-between accidents (atype = 20–24) were excluded after preliminary narrative classification of a smaller random sample of 550 narratives determined that those incidents never led to WMSDs. All other narratives were coded manually, as preliminary analysis indicated that searching for particular keywords in the narratives (e.g., "sprain," strain,"numb," "pain") using a semi-automated process was unsuccessful at identifying WMSD cases.

To ensure an inclusive analysis, potential WMSDs were coded using definitions provided from the Department of Labor and Industries (1994) and the Battelle Centers for Public Health Research and Evaluation (1999). Consistent with Battelle (1999), the presence of a WMSD was characterized using a nominal scale: MSD = 1 if a WMSD was clearly present in the narrative field description; MSD = 2 if a WMSD might be present based on the information presented in the narrative field; and MSD = 3 if a WMSD was clearly not present.

Each case classified as MSD = 1 or MSD= 2 was then assigned an injury cause. The injury cause characterization scheme was selected to separate acute exposures from overexertion events. Five injury causes were defined as: 1) acute exposures; 2) overexertion; 3) repetitive motion or prolonged static posture; 4) injury/illness from a prior incident; and 5) no clear indication of injury cause. Once narratives were coded, cases classified as MSD = 1 and MSD = 2 were combined with those already identified as WMSDs (hernia/rupture, joint, tendon, or muscle inflammation or irritation and sprain/strain).

Data Analysis

Cross-tabulations were chosen as the best way to represent the dataset. Variables present in the accident/injury/illness data associated with the selected data including nature of injury (natinj), accident/injury/illness classification (aii), accident type (atype), mine worker activity at the time of injury (mwactiv), part of the body affected (partbody), mine worker age (age), mine worker experience in years (exptot), and total number of days lost or days of restricted activity (dayslost+daysrest) were the chosen descriptor variables for the WMSDs cases. Source of injury (sourcinj) was excluded from the analysis because it varies by commodity and would not allow for generalization across mining sectors. Additionally, the methodology used to code these injury sources has been previously shown to inaccurately and inconsistently identify the source of injury (Battelle, 1999).

Results

WMSD Selection

Overall, 15,978 (31%) of the 51,857 total reports were identified as WMSDs. Of these cases, 14,889 (93%) were identified as WMSDs without using the narrative field description (Figure 1). The classifications from the narrative field analysis are presented in Table 1. As shown, the most common causes of injury were acute exposure events and overexertions. WMSDs from a repetitive motion or prolonged static posture or a prior injury/illness incident made up a small portion of the narrative cases examined.

WMSD Classification

Preliminary examination of the data by year indicated that the number of accidents, types of accidents, natures of injury, mine worker activities, and accident/injury/illness classifications did not vary significantly from year to year during the 5-year period of interest. As a result, the analysis was performed grouping all years together. Strains and sprains made up the majority of the final dataset (86%) and a significant portion (26%) of the total 51,857 filed reports. Handling material, slips or falls from all levels, and powered haulage and machinery were found to be the most frequently reported WMSD accident/injury/illness classification types (Figure 2, p. 277). In addition, the accident type overexertion, which is a combination of overexertions in pushing/pulling, lifting, or other activity (not elsewhere classified), was associated with 62% of the final dataset (Figure 2, p. 277). A significant number of struck against accidents were also found to contribute to WMSDs.

Table 2 (p. 278) shows the most common mine worker activities and the associated accident/ injury/illness classifications and body parts affected for WMSDs. Handling supplies or materials caused a significant proportion of all overexertion injuries and about one-fourth of all WMSDs reported. Walking/running, getting on and off of machines and equipment, using nonpowered hand tools, and machine maintenance and repair tasks were also hazardous activities. Handling supplies and using nonpowered hand tools were almost exclusively associated with overexertion accidents. Getting on and off equipment and machine maintenance and repair activities were commonly associated with overexertions and falls, and walking/running led to a more dynamic range of WMSD accident types. The back was by far the most affected body part, but the shoulder(s) and knee(s) were also largely affected.

Age & Job Tenure

WMSDs reported by age and total mining work experience are shown in Figure 3 (p. 279). Figure 3A shows the percentage of WMSD cases by age group. The number of WMSDs reported were similar within the 18 to 29, 30 to 39, 40 to 49, and 50 to 59 year age groups with most injuries being incurred by workers between 30 and 59 years of age. Figure 3-B shows the percentage of injuries by total mining experience. Most injuries were incurred by employees with less than 5 years of mining experience. A large proportion of WMSDs were also reported in workers with more than 20 years of total mining experience.

Days Lost

The median number of days lost (sum of days lost from work and number of days with restricted work activity) was 21 for all reported WMSD cases. Figure 4 (p. 279) shows the median days lost by age group, total mining experience, body part affected, and accident type. As shown in Figure 4A and Figure 4B, the number of days lost as a result of injury increased with age and total mining experience. Older workers, and those with more mining experience, showed more days lost from work as compared to their younger, or less experienced, counterparts. Shoulder and knee injuries were associated with the highest median days lost from work as shown in Figure 4C. The median number of days lost from work due to a shoulder injury was nearly double the days lost for a knee injury and more than 4 times the days lost for a back injury. Days lost did not vary by mine worker activity, but falls resulted in the highest median number of days lost at 29 days (Figure 4D). A similar numbers of days lost were found for overexertion, struck, and bodily reaction injuries, as shown in Figure 4D.

Commodity & Location

Table 3 (p. 280) shows the combinations of commodities and locations where most WMSDs occurred over the 5-year period examined. Based on commodity, coal made up a significant portion of the WMSDs reported. Stone made up the next highest proportion of all WMSDs, followed then by metal, nonmetal and, finally, sand and gravel. A large proportion of all WMSDs occurred in underground operations, followed closely by surface mining and then minerals processing mills and preparation plants. The combined commodity and location cross-tabulation revealed that in surface mining, the majority of WMSDs resulted from stone operations and surface coal operations. However, underground coal WMSDs far outweighed surface coal WMSDs.

Distributions of most common accident/injury/illness classification, mine worker activity at the time of injury, and accident type are presented in Figures 5 through 8 for the operations associated with the most WMSDs; underground and surface coal mines and stone surface mines and mill and preparation plants. Similar types of WMSD contributors were identified for these operations with handling materials and slip or falls being the most significant contributors. Some unique contributors were also identified. In underground coal operations, handling the power cable contributed to overexertion injuries (Figure 5, p. 280). In stone processing mills, non-powered hand tools contributed to overexertion injuries in many cases (Figure 6, p. 281). Operating front-end loaders and haulage trucks contributed to struck-against injuries in surface stone operations (Figure 7, p. 281). Similarly, operating bulldozers and haulage trucks contributed to struck-against injuries in surface coal operations (Figure 8, p. 282).

Discussion

Work-related musculoskeletal disorders reported to MSHA between 2009 and 2013 were categorized to determine areas of focus for future WMSD prevention research. Injury data was categorized through coded incident records prepared by NIOSH as well as through the examination of narrative fields. The current narrative classification process proved to be much more selective than that used in Battelle (1999). Battelle (1999) only excluded 24% of cases based on the details in the narratives, the current work excluded 52.5% of all read narrative cases (Battelle, 1999). The observed selectivity may be attributed to Battelle (1999) reading the narrative field descriptions for all nature of injury codes before recommending that the nature of injury codes most commonly associated with WMSDs (hernia/rupture, joint/tendon/muscle inflammation or irritation, and sprain/strain) could be assumed to represent WMSDs. In this study, the authors followed Battelle's recommendations and simply assumed a WMSD was present in all cases where the nature of injury was hernia/rupture, joint/tendon/muscle inflammation or irritation, and sprain/strain. This is where the methods of this study differed from those used by Battelle (1999).

WMSD Classification

In 1986, Stobbe, Bobick & Plummer (1986) reported that sprains and strains accounted for 25.2% of all reported mining injuries. This trend was shown to remain with the current injury dataset having 26.4% of the total reported cases classified as sprains and strains. This does not include the 1,089 WMSD cases identified after reading and coding the narratives, showing that strains and sprains remain a large contributing factor of mining-related injuries and illnesses today. This research also determined that 31% of the injuries reported to MSHA are WMSDs, indicating that WMSDs have not decreased significantly since 2003–04 or even 1983–84 when WMSDs accounted for 33% and 37% of the injuries reported to MSHA, respectively (Moore, et al., 2008). The percentage of WMSDs reported to MSHA has not changed over the last three decades.

It is important to note that the injury types traditionally hought to be associated with acute exposures or trauma rather than WMSDs (particularly fall and struck against accidents) were found to be contributors to WMSDs in the mining industry. Operating mobile equipment, for example, is not typically thought to result in a WMSD. However, our analysis determined that many of the WMSDs in surface stone and surface coal were associated with operating mobile equipment such as haulage trucks, bulldozers, and front-end loaders. Previous research has determined that many of these "struck against" accidents are due to the operator striking something inside the cab due to jarring and jolting (Wiehagen et al., 2001). Acute events, such as these, may have served as the "breaking point" for WMSD causation in conjunction with other exposures such as repetitive motion, prolonged static postures, frequent jarring and jolting, or heavy loads. This highlights a potential shortcoming of the current method of injury reporting. Critical details necessary to classify injuries are often excluded from narrative descriptions of the incident. This was apparent while classifying the narratives within this study, as the cause of injury was only denoted as repetitive or posture in 2% of all narratives classified, respectively. In contrast, the injury source was denoted as an acute exposure event in 22% of all narratives classified.

In terms of mine worker activity, handling supplies and materials proved to be the most common activity leading to WMSDs, accounting for just under one-fourth of the total WMSDs reported. Handling supplies or materials was also one of the most common activities contributing to both back and shoulder injury, as this activity might often require heavy lifting or awkward postures. These results are consistent with Dempsey and Hashemi (1999), who stated that handling represented the single largest source of workers' compensation costs and claims in all industries and that lower back and upper extremity injuries were associated with about 70% of these claims. Handling materials should continue to be a major research area for WMSD prevention in all types of mining.

Getting on and off of machines and equipment, and machine maintenance and repair tasks were also among the most hazardous activities reported. Getting on and off of machines and equipment often led to falls injuring the knee(s) or ankle(s), likely as a result of poor access systems or hazardous surface conditions. These results are consistent with Moore, et al. (2009), who reported that ingress/egress off of mobile machinery is a major contributing activity to falls in the mining industry. However, incidents involving getting on and off machinery and equipment also led to a significant proportion of overexertion injuries; it is likely that stepping onto debris/rocks or jumping down from the machinery led to injury upon ground or surface impact. It is also possible that an overexertion injury was sustained while trying to recover from a slip or trip event to prevent a fall. These types of injuries may be prevented by ensuring that mobile equipment ingress/egress systems are properly designed and maintained.

Mining maintenance and repair tasks have also been shown to involve nonroutine activities and hazards including poor lighting conditions and wet or cluttered walking surfaces that might not be seen in routine mining work (Heberger, et al., 2012). The most common accident type associated with maintenance and repair work was overexertion of the back or shoulder(s). Maintenance and repair tasks often involve work with awkward postures, work in confined spaces, heavy lifting, or prying and pushing material (Pollard, Heberger & Dempsey, 2014). A recent analysis of maintenance and repair injuries in U.S. mining recommended mitigating these risk factors through the redesign of machine guarding to be modular and lightweight, utilization of mechanical assists devices, hand protection, methods to control spillage, walkway maintenance, wearing suitable footwear, using proper tools, and improved equipment access (Pollard, Heberger & Dempsey, 2014).

Age

After about the age of thirty, the chances of developing a WMSD remain fairly consistent regardless of age. The low number of WMSDs reported in workers over the age of sixty may be attributed to the low number of active workers in this age category or movement of these employees to a supervisory role. In terms of job tenure, workers with less than 5 years of total mining experience exhibited the highest proportion of WMSDs. This population of workers likely had less experience in the work environment. This may have made them more susceptible to WMSD development due to work practices or being assigned more physically demanding tasks that are often assigned workers with limited tenure. The number of WMSDs reported also decreased consistently with more than 5 years of total work experience up until about 20 years of experience. At that point, the risk for WMSD development increased likely due to the effects of aging and the cumulative years of exposure to physically demanding work.

The total number of days lost (the sum of days lost from work and days of restricted work activity) was higher for older, more experienced workers. Although more experienced workers (especially workers with total mining experience of 5 to 20 years) were less likely to develop a WMSD, our results suggest that workers who developed WMSDs took longer to recover from their injuries, or sustained more serious injuries, than their less experienced coworkers. This effect, however, is likely a result of the aging and the reduced recuperative powers that accompanies increased tenure (Fotta & Bockosh, 2000; National Research Council, 2004). This increase in recovery time with age is consistent with previous research which found that recovery periods for workers over 55 years of age was nearly twice as long as those of workers under 35 years of age (Merchant, et al., 2000).

Commodity & Location

The majority of WMSDs occurred in coal mining, with the majority of coal-related WMSDs occurring underground when handling materials or due to slipping and falling. These results are consistent with previous research that found that the magnitude of potential exposures to WMSDs for coal mining is much greater than for metal and nonmetal mining (Margolis, 2010; Zhuang & Groce, 1995). Also, previous research has consistently identified the hazards of materials handling and slips and falls in underground coal mining (Fotta & Mallett, 1997; Gallagher, 1989; Stewart, et al., 2007). Stone processing mills and surface stone operations also experienced a high prevalence of WMSDs. Thus, although the results presented represent an absolute number of cases observed and do not consider the relative size of each of the mining commodities, future WMSD prevention research would be beneficial in underground and surface coal, stone processing mills and surface stone operations.

Limitations

Although WMSD identification via the methodology used in this study has been previously shown to be accurate, it was never validated by reading injury narratives to determine its level of agreement with incident narratives reported to MSHA (Form 7000-1). This is a limitation of this methodology that mostly relies heavily on the information provided in the injury reports that are subject to errors in coding before the data are examined or refined (Battelle, 1999). MSHA injury data were obtained from NIOSH to improve coding efficiency by using variables with labels that are created by NIOSH. These data are available in the public domain.

Rater bias was another potential source of error in this study. Narrative coding was performed by only one researcher. However, cases requiring classification using the narrative field description only represented 2,746 (16%) of the 17,635 potential WMSD cases once being filtered by nature of injury. Additionally, to ensure both accuracy and repeatability, the definitions used to classify the narrative fields were refined iteratively using a simple random sample of the population before the entirety of the narrative cases were classified, and a detailed classification guide was created that included sample narratives to be used for future studies.

Finally, it is possible that the MSHA injury/illness data combined with the proposed methodology used in this study may slightly overestimate WMSDs in the industry. Battelle (1999) found that there is an apparent lack of consistency in training coders on how to interpret codes or information in the fields using the current MSHA reporting system. As a result, it has been recognized that the supervisors filing the incident reports may not be fully knowledgeable about what constitutes a WMSD or a sprain or a strain (Battelle, 1999). Battelle (1999) also noted, that upon classification of the narrative field descriptions for all nature of injury codes, about 12% of the cases denoted as a sprain/strain did not in fact provide evidence for a WMSD in the narrative field. Although not all sprain/strain nature of injury narratives were classified in the current study, the authors noted several cases in which this misclassification held true. Few narratives provided a detailed description of the intensity or duration of the task being performed before and at the time of injury, repetition or frequency of the task being performed, or an injury/illness diagnosis. Future efforts should continue to refine the MSHA incident reporting system to provide for accurate and consistent coding for injury identification. It is also important to continue working with mining companies and organizations to reinforce the importance of providing detailed injury narratives.

Conclusion

Although mining has seen an increase in the level of mechanization and an increase in the emphasis placed on safety and health by mining companies, there has not been a significant change in the relative percentage of WMSDs as compared to all other injuries reported to MSHA (Coleman & Kerkering, 2007; Moore, et al., 2008). Strains and sprains compromise a majority of the WMSDs reported. Handling material continues to be associated with the highest number of WMSDs and falls are associated with the greatest number of days lost from work. The root causes of these falls and materials handling injuries were not examined as part of this analysis and should be an area of consideration for future injury prevention efforts in mining. Prevention research should also be focused on underground and surface coal, surface stone, and stone processing mills. WMSDs place a significant burden on mining company finances, but more importantly have the potential to affect a mine workers' quality of life. In many cases, the contributing factors for musculoskeletal disorders are largely preventable through work-place design, usage of correct tools, proper housekeeping and equipment modifications. Efforts should be made to remediate these contributing factors.

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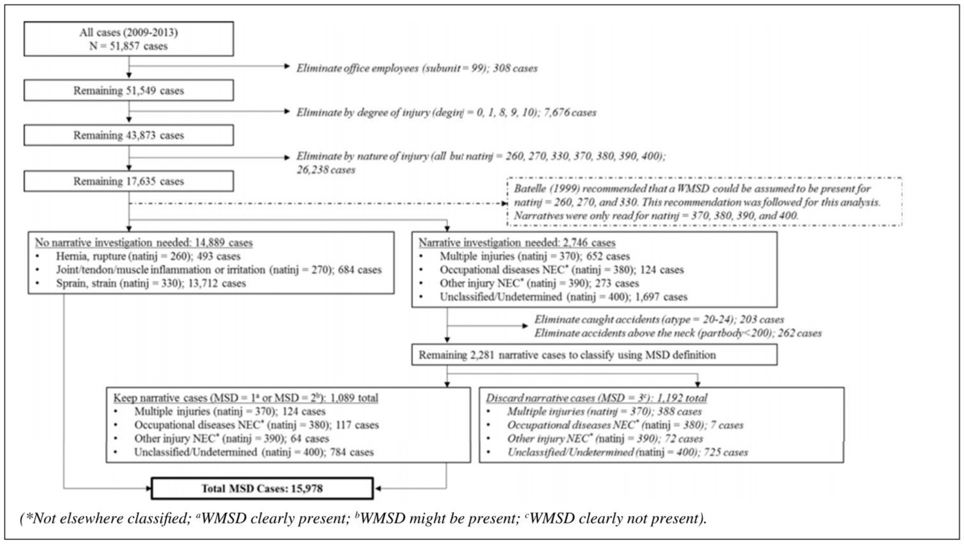

Figure 1.

Data selection technique used to separate WMSD cases from the entirety of the accident/injury/illness dataset.

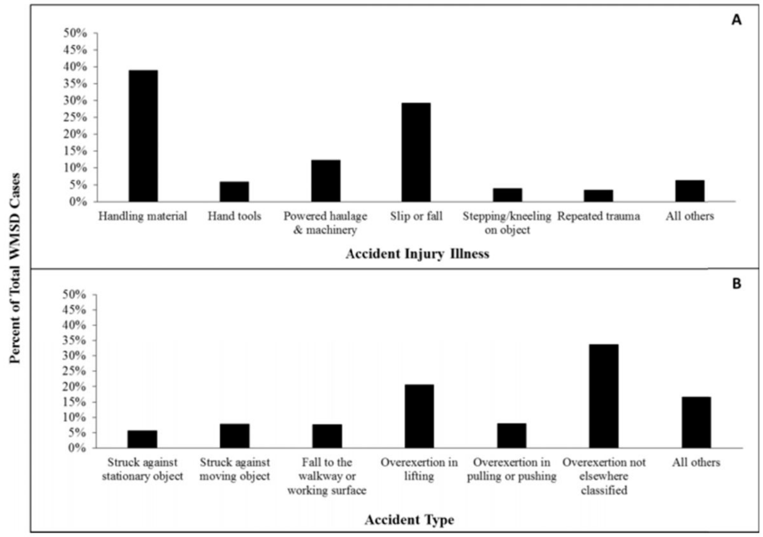

Figure 2.

Reported mining WMSDs by (A) accident/injury/illness classification and (B) accident type from 2009 to 2013.

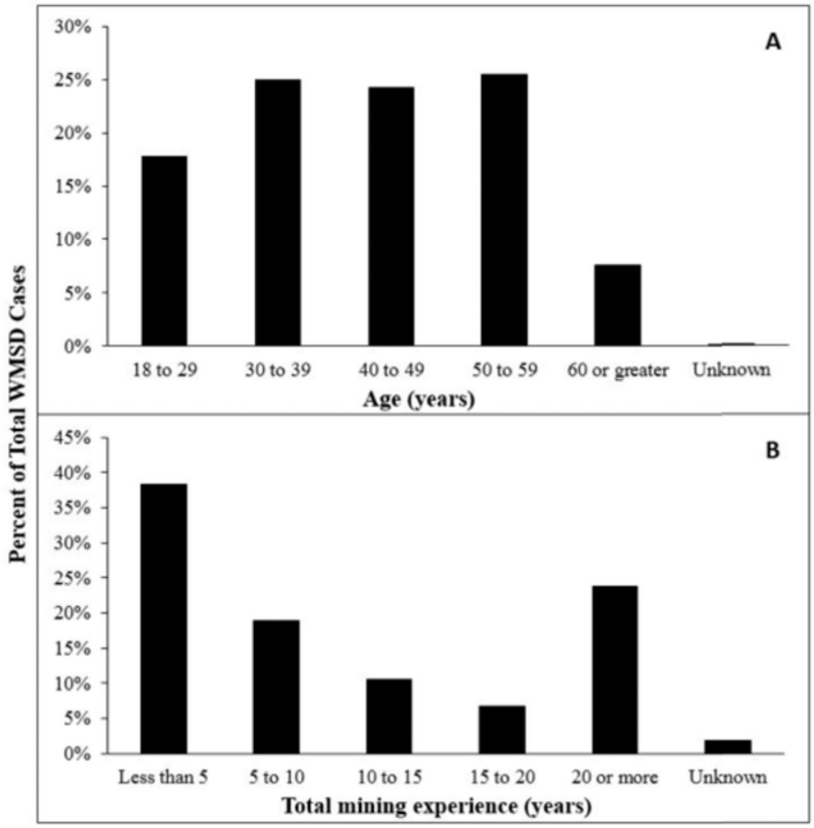

Figure 3.

Reported WMSDs by (A) mine worker age and (B) total mining experience from 2009 to 2013.

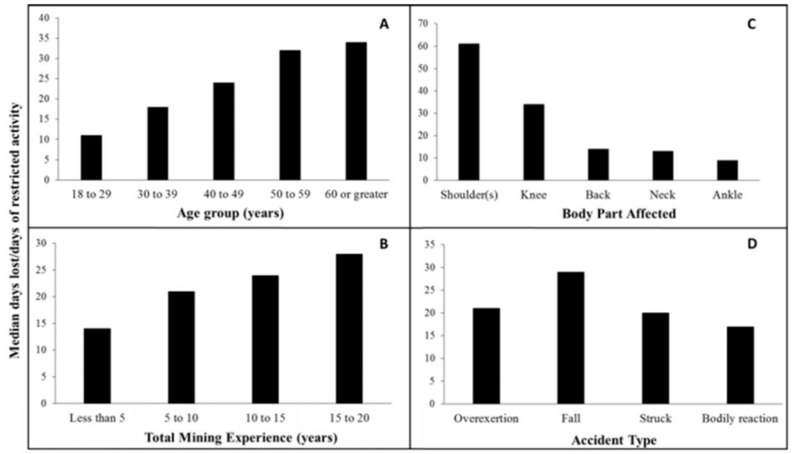

Figure 4.

Median number of days lost by (A) categorical mine worker age, (B) total mining experience, (C) body part affected and (D) accident type for WMSDs reported to MSHA (2009 to 2013).

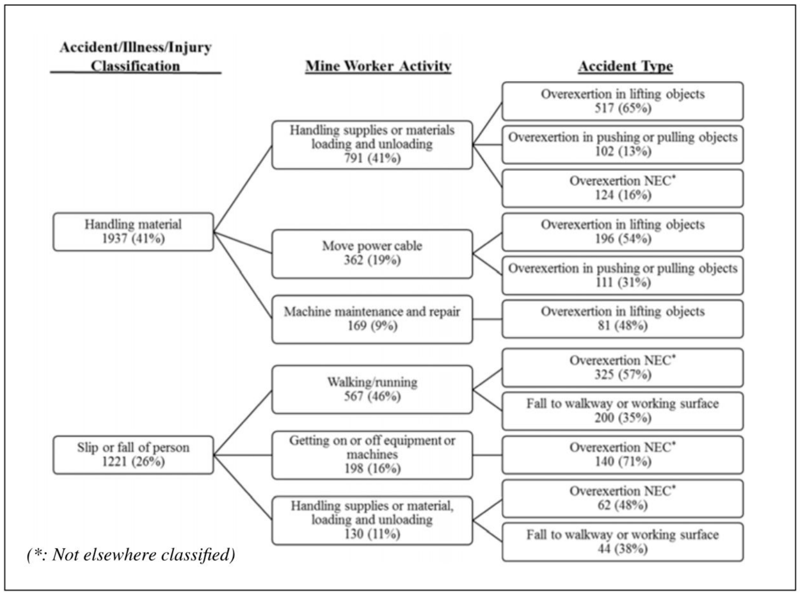

Figure 5.

Types of incidents contributing to 67% of the 4,722 WMSDs in underground coal mines between 2009 and 2013.

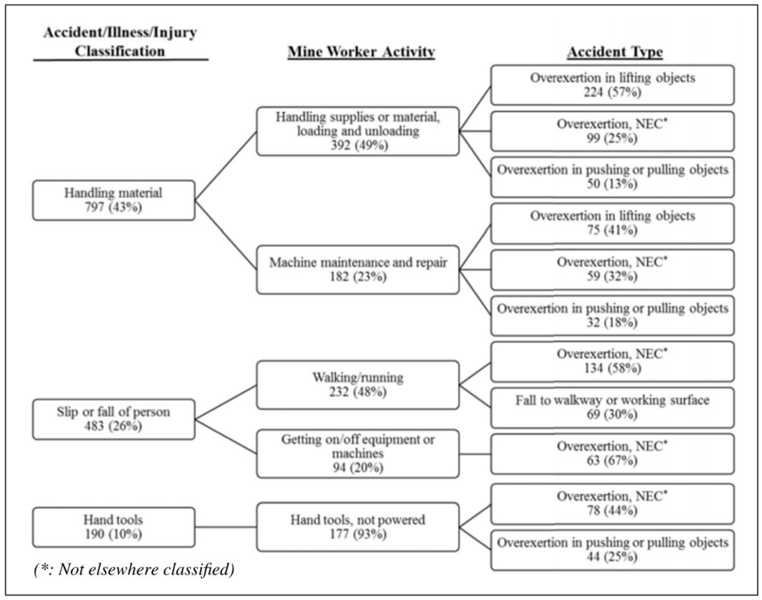

Figure 6.

Types of incidents contributing to 79% of the 1,871 WMSDs in stone processing mills between 2009 and 2013.

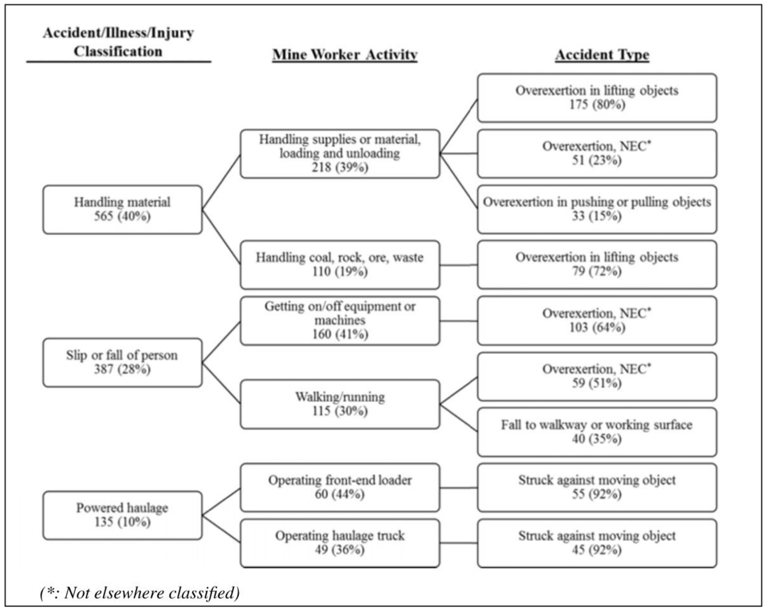

Figure 7.
Types of incidents contributing to 80% of the 1,397 WMSDs in surface stone mines between 2009 and 2013.

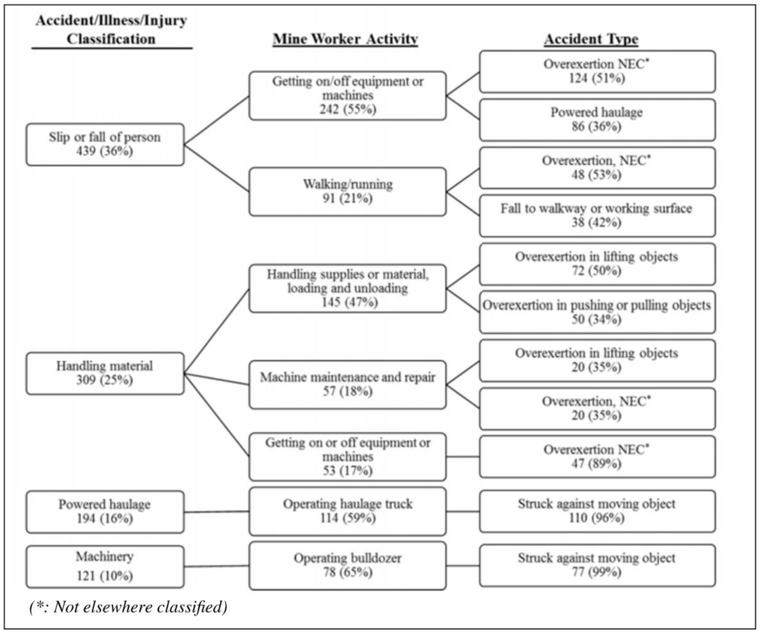

Figure 8.

Types of incidents contributing to 86% of the 1,233 WMSDs in surface coal mines between 2009 and 2013.

Table 1

Classification of narrative cases in terms of presence of WMSD and cause of injury.

		Injury Cause					Total
		Acute exposures	**Overexertion**	**Repetitive motion or prolonged static posture**	**Injury/illness from a prior incident**	**No clear indication of injury cause**	
WMSD Classification	WMSD clearly present	99	31	22	111	20	**283 (12%)**
	WMSD might be present	410	294	27	25	50	**806 (35%)**
	WMSD clearly not present	-	-	-	-	-	**1192 (53%)**
Total		**509 (22%)**	**325 (14%)**	**49 (2%)**	**136 (6%)**	**30 (1%)**	**2281**

Table 2

Most common mine worker activity and the resulting accident types and affected body parts for WMSDs.

Mine Worker Activity (count, % total WMSDs)	Accident Type (count, % Mine Worker Activity)	Affected Body Part (count, % Accident Type)
Handling supplies or material, loading and unloading – 3591, 23%	Overexertion – 3046, 85%	Back – 1419, 47%
		Shoulder(s) – 506, 17%
	Fall – 247, 7%	Back – 61, 25%
		Shoulder(s) – 59, 24%
		Knee(s) – 50, 20%
	Struck – 217, 6%	Knee(s) – 59, 27%
		Back – 23, 11%
		Ankle(s) – 23, 11%
		Neck – 21, 10%
Walking or running – 2477, 16%	Overexertion – 1082, 44%	Knee(s) – 517, 48%
		Ankle(s) – 275, 25%
		Back – 118, 11%
	Fall – 839, 34%	Knee(s) – 222, 27%
		Shoulder(s) – 180, 22%
		Back – 124, 15%
	Struck – 452, 18%	Ankle(s) – 149, 33%
		Knee(s) – 113, 25%
		Neck – 99, 22%
Getting on or off equipment and machines – 1755, 11%	Overexertion – 1077, 61%	Knee(s) – 392, 36%
		Ankle(s) – 208, 19%
		Back – 164, 15%
		Shoulder(s) – 129, 12%
	Fall – 480, 27%	Knee(s) – 126, 26%
		Back – 101, 21%
		Shoulder(s) – 62, 13%
	Struck – 167, 10%	Ankle(s) – 85, 51%
		Knee(s) – 47, 28%

Mine Worker Activity (count, % total WMSDs)	Accident Type (count, % Mine Worker Activity)	Affected Body Part (count, % Accident Type)
Machine Maintenance and Repair – 1601, 10%	Overexertion – 1119, 70%	Back – 416, 37%
		Shoulder(s) – 219, 20%
		Knee(s) – 120,11%
	Fall – 218, 14%	Shoulder(s) – 45, 21%
		Back – 44, 20%
		Knee(s) – 40, 18%
	Struck – 155, 10%	Knee(s) – 28, 18%
		Neck – 25, 16%
		Ankle(s) – 24, 15%
Hand tools, not powered – 921, 6%	Overexertion – 810, 88%	Back – 268, 33%
		Shoulder(s) – 249, 31%
	Struck – 53, 6%	Shoulder(s) – 11, 21%
		Knee(s) – 10, 19%
	Fall – 51, 6%	Back – 13, 25%
		Knee(s) – 12, 24%
		Shoulder(s) – 8, 16%

Table 3

Cross-tabulation examining WMSD cases for the 5-year period examined by commodity and location.

		Location				Total
		Underground operations	**Surface**	**Mill or preparation plant**	**All others**	
Commodity	Coal	4722	1233	456	377	**6788 (42.5%)**
	Metal	447	741	787	135	**2110 (13.2%)**
	Nonmetal	179	211	584	98	**1072 (6.7%)**
	Stone	125	1397	1871	64	**3457 (21.6%)**
	Sand & gravel	0	823	0	196	**1019 (6.4%)**
	Coal (contractor)	279	269	157	101	**806 (5.0%)**
	Non-coal (contractor)	64	353	248	61	**726 (4.5%)**
	Total	**5816 (36.4%)**	**5027 (31.5%)**	**4103 (25.7%)**	**1032 (6.4%)**	**15978**