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Identification of Work-Related Musculoskeletal Disorders in Mining

Eric Weston, Mahiyar F. Nasarwanji and Jonisha P. Pollard

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

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 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

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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,"

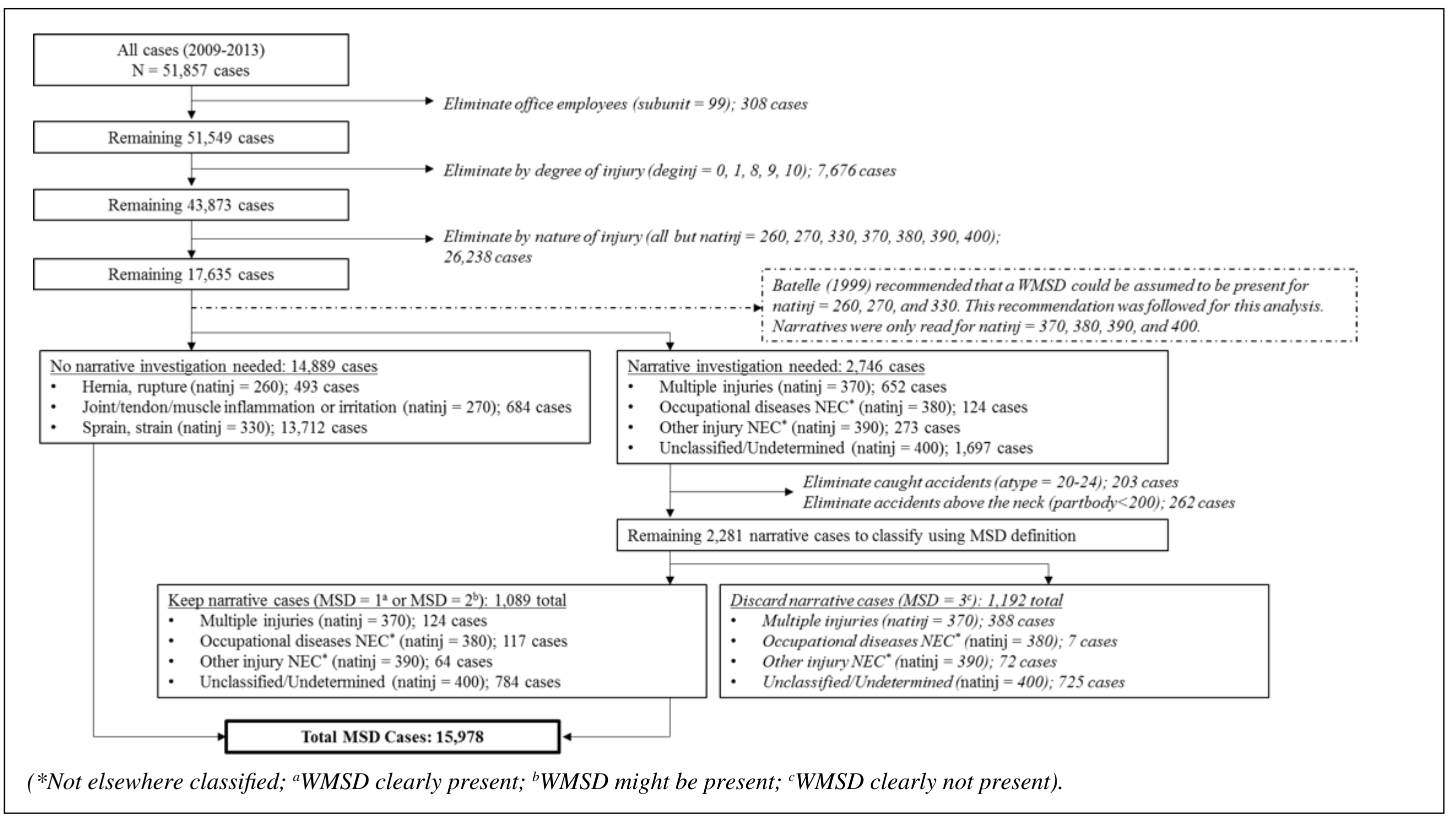

Figure 1. Data selection technique used to separate WMSD cases from the entirety of the accident/injury/illness dataset.

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.

		Injury Cause					
		Acute exposures	Overexertion	Repetitive motion or prolonged static posture	Injury/illness from a prior incident	No clear indication of injury cause	Total
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 1. Classification of narrative cases in terms of presence of WMSD and cause of injury.

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

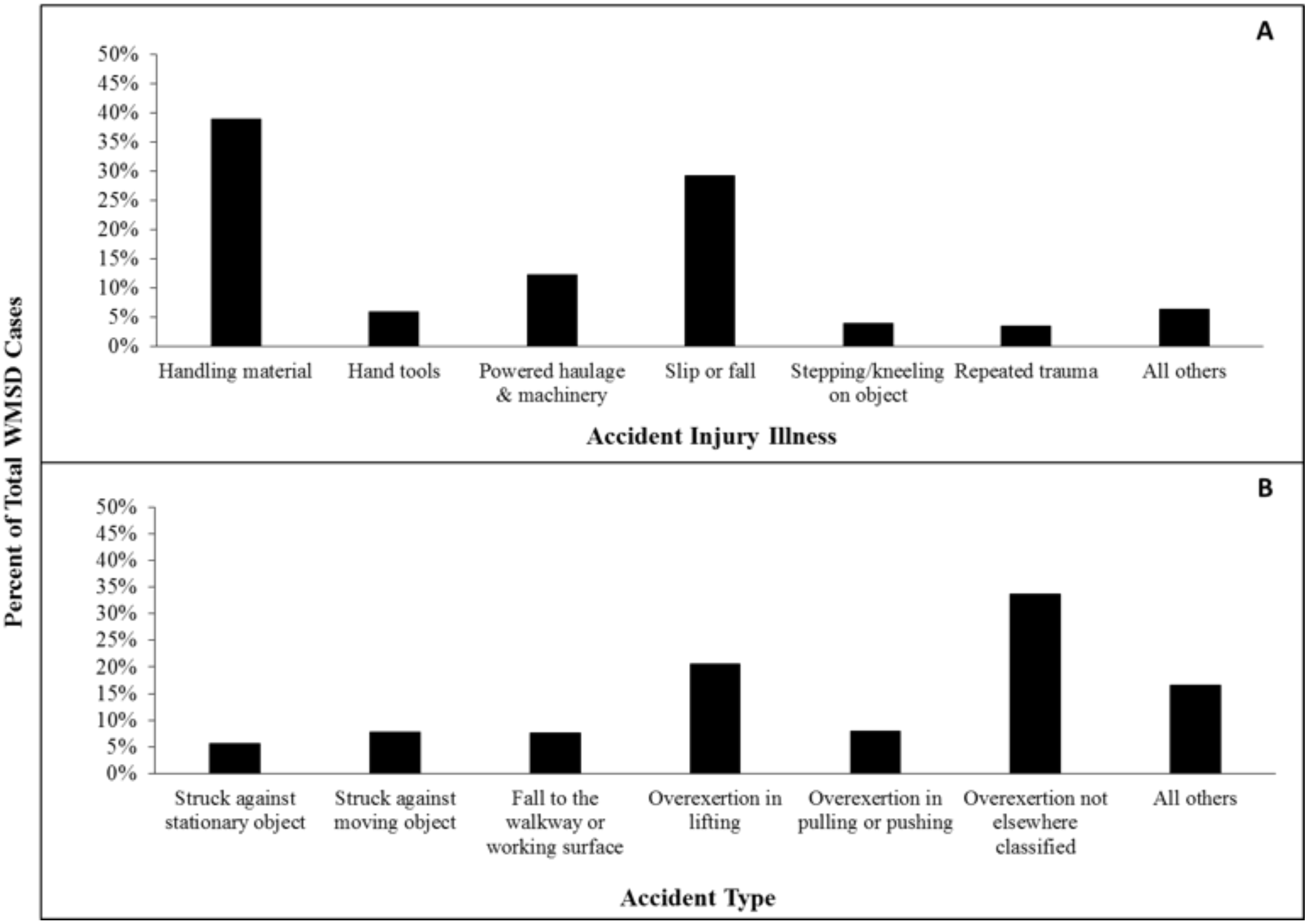

Figure 2. Reported mining WMSDs by (A) accident/injury/illness classification and (B) accident type from 2009 to 2013.

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

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

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 manual materials 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

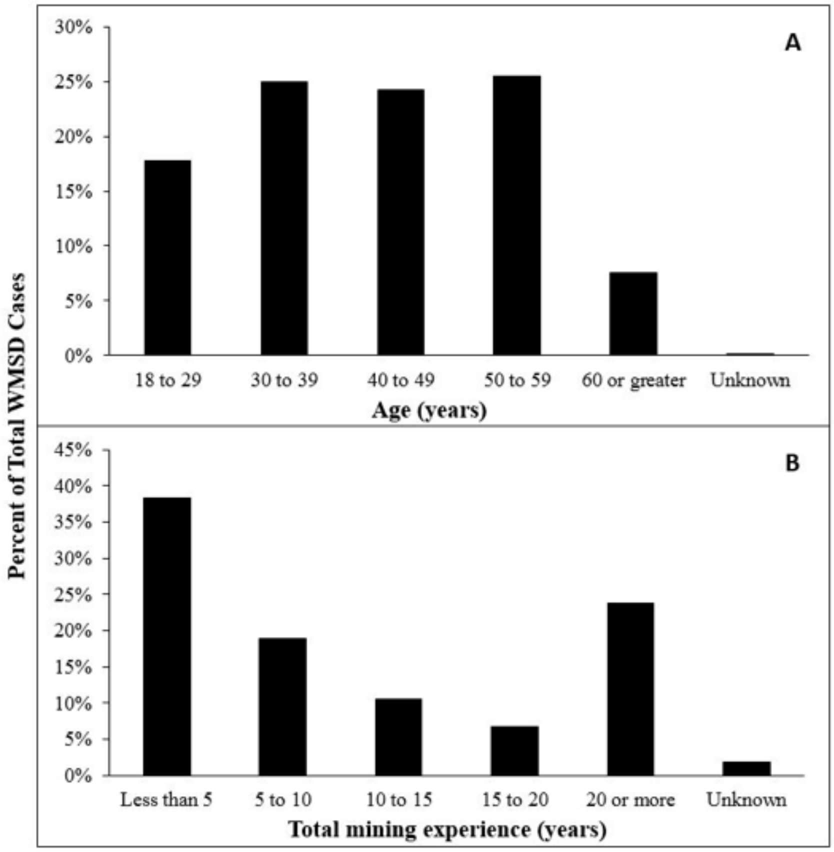

Figure 3. Reported WMSDs by (A) mine worker age and (B) total mining experience from 2009 to 2013.

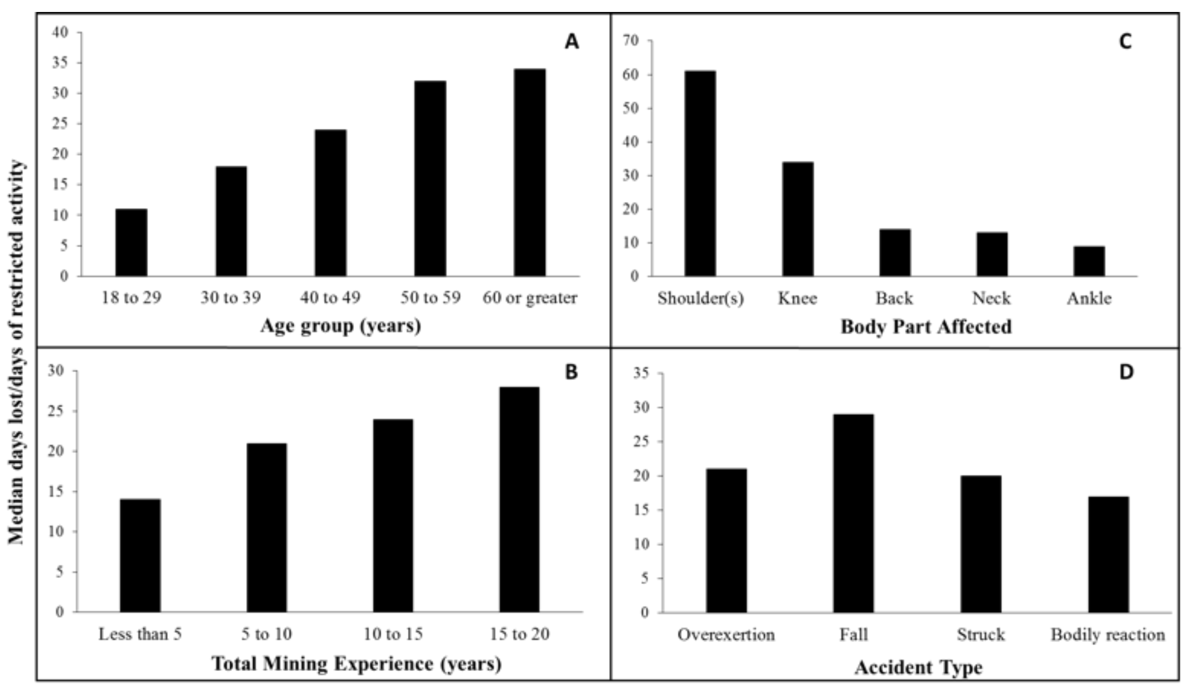

Figure 4. Median number of days lost by (A) categorical mine worker age, (B) total mining experience, (C) body part affected and (D) accident type for WMSDs reported to MSHA (2009 to 2013).

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.

		Location				
		Underground operations	Surface	Mill or preparation plant	All others	**Total**
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**

Table 3. Cross-tabulation examining WMSD cases for the 5-year period examined by commodity and location.

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

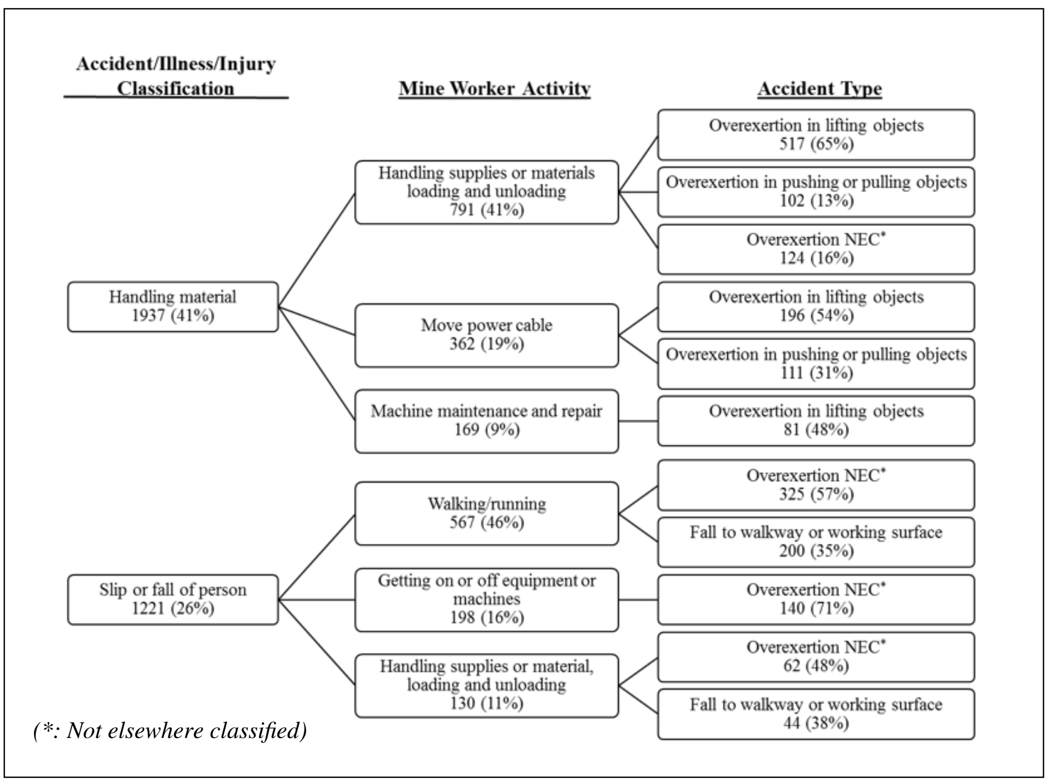

Figure 5. Types of incidents contributing to 67% of the 4,722 WMSDs in underground coal mines between 2009 and 2013.

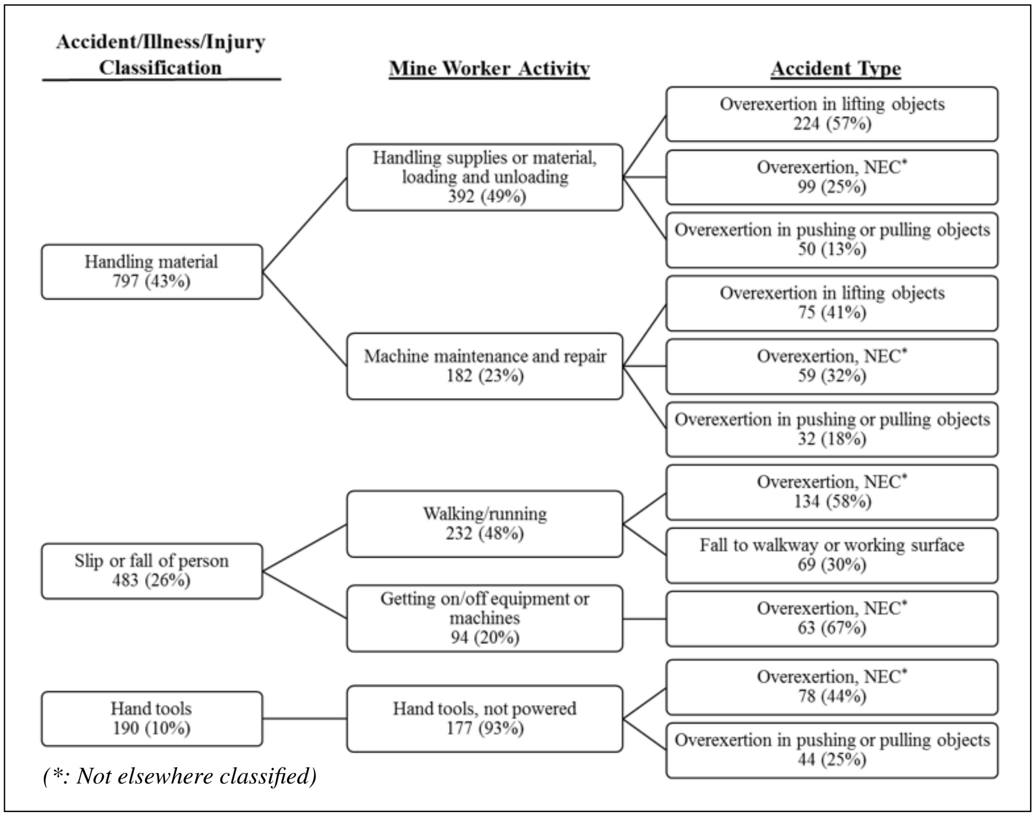

Figure 6. Types of incidents contributing to 79% of the 1,871 WMSDs in stone processing mills between 2009 and 2013.

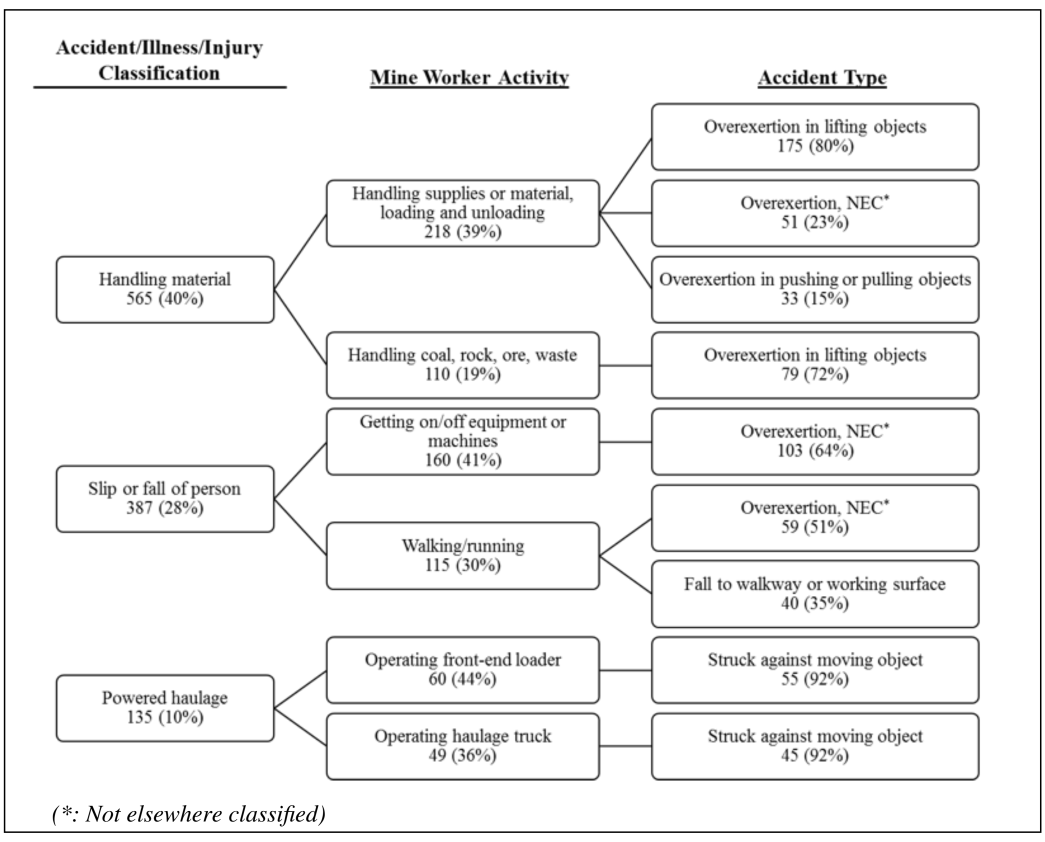

Figure 7. Types of incidents contributing to 80% of the 1,397 WMSDs in surface stone mines between 2009 and 2013.

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.

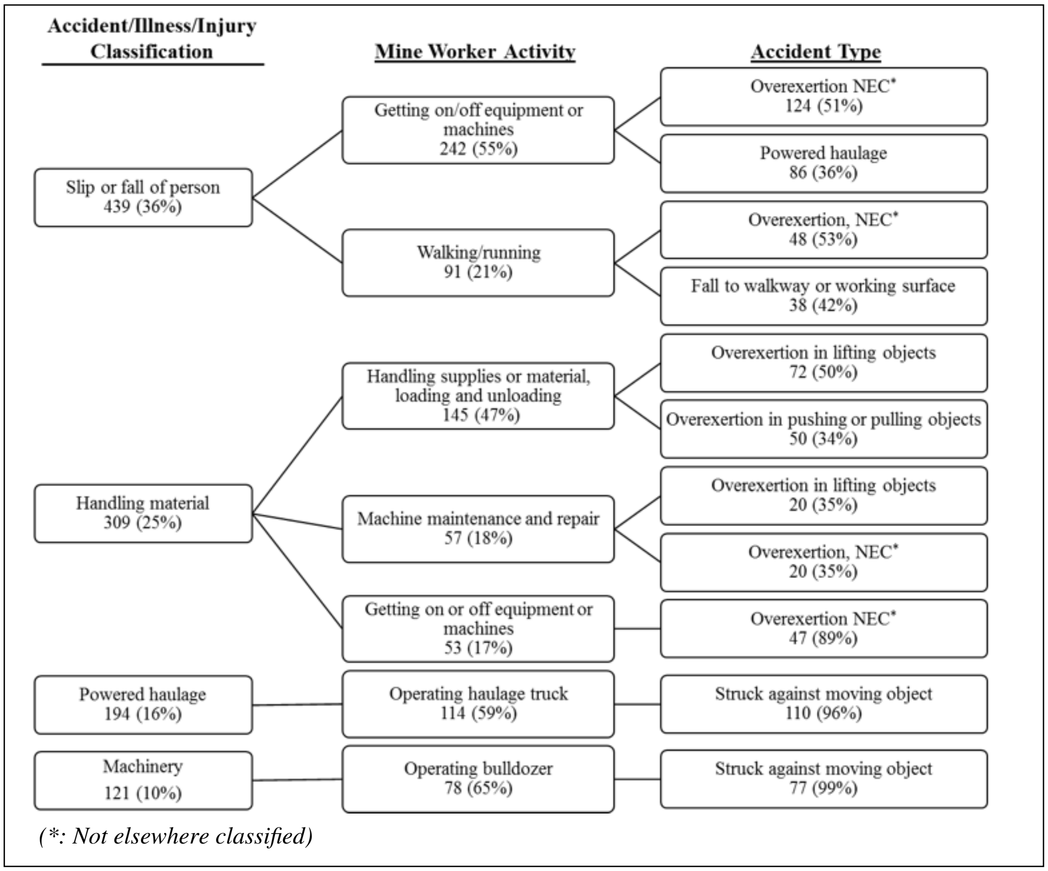

Figure 8. Types of incidents contributing to 86% of the 1,233 WMSDs in surface coal mines between 2009 and 2013.

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 workplace design, usage of correct tools, proper housekeeping and equipment modifications. Efforts should be made to remediate these contributing factors.

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OSHA's Enforcement of Forklift Standards & the Role of the General Duty Clause

Tracey L. Cekada and Christopher A. Janicak

Abstract

This study examined violations pertaining to powered industrial trucks cited by OSHA over the period of Jan. 1, 2011, to Dec. 31, 2013. Findings from this study identified a significantly greater proportion of violations issued for powered industrial trucks under the General Duty Clause compared to the proportion of violations issued under the federal standards of 29 CFR 1910.178, 29 CFR 1926.602(c) and (d), 1915.120, 1917.43 and 1918.65.

The most common hazards cited under the federal standards pertained to operator training issues. The most common types of hazards cited under the General Duty Clause pertained to seat belts, improper lifting of personnel, and improper lifting of materials. In most cases, when the General Duty Clause was cited, employers were referred to the requirements found in ANSI/ITSDF B56.1-2011, Safety Standard for Low Lift and High Lift Trucks, and ANSI/ITSDF B56.6-2011, Safety Standard for Rough Terrain Forklift Trucks.

Significant differences were found in the average fines levied for violations pertaining to forklift trucks. Both initial and current fines were significantly different when comparing fines for General Duty Clause violations to fines for federal OSHA standards. The General Duty Clause fines were more than 2 times greater than those issued for violations of federal OSHA forklift standards.

Keywords
Powered industrial trucks, General Duty Clause, OSHA, enforcement

Powered industrial trucks, often referred to as forklifts, lift trucks, or motorized hand trucks, are used primarily to move, lift, lower or transfer materials from one location to another. The operator can either be stationed on the truck or walking behind the truck. These trucks are powered by electric motors or internal combustion engines. There are many different types of powered industrial trucks and each presents its own unique hazards. Typical hazards encountered with powered industrial trucks include tip-overs; driving off loading docks or other elevated areas; falling between loading docks and delivery trailers, as unsecured trailers drift; and collisions or struck-by incidents with pedestrians and other materials (OSHA, n.d.). Falling debris, driver ejection and poor driving conditions are other hazards typically encountered. In addition to worker injury, forklift incidents can cause property damage to equipment, machinery, building structures, storage racks and sprinkler systems, to name a few.

According to NIOSH (2001), "Forklift overturns are the leading cause of fatalities involving forklifts and they represent about 25% of all forklift-related deaths." NIOSH's examination of forklift accidents revealed that "the forklift, the factory environment, and actions of the operator can all contribute to fatal incidents involving forklifts. In addition, these fatalities indicate that many employees and employers are not using or may be unaware of safety procedures and the proper use of forklifts to reduce the risk of injury and death" (NIOSH, 2001).

OSHA (1995) estimates that powered industrial trucks cause approximately 85 fatalities and 34,900 serious injuries each year. Early estimations according to the Bureau of Labor and Statistics (BLS) found that each year in the U.S., nearly 100 workers are killed and another 20,000 are seriously injured in forklift-related incidents (BLS, 1997; 1998).

Federal OSHA Standards Regulating Powered Industrial Trucks

OSHA has the responsibility of promulgating and enforcing workplace safety standards in the U.S. and its territories. This can be achieved by federal OSHA or through state plans. For employers that fall under federal OSHA's jurisdiction, powered industrial trucks can be regulated in the workplace through a variety of standards.

The application of these standards are based upon the industry and type of job tasks being performed. OSHA has also enforced the following federal standards as they relate to powered industrial trucks: 1915.120, Powered Industrial Trucks Operator Training, which references 1910.178; 1917.43, Powered Industrial Trucks; 29 CFR 1926.602(c) and (d), Construction Industry, Material Handling Equipment; 29 CFR 1915.120, Shipyard Industry, Powered Industrial Truck Training; 29 CFR 1917.43, Marine Terminals, Powered Industrial Trucks; and 1918.65, Mechanically Powered Vehicles Used Aboard Vessels.

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OSHA's General Duty Clause

Forklift hazards may also be cited under OSHA's General Duty Clause. The General Duty Clause should only be used "when there is no standard that applies to the particular hazard and in situations where a recognized hazard is created in whole or in part by conditions not covered by a standard." Only hazards that present serious physical harm or death may be cited under the General Duty Clause. This includes willful and repeated violations (OSHA, 2011).

According to OSHA's *Field Operations Manual* (FOM), the Occupational Safety and Health Review Commission and court precedent have established that the following criteria are required to prove that a violation of the General Duty Clause exists. If OSHA cannot substantiate each element, the citation cannot be issued if:

1) "the employer failed to keep the workplace free of a hazard to which employees of that employer were exposed;

2) the hazard was recognized;

3) the hazard was causing or was likely to cause death or serious physical harm;

4) there was a feasible and useful method to correct the hazard" (Lies & Mohan, 2014).

A general duty citation must involve both the presence of a serious hazard and exposure of the cited employer's own employees (OSHA, 2011). A hazard is defined as a "workplace condition or practice to which employees are exposed, creating the potential for death or serious physical harm to employees" (OSHA, 1970). This hazard must be reasonably foreseeable and recognized. This ability to "recognize the hazard" is probably one of the most difficult elements to define (O'Brien & Gallagher, 1990).

A hazard can be considered recognized by the employer through evidence that the employer had knowledge of the hazardous condition or practice; through documentation that identifies a hazard such as memos, standard operating procedures and safety procedures; through prior inspection history; from employee complaints and reports; through employer corrective actions to remediate the problem; through recognition of the hazard through the employer's relevant industry; and through common-sense recognition (i.e., any reasonable person would be able to identify the hazard) (OSHA, 2011). Employers can only be cited under the General Duty Clause for preventable hazards. Recklessness on the part of the employee or misconduct are not liable for citation under the General Duty Clause (DeClercq & Lund, 1991).

OSHA has used the General Duty Clause extensively resulting in thousands of citations in the early years of its inception (Morgan & Duvall, 1983). In more recent years, we are seeing an increase in the issuance of general duty violations as well. From fiscal year (FY) 2008 to 2011, there was an increase of more than 15% in the issuance of General Duty Clause violations by OSHA. OSHA supports this claim in a Jan. 5, 2011, web chat on OSHA's regulatory agenda stating, "We are also increasing our use of the General Duty Clause because the OSH Act makes it very clear that it is the obligation of employers to provide workplaces free of recognized hazards, whether or not there is an OSHA standard" (Morrison, 2011).

National Consensus Standards for Powered Industrial Trucks

American National Standards Institute (ANSI) has issued national consensus standards covering powered industrial trucks for a number of years. Most notably, OSHA has incorporated ANSI/ITSDF B56.1 into the 1910.178 regulations, which covers the design, construction and marking requirements for powered industrial trucks. When OSHA cannot cite an entity by one of these standards, compliance officers will enforce Section 5(a)(1) of the OSHA Act, referred to as the General Duty Clause.

ANSI/ITSDF B56.1, Powered Industrial Trucks, and ANSI/ITSDF B56.6, Safety Standard for Rough Terrain Forklift Trucks, are two standards that OSHA references as acceptable practices for controlling powered industrial truck hazards for which there is no applicable OSHA standard. Determination as to the type of trucks used in the workplace that fall under this standard is made through the forklift identification plate. OSHA recognizes the important contributions of these national consensus standards. As such, these voluntary standards can be used as guidance and recognition of industry accepted practice and they can play a role in evaluating employer responsibilities under the General Duty Clause (OSHA, 2007).

ANSI/ ITSDF B56.1 defines the safety requirements relating to the elements of design, operation, and maintenance of low lift and high lift powered industrial trucks controlled by a riding or walking operator, and intended for use on compacted, improved surfaces (ITSDF, 2012). The standard is a national consensus standard that provides guidance on forklift design, operation and safety features. ANSI/ITSDF B56.6 applies to rough terrain forklifts truck that are defined as a wheeled-type trucks designed primarily as a fork truck with a vertical mast and/or a pivoted boom, variable reach or of fixed length, which may be equipped with attachments. These trucks are intended for operation on unimproved natural terrain as well as the disturbed terrain of construction sites (ITSDF, 2011). Like ITSDF/ANSI B56.1, this national consensus standard also provides guidance on forklift design, operation and safety features.

Purpose of Study

The purpose of this study was to analyze enforcement data to identify significant factors related to OSHA's approach to issuing citations for violations of its powered industrial truck standards under section 5(a)(1) of the OSH Act of 1970, commonly referred to as the General Duty Clause, and the various federal OSHA standards governing the use of forklift trucks in the workplace. Additionally, this study sought to determine if the fining strategies differ when comparing General Duty Clause violations to federal standard violations and to determine the degree of impact contesting these violations has upon fines. Findings from this study can be useful for employers who use powered industrial trucks.

Methodology

Source of Data

This study examined violations issued from Jan. 1, 2011, to Dec. 31, 2013, using data from the U.S. Department of Labor (DOL). The data were extracted on Sept. 25, 2015, from

DOL's website. The files included violation data, inspection data, and General Duty Clause violation descriptions. The General Duty Clause violations were identified by finding key terms of "ANSI B56," "forklift," and "powered industrial truck" in the violation descriptions. The forklift violations examined in this study included violations issued for 29 CFR 1910.178, 29 CFR 1926.602 (c) and (d), 1915.120, 1917.43 and 1918.65. Due to differences in occupational safety regulations in some state plans, violations occurring in California, Oregon, Michigan and Washington were not included in this analysis. General Duty Clause violations cited under 5(a)(1) of the OSH Act were also included for analysis. To match violations to inspections, activity numbers and citation identification numbers were used.

Variables

Variables included for analysis in this study included the OSHA standard that was violated, the two digit North American Industrial Classification System (NAICS) code for the employer, the initial and current penalties assessed for the violations, information pertaining to whether the employer contested the violations or not, the type of inspection that resulted in the violation, and the type of hazard that was cited. To determine the hazard classifications, a coding system was established by the researchers. The type of inspection that resulted in a violation of the General Duty Clause was determined by OSHA using their classification system. Violations were classified as "contested" or "not contested" based on contest dates provided in the violation database. Monetary variables of initial penalty and current penalty were used to determine the fines assessed.

Descriptive Statistics

A descriptive analysis was conducted on the variables included in this study. Frequencies, percentages, averages and standard deviations were calculated where appropriate. This analysis includes the frequency and percentage of industries cited under the federal OSHA forklift standards and the General Duty Clause as defined by their two-digit NAICS code, the frequency and percentage of violations based upon the type of inspection, and the frequency and percentage of violations based upon the hazard classification. Frequencies and percentages were also used to describe the national consensus standards employers were expected to follow in order to meet the standard of compliance under the General Duty Clause.

Averages and standard deviations were calculated for the initial and current penalties assessed based upon the type of inspection. For the top 10 most frequently identified hazards that resulted in a citation for violating the OSHA forklift standards and General Duty Clause, averages were calculated for the initial and current penalties assessed based upon hazard classification. A percent decrease was calculated for each violation by comparing the initial penalty to the final penalty paid by the employer.

Inferential Statistics

T-tests for two independent samples were used to determine if significant differences exist in the average initial penalty, the current penalty, and percentage decrease in penalties when comparing employers who contested their violations to those who did not. Tests were also performed comparing penalties assessed under the General Duty Clause to those assessed under federal OSHA standards. A z-ratio was used to determine if significant differences existed between two independent proportions. In this study, the proportion of forklift violations cited under federal standards was compared to proportion of forklift violations cited under the General Duty Clause. Statistical significance for these inferential tests was determined using p =.05 and data was analyzed using IBM's Statistical Package for the Social Sciences (SPSS).

Results

Violations

During the analysis period, there were 18,549 violations cited under 29 CFR 1910, 29 CFR 1915, 29 CFR 1917, 29 CFR 1918 and 29 CFR 1926 involving powered industrial trucks. A total of 4,385 violations of the General Duty Clause were issued during the period of Jan. 1, 2011, to Dec. 31, 2013, of which 594 violations (13.5%) were confirmed to have resulted in violations pertaining to powered industrial trucks. A summary of the 15 most frequently cited standards involving forklift trucks appears in Table 1.

Forklift hazards cited using the General Duty Clause, which appears in the top 15 most frequently cited standards involving forklift trucks, most often pertained to seat belts, improper lifting of personnel with the truck, improper lifting of materials, and other forms of improper operation. Various versions of the ANSI/ ITSDF B56.1 and ANSI/ITSDF B56.6 were referred to for guidance in the narrative sections of the violations.

Standard	N	Percent of All Violations
Employee training (1910.178 L01) I	3,038	19.8
3 year operator evaluation (1910.178 L04 III)	2,368	15.4
Training certification (1910.178 L06)	2,070	13.5
Defective trucks (1910.178 P01)	1,450	9.4
Daily inspections (1910.178 Q07)	1,419	9.2
Operator training (1910.178 L)	660	4.3
Truck modifications (1910.178 A04)	628	4.1
Truck name plates (1910.178 A06)	585	3.8
Operator training (1910.178 L01 II)	906	5.9
OSHA's General Duty Clause (5 (A) (1))	594	3.9
Operator training format (1910.178 L02 II)	471	3.1
Truck repairs (1910.178 Q01)	449	2.9
Truck/attachment weight markings (1910.178 A05)	261	1.7
Unauthorized operators (1926.602 C01 VI)	295	1.9
Facilities for flushing and neutralizing spilled electrolyte, fire protection, etc. (1910.178 G02)	160	1.0
Total	15,354	100.0

Table 1. Top 15 most frequently cited standards involving forklift trucks (2011-13).

Inspections

During the analysis period, there were approximately 12,266 inspections that resulted in violations of the forklift standards or the General Duty Clause. Violations were most often the result of planned inspections accounting for approximately 49% of all violations followed by complaint inspections accounting for approximately 36% of all inspections (Table 2).

Type of Inspection	Frequency	Percent
Planned	5,963	48.6
Complaint	4,448	36.3
Referral	983	8.0
Accident	232	1.9
Programmed Related	204	1.7
Unprogrammed Related	162	1.3
Follow Up	125	1.0
Fatality/Catastrophe	101	.8
Unprogrammed - Other	24	.2
Programmed-Other	17	.1
Other	5	.0
Monitoring	2	.0
Total	12,266	100.0

Table 2. Type of inspections resulting in forklift violations (2011-2013).

Industry	Frequency	Percent
Primary Metal Manufacturing	3,024	24.7
Construction	1,983	16.2
Wood Product Manufacturing	1,971	16.1
Wholesale Trade	1,413	11.5
Retail Trade	741	6.0
Manufacturing	647	5.3
Transportation and Warehousing	584	4.8
Postal Service	569	4.6
Other Services (except Public Administration	268	2.2
Administrative and Support and Waste Management and Remediation Services	249	2.0
Sporting Goods, Hobby, Musical Instrument, and Book Stores	167	1.4
Public Administration	106	.9
Mining, Quarrying, and Oil and Gas Extraction	83	.7
Utilities	75	.6
Arts, Entertainment, and Recreation	67	.5
Real Estate and Rental and Leasing	65	.5
Agriculture, Forestry, Fishing and Hunting	55	.4
Educational Services	53	.4
Information	47	.4
Professional, Scientific, and Technical Services	34	.3
Accommodation and Food Services	31	.3
Health Care and Social Assistance	30	.2
Management of Companies and Enterprises	3	.0
Finance and Insurance	1	.0

Table 3. Forklift inspections by NAICS code (2011-2013).

Inspections by NAICS Code

Employers in primary metal manufacturing industries (NAICS = 33), the construction industry (NAICS = 23), and wood products manufacturing (NAICS = 32) were the top three most-often-cited industries for forklift violations accounting for approximately 57% of all inspections in which forklift violations were cited. A summary appears in Table 3.

Inferential Statistics Comparing Penalties Assessed Under the General Duty Clause to Penalties Assessed Under Federal OSHA Standards

T-tests were performed comparing average initial penalties and current penalties for violations cited under the General Duty Clause and penalties assessed under the various federal OSHA standards. In this part of the analysis, the researchers compared the penalties assessed for violations under the General Duty Clause to violations assessed under the federal OSHA standards.

For violations cited under the General Duty Clause, both initial and current penalties, were significantly higher than violations cited under the various federal OSHA standards. The average initial penalty assessed under federal OSHA standards was $1,667 while the average initial penalty assessed under the General Duty Clause was significantly different at more than 2 times higher at $4,039 ($t$ = 17.6., d.f. = 18,547, $p < .001$). The average current penalties assessed under federal OSHA standards was $968 while the average current penalty assessed under the General Duty Clause was also more than 2.5 times higher at $2,723 ($t$ = 9.0, d.f. = 600, $p < .001$) Because Levene's Test for this test was significant, equality of variances was not assumed and the appropriate t-test and degrees of freedom was used (See Tables 4 and 5, p. 288).

Inferential Statistics Comparing Percent Decreases in Penalties Assessed for Employers Who Contest Violations

Significant t-test results were obtained when comparing the average initial penalties and current penalties when comparing employers who contested the violations versus those who did not. The average initial penalties for those who contested the violations was $3,170 versus $1,595 for employers who did not (t = 9.4, d. f. = 1,799, $p < .001$). The average current penalties for those who contested the violations was $1,691 versus $954 for employers who did not (t = 5.9, d.f. = 1,783, $p < .001$). Because Levene's Test was significant for both tests, equality of variances was not assumed and the appropriate t-test and degrees of freedom were used (Tables 6 and 7, p. 288).

	Frequency	Percent	Average Penalty ($)	Standard Deviation ($)	95% C.I.
Federal Standard Violations	17,955	96.8	968	2,009	939 to 997
General Duty Clause Violations	594	3.2	2,722	4,756	2,340 to 3,104
Total	18,549	100.0	1,024	2,174	993 to 1,055

Table 4. Average current penalties by type of violation (2011-13).

	Frequency	Percent	Average Penalty ($)	Standard Deviation ($)	95% C.I.
Federal Standard Violations	17,955	96.8	1,667	3,137	1,621 to 1,713
General Duty Clause Violations	594	3.2	4,040	5,256	3,617 to 4,463
Total	18,549	100.0	1,743	3,253	1,696 to 1,790

Table 5. Average initial penalties by type of violation (2011-13).

	Frequency	Percent	Average Penalty ($)	Standard Deviation ($)	95% C.I.
Contested Violations	1,752	8.4	3,170	6,997	2,842 to 3,498
Uncontested Violations	16,797	91.6	1,594	2,520	1,556 to 1,632
Total	18,549	100.0	1,743	3,253	96 to 1,790

Table 6. Summary of initial penalties for contested violations (2011-13).

	Frequency	Percent	Average Penalty ($)	Standard Deviation ($)	95% C.I.
Contested Violations	1,752	8.4	1,691	5,189	1,448 to 1,934
Uncontested Violations	16,797	91.6	954	1,537	931 to 977
Total	18,549	100.0	1,024	2,174	993 to 1,055

Table 7. Summary of current penalties for noncontested violations (2011-13).

	Frequency	Percent	Average Penalty ($)	Standard Deviation ($)	95% C.I.
Contested Violations	1,752	8.4	1,691	5,189	1,448 to 1,934
Uncontested Violations	16,797	91.6	954	1,537	931 to 977
Total	18,549	100.0	1,024	2,174	993 to 1,055

Table 8. Proportions of forklift violations cited under federal OSHA standards and the General Duty Clause (2011-13).

Inferential Statistics Comparing Proportion of Forklift Hazards Cited Under the General Duty Clause to the Proportion of Forklift Hazards Cited Under the Federal Standards

In the final part of the inferential statistical analysis, a z-ratio was used to determine if a significance difference existed in the proportion of forklift hazards cited under the General Duty Clause to the proportion of forklift hazards cited under federal OSHA standards. Under the federal OSHA standards, approximately 3.5% of all violations cited during the 3-year period pertained to forklifts while approximately 13.5% of all General Duty Clause violations pertained to forklift-related hazards (Table 8). The z-ratio determined the proportion of forklift violations cited using the General Duty Clause was significantly greater than the proportion cited using federal OSHA standards ($z = 35.6$, $p < .001$).

Discussion

This study examined OSHA's enforcement of forklift standards under federal regulations and the General Duty Clause. Over the 3-year period this study covered, OSHA issued 18,549 violations related to forklift-related hazards of which approximately 594 violations were cited under the General Duty Clause.

Most often, employers were cited for operator training and evaluation issues under the federal OSHA standards. Operators were not trained, they were not reevaluated every 3 years, or the training did not meet the OSHA standards. The operator training requirements were updated and strengthened by OSHA in a final ruling published in December 1998. This analysis, which covered inspections during 2011 to 2013, found a surprisingly high number of violations for these areas more than 15 years after the regulations were changed. The most commonly violated standards pertain to some of the more fundamental aspects of forklift operator training and truck operation.

Hazards involving forklift trucks cited under the General Duty Clause were most often related to seat belt availability and use, improper lifting of personnel, and improper lifting of materials. Findings from this study determined a significantly disproportionate percentage of General Duty Clause violations being cited for powered industrial truck issues. Meaning, OSHA is citing forklift-related hazards under the General Duty Clause more often than other types of hazards. This could be interpreted in a few ways. First, some of the more common hazards associated with forklifts are not covered under the current OSHA standards and as a result, OSHA is compelled to use the General Duty Clause to remedy the situation since no federal regulation exists. It could also be interpreted as a lack of knowledge on the part of employers with regards to meeting industry accepted safety standards for forklift truck use and operation.

Three areas were most often cited using the General Duty Clause; seat belt use and availability, inadequate platforms for lifting personnel, and improper lifting of materials with the truck. While there are no specific OSHA standards pertaining to seat belt availability and use in a forklift truck, ANSI standards require their presence and use. ANSI/ITSDF B56.1-2011, Safety Standard for Low Lift and High Lift Trucks, states that an active operator protection device or system, when provided, shall be used. This operator protection, in the event of tipover, is intended to reduce the risk of entrapment of the head and torso between the truck and the ground but may not protect the operator against all possible injury.

ANSI/ITSDF B56.6-2011, Safety Standard for Rough Terrain Forklift Trucks, states that seat belts shall be provided that meet or exceed the requirements of ANSI/SAE J386. In several cases, the employer was cited under the General Duty Clause for not providing seat belts on the forklift when a retrofit seat belt was available from the manufacturer. In a letter of interpretation dated March 7, 1996, OSHA stipulates that "when an employer has been notified by a powered industrial truck manufacturer or association of the hazard of lift truck overturn and made aware of an operator restraint system retrofit program, then OSHA may cite Section 5(a)(1) of the OSH Act" (OSHA, 2015).

Another aspect of powered industrial truck use commonly cited under the General Duty Clause and covered under the ANSI standards is the practice of elevating personnel with the truck. Again while no federal standards apply to this practice, the ANSI standards provide detailed guidance on acceptable practices. These practices include using platforms that comply with the standards, ensuring the platforms are secured to the forks of the truck, and ensuring restraining systems such as guardrails and body belts with lanyards are used. As with the seat belt violations, employers have either not familiarized themselves with the requirements as stipulated in the ANSI standards for platforms used with powered industrial trucks or they have not taken appropriate action to ensure they are being met by employees.

This research study also found there were significant differences in the penalties assessed for forklift violations when comparing General Duty Clause violations to federal OSHA standards violations. The average violations assessed for forklift-related hazards are significantly greater when cited using the General Duty Clause versus federal OSHA standards. The penalties assessed were more than 2 times greater for general duty violations. This combined with the finding that a significantly greater proportion of General Duty Clause violations targeting forklift hazards compared to federal standards violations, should be of concern. Compliance officers are finding a large number of these hazards involving forklift trucks and the violations are carrying significantly larger penalties.

One option available to employers as a way to limit their exposures to OSHA violations and fines is to contest the violations. This study found that contesting the violations led to greater reductions in penalties assessed when compared to employers who did not contest. There could be several factors influencing these results. First, the average initial penalties assessed were higher for violations that were contested versus those that were not. The size of the initial penalty may have been a factor motivating employers to contest the violation to begin with. Another factor may have been the fact that an employer had a valid justification for contesting the violation and by doing so, prevailed in the legal process.

The results of this study provided an analysis of OSHA's enforcement of the federal standards related to powered industrial trucks and the use of OSHA's General Duty Clause in citing forklift-related hazards. Results from this study can aid employers by identifying the most commonly cited federal standards and national consensus standards involving forklift trucks so employers can better protect employees. Further work will be conducted by the researchers to ascertain the level of employers' knowledge about the federal OSHA standards and national consensus standards with which they are expected to comply.

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Use of Safety Equipment by Bicyclists in Rosario, Argentina: Prevalence & Motivations

Damian Uroz-Garelli, Marta Quaglino, Laura Prieto del Val and Nancy Carney

Abstract

Injuries from road traffic represent a considerable percentage of major causes of morbidity and mortality in Argentina. Surveys were conducted among cyclists in Rosario to determine their safety habits and the motivation behind these habits. Although 54.6% of the respondents confirmed to know the traffic regulations and rules for cyclists, 92.5% of them reported that they do not wear a helmet, 54.5% do not have a rear light or reflector, and 45.4% have run a red light. An important finding was that the probability of wearing a helmet was significantly higher in bicyclists who claimed to know the traffic laws (12%) versus those who did not (1%). Knowledge of traffic law was, in turn, influenced by educational level. Some of the most cited reasons for not using safety devices were discomfort, lack of interest and decreased hearing/visibiliy.

Keywords
bicycle, cyclists, traffic law, helmet use, Rosario

Given the universal necessity of overland transportation, road traffic accidents have constituted a major cause of global morbidity and mortality that has increased with the global proliferation of automobiles in the context of existing pedestrian and bicycle transport. Nearly half of the fatalities and injured were defined as "vulnerable road users," consisting of pedestrians, cyclists, and the operators and passengers of two- and three-wheeled motorized vehicles [World Health Organization (WHO), 2013]. In 2013, in Argentina, 5,094 people died in traffic accidents (WHO, 2013), eight percent of which were estimated to be cyclists (Luchemos por la vida, 2013).

Interventions designed to improve cyclists' safety such as compulsory helmet use, designated pathways for cyclists, and safer cycling environments have demonstrated significant decreases in mortality and morbidity for cyclists in several countries (Stevenson, et al., 2015), though laws mandating these interventions do not exist uniformly around the world. In many places where these protective laws exist enforcement is often lax, leading to limited voluntary participation by cyclists and in some cases, the lack of use of cycling equipment such as helmets, reflective vests and lights (Davidson, 2005). Furthermore, those utilizing bicycles as a primary method of transportation in developing countries tend to be less educated and earn lower income (Bacchieri, Gigante & Assunção, 2005; Davidson, 2005). While demographic information provides a plausible explanation as to why cyclists often do not follow safety guidelines, this theory has yet to be tested in the city of Rosario.

Located 300 kilometers north of Buenos Aires in the southern province of Santa Fe, Rosario is the third largest city in Argentina. With a population of around 1 million, the number of people living within city limits has increased dramatically over the past decade (Municipality of Rosario, 2014) while the availability of public transportation has increased minimally. As private vehicle ownership remains financially unfeasible for many, the number of people using bicycles as their primary mode of transportation has increased (Aronna, Bissio, Leone, Cagna & Coll, 1999) as have the number of traffic collisions involving bicycles. In 2002, deaths attributed to external causes in Rosario numbered nearly 700, representing 7.5% of the total deaths for that year. Of these, 103 of the incidents were due to traffic accidents, the highest portion of which involved motorcyclists (21.2%), followed by motor vehicles (13.6%) and cyclists (11.6%) (Geldstein & Bertoncello, 2006). While current municipal ordinances in Rosario regulate traffic rules for cyclists (Coll, 2005; Honorable Municipal Council, 2003; Road Safety Education Department, 2005; Urban Planning of Road Safety, 2004) and require the use of helmets and lighting to increase visibility by motorists, the alarming rate and seriousness of injuries to bicyclists demonstrates a need for increased understanding of why these injuries occur and how they can be prevented. This study aims to measure cyclists' compliance with current regulations and their knowledge of these regulations and also document the demographics of cyclists who fail to follow these safety-oriented traffic rules and the rationale behind their decisions.

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Methods

Population

A descriptive study of a cross section of cyclists was carried out by conducting an oral survey of cyclists on public roads in Rosario. Data collection was conducted through personal interviews with cyclists passing through particular parts of the city in the daytime Monday through Friday. During 3-hour shifts, interviewers, positioned near traffic lights and wearing local goverment waistcoats, attempted to stop all cyclists who appeared to be over the age of 18. Staff for data collection consisted of three supervisors for each area of the city and two trained interviewers per interview location. The survey was conducted in August 2011, and the weather conditions were always favorable.

After reviewing data provided by the Department of Statistics of the Municipality of Rosario regarding traffic accidents involving bicycles in Rosario, six locations with high rates of accidents were chosen to be interview locations. These locations covered areas in downtown Rosario and neighborhoods in the north, south, west and southwest districts. All participants gave informed consent to the experimental protocol approved by the University of Rosario and by the Ethical Committee for Medical Research at the Emergency Hospital of Rosario.

Data Collection

The survey was conducted through personal interviews carried out by individuals trained specifically for this study. The estimated time to complete the survey was less than 5 minutes.

The survey began with questions regarding age, gender and level of education. Additional questions included motivation for bicycle use, use of safety equipment, respect for traffic signals, perception of bicycle safety, previous experiences with the authorities resulting from improper bicycle use, and knowledge of traffic rules governing bicycle use. In addition, when negative responses were given regarding the use of helmets or lighting, the reasons for such responses were further investigated through open-ended follow-up questions. An open-ended question was also used to investigate why cyclists ran red lights when the respondent indicated that s/he had done so.

The answers to the open-ended questions for the use of helmets or lighting were subsequently organized in three possible categories. The reasons in the first category included discomfort, the perception that helmets inhibit one's field of vision or hearing; general disinterest or motivation in wearing a helmet or using lights; the belief that helmets are useless; or a general disliking toward them. The second category included responses such as a feeling of embarrassment when wearing a helmet; saying that nobody uses helmets or lights; or that it is not fashionable. The third category were economic factors, including the expense of purchasing a helmet and the lights.

The number of surveys to be completed was calculated assuming simple random sampling, to obtain an accuracy of +0.06 in the estimates of proportions, with a confidence of 95%. The sample size was 266 surveys. The resulting data were analyzed using contingency tables and chi-square test in the SPSS 18 software.

Results

Table 1 shows a total of 266 cyclists completed the survey: 192 men and 74 women. The average age was 34.9 years old, and only 5.6% of respondents reported to have completed a tertiary or university-level education. Respondants' behaviors, including helmet use, light or reflector use and crossing an intersection against traffic lights were not significantly influenced by gender or age.

When asked what their primary reason was for riding a bicycle, more than half of the respondants (54.9%) stated that cycling was their main mode of transportation to and from their workplace, 6.8% of them responded that the reason for riding a bike was to go to school or university and 9.4% answered that they use it for leisure. Additionally, more than 25% of respondents reported using their bicycles for all the aforementioned purposes. Three percent of respondents reported using a bicycle for other purposes.

Data regarding helmet use among participants show that only 7.5% (20/246) of cyclists wear a helmet when cycling. Interestingly, those who wear helmets were mainly found in the northern and southern zones of the city, and not in downtown. When cyclists were asked why they did not wear a helmet, 36.6% cited discomfort, the perception that helmets inhibit one's field of vision or hearing, general disinterest in wearing a helmet, the belief that helmets are useless or a general disliking toward them as the causes. Economic reasons were also given for not wearing a helmet (22.8 %), including the expense of purchasing a helmet and answers that indicated the respondent did not have the financial means to purchase the equipment. Reasons related to a feeling of embarrassment when wearing a helmet, saying that nobody uses one, or that it is not fashionable. were the third most common response (11%). The rest of the participants gave evasive answers or no answer at all.

Within the group of those who were familiar with the traffic regulations (54.6%), 12% of them wore a helmet, while only 1% of cyclists who claimed to not know the traffic regulations wore one ($p = .001$), indicating that knowing the traffic regulations significantly increases the probability of wearing a helmet.

	Total (%)
N	266
Male	192 (72.2%)
Female	74 (27.8%)
Age, yr	34.91 (18-60)
Educational level	
Completed primary school	122 (45.9%)
Completed secondary school	80 (30.1%)
Completed tertiary or university level	15 (5.6%)
Did not attend school/did not complete primary school	49 (18.4%)

Table 1. Demographic profile.

Furthermore, age significantly influenced knowledge of the traffic regulations ($p = .003$) with older bicyclists claiming to know the traffic regulations to a greater extent than younger bicyclists.

The percentage of cyclists using a bicycle light, reflector or some other luminous implement is 43.6%, which is higher than that of helmet use, but still relatively low. Downtown is the only place where there are more bicycles with lights than without ($p = .03$). The type of reasons given for not having a bicycle light follow a similar pattern as the reasons given for not wearing a helmet: discomfort, the perception that helmets inhibit one's field of vision or hearing, general disinterest in wearing a helmet, the belief that helmets are useless or a general disliking toward them were the most cited reasons (39.7%) followed by economic reasons (14.7%) and reasons related to a feeling of embarrassment, or the lack of use by other cyclists (7.8%),

When considering basic traffic laws for cyclists, 45.4% reported to having crossed an intersection against the traffic signal within the last year. Based on their answers, the most common reasons were the absence of other vehicles on the road (25.5%) and being in a hurry or being late for work (21.3%). Other reasons mentioned were to avoid a dangerous situation (2.1%), simply because they claimed to have not seen the sign (2.8%), habit (1.4%) or to follow another vehicle (0.7%). A high number of cyclists (41.1%) did not give any reason for having crossed an intersection against the traffic signal.

With regard to the supervision and control of bicycle traffic, only 13.5% of cyclists said they had received warnings from the authorities and most were from police, not from a traffic inspector. This distinction is important in Argentina, since the police are not in charge of controlling traffic rule compliance, while traffic inspectors are.

Educational level showed an almost significant effect ($p = .088$) regarding knowledge of traffic regulations, since the highest percentage of cyclists who claimed to have knowledge of traffic regulations had a university degree, followed by those who had only completed secondary studies (Table 2). On the other hand, educational level did not appear to determine perception of bicycle safety ($p = .603$). Bicycles were considered a safe or very safe method of transportation by 51.5% of the respondents while 47.7% of them rated them as not very safe or not safe (Table 3).

Discussion

The main findings from this descriptive study of bicyclists' behavior are that 92.5% of the respondents do not wear a helmet, 54.5% do not have a bicycle light or reflectors and 45.4% have crossed an intersection against the traffic signal within the past year. Discovering the rationale why cyclists do not use a helmet or lights is crucial for planning and developing effective strategies to promote safety and reduce cycling injuries.

In the present study, most cyclists cited lack of interest and motivations, lack of hearing or visibility and discomfort as the main reason for not wearing a helmet or not having bicycle lights, followed by reasons related to economical factors and then reasons including responded such as a feeling of embarrasment, saying that nobody uses one or that it is not trendy. One reason, such as helmet discomfort, has been one of the previously cited motives for not using a helmet (Faryaby, et al., 2014). This lack of comfort might be, at least partially, feasible to overcome by designing low-cost ergonomic helmets and informing people that they would eventually adapt to discomfort after wearing it repeatedly (Abeysekera & Shahnavaz, 1990). Providing a free helmet has also shown to be a useful strategy to encourage usage.

One study conducted in France assessed the influence of three different strategies for promotion of helmet use: 1) providing a helmet; 2) providing information to promote helmet use;

Knowledge of traffic laws	Primary school not completed (%)	Primary and secondary school completed (%)	Tertiary school or University completed	No response	Total (%)
Yes	21 (46.7%)	95 (52.8%)	26 (71.1%)	0 (0%)	142 (54.6%)
No	24 (53.3%)	82 (45.6%)	11 (28.9%)	0 (0%)	117 (45.0%)
No response	0%	3 (1.6%)	0%	4 (100%)	7 (0.4%)

Table 2. Knowledge of traffic laws according to educational level.

Perceived safety	Primary school not completed (%)	Secondary school completed (%)	Tertiary school/ University completed (%)	No respone (%)	Total (%)
Very safe	6 (13.3%)	17 (9.5%)	3 (7.3%)	0 (%)	26 (10.1%)
Safe	19 (42.2%)	78 (43.3%)	13 (34.1%)	1 (25%)	111 (41.7%)
Not very safe	13 (28.9%)	54 (30%)	16 (46.3%)	3 (75%)	86 (32.3%)
Not safe	7 (15.6%)	31 (17.2%)	3 (7.3%)	0 (0%)	41 (15.4%)
No response	0	0	2 (4.9%)	0 (0%)	2 (0.4%)

Table 3. Perceived safety of cycling according to educational level.

or 3) providing both information and a helmet. They found that while providing information had no effect on helmet use, procuring both a free helmet and information increased the probability of helmet use 4-fold and, interestingly, providing only a helmet increased the probability 7-fold. However, the impact of the intervention declined significantly within the first 5 months (Constant, Messiah, Felonneau & Lagarde, 2012). Helmet availability, therefore, is not sufficient to guarantee consistent use over time, and cyclists' rationale might be a determinant factor, too. In line with this, another study showed that helmet use still remained low in a population sample with no financial constraints (Jaques, 1994).

Another factor suggested that may also influence helmet use is climate conditions. Ledesma, et al. (2014) found that the rate of helmet use in motorcycle drivers increased when the weather conditions were unfavorable (rainy or cloudy) compared to when they were favorable (sunny). Since weather conditions were always favorable during the study period, it could be argued that our percentages of helmet use among bicyclists could have been higher if rainy or cloudy weather climate conditions had been present. This hypothesis needs to be tested in future studies.

Even though helmet use has been shown to reduce the risk of head, brain and severe injuries among cyclists by between 63% to 88% (Thompson, Rivara & Thompson, 2000), it can also increase cyclists' propensity to take more risks (Adams & Hillman, 2001) and make drivers of large vehicles leave narrow safety margins when overtaking (Walker, 2007). Opponents of helmet use also claim that to require cyclists to use helmets will decrease the number of cyclists and, therefore, the health benefits of cycling (Carnall, 1999). However, in countries where wearing helmets is mandatory, a decrease of cyclists has not been detected (Dennis, et al., 2010), while an increase in helmet use was observed.

Providing free equipment that increases cyclists' visibility, such as reflective vests, had similar results as providing free helmets (Constant, et al., 2012). A study conducted in Tanzania (Summer, et al., 2006) showed that while the distribution of vests led to a significant increase on their usage (9.5% in the intervention group compared to 2% in the control group) the total increase was still quite low. These results, together with Constant, et al.'s (2012) findings, suggest that even though cyclists usually cited economic reasons for not using a helmet or lights or reflectors, providing cyclists with this safety equipment only results in a modest increase in usage and is not sufficient to achieve high rates of use among adult cyclists, both in lower-income and higher-income countries.

The percentage of cyclists in our study who reported to have crossed an intersection against a red traffic light was 45.4%. This rate is high when compared to other cities such as Melbourne, where the non-compliance rate was 6.9% (Johnson, Charlton, Oxley & Newstead, 2013), but relatively low compared to the rate in Beijing, which reached 56% (Wu, Yao & Zhang, 2012). Reasons most commonly noted for crossing an intersection against a red light in our study were the absence of other vehicles or that the cyclists were in a hurry. Even though the lack of authority enforcing traffic laws was only reported by 2.1% of our respondents as their reason for crossing against a red traffic light, devices controlling cyclists' infractions have been proven to increase compliance with traffic regulations.

Installing micro-radar sensors in the pavement for monitoring cyclists' behavior in the city of Chicago improved compliance with traffic signals, which was 31% before and 81% after installation (Lang, 2013).

On the other hand, the Idaho Stop Law, first implemented in 1982, permits cyclists to treat stop signs as yield signs and red traffic lights as stop signs and it has been claimed to make cycling easier and safer. Though no increase in incidents have been observed in the areas where the law is in effect, we found no study that directly compared the rate of cyclists' incidents in areas where this law is in effect with others where it is not. Therefore, no conclusions can be made regarding the viability of this law at this time.

One important outcome from our study is the fact that knowing traffic regulations significantly increased helmet use among respondents, suggesting that having information of traffic regulations can affect cyclists' behavior. However, even though the rate of helmet users was greater among those who knew traffic regulations (12%) versus those who did not (1%), this percentage still remains low.

In a study conducted in Santa Fe, a city nearby Rosario , the authors reported similar observations with car and motorcycle drivers (Beltramino & Carrera, 2007). Only 12% of motorcycle drivers and 9% of car drivers wore a helmet or a seat belt, respectively. Even if they all knew the traffic regulations, which they had to learn in order to obtain their driving licences, the usage of safety devices remained low.

Recent observations indicate that the prevalence of helmet use by motorcycle drivers in Argentina has increased, reaching 46% according to the WHO (2013), 53.8% according to a national report (ANSV, 2012) and 69.8% when the observations were limited to the city of Mar del Plata (Ledesma, et al., 2014). Lower percentages of helmet use were observed when motorcycle passengers were taken into account, ranging from 24% (WHO, 2013) to 43.4% (Ledesma, et al., 2014). Unfortunately, data regarding helmet use by motorcyclists in Rosario are not available and, therefore, direct comparisons of helmet use by cyclists and by motorists is not possible.

In our study, knowledge of traffic regulations, in turn, was almost influenced by educational level. Cyclists with higher educational levels reported to know traffic regulations more than those with a lower level of education. This impact of educational levels on traffic behavior had been observed before. A study carried out in Iran (Sami, et al., 2013) reported that educational levels were significantly correlated to road traffic accidents, with less educated or uneducated people being those who suffered a higher number of fatal events. The educational levels of our respondents did not appear to influence the perception of safety.

Conclusions

Given the importance of helmet use in preventing head injury (Thompson, et al., 1996, 1999), discovering factors that encourage the use of helmets and other safety devices should be a priority. The current study suggests that knowing the traffic laws increases helmet use. Campaigns designed to inform cyclists about traffic regulations that concern them could have a positive effect on safety promotion. However, since the percentage of helmet use among respondents with traffic regulation knowledge was still modest, complementary measures should also be taken to increase the number of helmet users. A systematic review (Karkhaneh, Kalenga, Hagel & Rowe, 2006) confirmed that helmet use was more than four times higher following helmet legislation, with effectiveness ranging from modest to high. Greater effects were observed in places with lower baseline helmet use and when laws concerned all ages in the community.

The combination of helmet legislation in addition to promotional and educational campaigns seems to be an effective strategy for safety promotion, as demonstrated in a New Zealand survey where the rate of helmet use increased from 11% up to 94% over the last years (Povey & Novis, 2015). In Argentina, using a bicycle helmet, a light and reflectors is recommended but not mandatory. Only 13% of the respondents said they had received warnings from an authority and most of them were from police officers, not traffic officers, which indicates that bicycle safety supervision and control in Argentina is low. Therefore, some ways to improve the behavior of cyclists would be to organize a campaign in which the use of helmets, lights and reflectors was encouraged, police issued more warnings and more traffic signals were installed. This campaign could represent a transition period until the use of these devices by cyclists was made mandatory in Argentina.

Further research is needed to provide more information into the individual causes that lead people to take risks on the road that put themselves and others in danger. Additionally, reasons for wearing a helmet or using lights were not assessed among helmet and lighting users, respectively. It could be useful to know what motivate cyclists to use these devices, which could be, in turn, used to guide local prevention campaigns aimed at changing cyclists' attitudes toward road safety.

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