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Slip and Fall-Related Injuries in Relation to Environmental Cold and Work Location in Above-Ground Coal Mining Operations

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Background *The association between slip and fall-related injuries and environmental temperature was examined for mostly enclosed (inside vehicles, machinery, or buildings), outdoor (outside, not enclosed), and enclosed/outdoor jobs in the coal mining industry to see if differences existed among the three work locations that had varying exposure to cold temperatures.*

Methods *Temperature data from the National Climatic Data Center and injury data from the Mine Safety and Health Administration were evaluated from 1985–1990 for seven states. Proportionate methods were used to examine the relationship between slips and falls and temperature.*

Results *Proportionate injury ratios of slips and fall-related injuries increased as temperature declined for all three work locations. Proportion of slips and fall-related injuries that occurred while running/walking increased with declining temperature, with the ground outside as the most common source of these injuries.*

Conclusions *Outside movement becomes a greater hazard at freezing temperatures for workers in all locations, not just outdoor workers. Any intervention methods geared toward reducing injury incidents facilitated by cold weather must also be directed toward workers who spend time in more enclosed locations.* Am. J. Ind. Med. 38:40–48, 2000. *Published 2000 Wiley-Liss, Inc.*†

KEY WORDS: slips; falls; environmental cold; occupational injuries; Mine Safety and Health Administration data

INTRODUCTION

Falls have been documented as a leading cause of non-fatal injuries in the general public [Rice et al., 1989]. Slips, trips, and falls also are one of the most important sources of injury in occupational populations, comprising a large proportion of total injuries, and resulting in substantial economic cost [Manning, 1983; Buck and Coleman, 1985; Leamon and Murphy, 1995]. A wide variety of contributing factors lead to slip and fall incidents. Human factors, such as loss of coordination, loss of balance, and fatigue, can lead to slip and fall incidents, as can workplace conditions such as spilled liquid or debris, uneven or slippery surfaces, or objects placed in the path of travel [Davis, 1983; Manning, 1983; Buck and Coleman, 1985; Brock, 1996]. Personal characteristics, such as relative body weight, alcohol consumption, and use of psychopharmacologic agents, have also been associated with falls [Malmivaara et al., 1993]. Because no single cause of slips and falls exists, many factors with the potential to contribute to slip and fall incidents should be examined.

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External environmental conditions, particularly in the winter months, also can have an effect on the occurrence of slips and falls. Rain, ice, and snow can cause slippery surroundings, increasing the number of slips and falls, and injuries related to them, in the general public [Andersson and Lagerlöf, 1983; Lewis and Lasater, 1994; Jacobsen et al., 1995; Leamon and Murphy, 1995; Björnstig et al., 1997; Levy et al., 1998]. Cold weather, even in the absence of meteorological conditions such as ice and snow, can cause changes in the behavior, reaction time, and physiological processes of persons, which may affect their risk for a slip or fall injury [Holmer, 1991, 1993; Oksa and Rintamäki, 1995]. Furthermore, it is possible that the protective clothing worn in the cold can hamper movement and decrease dexterity, possibly making individuals more susceptible to a slip or fall injury [Tanaka et al., 1983; Havenith et al., 1995].

In certain occupational populations, numbers of slip and fall-related injuries were found to increase during colder temperatures and periods of inclement weather [CDC, 1995; Leamon and Murphy, 1995]. Hassi et al. [2000] documented an increase in rate of slips and falls as temperature decreased in both surface and underground mining operations. From this work, it was hypothesized that since slip and fall rates were found to increase as temperature decreased, miners who work outside would have a greater number of slips and falls than those who work inside, due to more direct contact with environmental cold and inclement conditions. The mining industry was chosen as it had the highest rate of cold exposure injuries [Jensen, 1983]. The objective of this article is to examine the association between environmental temperature and slip and fall-related injuries in above-ground mining operations, focusing on differences in proportionate injury ratios among miners who work in mostly enclosed locations, such as inside vehicles, machinery, or buildings, vs. those who work outside.

METHODS AND ANALYSIS

Source of Data

The mining industry was chosen as a target industry because of its high rate of cold injuries [Jensen, 1983], indicating the importance of environmental temperature. Coal mining injury data were taken from the Mine Safety and Health Administration (MSHA) dataset for injuries occurring from 1985–1990 in seven states with the highest numbers of reported injuries (IL, IN, KY, OH, PA, VA, WV). Injury was examined for surface-operations workers only, so injuries from work subunits designated as underground mining operations (the subunit codes designate the type of mining operations conducted at the mine), and injuries for workers with job titles classified as underground work, were omitted. Females made up only a small number of the injuries (less than 1%) of the current dataset. Consistent with previous studies [Lee at al., 1993], the analysis was restricted to male surface mine workers 18 years of age and greater.

Categorization of Injury

To determine the relative importance of slips and falls to other injuries, all injuries were categorized based on the MSHA code for circumstances most directly contributing to the injury. Groups with less than 1,000 injuries were pooled into an ''other'' category. Resulting categories were (1) *handling material*; lifting, pulling, pushing, shoveling material (n = 6,342); (2) *slip or fall of person*: slip or fall from an elevation or on the same level (includes falling while getting on/off equipment which is not moving) (n = 4,600); (3) *hand tools*: injuries related to non-powered tools when being used as a hand tool (n = 2,501); (4) *machinery:* injuries that result from the action or motion of machinery, or from failure of component parts, includes electric or air-powered tools (n = 2,103); (5) *powered haulage*: injuries that are caused by energized or moving unit (i.e., a person who suffers an injury as a result of falling from a moving vehicle) or failure of component parts (n = 1,541); and (6) other: not any of the above (none of the individual circumstances within the ''other'' category has more than 400 injuries) (n = 1,541).

To further describe the 4,600 slip and fall-related injuries, they were categorized with respect to the activity the worker was engaged in at the time of the incident (MSHA activity code). Most injuries occurred in one of the following four activity categories (1) getting on/off equipment, machines, etc. (n = 1,773); (2) walking or running (n = 1,020); (3) handling supplies or material, loading and unloading (does not include timber or power cables) (n = 598); and (4) machine or equipment maintenance/repair (n = 496). A fifth category called ''other'' was created for all other activities combined (n = 713). No individual activity within the 'other' category accounted for more than 150 injuries. Other variables used to describe slips and falls included source of injury (identifies the object, substance, exposure, or bodily motion which directly produced or inflicted the reported injury) and degree of severity.

Categorization of Job Titles

Each surface job title was placed into one of three location categories based on where the majority of work activity took place. These categories were mostly enclosed, outdoors, and both enclosed and outdoors. This categorization was facilitated by the recommendations of a MSHA supervisory mining engineer (B.L. Ryan, personal communication), and a NIOSH safety engineer (L. Rethi, personal communication). ''Mostly enclosed'' referred to locations generally protected from environmental cold, such as inside

buildings/shantys, or inside the cab of vehicles or machinery; ''outdoor'' referred to locations not generally protected; and ''enclosed/outdoor'' involved work in both locations. Outdoor job titles included auger operator, auger helper, rock driller, drill helper, barge attendant, coal sampler, quarryworker, shooter/blaster, and prep-pit/mill/maintenance/outdoor foreman. Enclosed/outdoor job titles included jobs such as electrican, carpenter, mechanic repairman, welder, safety director, and clean-up man. Job titles typical of the mostly enclosed work location included dispatcher, hoistman, engineer, operators of heavy equipment such as bulldozers, cranes, highlifts, booms, etc., as well as driver of supply, refuse, water, etc., trucks. The job title ''timekeeper/clerk/office help'' was also in the enclosed category, but this job title contributed less than 1% (n = 17) of the total injuries to the enclosed group. Although many of the workers in the enclosed group operated equipment outside, much of their time spent doing their job, i.e., operating equipment, took place inside the cab of the equipment in a protected, enclosed environment, thus these were considered mostly enclosed jobs. While these workers would receive some exposure to environmental cold during their work activities (such as entering/exiting vehicles and machines, unloading, making deliveries, positioning equipment, etc.), it was assumed that they would have more opportunity to be protected inside a heated vehicle/machine cab than workers who were outside for much longer periods of time.

In the mostly enclosed group, there existed the possibility that older models of certain pieces of heavy machinery may not have heated cabs. The result of this could be that some operators of these types of equipment may actually be exposed all day to environmental cold. To address this issue, the job titles corresponding to pieces of equipment that may not have heated cabs in older models were identified (L Rethi, personal communication) so that their contribution to the patterns seen in the enclosed work location could be ascertained.

Statistical Analyses; Temperature Association

Proportionate injury ratios [Hunting and Weeks, 1993], which are analogous to proportional mortality ratios, were used to examine differences in injuries among the work locations. Proportionate injury ratios and their 95% confidence intervals were calculated using SAS/STAT software [SAS, 1990] following the methods of Mantel and Haenszel [Mantel and Haenszel, 1959; Boyle and Parkin, 1991]. To compensate for differences in age distributions among the three occupation locations, proportionate injury ratios were age standardized using 10-year intervals, except for the first stratum, 18–24, which was a 7-year interval [Kupper et al., 1978; Boyle and Parkin, 1991].

The mostly enclosed work location was used as a reference population when comparing locations. It was predicted that mostly enclosed workers did not spend as much time exposed to cold temperatures as other workers and thus should be less affected by changes in environmental temperature. To relate injury to environmental temperature, injuries were matched with a temperature estimate from that same day in the same state. Weather data were obtained from the National Climatic Data Center (NCDC) in Asheville, NC. The NCDC is one of the National Oceanic and Atmospheric Administration's (NOAA) data centers and is responsible for housing and distributing climatic data. The estimates of daily temperature were calculated by averaging the daily temperatures from the major metropolitan weather stations for each state (ranging from four to seven stations per state). Temperatures were grouped into three classes, 32° F (0° C) and less, > 32–50° F (> 0–10° C), and > 50° F (> 10° C). When assessing differences among temperature classes, the > 50° F class was used as a reference category.

RESULTS

A total of 18,628 injuries were used in the analysis (Fig. 1). Of these injuries, 5,820 were incurred by mostly enclosed workers, 2,751 by outdoor workers, and the remaining 10,057 by people who worked both in enclosed locations and outdoors. Slips and falls were the second most numerous type of injury (n = 4,600), accounting for 25% of the total number of injuries (Fig. 2). Distribution of ages was found to differ significantly among the three work locations ($\chi^2 = 68.4$, $P = 0.001$), thus justifying age-standardization in subsequent analyses. Differences among the locations were strongly influenced by a less than expected number of workers 18 to 24 years old in the mostly enclosed location, and more than expected in the enclosed/outdoor location. Proportions of major types of injury differed among the three work locations ($\chi^2 = 1237.6$, $P = 0.001$) (Fig. 2). Slips and falls also ranked second within each work location separately, accounting for 30% (n = 1,761) of total injuries to mostly enclosed workers, 26% (n = 703) to outdoor workers, and 21% (n = 2,136) to enclosed/outdoor workers.

Both the enclosed/outdoor and outdoor work locations had significantly lower slip/fall injury ratios than the mostly enclosed location (Table I). In the examination of slip and fall-related injuries by temperature class, it was found that the proportional injury ratio of slips and falls increased significantly as the temperature decreased (Table II). This pattern also was evident in all three work locations when examined separately.

To address the issue that older models of certain pieces of equipment may not have heated cabs, the slip and fall-related injuries by temperature class analysis (Table II) was repeated for the enclosed group, without the job titles

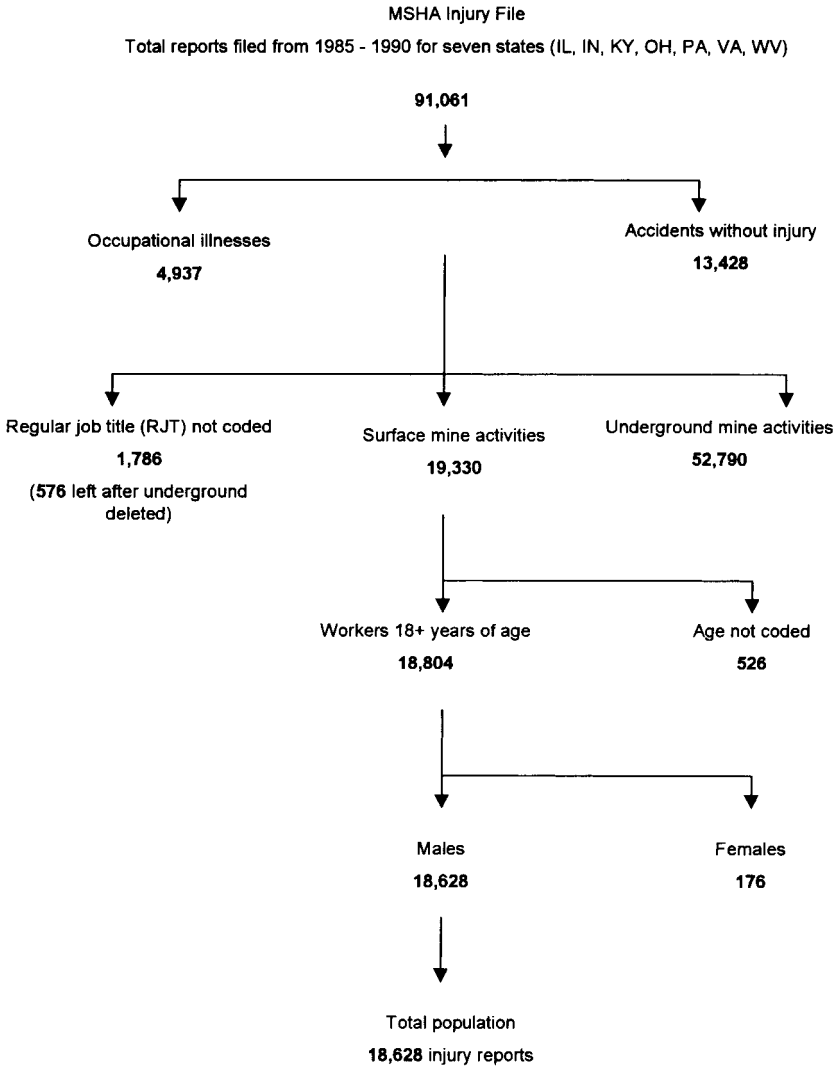

FIGURE 1. Selection of study group from Mine Safety and Health Administration dataset for injuries occurring from 1985–1990 in seven states with the highest numbers of reported injuries (IL, IN, KY, OH, PA, VA, WV).

corresponding to these pieces of equipment. The resulting odds ratio at $\leq 32°F$ ($\leq 0°C$) compared to $> 50°F$ ($> 10°C$) was 1.64 and was still statistically significant (95% CI were 1.31–2.05, $P < 0.0001$), indicating that there was still an increased proportion of slip and fall-related injuries at freezing temperatures in comparison to warmer temperatures. This indicates that these potentially misclassified injuries were not the driving force behind the association of slip and fall-related injuries with cold temperatures, and since both groups showed the same pattern independent of one another, they were kept together in the same work location for the rest of the analyses.

Although handling material injuries comprised the greatest proportion of injuries over all temperatures combined, at freezing temperatures, slip and fall-related injuries accounted for the greatest proportion in the outdoor and mostly enclosed work locations (36 and 40%, respectively), and the second greatest proportion in the enclosed/outdoor work location (27%) (Table II). At freezing temperatures, handling material injuries ranked second in the outdoor and mostly enclosed locations, at 34 and 24%, while ranking first in the enclosed/outdoor location at 32%.

The largest number of total slip/fall injuries occurred while workers were "getting on or off equipment or machinery" (Table III). Mine worker activity during slip or fall differed significantly among the work locations ($\chi^2 = 416.7$, $P = 0.001$). The majority of slip/fall injuries in the mostly enclosed and enclosed/outdoor work locations occurred while "getting on or off equipment or machinery," followed by "running/walking." In the outdoor location, the position of these two categories was reversed. As temperature declined below freezing, there was an increase in proportion of slip and fall-related injuries that occurred

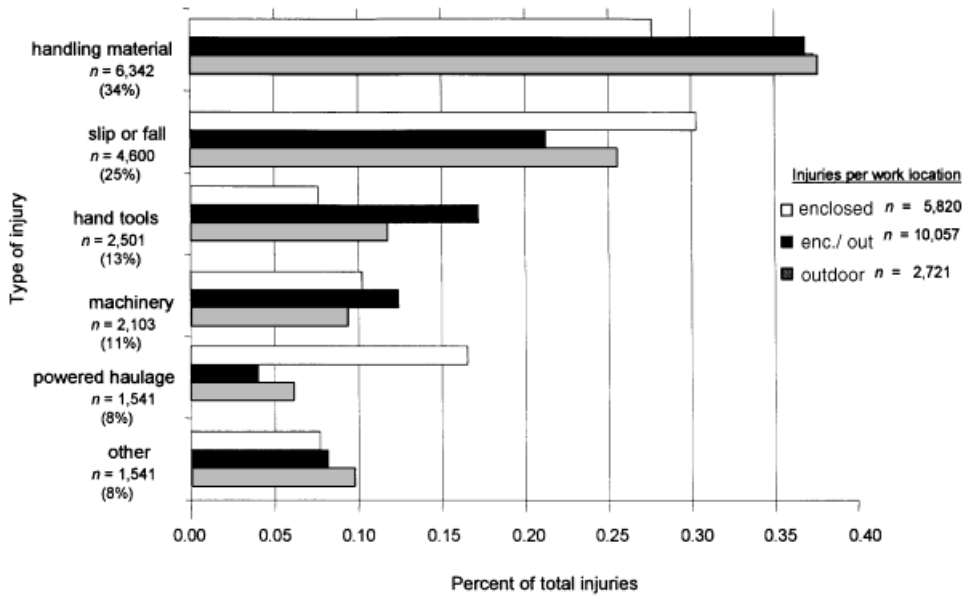

FIGURE 2. Proportion of each type of injury to total injuries (n = 18,628) in each of the three work locations.

TABLE I. Age-Adjusted Proportionate Injury Ratios Comparing Slip and Fall-Related Injuries to all Other Injuries for the Mostly Enclosed, Outdoor, and Enclosed/Outdoor Work Locations

Work location	Total injuries	Injury ratio	95% CI	*P*-value
Mostly enclosed	5,820	1.00	1.00	
Enclosed/outdoor	10,057	0.62	0.58–0.67	0.001
Outdoor	2,721	0.79	0.72–0.88	0.001

while running/walking in all three work locations (Table IV). At freezing temperatures, the largest portion of slips and falls occurred while running/walking in both the outdoor and enclosed/outdoor locations. Slips and falls while running/walking ranked second in the mostly enclosed work location; however, this group showed the greatest proportional increase at freezing temperatures. Over all work locations, the relative importance of slip and fall-related injuries occurring during running or walking increased with the decline in temperature (Table IV).

We further examined slips and falls while running/walking by looking at the source of injury, i.e., the object, surface, exposure, or bodily motion that directly produced or inflicted this type of reported injury (Table V). In all three work locations, the ground, walking surface, or steps/stairs outside were the greatest (or tied for the greatest) source of this type of injury over all temperatures. These outside surfaces accounted for 50% of the source of injury for mostly enclosed work locations, 34% for outdoor locations, and 39% for enclosed/outdoor locations, over all temperatures. The inside floor, walking surface, or steps/stairs came second (or tied, in the outdoor location), accounting for 24% of the source of injury for mostly enclosed work locations, 34% for outdoor locations, and 32% for enclosed/outdoor work locations, over all temperatures combined. The ground, walking surface, or steps/stairs outside was the only source of slip or fall while running/walking show a strong proportional association with declining temperature. This was the most important source of running/walking injuries at freezing temperatures in all work locations.

Of the 4,600 total slip and fall-related injuries, there were two fatalities, and less than 1% resulted in permanent total or permanent partial disability. The bulk of the remaining 4,561 slip and fall-related injuries (81%) resulted in days away from work, and 2% resulted in days of restricted work activity only. 17% were injuries that did not result in days away from work, nor restricted work activity.

DISCUSSION

Slips and falls became more important in relation to other types of injury at colder temperatures, constituting a substantial proportion of total injuries. While some work has shown occupational slip and fall-related injuries to increase at lower temperatures [Hassi et al., 2000; CDC, 1995; Leamon and Murphy, 1995], little has been done to compare

TABLE II. Age-Adjusted Proportional Injury Ratios of Slip and Fall-Related Injuries to Total Injuries in Each Temperature Class for all Work Locations Separately and Combined

Work location/temperature class	Total injuries	Proportion of slip/fall injuries	Injury ratio	95% Confidence interval	*P*-value
Mostly enclosed					
> 10°C (50°F)	3,416	28%	1.00	1.00	
> 0–10°C (32–50°F)	1,593	30%	1.10	0.96–1.25	0.161
0°C (32°F) and under	811	40%	1.73*	1.48–2.03	0.001
Enclosed/outdoor					
> 10°C (50°F)	5,866	19%	1.00	1.00	
> 0–10°C (32–50°F)	2,830	22%	1.17*	1.05–1.30	0.005
0°C (32°F) and under	1,361	27%	1.55*	1.36–1.78	0.001
Outdoor					
> 10°C (50°F)	1,623	24%	1.00	1.00	
> 0–10°C (32–50°F)	769	25%	1.08*	0.89–1.32	0.441
0°C (32°F) and under	359	36%	1.78*	1.40–2.29	0.001
All locations combined					
> 10°C (50°F)	10,905	23%	1.00	1.00	
> 0–10°C (32–50°F)	5,192	25%	1.13	1.04–1.22	0.002
0°C (32°F) and under	2,531	33%	1.64*	1.49–1.80	0.001

*Denotes Statistical Significance at $P \leq 0.05$.

TABLE III. Proportion of Total Slip and Fall-Related Injuries (n = 4,600) Occurring in Each Mine Worker Activity Category and Work Location[a]. Absolute Number of Injuries is Shown Under the Proportion in Each Cell

Mine worker activity at time of injury	Mostly enclosed	Enclosed/outdoor	Outdoor
Getting on/off equipment, machinery	55.6%	28.8%	25.3%
n = 1,773	(979)	(616)	(178)
Running/walking	16.1%	23.8%	32.3%
n = 1,020	(285)	(508)	(227)
Handling supplies/material, not timber or cables	10.3%	14.8%	14.2%
n = 598	(182)	(316)	(100)
Machine repair/maintenance	7.5%	14.9%	6.4%
n = 496	(132)	(319)	(45)
All other activities	10.4%	17.7%	21.8%
n = 713	(183)	(377)	(153)

[a]Not all column percentages add to 100 due to rounding. Row percentages not shown.

how enclosed vs. outdoor workers are affected. Although it was predicted that people who worked outside would have the highest proportion of slips and falls at cold temperatures, this was not entirely the case. Slip and fall-related injuries were associated with cold in all three work locations, as all showed a proportional increase in slips and falls as temperature declined. Over all temperatures, slips and falls were a more important source of injury for the enclosed location than other locations. Slips and falls have been documented elsewhere as an important source of injury in jobs such as truckers and drivers [Nicholson and David, 1985; Leamon and Murphy, 1995], which in the current study, along with equipment operators, were many of the jobs classified as mostly enclosed work.

The only type of slip and fall injury incident to show a strong increase with declining temperature were those that occurred while running or walking. This pattern was evident in all the work locations. Upon further examination, we found that a considerable percentage of running/walking slips and falls, regardless of whether job title was classified as ''mostly enclosed,'' ''outdoor,'' or ''enclosed/outdoor,'' had an outside surface as the source of injury, indicating

TABLE IV. Proportion of Slip and Fall-Related Injuries (n = 4,600) in Each Mine Worker Activity by Work Location and Temperature Class

	Mine worker activity at time of injury				
Work location/temperature class	**Getting on/off equipment, machinery**	**Running/walking**	**Handling supplies**	**Machine repair, maintenance**	**Other**
Mostly enclosed					
> 10°C (50°F)	56% (538)	15% (139)	10% (96)	7% (71)	12% (111)
> 0–10°C (32–50°F)	58% (280)	13% (62)	11% (55)	8% (40)	9% (42)
0°C (32°F) and under	49% (161)	26% (84)	9% (31)	6% (21)	9% (30)
Enclosed/outdoor					
> 10°C (50°F)	29% (330)	22% (250)	14% (163)	16% (184)	19% (214)
> 0–10°C (32–50°F)	31% (193)	22% (134)	16% (102)	14% (88)	17% (106)
0°C (32°F) and under	25% (93)	33% (124)	14% (51)	13% (47)	15% (57)
Outdoor					
> 10°C (50°F)	25% (95)	33% (125)	14% (54)	6% (23)	22% (85)
> 0–10°C (32–50°F)	24% (47)	30% (57)	13% (25)	9% (17)	24% (47)
0°C (32°F) and under	28% (36)	35% (45)	16% (21)	4% (5)	16% (21)
All locations combined					
> 10°C (50°F)	39% (963)	21% (514)	13% (313)	11% (278)	17% (410)
> 0–10°C (32–50°F)	40% (520)	20% (253)	14% (182)	11% (145)	15% (195)
0°C (32°F) and under	35% (290)	31% (253)	12% (103)	9% (73)	13% (108)

TABLE V. Source of Injury (i.e., The Object, Surface, Exposure, or Bodily Motion Which Directly Produced or Inflicted the Reported Injury) for Slip and Fall-Related Injuries That Occurred While Person was Running/Walking (n = 1,020) by Work Location and Temperature Class

Work location/temperature class	**Outside-ground, walking surface, steps/stairs**	**Inside-floor, walking surface, steps/stairs**	**Metal (wire, pipe, nails), broken rock, coal, waste, etc.**	**Vehicle, truck, car, surface mining machine, etc.**	**Other**
Mostly enclosed					
> 10°C (50°F)	46% (64)	25% (35)	9% (12)	8% (11)	12% (17)
> 0–10°C (32–50°F)	47% (29)	27% (17)	5% (3)	7% (4)	15% (9)
0°C (32°F) and under	57% (48)	19% (16)	7% (6)	5% (4)	12% (10)
Enclosed/outdoor					
> 10°C (50°F)	30% (76)	35% (87)	9% (23)	3% (8)	22% (56)
> 0–10°C (32–50°F)	37% (50)	36% (48)	8% (11)	2% (2)	17% (23)
0°C (32°F) and under	58% (72)	22% (27)	7% (8)	2% (2)	12% (15)
Outdoor					
> 10°C (50°F)	24% (30)	41% (51)	12% (15)	0% (0)	23% (29)
> 0–10°C (32–50°F)	42% (24)	30% (17)	9% (5)	2% (1)	18% (10)
0°C (32°F) and under	53% (24)	22% (10)	2% (1)	2% (1)	20% (9)
All locations combined					
> 10°C (50°F)	33% (170)	34% (173)	10% (50)	4% (19)	20% (102)
> 0–10°C (32–50°F)	41% (103)	32% (82)	8% (19)	3% (7)	17% (42)
0°C (32°F) and under	57% (144)	21% (53)	6% (15)	3% (7)	13% (34)

specifically that the injury occurred out of doors. Although it has been suggested that outdoor weather conditions such as snow and ice can make inside conditions more slippery [Leamon and Murphy, 1995], we did not see an increase in slip and fall-related injuries where inside surfaces were the source of injury as temperature declined. The percentage of outside surface source injuries increased in all work locations as temperature declined, indicating that outside movement becomes a greater hazard at freezing temperatures for workers in all locations, not just outdoor workers. It is possible that even more injuries occurred outside, but were not categorized that way because they were not specifically coded as occurring outside. For example, it is likely that slips and falls where broken rock, coal, waste, etc., was the source of injury occurred outside, but they were not coded as to where the injury took place.

It is evident that the strongest factor driving the overall proportional increase in slips and falls at freezing temperatures was the proportional increase in injuries occurring while running/walking. However, the possibility exists for increases in injury during other activities (such as getting on/off machinery, repairing/maintaining machinery or handling material) at cold temperatures, too, as cold weather may lead to slippery surfaces on vehicles and equipment, reduced dexterity for tool and equipment handling, or creating wet patches inside buildings. If there were small increases in injury during these activities, they could have been masked by the larger increases in running/walking-related injuries. This is a limitation of proportional analyses that we cannot circumvent. Because the MSHA datasets do not provide an estimate of person-hours at risk for each job title, proportional analyses were necessary to investigate the relation of injuries to cold. The usefulness of proportional analyses has been discussed widely in the epidemiological literature [Kupper et al., 1978; DeCoufle et al., 1980; Miettinen and Wang, 1981; Saracci, 1981; Wong and DeCoufle, 1982; Walter, 1986]. When examining relative importance, large increases in one type of injury may mask smaller increases in another type of injury, thus making them undetectable. Furthermore, an elevated proportional ratio can indicate a true elevation in risk, or it may be a reflection of a lowered risk for some other cause. However, choosing an employed population as a reference group can mitigate this problem [Notkola et al., 1987; Zwerling et al., 1995]. Because of the limitations of proportional methods, they commonly are used to generate preliminary results and hypothesis for future study.

Another limitation of this study is that temperatures on each day are state-wide averages, and may not reflect exact temperatures at each mine location. Because the weather stations used were metropolitan, temperatures could be warmer (due to the ''urban heat island'' effect) than actual conditions at the mines, which are likely to be in more rural areas. This could result in slip and fall-related injuries appearing to occur at temperatures higher than those at which they actually occurred. However, despite the possibility for reporting slightly elevated temperatures, there still was a strong increase in the proportion of slip and fall-related injuries below freezing. Thus, the use of metropolitan weather stations did not dampen the cold association.

Slips and falls occurring in surface-mining activities are capable of producing serious injuries, as has been noted with other occupational groups [Manning, 1983; Buck and Coleman, 1985; Leamon and Murphy, 1995]. In the current study, of the 4,545 slip and fall-related injuries that did not result in either death or permanent disability, 82% resulted in days away from work. Only 17% of the slips and falls were not serious enough to warrant time off work, nor restricted work activity. Our findings indicate that the effects of environmental temperature may be felt by all workers, including workers who spend most of their time in a mostly enclosed environment, because many enter and leave their protected environment during the work day. The donning of protective outdoor footwear by mostly enclosed workers who go outside even for short periods, may reduce slips and falls occurring outside. Any work done to improve outside surfaces, such as salting or graveling stairs, walkways, and parking lots could improve conditions for both mostly enclosed and outdoor workers. In conclusion, any intervention methods geared toward reducing injury incidents facilitated by cold weather must also be directed toward workers who do not have full-time outside work. Due to the instantaneous nature of slip and fall incidents, those whose work may expose them to environmental cold even for brief periods of the day may be at increased risk during these periods.

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