Transportation Fatalities in the Mining Sector: 2004—2008

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Transportation accidents are the leading cause of occupational fatalities in the mining industry. The younger the worker is, the greater the likelihood of the worker becoming a victim of these types of fatalities. A substantial portion of transportation fatalities result from jackknifed and overturned vehicle accidents. This study identifies some of the factors associated with these high fatality rates.

The mining, quarrying, and oil and gas extraction sector is composed of employers in oil and gas extraction, coal mining, metal ore mining, nonmetallic mineral mining and quarrying, other types of mining, and mining support activities. It has been identified as one of the more hazardous industries in terms of occupational fatality rates. In 2007 for example, when the United States industry-wide fatality rate was 4.3 fatalities per 100,000 employed persons, the mining sector experienced a fatality rate of 21.4 fatalities per 100,000 workers. During this period, the subsector fatality rates ranged from 13.3 fatalities per 100,000 workers in the oil and gas extraction subsector to as high as 24.8 fatalities per 100,000 workers in the coal mining subsector.[1]

Mining subsectors. The variability in subsector fatality rates is due, in part, to the differences in the types of activities found in the different subsectors and their inherent hazards. The oil and gas extraction sector industries operate and develop oil and gas field properties. Activities may include exploration for crude petroleum and natural gas; drilling, completing, and equipping wells; operating separators, emulsion breakers, desilting equipment, and field gathering lines for crude petroleum and natural gas; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property.[2]

The term *mining* is used in the broad sense to include ore extraction, quarrying, and beneficiating (e.g., crushing, screening, washing, sizing, concentrating, and flotation), all of which are customarily done at the mine site.[3] The mining sector, as defined by the North American Industry Classification System (NAICS), includes coal mining, metal ore mining and nonmetallic mineral mining and quarrying. Industries in the mining (except oil and gas) subsector primarily engage in mining, mine site development, and beneficiating (i.e., preparing) metallic minerals and nonmetallic minerals, including coal. Of these subsectors, there has been extensive research conducted on coal mining. BLS data show that employees in coal mining are more likely to be killed or to incur a nonfatal injury or illness, and their injuries are more likely to be severe than workers in private industry as a whole.[4]

The NAICS defines the subsector support activities for mining as establishments primarily providing support services, on a contract or fee basis, required for the mining and quarrying of minerals and for the extraction of oil and gas. Establishments performing exploration (except geophysical surveying and mapping) for minerals, on a contract or fee basis, are included in this subsector.[5]

Events. Previous research has identified differences in the events that resulted in an occupational fatality across the various mining industry subsectors. Because the nature of the work varies greatly across subsectors, so do the hazards the workers are exposed to on the job. For example, the leading causes of injuries in surface mine environments include materials handling, slips and falls, machinery, hand-tool use, power haulage, and electrical source contact.[6] A study conducted by the National Institute for Occupational Safety and Health found that power haulage events were involved in most fatalities in surface mining work locations and fall-of-ground events occurred most often in underground mining locations.[7]

In the oil and gas industry, the three most frequent fatal events in 2008 were transportation incidents (41 percent), contact with objects and equipment (25 percent), and fires and explosions (15 percent).[8] Support activities for oil and gas operations (NAICS code 213112) accounted for about half of fatal work injuries in oil and gas industries, on average, with 69 fatal work

injuries recorded in 2008, while drilling oil and gas wells (NAICS code 213111) averaged 34 fatal work injuries over the 5-year period, with 37 percent resulting from contact with objects and equipment.[9]

Worker age and occupational fatalities. The relationship between the age of a worker and the likelihood that he or she will sustain an occupational fatality has been confirmed in a number of studies.[10] This relationship may exist for a number of reasons including a lack of work experience by the victim, increased exposure to hazards from assigning younger workers more dangerous job tasks, and a reduced chance for older workers to survive a serious injury. Relationships between the age of the worker and specific events leading to the fatality have also been identified in a number of studies. For example, relationships have been identified between the victims age and involvement in fatal transportation accidents, electrocutions, and fatal falls.[11]

Although it has been well documented that workers in the mining industry experience injuries and fatalities at much higher rates than those in other industry sectors in the United States, the purpose of this study is to identify factors that are associated with these higher rates. Factors examined in this study include the age of the worker, the differences in fatality experiences across mining subsectors, and the events that led to a fatal transportation incident in the industry.

Method

Data. This study uses data from the BLS Census of Fatal Occupational Injuries (CFOI). The CFOI is an official, systematic, verifiable count of all fatal occupational injuries that occur during the year. It has been adopted by the National Safety Council and other organizations as the authoritative source for a complete count of fatal work injuries in the United States.[12]

To ensure that the fatalities are work related, cases are substantiated with two or more source documents or a source document and a follow-up questionnaire. The work-related deaths were classified as such if a work relationship could be established. Such a relationship was established if an event or exposure resulted in a fatal injury or illness of a person on the employers premises and the person was there to work. A work relationship was also established if the fatal injury or illness occurred off the employers premises and the person was there to work, or the event or exposure was related to the persons work or status as an employee.[13]

In this study, fatalities that occurred in the mining sector during the period from January 1, 2004, to December 31, 2008, were analyzed. The mining sector was defined as cases reported in mining, quarrying, and oil and gas extraction (NAICS code 21), as defined by the North American Industry Classification System. The cases were further classified into industry subsectors following the methods outlined in the NAICS manual.[14] To be included in this analysis, the workers had to be 16 years or older at the time of the event. For each case, data pertaining to the industry sector classification, year of the event, age of the victim, and transportation event descriptors were analyzed. The victim age classifications and fatality events were defined using the methods described in the Occupational Injury and Illness Classification Manual.[15]

Descriptive statistics. Descriptive statistics include the frequencies and percentages of cases by fatality event, age of the worker, and mining industry subsector. Fatality rates were calculated using the number of fatalities as determined by the CFOI data and the number of persons employed by detailed industry, sex, and age, as determined by data from the Current Population Survey (CPS).

Rate ratios. The *rate ratio* (RR) is a measure of association based on mortality rates. The methods for calculating the rate ratios and confidence intervals (CI) obtained in this study were those described by Kelsey and others.[16] Rate ratios and 95-percent confidence intervals were calculated by age group, comparing the fatality rate resulting from a particular event for the mining sector to the fatality rate that results from the same event for all other industries combined. The fatality rates were calculated using the number of fatality cases and the person-years of exposure as determined by the total number of employed persons for the 5-year analysis period. The 95-percent confidence intervals were used to determine whether significant associations exist between the fatality rates and industry sector across age groups.

Proportionate mortality ratios. A proportionate mortality ratio (PMR) was calculated for each NAICS industry classification following the procedures described by Spiegelman, Wang, and Wegman in their 1983 study, as well as those of Mantel and

Haenszel.[17] Mantel-Haenszel chi-square tests of significance were performed to determine if the proportion of observed jackknife and turnover deaths are significantly different from what would be expected.

Results

From January 1, 2004, to December 31, 2008, there were 862 fatalities identified in the CFOI data for the mining industry involving workers 16 years old and older. Approximately 92 percent of all fatalities were due to four events. Transportation accidents accounted for the largest percentage of fatalities, accounting for approximately 38 percent of all deaths, followed closely by fatalities involving contact with objects and equipment (34 percent). Table 1 provides a summary of the number of fatalities by event category. The fatality data for the four top event categories was further examined to determine fatality rates and rate ratios.

Table 1. Frequency of mining industry fatalities, by major event group, age 16 years and over, 2004-2008

Event	Frequency	Percent
Transportation	326	37.8
Contact with objects/equipment	291	33.8
Fires and explosions	96	11.1
Exposure to harmful environments	78	9.0
All other events	71	8.2
Total	862	100.0

Source: U.S. Bureau of Labor Statistics

The exposure measure used in this study was the number of employed persons as determined by the Current Population Survey (CPS). During the 5-year analysis period, the number of persons employed in the mining industry increased from approximately 539,000 in 2004 to approximately 819,000 in 2008. (See table 2.) The largest increase in employment occurred in the subsector support activities for mining—from 256,000 in 2004 to 498,000 in 2008, a 95-percent increase.[18]

Table 2. Employment in mining, age 16 years and over, 2004-2008

Industry	2004	2005	2006	2007	2008	Total
Oil and gas extraction	66,000	89,000	107,000	96,000	76,000	434,000
Coal mining	87,000	82,000	95,000	95,000	100,000	459,000
Metal ore mining	17,000	18,000	35,000	36,000	36,000	142,000
Nonmetallic mineral mining and quarrying	107,000	99,000	105,000	107,000	101,000	519,000
Type of mining not specfied	5,000	5,000	4,000	9,000	7,000	30,000
Support activities for mining	256,000	330,000	341,000	393,000	498,000	1,818,000
Total	538,000	624,000	687,000	736,000	818,000	3,402,000

Source: U.S. Bureau of Labor Statistics

Subsector analysis. Fatality rates were calculated for select mining subsectors using employment figures and the number of fatality cases for those subsectors. Fatality rates ranged from 18.5 fatalities per 100,000 person-years in the nonmetallic mineral mining and quarrying subsector to 32.5 fatalities per 100,000 person-years in the coal mining subsector. (See table 3.)

Table 3. Frequency of fatalities and fatality rates in selected mining industries, by major event group, age 16 years and over, 2004-2008

Industry	Frequency	Percent	Fatality rate (deaths per 100,000 person-years)
Oil and gas extraction (NAICS 211)	104	12.1	24.0
Coal mining (NAICS 2121)	149	17.3	32.5
Metal ore mining (NAICS 2122)	34	4.0	22.5
Nonmetallic mineral mining and quarrying (NAICS 2123)	96	11.1	18.5
Support activities for mining (NAICS 213)	476	55.2	26.2
Total	862	100.0	25.5

Note: Total may include subcategories not shown separately.
Source: U.S. Bureau of Labor Statistics

Transportation fatalities. As mentioned previously, transportation fatalities accounted for the greatest percentage of fatalities in the mining industry, with approximately 38 percent of all deaths. Over the 5-year period, 326 fatalities occurred in the mining industry, compared with 11,531 in all other industries. The fatality rate involving transportation accidents for the mining industry was 9.6 deaths per 100,000 person-years, compared with 1.6 deaths per 100,000 person-years for all other industries. (See table 4.)

Table 4. Frequency of fatalities and fatality rates due to transportation accidents, age 16 years and over, 2004-2008

Industry	Mining industry	All other industries
Transportation fatalities (N)	326	11,531
Percent of all fatalities	37.8	41.0
Transportation fatality rate (per 100,000 person-years)	9.6	1.6

Source: U.S. Bureau of Labor Statistics

A further breakdown of the transportation fatalities by event shows that, within the mining industry, highway accidents accounted for approximately 59 percent of all transportation deaths followed by nonhighway accidents (except rail, air, and water) with approximately 17 percent. (See table 5.)

Table 5. Frequency of transportation fatalities by event category, age 16 years and over, 2004-2008

Event	Frequency	Percent
Highway accidents	193	59.2
Nonhighway accidents (except rail, air, water)	55	16.9
Pedestrian, nonpassenger	33	10.1
Aircraft accident	20	6.1
Water vehicle accident	16	4.9
Railway accident	9	2.8
Total	326	100.0

Source: U.S. Bureau of Labor Statistics

To determine if there were increased risks for fatalities involving transportation accidents in the mining industry by age group, rate ratios and 95-percent confidence intervals were calculated. The rate ratios compared the fatality rate in the mining industry with the fatality rate for all other industries combined for a particular event. The rate ratios indicated that for all age

groups, the fatality rates for transportation accidents in the mining industry were significantly greater than the rates for all other industries. In addition, the rate ratio was greatest for workers in the 16- to 19-year age group (RR = 13.7; CI = 5.7, 33.3) and decreased as the workers age increased. The rate ratios and confidence intervals for all age groups appear in table 6.

Table 6. Rate ratios for transportation fatalities in the mining industry compared with all other industries by age group, age 16 years and over, 2004-2008

Age group	Rate ratio	95-percent confidence interval
16-19 years old	13.7	(5.7, 33.3)
20-24 years old	10.6	(7.5, 14.9)
25-34 years old	7.4	(5.8, 9.3)
35-44 years old	6.1	(4.8, 7.8)
45-54 years old	5.1	(4.1, 6.4)
55-64 years old	4.6	(3.4, 6.1)
65 years and over	4.5	(2.9, 7.1)

The 10 most frequent events that led to an occupational fatality were identified and are summarized in table 7. These 10 events accounted for 243 fatalities and approximately 83 percent of all transportation fatalities in the mining sector during the analysis period. Accidents involving jackknifed or overturned vehicles on the highway were the most frequently identified event, accounting for approximately 22 percent of all mining sector transportation fatalities. Approximately 39 percent of the jackknifed or overturned vehicle fatalities involved tractor trailers, while another 36 percent involved pickup trucks.

Table 7. Top 10 leading events for transportation fatalities in the mining industry, age 16 years and over, 2004-2008

Event	Frequency	Percent of All Transportation Fatalities
Jackknifed or overturned (no collision) highway accident	70	21.5
Moving in opposite directions, oncoming	43	13.2
Vehicle struck stationary object or equipment in roadway	32	9.8
Overturned vehicle, nonhighway accident	26	8.0
Pedestrian struck by vehicle	26	8.0
Re-entrant accident, moving in intersection	16	4.9
Aircraft accident	16	4.9
Re-entrant accident, moving in same direction	15	4.6
Vehicle struck stationary object, other than a vehicle	13	4.0
Fall from ship, boat	12	3.7
Total	243	82.5

Source: U.S. Bureau of Labor Statistics

To determine how the proportion of jackknife transportation fatalities in the mining industry compares with that of all other industries, proportionate mortality ratios (PMRs) were calculated along with the appropriate chi-squared significance tests.[19] (See table 8.) Results indicate that the mining industry, along with the wholesale trade industry and the transportation and warehousing industry, experienced significantly greater-than-expected proportions of jackknifed and overturned vehicle accidents, but the mining industrys observed proportion was the largest by a substantial margin. The PMR for mining was 197.19 ($X^2 = 37.57$, $p < .05$), whereas the PMR for the wholesale trade industry was 158.16 ($X^2 = 22.70$, $p < .05$), and the PMR for the transportation and warehousing industry was 113.19 ($X^2 = 9.48$, $p < .05$). The PMR of 197.19 indicates that the mining industry experienced approximately 197 percent of the number of jackknifed and overturned vehicle accidents in all industries.

Table 8. Proportionate mortality ratios by NAICS code comparing jackknifed and overturned vehicle deaths with all transportation deaths

Industry	NAICS Code	Jackknifed or overturned vehicle fatalities	Total transportation fatalities	Fatalities, other	Expected	Variance	X^2	PMR
Agriculture, forestry, fishing, & hunting	11	125	1,581	1,456	172.16	133.06	17.07	*72.61
Mining	21	70	326	256	35.5	30.77	37.57	*197.19
Utilities	22	8	76	68	8.28	7.33	0.08	96.67
Construction	23	189	1,624	1,435	176.84	136.11	1	106.88
Manufacturing	31	75	591	516	64.35	54.51	1.89	116.54
Wholesale trade	42	93	540	447	58.8	50.03	22.7	*158.16
Retail trade	44	50	506	456	55.1	47.02	0.67	90.75
Transportation and warehousing	48	406	3,294	2,888	358.69	231.25	9.48	*113.19
Information, real estate, finance	51-56	134	1,339	1,205	145.8	115.33	1.31	91.9
Education and healthcare	61-62	31	603	572	65.66	55.55	22.25	*47.21
Arts, recreation, food services	71	18	330	312	35.93	31.14	10.91	*50.09
Other services	81	17	251	234	27.33	23.84	4.92	*62.20
Public administration	92	81	850	769	92.56	76.6	1.9	87.51
Total		1,297	11,911	10,614	1,297.00	n/a	n/a	n/a

* PMR is significant at the .05 level.

Discussion

From 2004 to 2008, fatality rates in the mining sector were much higher than those in other industries in the United States. The fatality rates ranged from 18.5 fatalities per 100,000 persons employed in nonmetallic mineral mining and quarrying to 32.5 fatalities per 100,000 persons employed in coal mining.

The leading event for fatalities across all of the mining subsectors was transportation incidents. A primary reason for these kinds of fatalities is an increased level of workplace exposures to hazards. In other words, one could reasonably conclude that a majority of mining fatalities resulted from transportation accidents and contact with equipment because of the large extent to which transportation and production equipment are used in the industry.

Transportation accidents accounted for the greatest number of deaths for all age groups in mining and also resulted in significantly higher fatality rate ratios compared with all other industries. The majority of all transportation fatalities involved over-the-road vehicles and highway accidents, and the fatality rate ratios were greatest for the youngest age group and lowest for the oldest. The fatality rate ratios were statistically significant across all age groups. These significant rate ratios across age groups indicate that in the mining industry, the number of highway transportation accidents per person employed is significantly higher than in other industries. The highest rate ratios occurred among younger workers, and the ratios decreased as age increased. The higher fatality rate ratios for the younger age groups in mining could be related to their relative lack of experience with transportation equipment that is unique to the mining industry and because younger workers are more likely to operate this kind of equipment. Both of these factors are likely to decrease as age increases.

One important finding in this study is the relationship between the age of the victims and their transportation fatality experience. The transportation fatality rates and corresponding rate ratios identified significant differences in the fatality rates across age groups when the mining sector is compared with all other industries. Younger workers in the mining sector have significantly greater transportation fatality rates than their counterparts in other industries. Fatality rates generally decreased as worker age increased. However, the low rates that were found for the oldest age group were still many times greater than the rates for all other industries.

There are a number of possible reasons why the mining industry fatality rates decline as age increases. First, the trends might be related to differences in job tasks and hazard exposure. Younger workers may be more likely to work in a job task that exposes them to the kind of hazards that result in fatalities. As workers age, their responsibilities change and they are less likely to perform the more hazardous jobs.

Experience may also play a role in the fatality rate ratio trends. The youngest workers may be more likely to take risks or perform their job tasks in an unsafe manner because of a lack of experience. Numerous studies have indicated a negative relationship between time on the job and the likelihood of being involved in an accident. As the workers gain more experience on the job, they may be reducing their exposure to the job hazards by following safe procedures and taking fewer risks.

A second important finding of this study is the significantly greater proportion of fatalities due to jackknifed and overturned vehicles in the mining sector compared with all other industries combined. One plausible reason for this increased proportion of fatalities could in part be due to the types of vehicles being used in the mining industry and the types of loads being transported. As previously identified, approximately 39 percent of the jackknifed and overturned vehicle fatalities involved tractor trailers and approximately 36 percent involved pickup trucks. Accident descriptions indicated that a number of accidents involved vehicles that were loaded with material, as well as water tank trucks and vehicles towing mining equipment. Shifting material and liquids being hauled at the time may be a reason for the increased risk for a jackknifed or overturned vehicle involving the tractor trailers and tank trucks.

A large percentage of turnover accidents involving pickup trucks were the result of the vehicle leaving the roadway and then rolling over. In some cases, the reason for the pickup truck leaving the roadway was identified and in others it was not. Some examples of why the vehicle overturned included an inability to negotiate a curve and then leaving the roadway, swerving to avoiding another vehicle, and overcorrecting once the vehicle left the roadway.

Conclusion

The results from this study indicate that transportation fatality rates for workers are significantly greater for the mining industry compared with all other industries, with younger workers experiencing significantly higher rates than their counterparts in other industries. While accident prevention activities are necessary for all workers of all ages in mining, efforts should be focused on the younger workers engaged in the more hazardous job tasks that involve exposure to transportation equipment. It may be that the younger workers face greater exposure to these hazards; they also tend to have less experience on the job. These factors might help explain the higher fatality rates among younger workers.

Examples of prevention measures to stress include the use of engineering strategies to eliminate the hazards associated with fatalities involving contact with equipment and objects. Utilizing proper machine guarding techniques along with equipment maintenance programs to ensure guarding and safety devices remain in place and operable can go a long way toward eliminating many of the struck-by fatalities. But safeguarding and inspection programs should not just stop with equipment and machinery. The engineering and inspection programs should also focus on the mine structure itself to ensure that mine structure and its supports are adequate to prevent collapse of the walls, roof, and structure components.

Because it appears that fatality rates are greatest with younger workers, one method of offsetting the increased chances of a fatality due to inexperience is with *hazard recognition training*. This training can serve two purposes. First, because the younger workers lack work experience and have greater risk-taking behaviors, the training can make them aware of the potential hazards and control measures to follow. It may also be part of the mining and oil-and-gas-drilling culture to have the

new workers learn on the job rather than through formal instruction. But this lack of formal safety training may be contributing to the significantly higher fatality rates among younger workers.

Another possibility might be that the younger workers are exposed to some of the more deadly hazards on the job because of the manner in which work tasks are assigned in the mining sector. Exposing workers who are youngest and least experienced to the more dangerous jobs could help explain the higher fatality rates. Control measures could be implemented to eliminate the hazards where possible, reduce the likelihood of accidents, and train workers on the ways to recognize and avoid hazardous conditions, as well as to understand the consequences of performing job tasks in an unsafe manner, and the methods and techniques to follow in order to perform a job task safely.

The results from this study also identified significantly greater proportions of fatalities that result from jackknife and rollover accidents. Training and education programs for vehicle equipment operators could help reduce the likelihood of these jackknife and turnover accidents. Such training would include specific driving techniques to be used when hauling material, driving water tank trucks, and towing equipment. The hazards associated with driving tank trucks and tractor-trailers are well known—as evidenced, for example, by the special licensing requirements needed to obtain a commercial drivers license in the United States.

Defensive driving should be an integral part of all mining safety programs to reduce the accidents and fatalities involving pickup truck turnovers. Information contained in the accident descriptions suggests that, in many cases, if defensive driving skills had been used, the number of these types of fatalities might have been substantially reduced. One area needing additional research is in the investigation of the root causes for jackknife and turnover accidents.

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Notes

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18 U.S. Bureau of Labor Statistics, Current Population Survey (CPS), table 16, "Employed persons by detailed industry, sex and age, Annual Averages, 2004, 2005, 2006, 2007, and 2008; for more information, see CPS page of BLS website at http://www.bls.gov/cps/.

19 A proportionate mortality ratio (PMR) is the number of deaths from a specific cause in a specific period of time per 100 deaths from all causes in the same period. See *Terms of Environment: Glossary, Abbreviations and Acronyms*, U.S. Environmental Protection Agency website, on the Internet at http://www.epa.gov/OCEPAterms/.
