The Impact of Contract Operations on Safety in Underground Coal Mines

Buessing, Marric Grace


http://hdl.handle.net/2144/17892

Boston University
The Impact of Contract Operations on Safety in Underground Coal Mines

Corresponding Author:
Leslie I. Boden, PhD; lboden@bu.edu
Department of Environmental Health
Boston University School of Public Health
715 Albany Street, T-444W, Boston, MA 02118
Phone: 617-638-4635. Fax: 617-638-4857

First author: Marric Buessing, PhD, Department of Environmental Health, Boston University School of Public Health, Boston, MA; buessing@bu.edu

Running title: Contractor Operations and Coal Mine Safety

Funding: The Alpha Foundation for the Improvement of Mine Safety and Health, Grant AFSTI14-1.

Acknowledgments: We gratefully acknowledge funding from the Alpha Foundation for the Improvement of Mine Safety and Health, grant AFSTI14-1. We received excellent research assistance from Kathryn S. Tomsho, Andrew Busey, and Gregory MacAtee. The findings and conclusions are those of the authors and do not necessarily represent the views of the Alpha Foundation for the Improvement of Mine Safety and Health.

Potential conflicts of interest: The authors have no potential conflicts of interest to declare.
ABSTRACT

Objective:

To test for differences in injury rates for contract-operated underground coal mines relative to owner-operator mines in Kentucky, controlling for other covariates.

Methods:

We used disparities between MSHA contractor data and surface reclamation permit data to identify mines operated by contractors. We then used negative binomial regression to estimate injury rates from 1999-2013, controlling for mine and controller characteristics available from MSHA and the Energy Information Administration (EIA).

Results:

Contractor-operated mines with 15 or fewer full-time equivalents (FTEs) had a statistically-significant 57 percent higher covariate-adjusted reported traumatic injury rate than similar mines without contract operators. Larger contractor-operated mines did not have a statistically significant elevated rate.

Conclusions: We detected a significant elevation of traumatic injury rates only among the smallest contractor-operated mines. This increase appears substantial enough to warrant attention.
The Impact of Contract Operations on Safety in Underground Coal Mines

How a firm chooses to allocate employment has important consequences for the health and safety of workers. Weil\(^1\) discusses the use of subcontracting arrangements across a number of industries and shows the systematic negative effect these agreements can have on worker outcomes. Evidence from high risk industries such as petrochemical, construction and trucking indicate the potential negative effects associated with contracting.\(^2\)-\(^4\)

This study focuses on underground coal mining, as opposed to surface coal mining, because the risk of significant injury is higher in the underground environment.\(^5\) There are two main types of contracting arrangements prevalent in the coal industry: independent contractors and contract operators. An independent contractor is "any person, partnership, corporation, firm association or other organization that contracts to perform services or construction at a mine."\(^6\) Subcontracting of this variety provides for gains in specialization to the operator and in terms of economic efficiency more broadly. On the other hand, a contract operator runs day-to-day activities of the mining operation and is liable for employees but typically leases mine operating rights and equipment from a larger, unaffiliated company and sells all production to that company.

In the latter case, the owner of the mine may use the contractor to shift liability for pension and health obligations of union mine operators to other entities; to lower the cost of civil penalties arising from violations of the Mine Safety and Health Act; and to avoid other employment related costs. In addition, contracting can be a means of shifting legal liability to low capitalized entities as a means of reducing costs associated with potential torts. When contracting is used to pursue these ends, social costs can be significant.

There is some evidence that these ownership arrangements were used to avoid collective bargaining agreements in the early 1990s.\(^7\),\(^8\) For instance, Massey Energy had different ownership policies depending on the type of mining situation: the company should control high quality coal with good mining conditions; for
reserves that weren’t as attractive they set up financial relations with operators to guarantee ‘reasonably assured profit but avoid mining risk’; and finally thin seamed mines that were hard to extract from were given to contractors under a brokerage relationship (Nyden, 1993b). Referred to as the Massey Doctrine, this type of arrangement suggests that contract operations are likely smaller and riskier operations than owner-operated or subsidiary mine operators.

Determining which operations are contractor operations is challenging, so few studies have focused on determining the effect of these ownership arrangements on health and safety outcomes. However, several studies have attempted to characterize injury disparities between independent contractors and operator-employed mine workers. Muzaffar et al.⁹ evaluated data on both independent contract workers and traditional mine workers between 1998 and 2007 to determine if there were notable differences between the two groups in relation to fatal mining accidents. Their data indicated that the univariate odds of a fatal incident as opposed to a non-fatal incident were 2.8 times higher for contracted workers than operators. They also utilized a multivariate model, which associated other factors with fatality. These included being an independent contract worker, being more than 8 hours into a working day, and having less overall experience in that specific mine.

A 2011 study by Pappas and Mark¹⁰ suggested that there were large safety disparities between contractor-operated underground coal mines and non-contractor mines. Examining the period from 1992 to 2009, they calculated the contract operator injury rate per 200,000 hours to be 16.6, as compared to 10.8 for all mines. However, there were two major problems with this comparison. First, their method of identifying contractor-operated mines excluded mines with no injuries, thus biasing upward the calculated injury rate. In addition, the injury rate comparison did not take mine size into account. Contractor-operated mines are generally smaller, and smaller mines tend to have higher injury rates.

Work done by Buessing and Weil in a 2014 working paper¹¹ suggests that there is “increased risk exposure for contract operations and mines with high contractor utilization”. They used MSHA data from 2000
to 2010 and modeled factors leading to negative health outcomes, such as geology, unionization, mine size, controller, and history of violations. Their results suggested that there are certain contracting companies that are typically performing riskier work (construction, blasting, etc.). As a result, there are differences in the types of contractors that are hired – some that are higher risk positions, and some that have lower injury rates (engineers, for example). They suggest that there are increased rates of injuries among contractor workers overall.

The relationship between contractor-operated mining and workplace injury and illness may be an important aspect to consider in any strategy used to improve worker outcomes. The primary barrier to understanding this relationship has been a lack of data on these contracting arrangements.

**MATERIALS AND METHODS**

**Data**

The universe of mines considered for analysis is quarterly observations of all active Kentucky underground mines from 1999 through 2013.

To create this dataset, we linked:

- Mine Safety and Health Administration (MSHA) Data: We extracted quarterly production and employment files along with administrative records on mine operators from MSHA’s Enforcement Data (website: http://ogesdw.dol.gov/views/data_catalogs.php).

- Applicant Violator System (AVS) Data: This database from the Office of Surface Mines (OSM) has information on all the mining permits issued in the US. We were provided with an AVS data extract for all Kentucky permits going back to 1983. Each observation is a permit entry with issue date and expiration date. The data also contain information on the MSHA mine identifiers (MSHA IDs)
covered by the permit, the permit holder, its parent company, the operator and the operator’s parent company.

- **Surface Mining Information System (SMIS) Data:** Available through Kentucky’s Division of Mine Permits, the database was used as an alternative source for linking permits to MSHA IDs. Along with providing the relevant permit numbers for a MSHA ID, it also provided information on ownership and mine location. The interface can be accessed through the website (http://minepermits.ky.gov/Pages/SurfaceMiningInformationSystem.aspx).

- **Kentucky Mine Mapping Information System Data (KMMIS):** A tool provided by Kentucky’s Division of Mine Safety, this website provides information on permits issued for an MSHA ID. The information on the website allowed us to fill in missing data on the AVS database (website: http://minemaps.ky.gov/MineSearch.aspx)

- The EIA conducts a yearly survey (EIA Form-7A) to gather information on mine characteristics for operations that produced 10,000 or more short tons of coal and/or employed workers for 5,000 hours or more in a year. To use as covariates, the authors obtained variables gathered in the survey including union status, seam height, method of mining used in each working section, and number of beds. Some of the variables cannot be accessed publicly through the EIA, and we obtained them through a data access agreement with the EIA for use in this project.

Using these databases, we constructed a quarterly panel database of all active underground mines from 1999 through 2013. The database contained owner and operator information, as well as information about controlling company-subsidiary relationships. If the permit holder (that is the owner) was not the same as the operator and neither was connected to the other by common ownership or a subsidiary relationship, we concluded that the mine had a contractor operator. Otherwise, we concluded that the mine was owner-operated.
Some mines did not have permit data using our method merging MSHA IDs and time periods. We filled in this missing information by using the KMMIS and SMIS. Specifically, we first did a manual search for MSHA ID’s that had no permit information in the AVS. If any permitting information existed, it was entered in a manner similar to the AVS data and subsequently merged with the MSHA data using the MSHA ID. As a quality control measure, two research assistants independently conducted this process. Any discrepancy across the two independent entries was pulled for further review and, after comparing the two manual entries with the original source, one of the two was kept.

Some MSHA IDs had permitting information, but the permit dates did not cover all production periods. Each of these problematic observations was reviewed individually and our best judgment about the correct permit information for a given quarter was determined using the KMMIS and SMIS data.

There were situations where the controller listed by MSHA was a subsidiary of a larger company. To avoid counting a subsidiary as a contract operator, we gathered the top national coal producer lists from 1994-2012 (all years publicly available online through the Energy Information Administration (EIA)). We compared this list to our mine dataset to determine which of those companies that appeared on the EIA’s lists also appeared in our dataset. For those companies that were present in both lists, we acquired their subsidiaries’ names from the U.S. Security Exchange Commission for all years that information was available. For every subsidiary, we manually checked if they were listed as a controller in the MSHA dataset. This examination allowed us to account for spelling discrepancies between the S.E.C. and our mine dataset. We adjusted our algorithm to recode any mines operated by these subsidiaries as non-contractor operations.

Our analysis was further limited to include only mines with fewer than 60 FTEs (full time equivalent workers). Only 3 percent of mine-quarters that we identified as contractor-operated had more than 60 FTEs in a calendar quarter. To make proper statistical comparisons, it would be inappropriate to include larger mines in the non-contractor sample because there are very few comparable mines in the contractor sample. The sample
was then split by contractor status. There were 2,966 mine-quarters in the years 1993-2013 that were contractor-operated, 3,251 not contractor-operated, and 684 that lacked adequate information to determine contractor status.

Unlike the contractors in the MSHA contractor database, which include any contracting operation with work related to mining, this measure indicates which mines are owner-operated and which mines are contractor-operated. Because the method proposed in this report is not a direct measure of contract operations, but a proxy using other information, we compared our measure with information from external sources to determine the accuracy of our measure. These are described in an online appendix: Contractor Determination Quality Checks.

METHODS

Outcome variables

Injury Rates: We focus on the number of traumatic injuries. When considering reported injuries as an outcome, the issue of underreporting should be addressed. There are a number of reasons a mine may choose to not report injuries, including lowering workers compensation premiums which are (imperfectly) experience rated, and potentially decreasing the probability of inspection. Because some of these motivations may be related to reasons to contract out work, using reported injuries as a dependent variable could yield biased estimates. We considered using fatalities, which are the least likely of the measures to be underreported. However, fatalities are rare, so we did not have enough statistical power to link company characteristics to fatality rates. As a result, we provide results on our preferred measure – traumatic injuries. We use the definition for a traumatic injury provided in Morantz. Traumatic injuries probably suffer from less reporting bias than non-traumatic injuries because they are more obviously associated with working in a mine and less
likely to be questioned by the employer. Traumatic injuries are more prevalent than fatalities, but less likely to suffer from underreporting than are total injuries. About 40% of reported injuries are traumatic.

**Control variables**

A mine has many characteristics that could affect injury and violation rates beyond the fact that it is run by a contract operator. For instance, mines with very low seam heights are typically more dangerous, if all other factors that determine the probability of increased injury are equivalent between two mines. Also, larger mines will tend to have more injuries because more individuals are potentially exposed at any given time. It is important to control for all these factors to avoid attributing a relationship between contractor status and the outcomes of interest that can be explained by other features of the mine. The MSHA and EIA data provide a number of key mine characteristics, summarized in Table 1. These characteristics are controlled for in all the specifications.

Figure 1 indicates that our measure of contractor-operated mines was relatively flat until 2006, seemed to begin a decline until 2011 but has been increasing in recent years. Table 2 provides statistics describing our final sample and highlighting the difference in characteristics of mines identified as contractor-operated from those that are not contractor-operated. The table only provides information for mines with fewer than 60 FTEs (full time equivalent workers). As noted above, this is because there are very few mines identified as contract operations with more than 60 full FTEs. Even with this limitation, contract operations tend to be smaller both in terms of employment and production, in line with expectations about contract operator characteristics. In Table 2, contractor-operated mines’ injury rates appear to be lower than those of mines not operated by contractors. Contractor-operated mines also tend to have less recoverable reserves, have thinner coal beds, and are more likely to use conventional mining methods. These are all factors that make them less attractive to operate. We were unable to determine the contractor status of 11 percent of mine-quarters. These mines tended to have
characteristics more like contractor than non-contractor mines, with even lower average FTE employment, lower recoverable reserves, and greater use of conventional mining. (See Table 2.)

**Statistical Specification**

Injuries in a mine-quarter are count data and tend to be clustered at lower values such as 0 and 1. From Table 2, we can also see that the variance is much greater than the mean of the injury rate. For this kind of data, the appropriate statistical approach is negative binomial regression, which we use. The regression specification is:

\[ Y_{m,t} = \alpha + \beta C_{m,t} \times S_{m,t} + \gamma X_{m,t} + \tau_t + \delta_m + \epsilon_{m,t} \]

Where \( Y \) is the injury rate in a given mine \((m)\), quarter \((t)\), \( C \) is the contractor status of that mine, and \( X \) are a set of mine-quarter specific controls. We also include an interaction between contractor status and the size category of the mining operation \((S_{m,t})\), allowing the contractor effect to vary by size category. Finally, we include time \((\tau_t)\) and MSHA district \((\delta_m)\) fixed effects. To see if our results were sensitive to the omission of mines with unknown contractor status, we ran the traumatic injury regressions after having recoded all missing data on contractor status to zero and then to one.

**RESULTS**

Among mines with up to 60 FTEs, we identified the contractor status of 88 percent of the active underground coal mine-quarters in Kentucky between 1999 and 2013. We identified these mines by comparing the operator identified in MSHA records with the reclamation permit holder, supplemented with additional information about controllers and subsidiaries. We found no trend over the study period in the proportion of these mines operated by contractors (Figure 1). However, in the last 5 years of our data, there was an upward trend among the smallest mines, where contractor operation is concentrated.
Table 3 shows the impact of contractor status and mine size on total injury rates, allowing the contractor impact to differ by mine size. Column (2) shows the impact on traumatic injury rates. (For a full listing of estimated IRRs for both traumatic and all injuries, see Online Appendix Table A1.) Rather than presenting the regression coefficients, we use the Incidence Rate Ratio (IRR) for ease of exposition. The IRR for the injury regression is the ratio of the injury rate to a baseline rate related to a one unit increase in an independent variable. In Table 3, the reference group is non-union, non-contractor-operated mines using the continuous mining method. Each IRR indicates the ratio of the rate in contractor-operated mines to non-contractor-operated mines in the same size class.

In the 1999-2013 period, contractor-operated mines with 15 or fewer FTEs had a statistically-significant 57 percent higher covariate-adjusted traumatic injury rate than similar mines without contract operators (Table 3). There was no statistically significant difference in the covariate-adjusted traumatic injury rate in mines with more than 15 but no more than 30 FTEs. For mines with more than 30 and up to 60 FTEs, contractor-operated mines experienced a covariate-adjusted injury rate 73 percent of otherwise similar non-contract mines. That is, contractor-operated mines appear to be less risky in these mines.

When we ran the traumatic injury regressions after having recoded all missing data on contractor status to zero and then to one, we found small changes in the estimated IRRs reported in Table 3. However, our qualitative conclusions were not altered. (See Online Appendix Table A2 for these results.)

CONCLUSIONS

Using MSHA, EIA, and mining permit data, we categorized 89 percent of small underground coal mines in Kentucky by whether they were contractor-operated. We found a statistically significant increase in traumatic injury rates among the smallest of contractor-operated mines. This increase appears substantial enough to
warrant attention. Still, contractor-operated underground mines with 30 to 60 employees appeared to have lower injury rates than comparable mines that were owner-operated.

The recent decline in the price of coal may lead to changes in the operation of small mines. Larger mining companies may be less willing to operate these relatively marginal mines, which could result in their being closed or in more of them being operated by contractors. These developments could decrease or increase injury risk and should be followed.

Like Morantz,\textsuperscript{13} we found that unionized mines had much lower traumatic injury rates than non-union mines. On December 31, 2014, Kentucky’s last unionized mine shut down. Without the added protection that unions offer, the risk of injury is likely to increase unless operators and regulators increase their focus on injury prevention.

**Limitations**

The results in this analysis are not necessarily causal. There are a number of factors that could explain our findings. For instance, selection bias may be driving the relationship between potential contract operations and injury risk. Smaller mines are often more dangerous, and their production volumes tend to be lower. We control for mine size and productivity. However, these factors could still influence the results through an indirect channel. The type of non-contract operators running mines with these characteristics may be different on average than companies running larger operations. Willingness to operate a small mine in and of itself may indicate weaker management in general and safety management in specific.

Also, even though we attempted to minimize reporting bias by focusing on traumatic injuries, studies have shown that underreporting occurs even for traumatic injuries.\textsuperscript{15,16} If contractors report a smaller proportion of their injuries than do non-contractor-operated mines, studies like this one would underestimate the risk of contractor-operated mines. MSHA requires mine operators to report all injuries at the mine, including injuries of independent contractors. If independent contractors, which tend to have high injury rates, are more prevalent in owner-
operated mines, it would likely bias our results so as to not find an effect. We should note that these results apply only to underground coal mines in Kentucky. Experience may differ in West Virginia and other states with contractor-operated underground coal mines.
Figure Legend

FIGURE 1. Proportion of Underground Coal Mines Operated by Contractors, 1999-2014
All mines and small mines (<= 60 full-time equivalent employees)
REFERENCES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor indicator</td>
<td>Indicator for mine's status as a contract operation</td>
<td>MSHA, AVS, SMIS, KMMIS</td>
</tr>
<tr>
<td>Mine size</td>
<td>Full time equivalents (FTEs), or 500 employee hours per quarter (equivalent to 2,000 hours per year)</td>
<td>MSHA</td>
</tr>
<tr>
<td>Mine size categories</td>
<td>Category 1: 0 -15 FTEs; Category 2: 15 - 30 FTEs; Category 3: 30 - 60 FTEs</td>
<td>MSHA</td>
</tr>
<tr>
<td>Log of controller size</td>
<td>Natural log of controller size, with controller size measured in units of 100 FTEs</td>
<td>MSHA</td>
</tr>
<tr>
<td>Mine age</td>
<td>Age of mine in years since the first operator began work at the mine (top censored at 43)</td>
<td>MSHA</td>
</tr>
<tr>
<td>Productivity</td>
<td>Millions of tons of coal per 200,000 employee hours</td>
<td>MSHA</td>
</tr>
<tr>
<td>District indicators</td>
<td>Indicators for whether a mine is in a particular MSHA district (used to determine if the mine is in Kentucky)</td>
<td>MSHA</td>
</tr>
<tr>
<td>Subunit indicators</td>
<td>Indicators for a particular subunit (underground, surface, office, etc.)</td>
<td>MSHA</td>
</tr>
<tr>
<td>Quarter/year indicators</td>
<td>Indicators for whether an observation is in a particular year or quarter</td>
<td>MSHA</td>
</tr>
<tr>
<td>Inspection days</td>
<td>Number of MSHA inspection days (defined as five inspection hours) in a quarter</td>
<td>MSHA</td>
</tr>
<tr>
<td>Union indicator</td>
<td>Indicator for whether a mine is unionized</td>
<td>EIA</td>
</tr>
<tr>
<td>Number of coal beds</td>
<td>Number of coal beds at a particular mine</td>
<td>EIA - Confidential</td>
</tr>
<tr>
<td>Mean coal bed thickness</td>
<td>Average thickness, in inches, of the coal bed at a particular mine</td>
<td>EIA - Confidential</td>
</tr>
<tr>
<td>Recoverable reserves</td>
<td>Estimated tons of recoverable coal reserves (in 100,000 ton units)</td>
<td>EIA - Confidential</td>
</tr>
<tr>
<td>Traumatic injury</td>
<td>Amputations, enucleations, fractures, chips, dislocations, foreign bodies in eyes, cuts and lacerations, punctures, burns/scalds, crushings, burns, and fatal injuries.</td>
<td>MSHA</td>
</tr>
<tr>
<td>Mining method percentages</td>
<td>Percent of underground operation that uses a particular mining method (conventional, continuous, longwall, shortwall, and other).</td>
<td>EIA - Confidential</td>
</tr>
</tbody>
</table>
### TABLE 2. Study Sample Statistics. Kentucky Underground Mines with <= 60 Full Time Equivalent Employees (FTEs), 1999-2013

<table>
<thead>
<tr>
<th>Injuries per 200k hours</th>
<th>All</th>
<th>Contractor</th>
<th>Non-Contractor</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>9.4 (35.3)</td>
<td>8.3 (19.8)</td>
<td>10.4 (45.0)</td>
<td>8.4 (28.5)</td>
</tr>
<tr>
<td>Traumatic</td>
<td>3.9 (28.8)</td>
<td>3.4 (12.4)</td>
<td>4.3 (38.1)</td>
<td>3.1 (18.6)</td>
</tr>
<tr>
<td><strong>Basic operational characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal Productivity</td>
<td>0.6 (0.4)</td>
<td>0.6 (0.4)</td>
<td>0.6 (0.4)</td>
<td>0.6 (0.5)</td>
</tr>
<tr>
<td>Mine age (years)</td>
<td>6.6 (6.8)</td>
<td>5.9 (5.8)</td>
<td>7.2 (7.6)</td>
<td>9.0 (7.8)</td>
</tr>
<tr>
<td>FTEs</td>
<td>26.0 (15.4)</td>
<td>20.3 (12.0)</td>
<td>31.1 (16.3)</td>
<td>15.5 (11.6)</td>
</tr>
<tr>
<td>Fewer than 15 FTEs</td>
<td>29.7 (%)</td>
<td>39.5 (%)</td>
<td>20.8 (%)</td>
<td>57.3 (%)</td>
</tr>
<tr>
<td>15 to 30 FTEs</td>
<td>32.0 (%)</td>
<td>39.1 (%)</td>
<td>25.7 (%)</td>
<td>29.7 (%)</td>
</tr>
<tr>
<td>30 to 60 FTEs</td>
<td>38.2 (%)</td>
<td>21.5 (%)</td>
<td>53.5 (%)</td>
<td>13.0 (%)</td>
</tr>
<tr>
<td>Employees</td>
<td>24.7 (12.8)</td>
<td>21.1 (10.8)</td>
<td>28.0 (13.5)</td>
<td>16.9 (10.0)</td>
</tr>
<tr>
<td>Fewer than 14 Employees</td>
<td>27.2 (%)</td>
<td>35.0 (%)</td>
<td>20.0 (%)</td>
<td>51.6 (%)</td>
</tr>
<tr>
<td>14-28 Employees</td>
<td>35.6 (%)</td>
<td>41.3 (%)</td>
<td>30.3 (%)</td>
<td>34.3 (%)</td>
</tr>
<tr>
<td>28-50 Employees</td>
<td>34.8 (%)</td>
<td>22.3 (%)</td>
<td>46.3 (%)</td>
<td>13.8 (%)</td>
</tr>
<tr>
<td>50+ Employees</td>
<td>2.4 (%)</td>
<td>1.4 (%)</td>
<td>3.4 (%)</td>
<td>0.3 (%)</td>
</tr>
<tr>
<td><strong>EIA mine characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Union</td>
<td>0.8 (%)</td>
<td>0.0 (%)</td>
<td>1.6 (%)</td>
<td>0.0 (%)</td>
</tr>
<tr>
<td>Recoverable reserves</td>
<td>13.5 (34.6)</td>
<td>7.8 (14.8)</td>
<td>18.7 (45.1)</td>
<td>4.9 (19.2)</td>
</tr>
<tr>
<td>Number of coal beds</td>
<td>1.0 (0.1)</td>
<td>1.0 (0.0)</td>
<td>1.0 (0.1)</td>
<td>1.0 (0.0)</td>
</tr>
<tr>
<td>Mean bed thickness (inches)</td>
<td>42.2 (13.6)</td>
<td>38.5 (9.0)</td>
<td>45.5 (16.0)</td>
<td>38.2 (8.7)</td>
</tr>
<tr>
<td>Mining method</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>83.8 (%)</td>
<td>76.5 (%)</td>
<td>90.4 (%)</td>
<td>72.3 (%)</td>
</tr>
<tr>
<td>Conventional</td>
<td>10.7 (%)</td>
<td>17.1 (%)</td>
<td>4.8 (%)</td>
<td>12.4 (%)</td>
</tr>
<tr>
<td>Longwall</td>
<td>0.1 (%)</td>
<td>0.1 (%)</td>
<td>0.0 (%)</td>
<td>0.0 (%)</td>
</tr>
<tr>
<td>Shortwall/other</td>
<td>0.6 (%)</td>
<td>0.6 (%)</td>
<td>0.6 (%)</td>
<td>0.1 (%)</td>
</tr>
<tr>
<td><strong>Sample size (mine quarters)</strong></td>
<td>6,245</td>
<td>2,981</td>
<td>3,264</td>
<td>688</td>
</tr>
</tbody>
</table>

Numbers in parentheses are standard deviations.

Mine size is measured in Full Time Equivalents (FTEs), where each FTE is 500 employee hours.

Total injuries include all injuries underground subunit of mines in the sample.

Traumatic injuries are defined by the characteristics of the injury and include amputations, enucleations, fractures, chips, dislocations, foreign bodies in eyes, cuts and lacerations, punctures, burns/scalds, crushings, burns (chemical, electrical, and laser), and fatalities.

Productivity is measured as millions of tons of coal produced per 200,000 employee hours.

Inspection days are defined as total on-site inspection hours divided by five.

Union status was determined using EIA public fields mine data.
This table shows the Incidence Rate Ratio (IRR) for traumatic injury rates in contractor-operated underground coal mines compared with otherwise similar non-contractor-operated mines in the same size class.