EVALUATION OF THE COMPLETENESS OF INJURY AND ILLNESS REPORTING IN THE ILLINOIS MINING INDUSTRY: COMPARING WORKERS' COMPENSATION CLAIMS TO THE MSHA PART 50 PROGRAM

FINAL REPORT

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EXECUTIVE SUMMARY

The Mine Safety and Health Administration (MSHA) Part 50 program implements MSHA's authority to investigate and utilize information pertaining to, accidents, injuries, and illnesses occurring or originating in mines. It requires operators of coal, metal, and nonmetal mines to immediately notify MSHA of accidents.[1] Underreporting of injury and disease has been observed in mining as well as many other industries.[4-6] Analysis of patterns and causes of why injuries and illnesses are not captured by or underreported to the MSHA Part 50 Program would allow agencies to improve their reporting systems. This report compares Part 50 data to claims in the Illinois Workers' Compensation Commission (IWCC).

This study showed that 71% of mining-related IWCC claims were not captured by Part 50 Reports*. Chronic disease is poorly captured by Part 50. For example, Illinois hospital data indicates that there were over 6,000 unique individuals treated for respiratory health conditions diagnosed as a pneumoconiosis between 2000 and 2012, during that same period, 1,214 cases were filed with the IWCC and 90 cases of respiratory disease were reported to the MSHA Part 50 program.

- This study showed that the Part 50 program captures a higher proportion of acute injuries (43%) compared to chronic injuries or illnesses (6%) that occur in mines.
- The Part 50 program captured more cases of disease and injury associated with localized body parts compared to systemic processes.
- The Part 50 program inadequately captured diseases involving chronic exposures to chemicals or repetitive micro-trauma. Mechanisms of trauma such as "caught in/under/between an object" and "struck by an object"; and "falls"; were well reported.
- The Part 50 program poorly captured cases that were complex, severe, longer to adjudicate, or involved the use of an attorney.
- The smallest companies, measured by number of mines owned and average employment, had the lowest capture rates between the IWCC and the Part 50 program.
- Coal mines (n=51) in Illinois had more cases of injury and illness compared to metal/non-metal (MNM) mines (n=224) after controlling for mine size.

Recommendations:

- Consider a requirement to report chronic illness or injury even though the worker no longer is employed at the time of diagnosis or a workers' compensation case is filed.
- Consider focusing Part 50 audit investigations on small mines and on coal mines which had greater numbers of cases not captured by the Part 50 Program compared to large mines and MNM mines.
- Consider MSHA initiative to develop relationships with state workers' compensation systems to improve data collection and data sharing.

* Claims in the IWCC may not have matched to MSHA Part 50 reports for a number of reasons including lack of reporting by mine operators, geographic discrepancies between state of filing, regulatory guidelines that would not require the reporting of certain injuries and illnesses, or employment status of the IWCC claimant in the mining industry at time of claim.

1. INTRODUCTION

Mining is no longer one of the most dangerous jobs in our industrial work force given that there have been dramatic decreases in rates of injuries and fatalities since the 1970s[1]. Mining however does remain hazardous, and is associated with significant adverse health consequences.[2]

The Mine Safety and Health Administration (MSHA) Part 50 program implements sections 103 and 111 of the Federal Coal Mine Health and Safety Act of 1977 (Public Law 91-173). The purpose of this regulation is to implement MSHA's authority to investigate accidents, injuries, and illnesses occurring or originating in mines. It requires operators of coal, metal, and nonmetal mines to immediately notify MSHA of accidents. The MSHA Part 50 program also requires operators to file reports pertaining to accidents, occupational injuries and illnesses, as well as employment and coal production data.[3]

Underreporting of injury and disease has been observed in mining as well as many other industries.[4-6] Underreporting varies widely by type of workplace, worker characteristics, as well as the severity of injury and illness.[7-8] One study assessed underreporting to the United States Bureau of Labor Statistics (USBLS) and state workers' compensation systems in Michigan using a capture-recapture analysis.[9] They estimated that the number of work-related injuries and illnesses in Michigan was three times greater than the official estimate derived from the USBLS annual survey. There is also evidence that there is significant underreporting to the MSHA Part 50 program. This impairs the agency's ability to develop an appropriately targeted public health and industrial hygiene response.[6]

A number of factors have been associated with increased risk of injury and illness in mines. Smaller enterprises appear to have increased risk of injury and illness in many industries, including mining.[10-14] Worker inexperience has also been implicated as a risk factor for injury. Studies have shown a higher risk of injury in the first few years of a miners' career. Higher injury rates have also been observed among younger miners (<30 years old) and those with 10 years or more of experience in their current job.[11] Mine and miner characteristics may influence the patterns of reporting injury and illness rates. A deeper understanding of these patterns would allow agencies to interpret and improve their surveillance systems.

This report compares MSHA Part 50 program data to mining-related claims filed with the Illinois Workers' Compensation Commission (IWCC). Illinois was chosen because it is an important mining state which collects substantial data on workers' compensation claims. Our research group at the University of Illinois at Chicago, School of Public Health has full access to this data set and obtained access to Illinois MSHA Part 50 data in order to perform this analysis.

In 2012, Illinois ranked 5th among the 50 states in coal production, with 22 coal mines (14 underground, 8 surface) producing 48,486,000 short tons of coal.[15] MSHA's Mine Address and Employment data set recorded 6,921 workers employed in the mining industry in Illinois in 2012. In that same year there were 36 miner fatalities nationally and a rate of 2.6 recordable injuries per 200,000 hours worked.

The National Mining Association estimates that the need for a robust mining work force in the U.S. will continue. They estimate that as many as 55,000 new employees will be needed to meet demand for coal and other mined materials over the next decade.[†] While the legislative mandate exists to collect data to monitor illness and injury events in this population, those cases that are not captured or are not reported need to be addressed to make this surveillance more useful. Accurate monitoring of these events will allow MSHA to: 1) identify numbers, rates, and trends of injuries and illnesses, 2) elucidate the factors that lead to illness and injury, 3) identify emerging problems, and 4) plan and evaluate targeted prevention and enforcement efforts. The findings in this report may assist MSHA in identifying weaknesses in the Part 50 program that can be remedied to improve the program in the future.

[†] National Mining Association Employment Statistics. 2016. http://www.nma.org/index.php/employment-statistics. Last accessed June 6, 2016.

2. METHODS

This study evaluated the extent to which mining-related injuries and illnesses were either not captured by or not reported to the MSHA Part 50 program using Part 50 data obtained from MSHA linked to IWCC data housed by the University of Illinois at Chicago, School of Public Health. Using probabilistic matching methods, we matched those cases that appeared in both data sets. We performed analyses at the individual, mine, and company level to describe those characteristics associated with reporting or capture of an injury or illness to the MSHA Part 50 program.

2.1 Data Sources

2.1.1 MSHA Part 50 reports

MSHA is authorized to collect data on workplace injuries and illnesses under Section 103 of Public Law 91-173, amended by Public law 95-164. The Code of Federal Regulations (CFR) Part 50.20 requires a report to be filed for each "accident, occupational injury, or occupational illness occurring" at a given mine. The form, specifically titled "Mine Accident, Injury and Illness Report MSHA Form 7000-1" must be filed within 10 working days of an event. The date of an accident is generally known for acute events, which covers most acute injuries and acute physical reactions (e.g., contact dermatitis). A Part 50 report must be submitted to MSHA if an injury requires more treatment than first aid. Reports are filed regardless of whether an employee is directly employed by the mine or by a mining contractor. Each report contains information about the employee, the employer, the accident/illness event, and the MSHA mine ID.

The date of occurrence for chronic injuries or illnesses is often poorly defined. Due to the long latency of chronic conditions, it may be hard to pinpoint an exact date that marks the onset of the illness or injury event. This includes conditions such as cumulative trauma disorders, hearing loss, and chronic lung diseases such as pneumoconiosis. For chronic processes, a case among an active mine employee must be reported to MSHA within ten days of the diagnosis. However there is no clear requirement to file a Part 50 report if the employee has left the company.

This study focused on a comparison of Part 50 reports and IWCC claims. We obtained all Part 50 reports in the United States for the years 2000 through 2013 from MSHA and selected only those Part 50 reports filed for mines in Illinois (**Figure 2.1**). We selected cases if the mine where the injury/illness was reported was known to be in Illinois using MSHA's Mines database. Our final database of Part 50 reports in Illinois contained 9,052 instances of injury and illness.

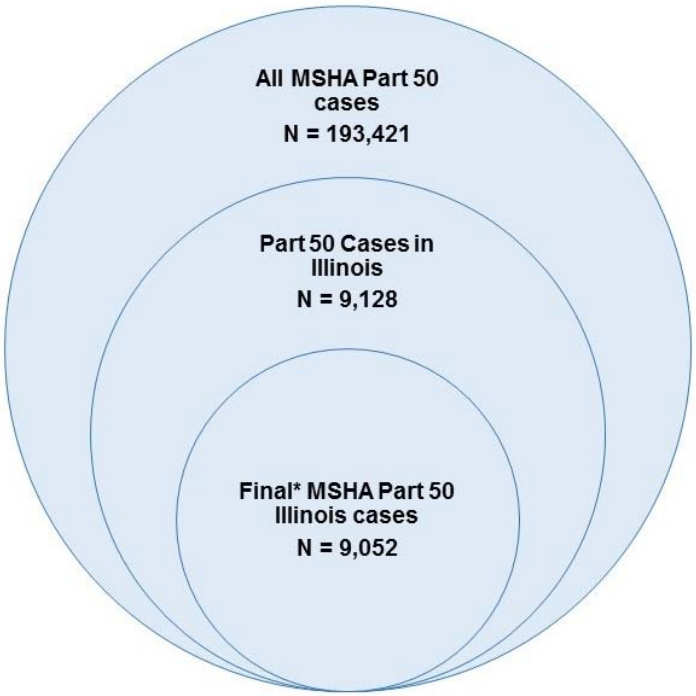

Figure 2.1 Case selection and cleaning process for identifying all Illinois claims in the MSHA Part 50 data, 2000-2013.

* After de-duplication of records.

2.1.2 Illinois Workers' Compensation Commission Claims

The IWCC operates the administrative court system for workers' compensation cases in Illinois. There are approximately 60,000 claims filed with IWCC for financial compensation each year. Unlike single carrier states with a well-organized and centralized reporting system (e.g. Washington), in Illinois the IWCC only handles claims in which the employee and employer are unable to resolve compensation issues without administrative intervention. If a claim or portion of a claim is settled prior to adjudication through the IWCC, it will not be reported in the dataset. Once the claim is filed, an arbitrator conducts a hearing to evaluate the issues. The arbitrator's decision can subsequently be appealed before a panel of three commissioners. Based on an internal analysis, very few "medical only" claims, those injuries or illnesses which are less severe, and where the relief sought is only payment of medical costs, are disputed through the court system. The disputed claims are almost exclusively indemnity claims in excess of $1,000. Our analysis of IWCC data showed that among large employers, over 80% of indemnity claims in excess of $1,000 ended up in litigation in the court system. Therefore, while not all workers' compensation claims in Illinois appear in the IWCC reporting system, the most severe cases do.

The data used in the present investigation included claims from 2000–2013. Only claims with a final decision claims were included in the matching process. Those claims that were dismissed, pending, or had an unspecified status were removed (N = 366, 6%). While these claims may still represent the occurrence of an injury or illness, we elected to remove them in order to provide conservative estimates of the degree of underreporting or non-capture in the Part

50 program. The dataset includes information on employer and employee demographics (age, gender, marital status, and number of dependents), cause and type of injury or illness, level of temporary and permanent disability, and details on the compensation costs associated with the injury.

The IWCC database does not have industry or occupation codes. Therefore, a multi-step, case-selection algorithm was used to identify mine workers within the IWCC claims database. The name of the employer or company is available for every case allowing us to use general keywords to compare these to a list of company names of registered mining companies in Illinois during the time period of the study. This list was derived from MSHA's Employment and Production data set. We included variations of these search terms to account for misspellings or abbreviations. Company address data was also used to confirm that the study participant was employed by a specific mining company. The final list of employers was manually reviewed to remove non-mining companies. Employees of mining equipment supply companies were excluded. This selection process is described in a recent publication by our research team (Mabila et al. 2015).[15] Administrative and other staff not directly involved in mining processes were included in the analysis, as there was no way to identify job titles within the IWCC data set. Our final database of IWCC cases for employees of Illinois mines contained 6,106 claims (**Figure 2.2**).

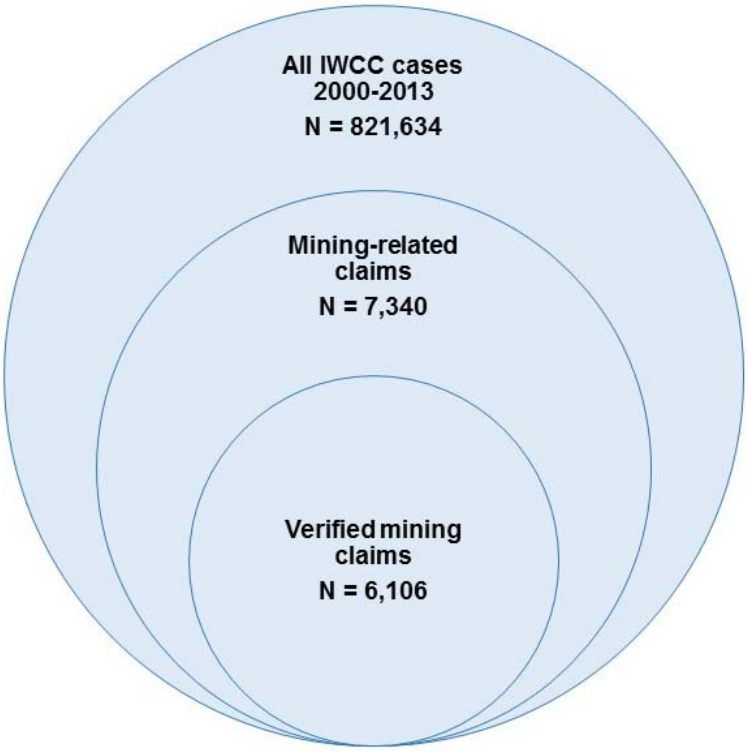

Figure 2.2 Case selection and cleaning process for identifying all mining-related claims in the Illinois Workers' Compensation Commission data, 2000-2013.

There are two main methods for linking data: "deterministic" and "probabilistic." Deterministic linkage involves the exact, one-to-one character matching of pre-designated variables across two or more datasets. This technique is frequently used when identifiers, such as name and social security number, are available. Probabilistic linkage requires the researcher to make assumptions regarding the probability that records from two different databases match. The investigators then decide whether the records match and should be included in the combined data file.

Although deterministic linkage methods intuitively provide greater confidence that records from two different databases match, the idea of deterministic linkage, in practice, is far more complicated. For example, misspelled names or errors in data entry would prevent matching of cases that describe the same person. Probabilistic linkage can solve this problem, and is frequently used even when identifiers are available. This technique allows greater flexibility and offers the ability to match a larger number of cases. The probabilistic linkage process generates probabilities of a match based on the number of variables that exactly match and the variables that are close, but not exact, matches.

Prior to performing probabilistic linkage with the MSHA and IWCC data, we generated standardized keywords for company names in both data sets. This was done to homogenize syntax and spelling to allow the statistical software to correctly identify matched companies across the databases. For example, in most cases we deleted abbreviations at the end of company names, such as "Inc." or "Co." Second, some companies went through restructuring, renaming, or take-overs during the study period. We generated a list of companies in each data set, by year, and standardized the spelling of those that appeared in both for that year. If there was a discrepancy, we attempted to verify the true company name of the mine through MSHA and other publicly available data on current controllers of the mine.

After reviewing both databases for completeness and uniqueness of variables, we identified the following variables to be used in a multi-stage linkage process: employee date of birth (DOB), employee sex, employee last name, company keyword name, and accident date. To allow for some mismatched and missing data between databases, we did not use all variables in each step. The idea behind multi-stage matching is to start the process using only "high probability" variables that will result in low false match rates. Each subsequent step adjusts the linkage criteria for any remaining cases, allowing for greater variability in the linkage criteria and as a consequence, less certainty of a true match. In other words, the probability of a false match increases with each subsequent step, but within each step only unmatched cases are included so the matching pool is shrinking. The linkage map for the multi-stage linkage process is listed in **Table 2.1**.

Table 2.1 Variables from the MSHA and IWCC databases used in the ten stages of the linkage process to identify confirmed and possible matches.

	Linkage Stage	Variables used in each linkage stage						N Cases Matched
Confirmed Matches	1	Date of Birth	Sex	Company Name[a]	Accident date	Employee Last Name	Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	309
	2	Date of Birth	Sex	Company Name	Accident year	Employee Last Name	Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	50
	3	Date of Birth	Sex	Company Name	Accident date		Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	1,006
	4	Date of Birth	Sex	Company Name	Accident date ± 7 days		Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	82
	5	Year of Birth	Sex	Company Name	Accident date		Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	45
	6	Date of Birth	Sex	Company Name		Employee Last Name	Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	93
	7	Year of Birth	Sex	Company Name	Accident date ± 7 days		Met subsequent validation criteria: part of body, ZIP code, accident mechanism, restricted work days; and limited-duty days.	24
Possible Matches	8	Date of Birth	Sex	Company Name	Accident date			96
	9	Date of Birth	Sex	Company Name		Employee Last Name		83
	10	Date of Birth	Sex		Accident date	Employee Last Name		93

[a] A unique company name keyword was used instead of full company name.

We validated matches using other data present in both datasets after each stage of the linkage process. The validation variables included body part injured; ZIP code of injury site; accident mechanism (e.g., fall from height, struck by); whether or not the employee received restricted work days; and whether or not the employee received limited-duty days. If cases from the two databases matched on any of the validation variables, the matched pair was designated as a positive match.

Cases from both datasets that linked on the matching and validation criteria were removed from the case pool and designated as confirmed matches within each step. Cases that did not match on the linkage criteria, or did not match on the validation criteria, were defined as unmatched cases and kept in the case pool for additional linkage stages.

We ran three more linkage stages without the same validation steps to match those cases that had more missing variables. **Table 2.1** lists the three stages for identifying possible matches in steps 8 through 10. Unlike the confirmed matches, we accepted any 1:1 matches regardless of whether or not we could validate the match on any of the five validation variables. According to linkage theory, effective linkage is indicated by high linkage rates in the earliest stages where the probability of false matches is low. In our linkage process, a majority of matches were identified by the end of the 3rd stage of the linkage process (76% of all matches; 85% of confirmed matches). Stage 3 had the highest linkage rate because name of the injured employee was missing in a large proportion of the MSHA cases.

After all linkage steps were complete, we identified cases in the MSHA and IWCC databases as confirmed matches (stages 1-7 in **Table 2.1**), possible matches (stages 8-10 in **Table 2.1**), or unmatched. Those cases that were successfully matched between the IWCC and MSHA Part 50 data sets were considered “reported”, or in the case of chronic disease “captured”, for the purpose of this study. Cases that we believe should have been reported according to the regulatory requirements of the Part 50 program were considered “unreported”. Chronic cases which may have been filed by an employee who had left the company were considered “not captured” since there may have been no regulatory requirement for reporting, however these represent important cases for consideration. The cases in the IWCC data that did not match to Part 50 reports were considered those accidents, injuries, or illnesses that were not reported or captured by the Part 50 program. This report provides a detailed assessment of the individual and company characteristics of cases which were reported or captured, as well as those that were not reported or captured by the MSHA Part 50 program.

2.3 Data Analysis

2.3.1 Individual Mine-Worker Data

We had three sets of cases to analyze after the matching process: (1) cases that matched, appearing in both the MSHA Part 50 and IWCC systems as either confirmed or possible matches, (2) cases that only appeared in the MSHA Part 50 reports, and (3) cases that only appeared in the IWCC claims data. We then analyzed the characteristics of the injured mine employee to see what factors might have affected injury and illness reporting. We examined

demographic characteristics including age and gender; as well as injury/illness event details, including nature of injury and injury body location (see **Appendix I** for complete list of variables and data sources). We analyzed differences across these groups by either continuous or categorical means depending on the distribution of each variable. We used the χ^2 test for categorical variables and the t-test and Mann-Whitney *U* for continuous outcomes, depending on the normality of the distributions to test for statistical differences between matched cases and either the unmatched MSHA or IWCC data.

Exploratory analysis of the data indicated that cases of acute injury were matched between databases at a greater rate than cases of disease or chronic injuries (e.g., cumulative trauma disorders and respiratory diseases). Therefore, we adopted a broad definition of potentially-chronic cases based on body part affected, accident mechanism, and nature of injury. **Table 2.2** lists the body part, injury nature, and accident mechanism that we used to identify chronic conditions under our expanded definition.

Table 2.2 Body part, nature of injury, and accident codes selected for expanded analysis of chronic conditions in the MSHA Part 50 and IWCC data sets.

IWCC	MSHA
Body Part	
Ear(s)(Internal)	Ear(s) Internal & External
Heart	Ear(s) Internal & Hearing
Lung(s)	Nose/Nasal Passages/Sinus/ Smell
Heart & Lung(s)	Abdomen/Internal Organs
Spleen	Chest (Ribs/Breast Bone/Chest Organs)
Body Systems	Hips (Pelvis/Organs/ Kidneys/ Buttocks)
Digestive System	Body Systems
Musculoskeletal	
Respiratory System	
Body Parts	
Nature Of Injury	
Hearing Loss Or Impairment	Contagious, Infectious Disease
Ganglion Cyst	Dermatitis, Rash, Skin Or Tissue Inflammation
Poisoning Systematic, Unspecified	Inflammation, Bursitis, Tenosynovitis, Miner's Knee, Cellulitis
Poisoning Systematic, Upper Respiratory	Poisoning, Systematic
Poisoning Systemic, Influenza	Pneumoconiosis
Pneumoconiosis, Unspecified	Asbestosis
Pneumoconiosis	Coal Workers' Pneumoconiosis
Other Pneumoconiosis	Silicosis
Hemorrhoids	Heart Attack, Angina, Arrhythmia
Eye, Other Disease Of The Eye	Cerebral Hemorrhage, Stroke, Aneurysm
Loss Of Vision	Occupational Diseases, Arthritis, Degenerative Disc Disease
Mental Disorders	Hearing Loss, Impairment
Nervous System, Unspecified	
Injury To Nerves/Muscles/ Ligaments	
Tendonitis/ Bursitis	
Unspecified Respiratory System	
Upper Respiratory System	
Upper Respiratory System, Influenza Or Pneumonia	
Symptoms And Ill-Defined Conditions	
Carpal Tunnel Syndrome	
Occupational Disease	
Heart Condition (Includes Heart Attack)	
Accident Code	
Heart Attack	Ingestion Of Radioactive, Caustic, Toxic, & Noxious Substance
Rubbed By Repetition Or Pressure	Absorption Of Radioactive, Caustic, Toxic, & Noxious Substance
Contact By Inhalation	Inhalation Of Radioactive, Caustic, Toxic, & Noxious Substance
Contact By Ingestion	
Contact By Absorption	
Exposure To Noise	
Noise, Sudden Or Single Exposure	
Repeated Noise Exposure	
Repetitive Trauma	

2.3.2 Company-Level Data

Mining companies may have varied cultures or procedures that affect Part 50 reporting. We therefore also linked company-level data to the Part 50 and IWCC cases. All data on mining companies came from publicly-available MSHA data sets, including the Employment and Production, and Mines data sets. In addition to analysis by company, we analyzed differences in reporting by commodity, either coal or metal/non-metal. These two categories were selected because no mining company in Illinois owned both coal and metal/non-metal (MNM) mines. MNM mines include stone; sand and gravel; and metal mines. We evaluated company size through (1) their average number of employees per year and (2) the number of mines owned and the number of years each mine was owned (assessed as total mine-years). Coal and MNM mining companies were not significantly different in their sizes except for a few very large coal mines.

"We analyzed those cases of injury or illness that appeared in the IWCC dataset, but were not found in the MSHA Part 50 reports."

We analyzed those cases of injury or illness that appeared in the IWCC dataset, but were not found in the MSHA Part 50 reports. These cases may not appear in the MSHA Part 50 database for one of two reasons; they may not be reported to MSHA despite being required to be reported, or they are not captured by MSHA's Part 50 Program because the injury or illness occurs after the mine employee has left mine work. We assessed the number of uncaptured and underreported cases per company as well as the number of these cases as a percentage of all cases submitted in the MSHA and IWCC systems. We also analyzed cases with chronic etiologies that were not captured by Part 50 within companies.

2.3.3 Mine-Level Data

We obtained information on employment, production, violations, "significant and substantial" (S&S) violations, and citations for all mines that had Part 50 reports in our study from three publicly-available MSHA databases.[iii] A violation is considered "S&S" when "there exists a reasonable likelihood the hazard contributed to will result in an injury or illness of a reasonably serious nature."[iv] Unfortunately, the IWCC system does not specify the mine at which the injured employee worked. The IWCC data only identifies the company for which the employee worked at the time of injury or illness. The Part 50 system does collect information at the mine level as well as the company level. Therefore we could only provide an analysis of the mine characteristics of those cases that matched between the IWCC case and the Part 50 data.

Individual injury and illness reports were grouped by mine and company and the total number of Part 50 reports and number of Part 50 reports per employee was calculated. This was done to understand the pattern of reporting. There were 275 mines operating in Illinois during the

[iii] MSHA Open Government Data Sets. Available at: http://www.msha.gov/OpenGovernmentData/OGIMSHA.asp
[iv] MSHA Office of Assessments Citation and Order Explanations. Available at: http://www.msha.gov/programs/assess/citationsandorders.asp

study period that submitted cases to the Part 50 system, including 51 coal mines and 224 MNM mines.

The MSHA databases used in this analysis were the annual Employment and Production database, the Violations database, and the Mines database. Data in the Violations and Employment and Production databases was collected annually. The Mines database describes unchanging aspects of the mine, so these data remained constant throughout the study period. We linked all mine-level data to individual Part 50 cases using the MSHA Mine ID.

Our preliminary analysis of average mine size indicated that coal mines in Illinois had significantly more employees than MNM mines. We therefore conducted all analyses separately for coal and MNM mines. The total number of employees reported at a mine during the study period divided by the number of years during which employees were reported was used as our measure of mine size.

MSHA and the National Institute for Occupational Safety and Health (NIOSH) report on mining injuries by mine size; however, these agencies have slightly different categories for mine size. Therefore, we used NIOSH and MSHA reports as guidance and divided mines into the following size categories from smallest to largest: 1–4 employees per year, 5–9 employees per year, 10–19 employees per year, 20–49 employees per year, 50–99 employees per year, and 100 or greater employees per year. The F-test was used to compare means for independent and dependent variables across the levels of mine size separately for coal and MNM mines.

All mines had information about the presence of a safety committee at the mine, however, only 4/224 MNM mines had safety committees. Therefore, we only analyzed the effect of the presence of a safety committee for coal mines, and compared means and prevalence of independent and dependent variables for those.

We analyzed violations, S&S violations, citations, and orders as variables of increasing severity that may indicate a work environment that could result in a greater number of accidents or injuries. The detailed definitions for each level of severity can be found at http://www.msha.gov/PROGRAMS/assess/citationsandorders.asp. Briefly, S&S violations must meet four criteria: 1) underlying violation of a mandatory standard; 2) existence of a discrete safety hazard contributed to by the violations; 3) a reasonable likelihood that the hazard contributed to the will result in an injury; and 4) a reasonable likelihood that the injury in question will be of a reasonably serious nature. We analyzed presence or absence of any S&S violations for a given mine. Coal mines found to be in violation can be issued "orders" to install safeguards at a specific mine. We analyzed presence or absence of Safeguards at a mine as a binary outcome. MSHA inspectors can issue so-called Orders (orders of withdrawal) when conditions at a mine exist as a result of an accident that threatens the safety of miners. We analyzed presence or absence of Orders at a mine as a binary outcome.

The number of annual violations reported by MSHA was collected for each mine that also reported at least one Part 50 injury or illness case in our study. All but two mines had at least one violation reported during the study period. The number of violations was highly correlated with the number of employees at a given mine. Therefore, we analyzed mines by raw

number of violations as well as violations per average number of employees. Violations were analyzed by mine size category.

The mine-level data was also used to evaluate associations with the total number of Part 50 reports, Part 50 reports per employee, and the percentage of Part 50 reports that matched to IWCC claims. We also analyzed mine characteristics associated with chronic disease reporting in the Part 50 system. It should be noted that not all mines reported chronic cases to the Part 50 system. We have analyzed chronic disease reporting by mine size and violations.

3. RESULTS: INDIVIDUAL CHARACTERISTICS ASSOCIATED WITH UNDERREPORTING TO THE MSHA PART 50 PROGRAM

3.1 Case Matching in Part 50 and IWCC Datasets

"The Part 50 program inadequately captures illnesses and injuries that result from chronic exposures."

We identified 1,609 confirmed matches of injury or illness in the MSHA Part 50 and IWCC reports from 2000–2013. We identified an additional 179 possible matches, for a total of 1,788 matched cases. These 1,788 cases represent only 20% of the 9,052 MSHA Part 50 reports filed during the study period and 29% of the 6,106 cases of injuries and illnesses to mining employees in the IWCC database. A total of 4,318 IWCC cases were not captured by the MSHA Part 50 Program during the observation period. In other words 71% of mining related injuries or illnesses, severe enough to result in a workers' compensation claim were not captured by MSHA's Part 50 program between 2000 and 2013 (see **Figure 3.1**).

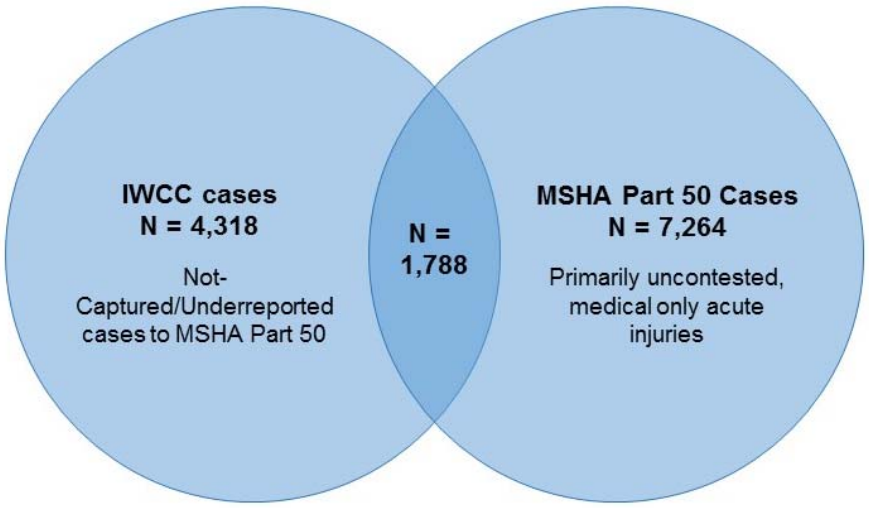

Figure 3.1 – Venn diagram of overlapping cases between the MSHA Part 50 Program data and the Illinois Workers' Compensation Commission data in Illinois, 2000 – 2013.

It should be noted that the workers' compensation dataset predominately captures indemnity cases which are the most severe cases frequently involving long term health effects and chronic illnesses. As will be demonstrated below, the Part 50 program inadequately captures illnesses and injuries that result from chronic exposures, likely due to the lack of a reporting

requirement for events that occur after an employee has left a company. Acute cases of less severe injuries are less likely to appear in the IWCC data set since they are usually "medical only" cases which are not contested.

Figure 3.2 shows the percentage of matched cases by case-year in the MSHA and IWCC databases. This graph combines confirmed and possible. The dip in matched percent for IWCC cases in 2007 is due to an extremely high number of cases with 2007 as the Accident Date. We believe this was due to the closure of a large mine in 2007 and the subsequent rush to file IWCC claims. Of note IWCC cases in our study population were filed between 2000 and 2013, yet the Accident Date could have been any time prior to the filing date.

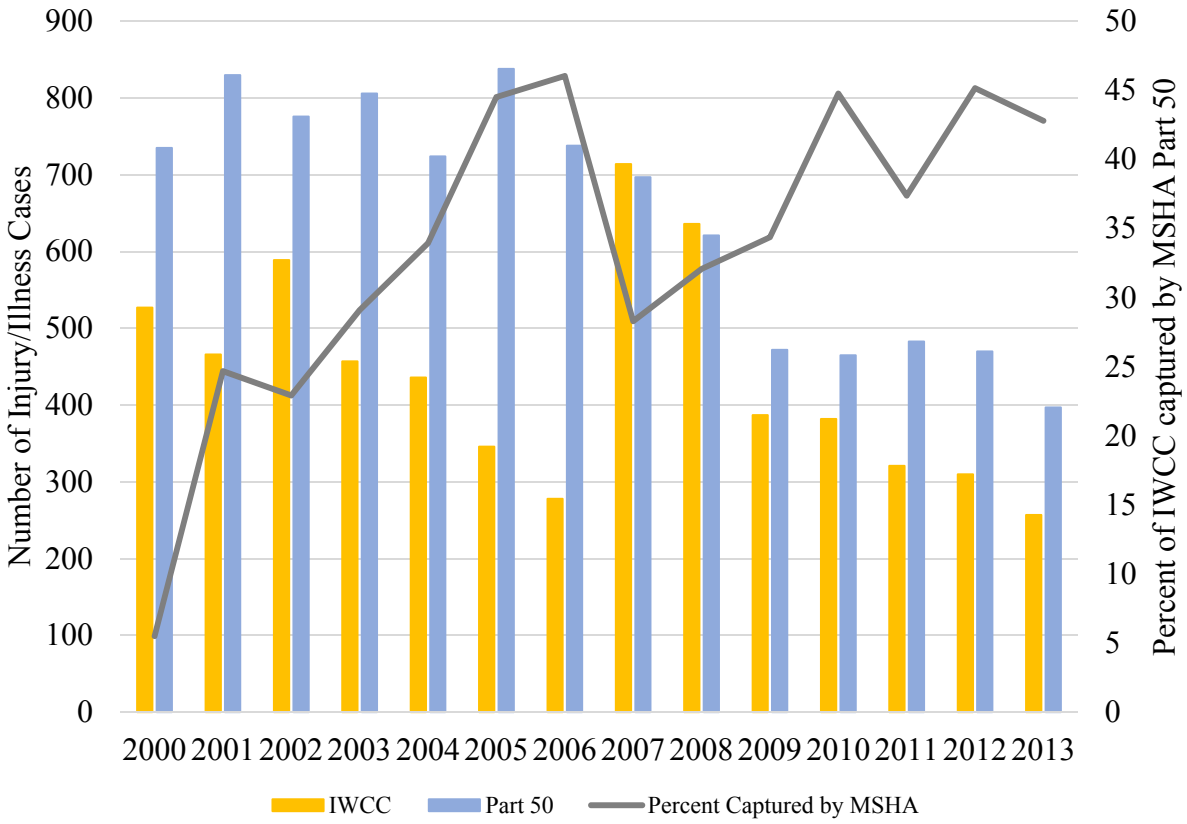

Figure 3.2 Number of mining-related injury/illness claims in the Illinois Workers' Compensation Commission (IWCC) and MSHA Part 50 Program data, as well as the percent of IWCC claims that were reported to the MSHA Part 50 Program by year, 2000-2013.

3.2 Which Cases Were Not Captured By MSHA Part 50 Reports?

Reporting status varied significantly by injury and illness characteristics, employee demographic factors, workers' compensation claim variables, and company-level factors.

3.2.1 Injury/Illness Characteristics Associated with IWCC Claims Not Captured by MSHA Part 50.

In order to better identify illnesses and injuries that develop over a long period of time, we characterized cases as chronic or acute in nature using the body part, nature of injury, and accident codes found in **Table 2.1** of the Methods section. We identified 1,889 total chronic cases in the IWCC data. Only 6% of these chronic cases (N = 106) were captured by the MSHA Part 50 program compared to 43% of the acute cases ($p < 0.0001$). Carpal tunnel syndrome (17%) and pneumoconiosis (4%) were conditions with the lowest capture rates in the Part 50 data.

An important illustration of the difficulties in capturing chronic conditions in the Part 50 program can be seen in the analysis of respiratory conditions. We used fields describing the body part affected, nature of injury and cause of injury/illness, and identified only 90 respiratory health cases that were captured by the Part 50s between 2000 and 2013. In contrast, we identified 1,214 respiratory health cases in the workers' compensation. This is also likely a significant underestimation of the burden of respiratory disease. Based on Illinois hospital data, there were over 6,000 unique individuals treated for respiratory health conditions diagnosed as a pneumoconiosis between 2000 and 2012.

In contrast, the highest percentage of captured cases was associated with injuries to the extremities. Such cases are usually the result of acute events. Cases of chronic disease or injury are not required to be reported to the MSHA Part 50 Program if the miner has retired or left the mining industry. This may be the cause of the low rates of capture (6%) for chronic processes. Acute injuries to active workers that require more than first aid, in contrast, should be reported to the MSHA Part 50 Program. Of the acute injuries and illness in the IWCC data that met the criteria for reporting, only 43% were matched to cases in the MSHA Part 50 data.

Similar findings were seen in the analysis of the mechanism of illness or injury. Nearly all of the cases involving exposures over long durations such as "radiation, caustic, noxious, or toxic substances, and particulate matter" in the workers' compensation data were not captured in the Part 50 data. Only 3% of cases with these mechanisms matched out of the 1,231 workers' compensation cases.

Among the uncaptured cases, those employees with chronic conditions were significantly older than employees with acute injuries or illnesses (55 years vs 46 years, $p < 0.0001$). Among the uncaptured IWCC claims, chronic cases took significantly longer to settle than acute cases (median 3.4 versus 2.0 years, $p < 0.0001$). Similar to these findings among the uncaptured cases, reported chronic cases took significantly longer to adjudicate than acute reported cases (2.1 vs 1.5 years, $p < 0.0001$).

Of note, the MSHA Part 50 captures injuries that do result in days lost or restricted work. These cases would not be expected to appear in significant numbers in the IWCC considering that the first three days of lost or restricted work is not compensable. Of the 9,052 MSHA Part 50 cases, 55.3% (n=5,010) were cases with fewer than four days of lost or restricted work. In contrast, 38% of the workers' compensation claims involved temporary total disability (TTD i.e. lost work days) while 62% resulted in some level of partial permanent disability (PPD)

associated with restricted work. As expected, matching rates between IWCC claims and MSHA cases was higher for those MSHA cases involving 4 or more days of lost work or restricted work compared to those involving 3 or fewer lost days or restricted work (39% vs. 8%).

3.2.3 Complexity and Severity of Claims

The complexity and severity of the injury/illness were two other important factors that affected capture of cases by the MSHA Part 50 program (**Table 3.1**). We evaluated two indicators of complexity: 1) the time from the date of accident to the date of a workers' compensation claim finalized, and 2) whether or not the injured worker hired an attorney to help litigate their claim. We then evaluated three indicators of severity: 1) permanent partial disability (PPD), 2) total temporary disability (TTD), and 3) the total compensation award. In general the more complex cases were less likely to be captured by the Part 50 program, but the more severe cases, and therefore perhaps the most obvious cases, were more likely to be captured.

Table 3.1 Differences in complexity and severity of injury/illness claims by reporting status to the MSHA Part 50 program, 2000-2013.

Variable	Captured Median	Not Captured Median	P-value[a]
Complexity of Injury/Illness Claims			
Years[b] to Decision	1.5	2.5	<.0001
Used Attorney (N, %)			
Yes	894 (21)	3,302 (79)	<.0001
No	1,026 (54)	881 (46)	
Severity of Injury/Illness Claims			
Percent Permanent Partial Disability	12	4	<.0001
Total Compensation Award	19,424	13,807	<.0001
Total Temporary Disability (weeks)	7.4	3.3	<.0001

[a] P-values are from Mann-Whitney U tests for comparing median values or from Chi-square tests for categorical variables.
[b] Years from date of accident to the date a workers' compensation decision was made.

3.2.3.1 Complexity of Claims – Time to Decision and Use of an Attorney

The IWCC database includes the time from the date of the accident to the date a workers' compensation settlement was decided ("time to decision"). As time to decision increases, so does the complexity (legal or medical) of a case. The median time to decision for IWCC claims that were reported to Part 50 was 1.5 years compared to 2.5 years for cases that were not captured (p <.0001). This result suggests that those cases that are resolved faster are more likely to be captured by the MSHA Part 50 program.

The use of an attorney is another indication of increased complexity. The Part 50 program captured fewer IWCC claims in which the employee hired an attorney to represent them in the administrative court. Only 21% of the claims where the employee hired an attorney (N =

894) were captured by MSHA, compared to 54% of the cases in which the employee did not hire an attorney ($p < 0.0001$).

3.2.3.1 Severity of Claims – TTD, PPD, and Amount of Compensation

In contrast to complex claims, those that were more severe were had a greater likelihood of being captured by the Part 50 program. Permanent Partial Disability (PPD) reflects the degree of lasting impairment resulting from an injury or illness, and is reported as a percent ranging from zero (no lasting impairment) to 100 (total disability). The median PPD among reported cases was significantly higher than the median PPD among unreported cases (12% vs 4%, $p < 0.0001$).

The IWCC data includes time of temporary total disability (TTD), another indicator of injury/illness severity. TTD reflects the time in which the employee is totally unable to work as a result of the occupational injury or illness. Generally, severity of the injury/illness increases as TTD increases. The median number of weeks awarded for TTD among unmatched cases was 7.4 weeks compared to 3.3 weeks for cases that were captured by MSHA ($p < 0.0001$).

The amount of money awarded the claimant in the final settlement is our final indicator of severity in the IWCC data. Adjusting for inflation, the median final settlement amount for cases reported to MSHA was $19,424 compared to $13,807 for unreported cases ($p<0.0001$). Our results from the PPD, TTD, and total award analyses suggest that those acute, severe, and costliest cases are significantly more likely to be reported to and captured by MSHA's Part 50 program.

3.2.1 Employee Demographic Variables Associated with Underreporting

The comprehensiveness of capture varied significantly by demographic factors (**Table 3.2**). The mean age of non-captured cases was significantly older than the mean of those cases that were captured (51 vs. 45, $p <.0001$). This age difference may reflect the higher burden of chronic conditions in older employees, which are poorly captured by the Part 50 program. Chronic conditions develop over time and therefore more often occur in older workers. Cases involving female employees were less likely to be represented in the Part 50 program (22% vs. 32%, $p = 0.01$). Overall, however, the percentage of female employees in this data set (2.4%) is extremely low, which precludes a more nuanced interpretation of this gender difference. Workers whose injuries or illnesses were not captured were also more likely to be married (70% vs 63%, $p < 0.0001$), but less likely to have any dependents (73% vs. 59%, $p < 0.0001$).

Table 3.2 Distribution of demographic factors across reporting status to the MSHA Part 50 program, 2000-2013.

Variable	Reported N (%)	Unreported N (%)	P-value[a]
Gender			
Male	1,891 (32)	4,071 (68)	0.01
Female	31 (22)	113 (78)	
Marital Status			
Married	1,364 (30)	3,257 (70)	<.0001
Unmarried	427 (37)	729 (63)	
Dependents			
Yes	796 (41)	1,160 (59)	<.0001
No	1,126 (27)	3,024 (73)	
Age (mean, sd)	44.5 (11)	51.1 (11)	<.0001

[a] P-values are from Chi-square tests for categorical variables and from t-tests for continuous variables.

4. RESULTS: MINE CHARACTERISTICS ASSOCIATED WITH UNDERREPORTING TO THE MSHA PART 50 PROGRAM

4.1 Overview of Illinois Mines

There were 323 mines in operation in Illinois at some point during 2000-2013, however only 275 mines had any Part 50 reports filed with MSHA during this time period. By commodity, 51 of these mines were coal mines and 224 were MNM mines. The MSHA Part 50 data identifies the mine in which the event occurred, and therefore we can examine mine-level characteristics for all Part 50 cases, matched to IWCC cases. The IWCC data has no information about the mine in which the injury/illness occurred, only providing the name of the responsible company, and therefore we are unable to examine mine-level variables for IWCC claims that were not captured by Part 50. In this section, we describe those mines that did file Part 50 reports between 2000 and 2013.

The distribution of mine size, as measured by number of employees per mine-year, varied significantly by commodity with coal mines having a higher proportion of large mines (≥100 employees/year) compared to MNM mines, (χ^2 $p < 0.0001$) (**Table 4.1**). We calculated the average number of employees by summing the total number of annual employees reported to MSHA throughout the entire study period, then dividing by the number of years for which that mine reported employees.

Table 4.1 Distribution of Illinois mines appearing in the MSHA Part 50 data (N = 275) by mine size and commodity, 2000 – 2013.

Average number of employees[a]	Commodity	
	Coal	MNM[b]
	N (%)	N (%)
1 – 4	2 (4)	44 (20)
5 – 9	3 (6)	66 (29)
10 – 19	3 (6)	60 (27)
20 – 49	18 (35)	38 (17)
50 – 99	7 (14)	10 (4)
≥100	18 (35)	6 (3)

[a] Average number of employees per mine-year.

[b] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

4.2 Reports of Violations

All but two mines that had Part 50 cases received notice of violations from MSHA during the study period leaving 273 mines for this analysis. The two that did not receive any violations were coal mines that were labeled as abandoned in 2013. The number of violations was highly associated with mine size. We controlled for this by analyzing the number of violations per average number of employees.

Table 4.2 lists the mean number of violations per employee by mine size category for coal and MNM mines. An F-test finds that mean number of violations per employee differs across mine size categories for coal ($p = 0.001$) and MNM mines ($p < 0.0001$). Mean violations per employee decrease across increasing mine size categories for MNM mines, whereas violations per employee exhibits a U-shaped curve in relationship to mine size. Violations per employee are highest in the smallest and largest mines.

A subset of the violations were deemed to be "significant and substantial" (S&S) by MSHA. F-tests find that average number of S&S violations differs across mine size for coal mines ($p = 0.03$) MNM mines ($p = 0.0002$). The relationships between S&S violations and mine size for coal and MNM mines is similar to the trends observed for all violations. The mean number of citation violations per employee differed significantly across mine size for both coal ($p = 0.0009$) and MNM ($p < 0.0001$) mines.

Table 4.2 Average number of violations and S&S violations per employee by mine size and commodity.

Employees per mine-year	Commodity					
	Coal			MNM[a]		
	Violations Mean (SD)	S&S Violations Mean (SD)	Citations Mean (SD)	Violations Mean (SD)	S&S Violations Mean (SD)	Citations Mean (SD)
1–4	7.9 (8.9)	2.9 (2.9)	7.2 (7.9)	7.7 (5.0)	1.6 (1.5)	7.6 (4.9)
5–9	2.1 (3.1)	1.3 (2.1)	2.0 (2.8)	5.8 (3.6)	1.0 (0.9)	5.7 (3.6)
10–19	0.6 (0.5)	0.2 (0.2)	0.6 (0.5)	4.5 (2.4)	0.8 (0.6)	4.5 (2.3)
20–49	3.1 (3.6)	1.2 (1.3)	3.0 (3.5)	3.7 (2.8)	0.6 (0.7)	3.7 (2.8)
50–99	4.2 (3.7)	1.2 (1.0)	4.0 (3.5)	4.5 (5.2)	1.0 (1.7)	4.4 (5.1)
≥100	10.5 (6.8)	2.7 (1.8)	10.2 (6.7)	2.8 (1.0)	0.5 (0.4)	2.7 (1.0)

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

4.3 Injury and Illness Case Reporting in the MSHA Part 50 Program and Mine Characteristics

Mines in Illinois had between one and 1,733 Part 50 injury and illness reports from 2000–2013. Coal mines, which on average were larger than MNM mines, averaged 137 cases per mine and MNM mines averaged 9 cases per mine. There was an increase in number of cases as mine size increased for both coal and MNM mines. Of the 275 mines, 76 (28%) had only one Part 50 report during the study period, 7 of which were coal mines.

As we saw for total number of violations, the number of Part 50 reports varied by mine size. Therefore we analyzed Part 50 reporting using the number of reports divided by average number of employees. Coal mines averaged 0.86 Part 50 reports per employee and MNM mines averaged 0.44 Part 50 reports per employee.

Table 4.3 displays the number of Part 50 reports per employee by mine size for coal and MNM mines. An F-test indicates that the average number of cases per employee was greater in the smallest and largest mines for coal mines ($p = 0.01$), but shows no difference in mean number of cases per employee among the different sizes of MNM mines ($p = 0.09$).

Table 4.3 Average Part 50 reports per employee by mine size for coal and MNM mines.

Employees per mine-year	Commodity			
	Coal		MNM[a]	
	Mean (SD)	Range	Mean (SD)	Range
1–4	1.54 (0.17)	1.42 - 1.67	0.38 (0.17)	0.20 - 0.89
5–9	0.17 (0.03)	0.14 - 0.20	0.42 (0.44)	0.10 - 2.67
10–19	0.28 (0.22)	0.06 - 0.50	0.40 (0.30)	0.06 - 1.60
20–49	0.52 (0.74)	0.03 - 3.24	0.52 (0.38)	0.03 - 1.53
50–99	1.08 (0.97)	0.27 - 2.98	0.69 (0.47)	0.18 - 1.65
≥100	1.25 (0.66)	0.24 - 2.39	0.54 (0.24)	0.16 - 0.80

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

MSHA also reports whether or not a mine has a safety committee present. Only four of the 224 MNM mines had safety committees compared to 8/51 (16%) of coal mines. Presence of a safety committee did not vary by mine size (χ^2 $p = 0.13$).

4.4 Part 50 Reports for Injuries and Illnesses with Latent or Chronic Etiologies

We identified 673 Part 50 reports for chronic injuries and illness as described in the Methods section. These cases occurred at 124 mines (39 coal, 85 metal/non-metal). Over half (45/85) of the MNM mines with chronic cases had a single case whereas only 7 out of 39 coal mines with chronic cases had a single case. As seen in **Table 4.4**, as the number of employees per mine increases, the average number of chronic cases per mine increases as well. This trend is observed for both coal and MNM mines.

Table 4.4 Mines with chronic illnesses or injuries reported to the Part 50 Program by mine size, 2000 - 2013. Average number of chronic cases is calculated for only those mines with at least one chronic case.

Employees per mine-year	Commodity			
	Coal		MNM[a]	
	No. Mines with ≥1 chronic case n (%)	Mean chronic cases/ mine	No. Mines with ≥1 chronic case n (%)	Mean chronic cases/ mine
1–4	1 (3)	1.0	7 (8)	1.0
5–9	0 (0)	0	16 (19)	1.4
10–19	0 (0)	0	22 (26)	1.4
20–49	13 (33)	2.9	24 (28)	2.8
50–99	7 (18)	4.1	10 (12)	6.5
≥100	18 (46)	20.4	6 (7)	7.3

[a] Metal/Mom-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

Chronic cases identified from Part 50 reports appeared as IWCC cases at approximately similar rates as we saw above for all cases: coal mines averaged 20.1% of chronic cases matched to IWCC data and 6.7% of MNM cases matched. There was, however, no difference in the percentage of Part 50 reports that appeared in IWCC for those mines that reported at least one case. Of the mines that had chronic cases, only 15% (13/85) of MNM mines and 49% (19/39) of coal mines had any chronic cases match.

4.5 Safety Committees

MSHA maintains information on whether or not there is a safety committee present at each mine in their database. We examined the relationship between the presence of a safety committee and the matching rates of Part 50 cases at those mines. Only 12 mines out of 275 had a safety committee (4 MNM, 8 coal). Combining commodities, we observed a significant increase in matching rate among those mines that had a safety committee (19% matching vs. 7%

matching, p = 0.003). When we examined this effect within commodity, we observed no difference in matching rates between those mines with a safety committee and those without. This lack of significant finding may be due to the small number of mines with a safety committee in this sample.

5. RESULTS: COMPANY CHARACTERISTICS ASSOCIATED WITH UNDERREPORTING TO THE MSHA PART 50 PROGRAM

5.1 Injury and Illness cases for Illinois Mining Companies

Nearly half (178/370) of the mining companies in Illinois that we identified using MSHA data had at least one injury or illness case reported to the MSHA Part 50 program or appearing in the IWCC claims. There were no reports or claims for 192 companies (48%) from 2000–2013. Of the 178 companies with either IWCC or MSHA reports, 56 had both Part 50 reports and cases that appeared in the IWCC system, 117 companies had only Part 50 reports and no IWCC cases, and the remaining 5 companies had cases that only appeared in the IWCC system with no Part 50 reports.

We analyzed the data for mining companies in several ways: 1) by the presence or absence of MSHA Part 50 cases, 2) the total number of MSHA and IWCC cases per company, 3) the percent of MSHA cases matched to IWCC cases, 4) if a company had more IWCC cases than MSHA cases reported, and 5) the percentage of cases matched in the two reporting systems for those 56 companies that had at least one case in both databases.

Of those companies with MSHA Part 50 cases, coal companies in Illinois were significantly more likely to report at least one case to the MSHA Part 50 system compared to MNM companies, 56% and 42%, respectively, χ^2 $p = 0.02$. Coal companies were similarly more likely to have cases appear in the IWCC system than MNM companies, albeit at lower rates, 35% and 11%, respectively, χ^2 $p < 0.0001$.

As company size increased, as measured by number of mines owned, the likelihood of having at least one injury or illness case reported to the MSHA Part 50 Program increased. Very few companies that owned only one mine in Illinois during the study period reported cases of injury or illness to MSHA Part 50 (19% of such companies) or had cases appear in the IWCC (<10% of companies). While reporting increased with number of mines owned for both coal and MNM companies, a greater proportion of coal companies reported at least one injury or illness to MSHA Part 50 in each category of company size than MNM companies (**Table 5.1**). IWCC cases were less likely to be present at mines of all sizes than MSHA Part 50 cases (data not shown).

Table 5.1 Percent of mining companies that had at least one case reported to the MSHA Part 50 program between 2000 and 2013 by number of mines owned and commodity (coal or MNM).

Mines owned per company	All Mines ≥1 case	Coal ≥1 case	MNM[a] ≥1 case
1–2	19%	25%	17%
3–9	40%	76%	32%
≥10	70%	100%	68%

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

As the number of employees at a company increased, so did the likelihood of any injury or illness being reported to either MSHA or appearing in the IWCC. Mining companies that averaged 5 or fewer employees per mine-year were very unlikely to have cases in either database. Only 16% of these companies had any cases in the MSHA Part 50 system and only 2% had cases in the IWCC system. Of the remaining 180 mining companies that averaged greater than 5 employees per mine-year, 80% had at least one case in the MSHA Part 50 system and 32% had at least one case in the IWCC system. Sixty-three of 64 (98%) companies that averaged 20 or more employees had at least one Part 50 report. As we saw for number of mines owned, coal companies were more likely to have Part 50 reports than MNM companies within each category of average number of employees (data not shown).

Coal companies were larger than MNM by average number of employees with the result that coal companies had more cases in the Part 50 program IWCC system. Coal companies averaged 174 Part 50 reports and 79 cases appearing in the IWCC system, compared to 15 and 3 cases in each system respectively, for MNM mines. Over 50% of coal and MNM companies had no cases appear in the IWCC system. The number of MSHA Part 50 reports filed by companies increased steadily for coal mines as the average number of employees increased; however for MNM mines, this number peaked in companies with the average of 20–49 employees per mine-year (**Table 5.2**). In contrast, we observed an inconsistent pattern of IWCC claims across company size for coal companies, with the highest average claims per employee (per mine-year) highest for companies with 10−19 and ≥50 average employees per mine year. The average number of IWCC claims increased steadily across each category of average employees per mine-year for MNM companies.

Table 5.2 Average number of cases in the MSHA Part 50 and IWCC data for coal and MNM companies in Illinois by average number of employees per mine-year.

Employees per mine-year	Coal Companies		MNM[a] Companies	
	MSHA	IWCC	MSHA	IWCC
≤5	0.3	0	0.5	0.1
5−9	0.2	0.3	0.7	0.02
10−19	0.4	1.7	0.7	0.1
20−49	0.9	0.3	1.5	0.3
≥50	1.8	1.1	0.5	0.6

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

5.2 Analysis of mining companies with underreporting to the Part 50 Program

We identified 61 mining companies associated with all 6,106 claims in the IWCC data. Nearly all mining companies identified in the IWCC had cases that were not captured by the MSHA Part 50 Program (n = 57). On average, 30% of their IWCC cases were not captured by MSHA data. A quarter of companies (n = 16) who had IWCC claims filed, had no matches in the MSHA Part 50 dataset indicating that all of the IWCC cases from those companies during this time period (n = 183) were not captured by the Part 50 Program.

While it seems logical to expect that all cases which resulted in an indemnity claim in the IWCC data would also appear in the MSHA Part 50 Program, this may not be the case if the employee filed the claim after his/her employment had terminated. The ability to capture these claims in the MSHA Part 50 program may require a regulatory change. As expected, the converse where many Part 50 reports that did not result in an IWCC claim was to be expected as not every injury or illness reported to MSHA Part 50 would be severe enough to result in litigation.

We have labeled IWCC cases that did not match cases in the Part 50 Program as "uncaptured" cases. While the distribution of coal and MNM companies was roughly equal in the IWCC (30 coal companies, 31 MNM companies), the coal companies comprised 94% of the cases in IWCC (n = 5,760). **Table 5.3** lists the companies in order of the proportion of IWCC cases that were not captured by the MSHA Part 50 Program. The companies with the greatest number of such cases were American Coal Company (n=586), Wabash Mine Holding Company (n = 481), Peabody Coal Company (n = 453), Freeman United Coal Company (n = 364), Consolidation Coal Company (n = 331), Old Ben Coal Company (n = 318), and Monterey Coal Company (n = 307). Interestingly there were four companies where we were able to identify all of their IWCC claims in the Part 50 dataset.

Table 5.3 Mining companies with IWCC claims that were not captured in MSHA Part 50 Program. The percent uncaptured is the number of IWCC cases not matched to MSHA Part 50 cases divided by the total number of IWCC cases for each company.

Company Name	# of Cases NOT Matched to MSHA Part 50 Cases	# of IWCC Cases Matched to MSHA Part 50 Cases	Total # of IWCC Cases	Percent Uncaptured in MSHA Part 50
Blackhawk Mining	4	0	4	100%
Brushy Creek Coal	130	0	130	100%
Buzzi Unicem USA	1	0	1	100%
Charleston Stone	1	0	1	100%
Columbia Quarry	1	0	1	100%
Delta Mine Holding	20	0	20	100%
Duck Creek Sand And Gravel	1	0	1	100%
Hastie Mining	4	0	4	100%
Illinois Resources	1	0	1	100%
Manley Brothers Of Indiana	2	0	2	100%
Mid America Sand And Gravel	1	0	1	100%
Midwest Material	1	0	1	100%
Prairie Material	4	0	4	100%
Riverstone Group	1	0	1	100%
Sahara Coal	10	0	10	100%
Sheridan Sand And Gravel	1	0	1	100%
Arch Minerals	172	5	177	97%
Black Beauty Coal	153	7	160	96%
Alliance Materials	13	1	14	93%
Consolidation Coal	331	31	362	91%
Mississippi Lime	8	1	9	89%
Wabash Mine Holding	481	64	545	88%
Meyer Material	20	3	23	87%
Old Ben Coal	318	50	368	86%
Peabody Coal	453	89	542	84%
JM Huber	3	1	4	75%
S Coal	6	2	8	75%
Thelen Sand And Gravel	3	1	4	75%
Monterey Coal	307	112	419	73%
Freeman United Coal	364	136	500	73%
Coal Miners	58	24	82	71%
International Coal Group	54	23	77	70%

Company Name	# of Cases NOT Matched to MSHA Part 50 Cases	# of IWCC Cases Matched to MSHA Part 50 Cases	Total # of IWCC Cases	Percent Uncaptured in MSHA Part 50
Wedron Silica	16	7	23	70%
Springfield Coal	20	9	29	69%
Tri County Coal	84	42	126	67%
Turris Coal	35	19	54	65%
American Minerals	6	4	10	60%
Falling Springs Quarry	3	2	5	60%
Maryan Mining	4	3	7	57%
Centre Crown Mining	13	10	23	57%
Lafarge	18	15	33	55%
Big Ridge	149	128	277	54%
White County Coal	159	148	307	52%
Carmeuse Lime	1	1	2	50%
Elmhurst Chicago Stone	1	1	2	50%
US Silica	4	4	8	50%
Unimin	28	29	57	49%
Vulcan Materials	33	38	71	46%
Bluff City Minerals	5	6	11	45%
American Coal	586	726	1312	45%
Mach Mining	26	39	65	40%
Nubay Mining	19	30	49	39%
Illinois Cement	5	9	14	36%
Knight Hawk Coal	27	49	76	36%
Anna Quarries	4	8	12	33%
Hanson Material Service	7	17	24	29%
M Class Mining	4	19	23	17%
Illinois Mining	0	1	1	0%
Keyesport Sand And Gravel	0	1	1	0%
Patton Mining	0	5	5	0%
Vigo Coal	0	2	2	0%

The number of coal (n=28) and MNM (n=29) companies with uncaptured cases was similar. Companies with uncaptured cases varied considerably by total mine-years of operation during the study period, total employees, and average employees per mine-year (**Table 5.4**). The majority of companies (67%) with uncaptured cases owned only 1-2 mines

The smallest mining companies had the lowest capture rate of IWCC claims in the MSHA Part 50 program. **Tables 5.5 and 5.6** display percent of cases captured for coal and MNM companies by mine size assessed by total mines owned and average employees per mine-year, respectively. Coal companies had capture rates which increased fairly consistently as company size increases in both tables; however, capture rates peaked for medium sized MNM companies, (20-49 employee per mine-year).

Table 5.4 Description of those companies with injury and illness cases that were not captured by the MSHA Part 50 Program, 2000-2013. Companies are described by number of mines owned, number of mine years, average number of employees per mine-year, and the percent of cases that were not captured by the MSHA Part 50 Program.

Company Name	Mines Owned	Mine-Years	Average Employees per Mine-Year	Percent Uncaptured by MSHA Part 50
Coal Companies				
Blackhawk Mining	3−9	9	5−9	100%
Brushy Creek Coal	1	1	10−19	100%
Delta Mine Holding	1	2	5−9	100%
Illinois Resources	1	2	5−9	100%
Sahara Coal	1	2	<5	100%
Arch Minerals	2	3	≥50	97%
Black Beauty Coal	3−9	40	≥50	96%
Consolidation Coal	2	17	≥50	91%
Wabash Mine Holding	1	8	≥50	88%
Old Ben Coal	2	8	≥50	86%
Peabody Coal	3−9	42	≥50	84%
S Coal	3−9	11	20−49	75%
Monterey Coal	2	13	≥50	73%
Freeman United Coal	3−9	32	≥50	73%
Coal Miners	1	1	≥50	71%
International Coal Group	1	9	≥50	70%
Springfield Coal	3−9	10	20−49	69%
Tri County Coal	1	4	≥50	67%
Turris Coal	1	4	≥50	65%
Maryan Mining	1	6	≥50	57%
Centre Crown Mining	1	1	≥50	57%
Big Ridge	3−9	34	≥50	54%
White County Coal	2	17	≥50	52%
American Coal	2	18	≥50	45%
Mach Mining	1	9	≥50	40%
Nubay Mining	1	5	≥50	39%
Knight Hawk Coal	3−9	56	20−49	36%
M Class Mining	1	5	≥50	17%
MNM Companies				
Buzzi Unicem USA	1	3	≥50	100%
Charleston Stone	1	14	10−19	100%
Columbia Quarry	3−9	40	20−49	100%
Duck Creek Sand And Gravel	1	14	5−9	100%
Hastie Mining	2	28	10−19	100%
Manley Brothers Of Indiana	1	14	20−49	100%
Mid America Sand And Gravel	1	14	5−9	100%
Midwest Material	2	19	5−9	100%

Company Name	Mines Owned	Mine-Years	Average Employees per Mine-Year	Percent Uncaptured by MSHA Part 50
Prairie Material	3–9	7	5–9	100%
Riverstone Group	3–9	91	10–19	100%
Sheridan Sand And Gravel	1	4	<5	100%
Alliance Materials	3–9	45	<5	93%
Mississippi Lime	1	2	≥50	89%
Meyer Material	3–9	66	10–19	87%
JM Huber	3–9	25	≥50	75%
Thelen Sand And Gravel	2	18	20–49	75%
Wedron Silica	1	14	≥50	70%
American Minerals	1	4	20–49	60%
Falling Springs Quarry	1	14	20–49	60%
Lafarge	≥10	89	20–49	55%
Carmeuse Lime	1	13	20–49	50%
Elmhurst Chicago Stone	3–9	41	10–19	50%
US Silica	1	14	≥50	50%
Unimin	3–9	81	20–49	49%
Vulcan Materials	≥10	200	20–49	46%
Bluff City Minerals	2	15	≥50	45%
Illinois Cement	2	18	≥50	36%
Anna Quarries	1	14	20–49	33%
Hanson Material Service	3–9	65	20–49	29%

Table 5.5 Mean capture rate (%) per company of IWCC claims by the MSHA Part 50 Program stratified by number of mines owned for coal and MNM companies in Illinois, 2000 to 2013.

	Commodity			
	Coal		MNM[a]	
Mines owned per company	N	Mean % Captured	N	Mean % Captured
1–2	24	10	54	2
3–9	25	11	116	1
≥10	12	20	136	4

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

Table 5.6 Mean capture rate (%) per company of IWCC claims by the MSHA Part 50 Program stratified by average number of employees per mine year for coal and MNM companies operating in Illinois, 2000 to 2013.

Employees per mine-year	Commodity			
	Coal		MNM[a]	
	N	Mean % Captured	N	Mean % Captured
≤5	11	0	146	0
5−9	10	0	73	2
10−19	5	2	46	3
20−49	9	12	24	10
≥50	25	19	15	5

[a] Metal/Non-Metal (MNM) includes metal, non-metal, stone, and sand and gravel mines.

5.3 Violations and Cases

The number of violations that a company received was highly correlated with its overall number of MSHA Part 50 cases, regardless of commodity (Spearman's $rho_{all} = 0.94$, $rho_{coal} = 0.93$, $rho_{MNM} = 0.88$). There was also a strong association between the number of violations a company received and the percent of its Part 50 reports that were severe enough to have appeared in the IWCC dataset (Spearman's $rho_{all} = 0.52$, $rho_{coal} = 0.52$, $rho_{MNM} = 0.35$, $p < 0.0001$ all). We found no clear association between number of violations per employee and percent of MSHA cases severe enough to appear as IWCC cases when we controlled for company size.

We found no correlation between number of IWCC cases and number of violations a company received when examining those companies with at least one IWCC case (Spearman's rho = 0.098, p = 0.47). Those companies with at least one IWCC case had 0.76 violations per employee compared to 1.00 violation/per employee at those companies without IWCC cases (p = 0.12). Companies with non-captured cases did not have significantly more violations per employee than all companies: coal and MNM companies with non-captured cases had 1.1 and 1.0 violations per employee, respectively.

5.4 Cases with Chronic Etiologies

Chronic injuries and illnesses were also analyzed at the company level. The conditions that we considered as chronic cases can be found in **Table 2.2**. The majority of companies in the MSHA data (76%) and IWCC data (91%) had no chronic cases (**Tables 5.7 and 5.8**). The majority of companies with at least one chronic injury or illness in the MSHA Part 50 data were MNM companies (69% vs. 31%). The number of companies with at least one chronic injury or illness case in the Part 50 data increased with increasing average employees per mine-year for coal companies, but not for MNM companies. Compared to coal companies, MNM companies were more likely to have at least one chronic case in the MSHA data (44% vs 20%) and the IWCC database (28% vs 3%). While fewer companies had chronic cases in the IWCC data, the number of these cases per company was greater in the workers' compensation dataset than in the Part 50 reports.

Table 5.7 Number of companies[a] that had at least one chronic case in the MSHA Part 50 database and those that had none by commodity and number of mines owned.

Mines owned per company	≥1 Chronic Case			No Chronic Cases		
	Coal N (%)	MNM N (%)	All	Coal N (%)	MNM N (%)	All
1–2	4 (50)	4 (50)	8	20 (29)	50	70
3–9	13 (57)	10 (43)	23	12 (10)	106 (90)	118
≥10	10 (18)	46 (82)	56	2 (2)	90 (98)	92
Total	**27 (31)**	**60 (69)**	**87**	**34 (12)**	**246 (88)**	**280**

[a] The total number of companies in this table is 367. Three companies were contractors and therefore do not have a set number of mines associated with their operation.

Table 5.8 Number of companies[a] that had at least one chronic case in the MSHA Part 50 database and those that had none by commodity and average employees per mine-year.

Employees per mine-year	≥1 Chronic Case			No Chronic Cases		
	Coal N (%)	MNM N (%)	All	Coal N (%)	MNM N (%)	All
≤5	0 (0)	2 (100)	2	11 (7)	144 (89)	155
5–9	0 (0)	13 (100)	13	10 (14)	60 (86)	70
10–19	1 (6)	17 (94)	18	4 (12)	29 (88)	33
20–49	4 (21)	15 (79)	19	5 (36)	9 (64)	14
≥50	22 (65)	12 (35)	34	3 (50)	3 (50)	6
Total	**27 (31)**	**59 (69)**	**86**	**33 (12)**	**245 (88)**	**278**

[a] The total number of companies in this table is 364. Three companies were contractors and therefore do not have a set number of mines associated with their operation. An additional three companies were missing data on average annual employment.

6. CRITICAL REVIEW OF ERG REPORT

The current analysis of injury and illness underreporting in MSHA Part 50 data in Illinois arose from an attempt to replicate and make improvements to the original underreporting analyses performed by the Eastern Research Group (ERG) in California and Kentucky. As part of the Statement of Work (SOW) in our contract with the U.S. Department of Labor's Chief Evaluation Office, we have critically reviewed of the ERG analysis and report. We found that there were several important limitations to the ERG analysis with regards to data sources and methods.

6.1 Data Limitations

First Report of Injury (FROI) data from Kentucky was used in the original analysis on underreporting, which is problematic because there is a one-day-lost minimum threshold for entry into the KY system. Less severe injuries, or those resulting in less than one day of lost work were not used in the matching process. To address this, the ERG excluded all cases from the MSHA Part 50 data that had a degree of injury indicating no physical injury to the employee had occurred, however, this retains cases in the MSHA data that would not be eligible for entry into the KY FROI data based on the one-lost-day threshold. There are additional categories of degree of injury that could have been excluded from the MSHA Part 50 data to make a more comparable data set to the KY FROI data, specifically those that indicated an injury with days of restricted activity only and no days away from work without restrictions. If these restrictions were made in the original analysis, it was unclear from the report. With these types of injuries retained in the Part 50 data used in the ERG analysis, underreporting would be artificially inflated because there are additional injuries/illnesses included in the Part 50 data that would not have originally been included in the KY data. It also appears that there was an assumption of no misclassification of days away from work in the Part 50 or FROI data. The probabilistic linkage methods we used in the current report allowed for some misclassification of days of lost work.

Neither the data from California nor Kentucky included employee name, a uniquely identifying variable that could have greatly improved match rates if it were available. It is unclear whether or not names were not released from the WC agencies in CA and KY, or if it was received and not used in the matching procedures.

The analysis presented in this report has expanded the prior analysis conducted by the Chief Evaluation Office of the USDOL using Kentucky and California data.[v] This report adds to the previous work in several respects. Our analysis did not rely exclusively on FROI, but added information contained in state workers' compensation data. This information is unavailable in the FROI data and in the Part 50 reports. Additionally we have information on hospital measures and long term outcome measures such as settlement costs and percent disability which provides

[v] Eastern Research Group. Evaluation of accuracy and completeness of nonfatal injury and illness reporting in the mining industry. Prepared for the Department of Labor (Internal Report). Submitted on June 11, 2013.

an indicator of the severity of the disease or injury. This report analyzes the pattern, type, and severity of injuries and illnesses suffered by employees of mining companies in Illinois.

6.2 Methodological Limitations

Our main concern with the methods used by the ERG in their analysis of workers' compensation and Part 50 data was the reliance solely on deterministic matching methods. It appears considerable work was done to standardize fields in the two data sets prior to matching, but that only a single-pass approach was used to link the WC and Part 50 data. Deterministic linkage involves the exact, one-to-one character matching of pre-designated variables across two or more datasets; this technique is frequently used when identifiers, such as name and social security number, are available. As discussed above, names were not used in the matching process. Misspellings or errors in data entry can prevent the matching of cases through deterministic methods.

Alternatively, probabilistic methods allow greater flexibility and offer the ability to match a larger number of cases. The probabilistic linkage process generates probabilities of a match based on the number of variables that exactly match and the variables that are close, but not exact, matches. Probabilistic linkage is accomplished through multiple passes, or steps, which begin with the highest level of precision and then modify the precision with each subsequent step, thereby, ensuring that higher probability matches are identified in the initial step, and removed from the datasets prior to subsequent steps, so that they don't match again to another case when the matching criteria is less rigorous. In the subsequent passes, "fuzzy" matching criteria are used to throw out a broad net for matching and allow for data entry errors, intentional omissions or differences in coding procedures. Typically, 70% or more of all matches occur in the first and most rigorous step of the linkage procedure. Appropriate sensitivity models are run following the completion of the linkage process to assess whether the cases in the first round of matching vary substantially from those linked during later steps. We employed probabilistic methods in our analysis of IWCC and Part 50 data to increase the likelihood of matching as well as to overcome of the limitations with regard to misspellings and data entry errors in these data. Employing probabilistic methods instead of deterministic linkage methods would be the best opportunity for a re-analysis of the CA, KY, and Part 50 data.

Once the data sets were matched, it appears there was no attempt to understand the mine- or company-level characteristics associated with those claims that did match records in the Part 50 data. The Part 50 data includes the ID of the mine at which the employee was injured, which can be linked with numerous additional MSHA databases which include information about the mine in which the injury occurred. Through linkage with these databases, we were able to compare the mine- and company-level factors for those Part 50 cases that matched the IWCC data and those that did not. For those IWCC claims that did not match to Part 50 cases, we were able to examine company-level factors associated with underreporting.

Our study on underreporting in Illinois attempts to address many of the issues we found with the ERG report. We have used as many unique identifiers as possible, including names, to improve matching. Further, we employed probabilistic linkage methods to overcome some of the

data issues discussed above such as misspellings or misclassification of days away from work. We believe that if the methods we employed with the IWCC an MSHA data in Illinois were employed in the linkage of KY and CA workers' compensation data to MSHA Part 50 cases, we would have a more accurate and nuanced understanding of the extent of underreporting to Part 50 in these two states.

There were discrepancies in the categorization schemes for some variables between the MSHA and IWCC databases. For example, we would expect distribution of injuries by body location to be the same for matched cases. That is, a case of a sprained ankle would be designated as a lower-body injury in both datasets, regardless of how well the injury was diagnosed. This is not always the case. While body location was one of our validation variables, we did not require a perfect match on all validation variables. Because of this, some of the data presented below will have different numbers of confirmed and possible matches within a category across MSHA and IWCC databases.

7. CONCLUSIONS AND RECOMMENDATIONS

This detailed study of MSHA Part 50 Reporting system focused on mining injuries and illnesses in the State of Illinois. We had the unique opportunity to utilize administrative data from the Illinois Workers' Compensation Commission (IWCC) and link it to MSHA Part 50 reports. We then analyzed those cases that resulted in workers' compensation claims, but never were captured by the MSHA Part 50 Program. We were able to study the characteristics of the individual suffering the injury or illness, as well the mine, and mining company where the event took place to see what factors may have influenced capture rates.

These findings may assist MSHA in improving the program with more comprehensive reporting. This study provides further insight into the data that is captured and missed by Part 50. The multi-stage matching approach used in this study allowed us to accurately identify those cases that appeared in both datasets. Overall this study showed that 71% of IWCC claims were not captured by the Part 50 program. Roughly a third of the injury/illnesses claims in the IWCC data were for chronic conditions, some of which may not be required to be reported to the Part 50 Program. Of the acute conditions, which would be expected to be reported to the Part 50 Program, we found that 57% were not reported. This is an indication of the likely magnitude of underreporting of acute injuries and illnesses in the Illinois mining industry.

7.1 Major Results

7.1.1 Chronic Disease and Injuries are Underreported Compared to Acute Processes

The findings from this study show that the MSHA Part 50 reporting system captures a substantially higher percentage of acute injuries that occur in mines than chronic injuries or illnesses.

Systemic diseases were poorly captured when compared with injuries or disease associated with localized body parts. Only 35 occupational diseases were found in the MSHA database, 2 of which were matched.

Mechanisms of disease involving chronic exposures were also not captured by Part 50, including chronic exposure to chemicals or substances, or repetitive micro-trauma. Mechanisms such as "Caught in/under/between an object" and "Struck by an object"; "Falls"; and "Overextension" cases were relatively well-captured.

This finding is a partly function of the regulatory mission of the Part 50 program which is focused on the reporting of "accidents" and less focused on chronic injuries and illnesses. The reporting structure of the Part 50 Program is geared towards reporting clearly-defined events with clear proximate causes. Efforts to expand the focus of the regulatory mission of Part 50 may be needed to improve chronic disease reporting.

7.1.2 Demographic Associations with Underreporting

Cases involving older workers were less likely to be reported. This may be a function of older age being associated with chronic disease.

Workers with dependents were more likely to have IWCC claims reported to the Part 50 program. It is possible that those miners with more dependents had more incentive to file a claim with the IWCC for their injury or illness.

7.1.3 Complexity of Unreported Cases

Uncaptured claims are more complex. They took longer to adjudicate, and more frequently involved use of an attorney.

Severe acute injuries resulting in claims to IWCC were more likely to be captured by the Part 50 Program than chronic conditions. Acute cases determined to involve disfigurement, greater compensation, and total temporary disability were in this group.

Injury and illness cases with chronic etiologies in the IWCC data were captured at a very low rate in the MSHA Part 50 Program.

7.1.4 Mine and Mining Company Characteristics and Underreporting

Only 4 companies in Illinois reported all of their IWCC cases in the Part 50 Program. Forty-four companies reported none of their IWCC cases to MSHA.

Case-capture rates increased for coal mine companies as the size of the company increased. For MNM companies, capture rates between the IWCC and MSHA Part 50 data were highest for mid-sized companies (20-49 employees/mine-year). Seven large coal companies had more than 100 cases which were not captured, most of these were chronic cases.

The number of Part 50 reports per employee was greater in the smallest and largest coal mines, but greatest for mid-sized MNM mines.

Coal mines in Illinois had more cases of injury and illness compared to MNM mines. This difference remained after controlling for mine size. The largest mines had the greatest number of IWCC claims captured by the Part 50 program. These results indicate that large mines were more likely to be reporting the more serious cases.

7.2 Limitations

There were several limitations to this study regarding the data sources and analytical approach. A major limitation of our study was the lack of mine-specific data in the IWCC system. The company for which the employee worked is listed, therefore we used company-level data, aggregated from MSHA public-use data sets, to analyze workplace factors that influence capture rates of injury and illness between these two data system. We were unable to analyze mine-level factors that directly influence reporting.

Furthermore, the IWCC data did not contain job title or specific occupation of the employee. Consequently, administrative and other staff not directly involved in mining processes were included in the analysis, as there was no way to exclude these workers from the IWCC data. We included all job titles, including administrative staff, in the Part 50 Data in order to match the data sets more exactly.

We restricted our data set of Part 50 cases to those originating in Illinois. This, however, may have reduced the number of cases from IWCC that matched to the Part 50 data. It is possible that a Part 50 case could originate from a contiguous state (e.g., Indiana or Kentucky), but have a workers' compensation claim in Illinois. An example of this might be that an employee is injured in a surrounding state, but works for a company that is based in Illinois. In this case, the Part 50 report and the IWCC claim may be listed in different states. We propose trying to link remaining unmatched IWCC cases to Part 50 claims from surrounding states.

Finally, a large proportion of uncaptured cases in the IWCC data may not be required to be reported to the MSHA Part 50 Program, either as a result of timing of diagnosis or severity of injury or illness. The vast majority of chronic cases (94%) in the IWCC data set were not captured by the MSHA Part 50 Program, however, these may have been claims filed by mine employees after they had retired or left the mining industry. In these instances, mine operators would not be required to report these injuries or illnesses to MSHA. The IWCC database does not indicate whether or not the employee was actively employed in the mining industry at the time of the injury or illness diagnosis. It is assumed that employees experiencing an acute occupational injury or illness are actively employed at the time of injury, therefore we would expect these IWCC cases to be reported to MSHA.

7.3 Recommendations:

7.1.1 MSHA may consider regulatory change to require reporting of chronic illness regardless of employment status.

Consideration should be given to require reporting chronic illness or injury attributed to a mine even though the worker no longer is employed at the time of diagnosis or a workers' compensation case is filed.

7.3.2 MSHA may consider focusing on small mines to improve reporting.

Our results indicate that the smallest mines, both coal and MNM, were very unlikely to have cases identified in both the MSHA and IWCC data. It is possible that these mines have the poorest record-keeping and therefore are not properly filing reports that the larger mines are better able to complete.

7.3.3 Focus on Coal Mines

Coal mines in Illinois had greater numbers of unreported cases than MNM mines. In addition they had a greater number of chronic disease cases which are likely to be more complex and severe.

7.3.4 Consider MSHA Initiative to Develop Relationship with State Workers' Compensation Systems

State workers' compensation systems capture a large volume of the most severe and complex cases. MSHA may consider exploring the development of relationships with individual states to require that injury and illness cases related to mining companies be reported directly to MSHA. This data is in the public domain and should therefore be made available. This would increase reporting to MSHA for these most important and significant injuries and illnesses.

8. REFERENCES

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APPENDIX I.

Table I. Complete list of variables, with their data sources and treatment, used in the analysis of individual factors associated with injury and illness underreporting to the MSHA Part 50 Program, 2000-2013.

Variable	Datasets: MSHA/IWCC/Both	Distributions analyzed
Employer name	Both	Categorical
Injury mechanism	Both	Categorical
Injury body location	Both	Categorical
Injury Severity	Both	Categorical
Employee age	Both	Continuous
Employee sex	Both	Binary
Accident year	Both	Discrete
Occupation/Job title	MSHA	Categorical
Mine type	MSHA	Binary
Total mining experience	MSHA	Continuous
Work experience at mine	MSHA	Continuous
Work experience in job title	MSHA	Continuous
Days lost work	MSHA	Binary & Continuous
Days restricted work	MSHA	Binary & Continuous
Marital status	IWCC	Binary
Disfigurement	IWCC	Binary & Continuous
Percent permanent disability	IWCC	Binary & Continuous
Total temporary disability	IWCC	Binary & Continuous
Total workers' compensation	IWCC	Binary & Continuous
Average weekly wage	IWCC	Continuous
Number of dependents	IWCC	Discrete