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Final Technical Report

1.0 Cover Page

Project Title: Clarifying Distribution, Trends, and Determinants of Adverse Health in United States Miners: Exploration and Integration of Existing Data Systems

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2.0 Executive Summary

Recent tragedies in our nation's coal mines, including the explosions and fires at the Sago and Upper Big Branch mines in West Virginia, have brought the dangers of contemporary mining to the forefront of public attention. While injuries and fatalities from mining safety failures are dramatic and highly visible, morbidity and mortality from mining-related chronic health disorders can be more difficult to identify and affect a much larger portion of the mining population. Miners in the United States continue to suffer from an excess of chronic respiratory disease as well as other adverse health effects resulting from their occupational exposures.

The objectives of this research project were to perform a systematic evaluation, analysis, and integration of data from federal and state agencies and other organizations to study determinants of miners' risk for respiratory and cardiovascular disease outcomes.

We have evaluated national datasets including the federal Black Lung Benefits Program (BLBP), the NIOSH Coal Workers' Health Surveillance Program (CWHSP), national population-based surveys, and data from the Mine Safety and Health Administration (MSHA). The analysis of the BLBP data revealed that average lung function measurements in claimants have improved since the passage of dust control regulations, but during the same period, the prevalence of severe pneumoconiosis including progressive massive fibrosis appears to have worsened.

Our analysis of surveillance data from the CWHSP showed a relationship between the category of simple pneumoconiosis on chest radiographs and declines in lung function, indicating that simple pneumoconiosis is not a benign condition.

We analyzed data from national surveys and state based surveys which showed high rates of smoking and other forms tobacco use in extraction workers compared to other workers, an important consideration in these workers exposed to occupational respirable dust.

In addition, we linked data from MSHA to state-based datasets showing that mines in New Jersey that reported higher injury rates also reported more cases of silicosis. Investigation of state-based data from Illinois showed a higher rate of workers' compensation claims for cardiopulmonary disease in miners compared to non-miners. The number of cardiopulmonary claims were fewer in large mine operations, and if there was a safety committee present at any of the mines owned by that company. A linkage between MSHA Part 50 program reports of injury and illness and Illinois Workers' Compensation Commission data showed that claims for all injuries and illness were underreported to MSHA, and that chronic respiratory disease and illness were much less likely to be reported to MSHA than claims for injury. There are clear opportunities for improvements in the regulatory requirements and/or program training and enforcement.

Overall, the findings of this project highlight the great wealth of public health information that exists in these national and state occupational health datasets. That information is greatly enhanced when careful linkages combining these data can be performed. This would greatly inform the allocation of limited resources to appropriate preventive interventions. The results from each of the sub-studies performed in this project demonstrate the current utility of this approach, and the possibilities that would exist if certain changes were made to standardize data collection and enhance the ease of linkages in the future.

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3.0 Problem Statement and Objective
Focus Area – Health: - a) Surveillance of health conditions for miners; b) Respiratory disease

Recent tragedies in our nation's coal mines, including the explosions and fires at the Sago and Upper Big Branch mines in West Virginia, have brought the dangers of contemporary mining to the forefront of public attention. While injuries and fatalities from mining safety failures are dramatic and highly visible, morbidity and mortality from mining-related chronic health disorders can be more difficult to identify and affects a much larger portion of the mining population. Miners in the United States continue to suffer from an excess of chronic respiratory disease as well as other adverse health effects resulting from their occupational exposures.[1,2,3]

Modern mining technology has improved productivity and modern dust control regulations have reduced permissible dust limits in coal mines, but neither development has eliminated the risks of exposure to respiratory hazards in the mine atmosphere and the associated adverse health effects, including chronic respiratory illness. Occupational exposure to coal mine dust has been clearly shown to cause a broad spectrum of respiratory diseases, encompassed by the term coal mine dust lung disease (CMDLD).[4] Important among them are the pneumoconioses. While there had been remarkable progress in reducing pneumoconiosis in coal miners after implementation of the Federal Coal Mine Health and Safety Act of 1969 (The Act), recently this trend has reversed. Since 1995, the rate of coal workers' pneumoconiosis (CWP) among U.S. coal miners has been increasing.[5] Equally disturbing is the increased incidence of rapidly progressive pneumoconiosis (RPP),[6] and progressive massive fibrosis (PMF), the most severe occupational respiratory disease seen in relatively young coal miners.[7] In addition to pneumoconiosis, miners exposed to respirable silica and coal mine dust can develop chronic obstructive pulmonary disease (COPD) including chronic bronchitis and emphysema,[8–12] as well as deficits in lung function.[13–16]

Less is known about the risk of cardiovascular disease (CVD) in miners. Though published research is sparse, one study of U.S. miners reported an increased risk of mortality from ischemic heart disease associated with cumulative exposure to coal dust and with coal rank.[17] The root causes of CVD among miners are complex and include occupational as well as personal risk factors. Occupational risk factors for CVD in the U.S. mining workforce include exposure to fine particulates, noise, vibration, heat, carbon monoxide, shift work, and mandatory overtime. CVD personal risk factors prevalent in this population include: male gender, hypertension, smoking and other tobacco use, obesity, lack of exercise, high fat diet, alcohol abuse, diabetes mellitus, dyslipidemia, and obstructive sleep apnea.

There are important gaps in understanding the impact of lung disease and CVD in this population. Datasets held by federal, state, and private agencies contain untapped information that can inform our understanding of the prevalence and severity of these diseases. This information could be invaluable in improving our understanding of workplace and personal risk factors and result in targeted interventions to prevent disease and promote health. Examples of such datasets include: workers' compensation systems, health insurance data, mine-specific exposure information, and clinical assessments for disability and compensation programs. Thus far, these data systems have been underutilized in efforts to assess the public health importance of respiratory and cardiovascular diseases in miners.

A recent study using West Virginia State Occupational Pneumoconiosis Board records demonstrated how non-surveillance data can be used to improve our understanding of disease in mining populations.[7] This study demonstrated that contemporary dust exposures have resulted in severe lung dysfunction and premature death among young miners. Records from miners with PMF whose claims were approved by the Board between January 2000 and December 2009 were reviewed. The authors reported that among the 138 cases of PMF, the average interval from a normal chest radiograph to PMF was only 12 years, and that miners' lung function declined "at a markedly accelerated rate compared with declines observed in non-smoking and smoking non-miners of a similar age". The vast majority of affected miners worked only after establishment of the current permissible exposure limit for coal mine dust by The Act.

The objectives of this research were to perform a systematic evaluation, analysis, and integration of data from federal and state agencies and other organizations to study determinants of miners' risk for respiratory and cardiovascular disease outcomes. We hoped to identify sub-populations of miners as well as specific workplace and mining practices that may put miners at increased risk for respiratory and cardiovascular disease. Our long-term goals are for this information to be used to develop interventions that would reduce the risk of disease, mitigate the most significant exposures to ultimately reduce the burden of illness with its resultant morbidity and mortality. To accomplish this goal we had three specific aims:

1. Systematically evaluate the structure, content, quality, and scope of existing data systems for information on contemporary trends, distribution, severity, and associated determinants of health and disease in modern miners.
2. Analyze each dataset for information regarding disease prevalence and associated risk factors for traditionally monitored diseases such as pneumoconiosis along with less-understood diseases such as emphysema, chronic bronchitis, and CVD.
3. When useful and feasible, link databases to provide a more complete understanding of the burden of, and risk factors for, respiratory and cardiovascular disease among miners. Information analyzed from multiple individual datasets from the same population may provide a more complete understanding of disease occurrence and risk factors than unlinked single data sources.

4.0 Research Approach

Our overall research approach was to use epidemiologic methods to analyze datasets from multiple agencies and organizations and integrate these data to document determinants of miners' risk for respiratory and cardiovascular disease in the U.S. In the following section, we detail our research approach for each of our data sources and linkage methods.

4.1 National datasets

4.1.1 U.S. Department of Labor (USDOL), Office of Workers' Compensation Programs (OWCP), Division of Coal Mine Workers' Compensation (DCMWC)

The USDOL OWCP/DCMWC administers the Black Lung Benefits Program (BLBP), which provides benefits to former coal miners who meet the criteria for disabling Black Lung disease. Little is known about the health of former coal miners in the U.S., but it is thought that the majority of U.S. coal miners apply for BLBP benefits at some point in their career. The goal of this analysis was to systematically explore the BLBP data to determine their utility in understanding the health status of former U.S. coal miners.

DCMWC maintains claimant data in two large data systems: the Automated Support Package (ASP), which includes the claims accession log, and the Automated Correspondence System (CORS). CORS data contain abstracted summaries of the Black Lung examination results including chest radiographs (chest X-rays) interpreted according to International Labour Organization (ILO) standards; pulmonary function tests results (PFTs); and medical history and physical examination notes (PE). A miner, or the miner's surviving dependent, may have multiple claims and multiple exams per claim in CORS.

Our primary aim for the DCMWC data was to describe the data and estimate the overall prevalence of CWP and deficits in lung function in former U.S. coal miners. Our secondary aim was to explore the utility of these data for describing the occurrence of other cardiopulmonary health conditions in this population, including asthma, COPD, and CVD, and to identify risk factors for these health outcomes including smoking and obesity.

The Act mandated dust control regulations that were instituted starting in 1970. We therefore hypothesized that there may be differences in spirometric and radiographic abnormalities between those miners who had worked exclusively after the dust controls were enacted ("post-regulation," or "post-reg.") and those miners employed before the regulations were enacted ("pre-regulation," or "pre-reg.").

After putting in place interagency data use agreements, we received the data from all miner and survivor claims for Federal Black Lung benefits from January 1, 2000 through December 31, 2013. We subsequently completed an analysis that addressed our goals for these data.

4.1.2 Health Resources Services Administration (HRSA) – Office of Rural Health Policy, Black Lung Clinics Program (BLCP) data systems

HRSA funds 15 grantees to provide medical surveillance, diagnostic services, and benefits counseling for miners who are at risk for both work-related and non-work-related diseases. These HRSA clinics are located in mining regions of the United States including Colorado, Wyoming, and New Mexico in the West, and West Virginia, Pennsylvania, Ohio, Kentucky, and Illinois in

the East and Midwest. Data from the 2011-2012 grant year shows that the BLCP served 13,590 coal miners, of whom 2,153 were active and the remainder were retired or had left the industry.

Our investigators have worked with HRSA to develop parameters for collection of de-identified data for aggregate analysis that assures data quality. We have begun to pilot the use of the clinic data by comparing BLCP patients who are miners with those who are non-miners in order to understand the excess burden of disease and risk factors specific to our clinic population.

4.1.3 Mine Safety and Health Administration (MSHA) Datasets

MSHA maintains many datasets to monitor compliance of U.S. mining operations with The Act. Of particular use to this study are those datasets that include data on accidents and injuries, employment and production, dust and noise sampling, mine characteristics, and violations. Our goals for these data were to determine if there was an association between these mine and company characteristics and reports of injury and disease to identify factors that may increase risk for these conditions.

We computed company-level variables for mining operations in Illinois, such as average mine size, commodity, presence of safety committees, employee overtime, production variables, average seam height (coal mines only), and injury rates using data from the MSHA Address/Employment, Accident/Injury, and Mines datasets. These company-level variables have been evaluated for use in the linkage analysis of Illinois Workers' Compensation Commission and MSHA data, detailed below.

4.2 State-based Data Collection Systems

State-based data systems have been underutilized in efforts to assess respiratory diseases and CVD in miners. We focused our efforts on Workers' Compensation (WC).

In Colorado, we assessed the Colorado workers' compensation data, housed by the Department of Public Health and Environment for its usefulness in understanding respiratory and cardiovascular health of miners in Colorado. In Illinois, the University of Illinois-School of Public Health (UIC-SPH) is the *bona fide* agent of the State and stores hospital discharge, outpatient, and workers' compensation claims databases. We used methods developed at UIC-SPH to analyze and link Illinois databases.[18,19] In New Jersey, there is a small but stable surface aggregate mining industry. While little work has been done specifically on miners' health in New Jersey, the state is funded by NIOSH to do extensive occupational health surveillance, and our research team has a longstanding working relationship with the director of that program. In West Virginia, our investigators have worked with the West Virginia Occupational Pneumoconiosis (OP) Board using their data on coal miners to investigate the increase in PMF and RPP among miners in WV.

4.2.1 Workers' Compensation Data

These data include information on workers who have applied for compensation and include information on demographics, diagnoses, employer of record, limited work history, percentage of disability, lost time, and cost of illness. The West Virginia Workers' Compensation OP Board collects and stores information from miners who have applied for compensation. The Board's files are maintained at the Occupational Lung Center in Charleston, WV, and include submitted medical evidence as well as original chest radiographs, spirometry, and limited exercise testing results.

In states where we are able to access WC data, we conducted a descriptive analysis of all respiratory and cardiovascular illness cases over the past ten years where mining companies are listed as the employer. We also reviewed other cases of pneumoconiosis during this same time period to ascertain if they were mining related, and analyzed available lung pathology for a number of compensated cases.

4.3 Data Linkage

A primary goal of this project was to examine multiple data systems that contain information about the health of U.S. miners and link those datasets to better understand the individual-, mine-, and company-level determinants of disease in this population. Data linkage, in this project, refers to the joining of two or more datasets. We performed data linkages when records in two or more datasets shared one or more common identifiers.

We successfully linked multiple MSHA datasets to each other using unique ID variables in each dataset. In this manner, we were able to link MSHA data on employment and production, accidents and injuries, and violations. We completed an analysis of the linked Illinois Workers' Compensation Commission (IWCC) and MSHA data from 1990-2010, which has provided insight into those company-level factors associated with respiratory and cardiovascular injuries and illnesses in Illinois. In New Jersey, we successfully linked the silicosis registry data with MSHA data and have completed an analysis of these data. In West Virginia, for certain of the compensated cases of pneumoconiosis, we were able to link to and analyze existing lung pathology specimens. Our findings from these linkage analyses are detailed below in Section 3, "Summary of Accomplishments."

4.4 Statistical Analyses

Data analysis included developing estimates of disease occurrence and 95% confidence intervals for the outcomes of interest. Associations with potential risk factors were investigated using univariate, bivariate, and multivariate analytic methods. Bivariate methods included Mantel-Haenszel chi-square tests for categorical variables, and t-tests for continuous variables. Multivariate analysis included modeling techniques appropriate for the outcome measure. For example, to assess associations with prevalence, binomial regression was used, whereas logistic regression was used for binary outcomes.

5.0 Summary of Accomplishments

5.1 National Datasets

5.1.1 U.S. Department of Labor, Division of Coal Mine Workers' Compensation

We received de-identified BLBP benefit claims data (ASP and CORS) from the DCMWC per a Memorandum of Understanding (MOU) that was finalized in November 2014. Using sample data previously obtained from DCMWC, we established data cleaning and management protocols in advance of receipt of the full dataset. We linked the ASP and CORS data by unique study IDs for the claim and miner. The variables we obtained from the ASP data included: miner's year of birth, years of mining tenure claimed, years of mining tenure verified, regional office where the claim was filed, and the state in which the individual last worked as a coal miner. Clinical data obtained from the CORS dataset included: spirometric results (FEV_1, FVC, and FEV_1/FVC ratio), chest x-ray ILO classification, and medical history and physical examination summaries.

These data had been gathered as text files and therefore required considerable manipulation and cleaning to facilitate analysis. This was accomplished through a combination of statistical programming and manual review and cleaning. Statistical programming included designing text scanning routines to identify records that included information on risk factors for respiratory and cardiovascular disease that were not otherwise available in the administrative data. Data elements that were not recorded electronically in the ASP or CORS datasets included the miners' gender, smoking history, and comorbid conditions including whether they were overweight or obese at the time of the exam and the presence of other chronic diseases. We searched for these risk factors and comorbid conditions, including asthma, cardiovascular diseases, and lung cancer. A list of conditions and search terms is found in Appendix A.

The goal of the analysis of DCMWC data was to describe the respiratory status of miners at the time of their most recent claim in the BLBP. The ASP dataset included 48,841 claims from 2000 to 2013 (Figure 1). Among these, we classified 30,944 (63.3%) as the most recent claims. If a miner (or survivor) made only a single claim, this was selected for analysis. For those claimants with multiple applications, the last of these claims was selected for analysis. Claimants were excluded if important clinical data was missing, such as a valid PFT (n = 621) or chest x-ray (n = 1,477). Claimants were also excluded if years of mining tenure claimed was less than 5 years or if they were still working at the time of the claim (n= 143).

The PFT data were analyzed using the American Thoracic Society (ATS) and European Respiratory Society (ERS) definitions of pattern and severity of respiratory impairment (Figure 2).[20] Chest x-ray data were classified using ILO system focusing on small opacity profusion and category of PMF, which were displayed as a five-category scale (0/- to 0/1; 1/0 to 1/2; 2/1 to 2/3; 3/2 to 3/+; PMF, including categories A, B, C).

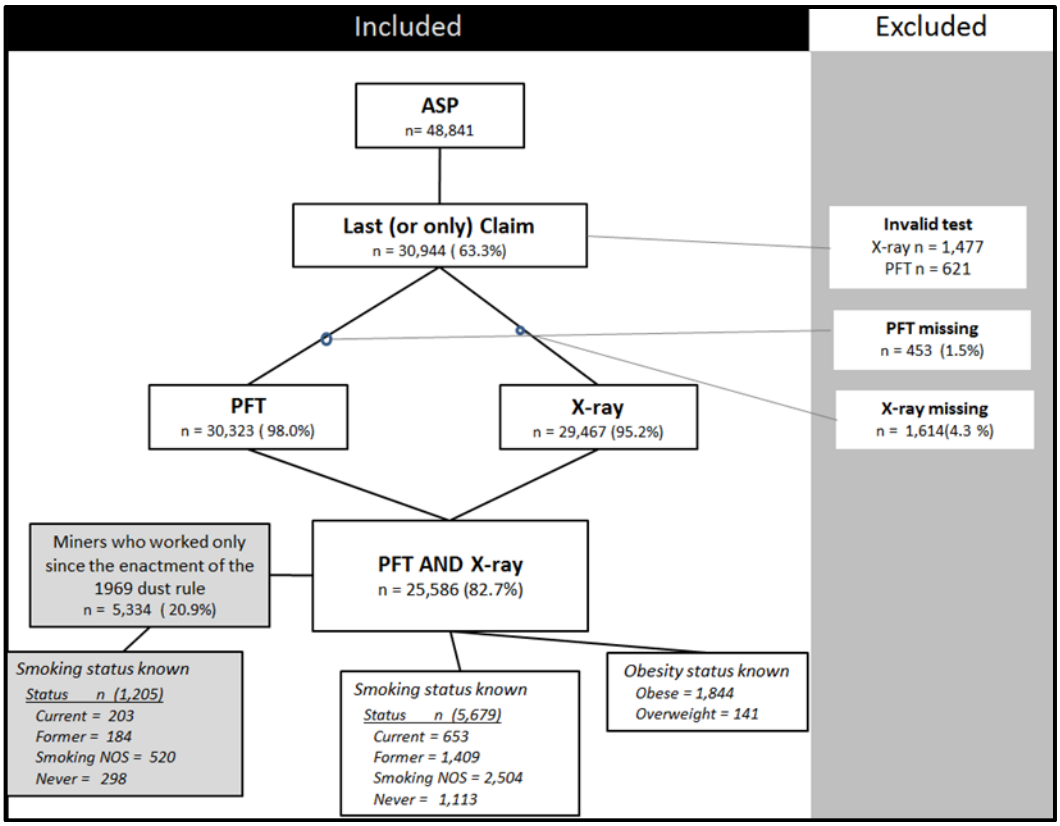

Figure 1. Selection process for identifying BLBP benefit claims from the ASP and CORS DCMWC data for analysis, 2000 − 2013.

Pattern of Impairment

- Obstructive: $FEV_1/FVC < LLN$; $FVC > LLN$; and $FEV_1 < LLN$, or
- Restrictive: $FEV_1/FVC > LLN$; and $FVC < LLN$ or
- Mixed: $FEV_1/FVC < LLN$; and $FVC < LLN$

Severity of Impairment

- $FEV_1 \geq LLN$ (Normal)
- 70% reference $\leq FEV_1 < LLN$ (Mild)
- 60% reference $\leq FEV_1 <$ 70% reference (Moderate)
- $FEV_1 <$ 60% reference (Moderately Severe or worse)

Figure 2. Spirometry outcome definitions based on results of pulmonary function tests. LLN = Lower limit of normal.

5.1.1.1 Results: Demographics.

Data comprised all miners with at least one claim (n=25,586). The mean age of miners at the time of filing their last BLBP benefit claim was 62.6 years (range 24 to 100). The mean tenure of

coal mine employment (CME) claimed and verified by DCMWC were 24.1 (range 5 to 70) and 19.8 (range 0 to 50) years, respectively. The majority worked in eastern mines (Table 1).

Table 1. Demographic and geographic characteristics of BLBP claimants at the time of their last claim, 2000 – 2013.

Variable	*Mean*	*Std Dev*	*Range*
Age at claim filing (years)	62.6	9.86	24 − 100
CME[a]			
Claimed	24.1	8.98	6 − 70
Verified	19.8	9.74	0 − 50
	N	***%***	
State of last CME			
Kentucky	9481	37.1	
West Virginia	6593	25.8	
Other Eastern[b]	7033	27.5	
Midwest	1601	6.3	
West	566	2.2	
Other[c]	312	1.2	

[a] Coal mine employment
[b] Alabama, Ohio, Pennsylvania, Tennessee, and Virginia
[c] Maryland, North Carolina, New York, Unknown

5.1.1.2 Results: Spirometry and Chest Radiographs

Spirometry findings for 25,586 miners are shown in Table 2. Of the spirometry for any miner, 8.3% met the ATS definition for an obstructive pattern of impairment, 29.8% for a restrictive pattern of impairment, and 13.8% for a mixed pattern of impairment. Impairment severe enough to be considered disabling for coal mine work (FEV_1 < 60% reference) was found in 20.6% of claimants overall, including 22.4% of pre-reg miners compared to 15.1% of post-reg miners. However, post-reg miners were more likely to have PMF or high category simple pneumoconiosis (≥ ILO category 2/1) compared to pre-reg miners.

Table 2. Results of spirometry and chest radiographs among claimants in the Federal Black Lung Benefits Program from 2000 to 2013.

	Pre-Reg Miners[a] (n=20,252)		Post-Reg Miners[b] (n=5,334)		
Severity of Impairment	**n**	**%**	**n**	**%**	**p-value**
$FEV_1 \geq$ LLN (Normal)	10,301	53%	3,323	53%	0.6375
$70\% \leq FEV_1 <$ LLN (Mild)	2,063	11%	1,153	18%	<0.0001
$60\% \leq FEV_1 < 70\%$ (Moderate)	2,624	14%	845	14%	0.2121
$FEV_1 < 60\%$ (Mod Severe or worse)	4,327	22%	950	15%	<0.0001
Chest x-ray Opacity Profusion					
Normal					
0/- to 0/1	11,270	58%	3,546	57%	0.0123
Abnormal					
1/0 to 1/2	6,626	34%	2,012	32%	0.0049
Advanced Pneumoconiosis					
2/1 to 2/3	720	4%	308	5%	<0.0001
3/2 to 3/+	68	1%	40	1%	<0.0001
PMF (A, B, C)	631	3%	365	6%	<0.0001
Total Abnormal:	8,045	42%	2,725	43%	<0.0001

[a]Miners whose work tenure includes time prior to the institution of dust control regulations of the Federal Coal Mine Health and Safety Act of 1969, (defined as born before 1/1/1952).
[b] Miners who began working after the institution of dust control regulations (defined as born on or after ≥ 1/1/1952)
[c] LLN=Lower Limit of Normal by Hankinson et al. 1999.

Using this large but previously untapped dataset, we found substantial pulmonary impairment among former U.S. coal miners who filed for BLBP benefits between 2000 and 2013. The proportion of miners with lung function impairment appears to be lower in miners who have only worked since The Act compared to those miners whose work tenure also included exposures before the institution of dust control regulations in 1970. It is of concern that the proportion of post-regulation miners with high-profusion-category simple pneumoconiosis and PMF appears to be greater in the cohort of miners whose entire mining tenure occurred after the enactment of federal dust limits. This latter finding is consistent with results from the Coal Workers' Health Surveillance Program reported by the National Institute for Occupational Safety and Health (NIOSH) from its surveillance of active miners.

An abstract of these findings entitled, *"Spirometry and Chest Radiographs in US Coal Miners: Analysis of Data from the Federal Black Lung Program,"* was submitted to the ATS for their annual meeting in 2016.

5.1.1.3 Programmatic Recommendations

The DCMWC datasets are a rich source of information for understanding the health status of our nation's former coal miners for both public health research and practice. These data are unique in that they capture high-quality spirometric and radiographic pulmonary health data. Another strength of these data is that the majority of U.S. coal miners who have worked for

significant periods apply for BLBP benefits, although that number has not been quantified. The chest x-ray profusion score data were overall robust, but because they are recorded electronically into a free-text field, these data required significant data management resources before an analysis could be conducted.

These data also have significant potential to contribute to our understanding of comorbid conditions, such as CVD, as well as our understanding of the distribution and role of demographic and other risk factors for adverse health outcomes in this population. Much of this information, however, currently resides in the free-text fields written by the examining physician and recorded on the BLBP paper forms used for filing a claim. Important data fields that were sporadically reported in an unstandardized fashion include the miner's gender, race/ethnicity, smoking and other tobacco use, weight, and comorbid conditions. The development of simple check boxes and/or numeric data entry fields in the CORS data entry system could facilitate data entry for much of this information including: gender, race/ethnicity, ILO classification of chest x-ray, smoking status and pack years, and presence of some key conditions including obesity (by entering weight and height), and presence or absence of comorbid conditions including CVD. Table 3 provides broad recommendations for standardizing entry for some of these fields.

Table 3. Recommendations for standardizing entry for BLBP data.

Data Element	Issue	Recommendation
Gender	Not recorded	• Standardize data entry • Add a check box to data entry form for: ▪ Gender ▪ ILO Classification
X-ray profusion score	Entered as text field	
Smoking status and pack-years	Entered only as notes in physical exam/history notes	4. Add a check box to data entry form 5. Improve collection of smoking data to enable accurate calculation of pack years of exposure
Comorbid conditions		• Standardize list of most common comorbid conditions
Weight and Height		• Add as a standard field • Standardize measurement units

5.1.2 U.S. Department of Labor, Mine Safety and Health Administration (MSHA)

5.1.2.1 Violations Data

We completed our evaluation and analyses of the MSHA violations databases, which contain information on citations issued to mines by MSHA. This data contains the type of violation, severity of the infraction, and the dollar amount of any fines. Our investigators were interested in understanding the relationship between inspection outcomes and illness. Large numbers of citations or severe infractions may indicate less attention paid to safety measures in the

workplace. The analysis was conducted using Illinois and New Jersey data. We restricted the analysis to regular inspections, which comprise 67% of all inspections from 2000 to 2013, because other inspection types (such as follow-up and accident investigations) occur after a significant safety or injury event and are not appropriate for this analysis.

We found significant variation in the number of citations as a percentage of inspections. The severity of citations also varied by commodity as well as within commodity by state. Severity is assessed by multiple indicators, including the degree to which the violation cited is "significant and substantial," the "likelihood" of the violation to cause injury, and the monetary size of the fine. Variation by commodity largely reflects the differences in mine size by commodity, e.g. coal mines tend to be larger operations than metal and other non-metal mines in Illinois. There is also significant variation by state within commodity, for example, sand and gravel mines in New Jersey received a higher percentage of citations classified as having "at least a reasonable likelihood" of causing an accident compared with those in Illinois (23.1 vs. 17.1). For commodities mined in both New Jersey and Illinois, the average proposed penalties were similar between the two states, but the maximum penalties were larger in Illinois.

5.1.2.2 Other MSHA Datasets

We analyzed the Address/Employment, Accident/Injury, and Mines datasets from MSHA as well. These datasets have been used to calculate company-level variables for mining operations in Illinois, such as average mine size, commodity, presence of safety committees, employee overtime, production variables, average seam height (coal mines only), and injury rates. These company-level variables have been calculated for use in the linkage analysis of Illinois Workers' Compensation Commission and MSHA data, detailed below.

5.1.3 Health Resources Services Administration (HRSA) – Black Lung Clinics Program (BLCP) data systems

5.1.3.1 Performance Improvement Monitoring System (PIMS)

BLCP PIMS reports are based on data submitted annually by all grantees (clinics) as required by, and provided to, Congress. Unfortunately, the clinics submit this data in aggregate form, with no ability to analyze patient-level data. This is a severe limitation on the utility of this dataset for detailed analysis. In addition, the definitions for coal mine dust lung disease have changed significantly over the years making it difficult to compare data over time. HRSA provided us with their complete dataset for the BLCP for the years 2008-2011. BLCP grantees reported an aggregate total of 35,858 clinic "users" (patients). In 2011, 40% of clinic users were coal miners, the majority of whom were white (95%), male (99%), and over age 60 (60%). The category of users included those with both medical encounters as well as those for other services, including benefits counseling and health education. Medical encounters totaled 40,554, a number which includes medical testing visits as well as provider visits.

5.1.3.2 BLCP Patient-Level Pilot Data

We analyzed data from one of the BLCP clinics with electronic data-tracking capability, in order to evaluate the usefulness of this data and develop a generalizable data collection instrument for the program. This clinic had data on 259 miners who were screened in 2011. The mean age of the miners was 65 years (29-87), and 95% of them were male. Of this population of miners, 65% were coal miners. Forty-three (17%) of the 259 miners had chest x-ray B reading profusion scores of $\geq$1/0. Four percent (n=11) had a lung nodule concerning for either

conglomerate opacity or lung cancer for which follow up was arranged. Only 7% reported current smoking, though 36% were former smokers, and 56% reported never smoking. Cardiovascular diseases and risk factors were common in this population: 42% reported high cholesterol, 26% reported chest pain suggestive of angina, 9% reported previous heart attack, 6% reported stroke, and 47% reported hypertension. Average body mass index was 29.6 (range 19 – 47), and 86% were overweight or obese. An abstract reporting this work was accepted by the American Thoracic Society (ATS) and presented at their 2015 annual conference in Denver.[21]

5.1.3.3 Development of Data Collection Instrument

Former miners comprise approximately 80% of the 11,000 coal miners evaluated yearly by the BLCP. One of our project goals was to work with the BLCP to develop a data collection instrument to be used to improve our understanding of the evolution of coal mine dust lung disease after cessation of coal mine exposures, as well as to investigate both personal and workplace (e.g., vibration, noise, particulate matter, shift work, prolonged hours of work) risk factors that may lead to cardiopulmonary disease. Historically, research efforts have been focused predominantly on the examination and study of active coal miners, and former coal miners have been comparatively less well studied. In the current climate of declining coal mine employment in the U.S., with rapidly rising numbers of former miners, this database will provide important new information to supplement our understanding of cardiopulmonary health in former coal miners.

This instrument is intended to serve three purposes: 1) Gathering data for the PIMS reporting; 2) intra- and inter-facility quality improvement with oversight from board-certified pulmonologists; and 3) population-based research. The web browser-based electronic data collection application known as the Research Electronic Data Capture (REDCap) system has been employed to set up the Black Lung Clinical Research Database. This system is being used to collect data such as detailed occupational histories; smoking histories; pulmonary function testing; chest x-ray findings; and other relevant clinical data. Since the time of the last progress report, we have completed development of this instrument, pilot tested it for use by HRSA BLCP grantees, and are now employing it in the collection of data at a number of HRSA BLCP sites. We have applied for and received approval from the Institutional Review Board at UIC for establishment of the research component of this database. Currently, the programs at UIC, Northwestern University, Shawnee Health Services in Illinois, and National Jewish Health in Colorado, are participating in longitudinal data collection. Three clinics in West Virginia will begin data collection in January, 2016. Our plan is to continue to expand this instrument to all other HRSA grantee sites. We have support from HRSA to expand these efforts.

5.1.4 National Survey Instruments with Data Related to Mining

We completed an analysis of the publically available data from the National Survey on Drug Use and Health (NSDUH). We have submitted a manuscript based on this work entitled "Cigarettes, smokeless tobacco and poly-tobacco use among workers in three dusty industries" to the Journal of Environmental and Occupational Medicine, which is being reviewed. An abstract of this work was accepted by the ATS and presented at their 2015 annual conference.[22] A summary of that study follows.

5.1.4.1 Introduction

While cigarette smoking rates have fallen dramatically in the 50 years, the prevalence of tobacco product use including cigarettes and smokeless tobacco (SLT) rates remains high in some groups of blue-collar workers. The health consequences of smoking among some workers may be compounded by occupational exposure to organic and inorganic dust, increasing the risk of adverse respiratory and other health outcomes. Smoking and SLT use patterns vary among workers in blue-collar industries with the highest rates of reported among construction and extraction (e.g., mining and petroleum extraction) sector workers. SLT can be substituted for cigarettes in occupational settings where smoking is prohibited. There is little information on tobacco use behaviors for workers in most dusty industries. The aim of this analysis was to conduct an in-depth assessment and comparison of tobacco use prevalence and risk factors among workers in three dusty industries: agriculture, construction, and extraction.

5.1.4.2 Methods

This analysis used publicly available data from the 2006 to 2012 National Survey on Drug Use and Health (NSDUH). The sample included employed, working-age men (18 to 64 years of age). The survey included data on socio-demographics, current tobacco use (cigarettes, SLT, and concurrent use of cigarettes and SLT ["dual use", and a form of polytobacco use]), occupation, industry, health, healthcare coverage, and substance use including alcohol.

All analyses accounted for the complex sample design and all estimates were reported as weighted except for sample sizes. Prevalence and 95% confidence intervals were calculated for socio-demographics, tobacco use, occupation, industry, health, healthcare coverage, and substance use. Trends in tobacco use prevalence were assessed by comparing annual average rates from 2006 to 2009 and 2010 to 2012. Logistic regression was used to assess associations between employment in each industry group (agriculture, construction, extraction, and all other employed men, using all other employed men as the reference category) and current tobacco use behaviors.

5.1.4.3 Results

Smoking rates were higher (Figure 3), as were the odds of smoking (Table 6), among men working in extraction and construction compared with those working in agriculture or all other male workers. The prevalence and odds of SLT and dual use were significantly higher among all three groups of dusty industry workers compared with other workers and particularly high among extraction workers (OR_{SLT} =3.3; OR_{DUAL} =2.6). The prevalence of any type of tobacco use was also unexpectedly high among men in the extraction industry (60.4%), but was also elevated among construction workers (48.3%) compared with other workers (36.8%) and agricultural workers (39.8%).

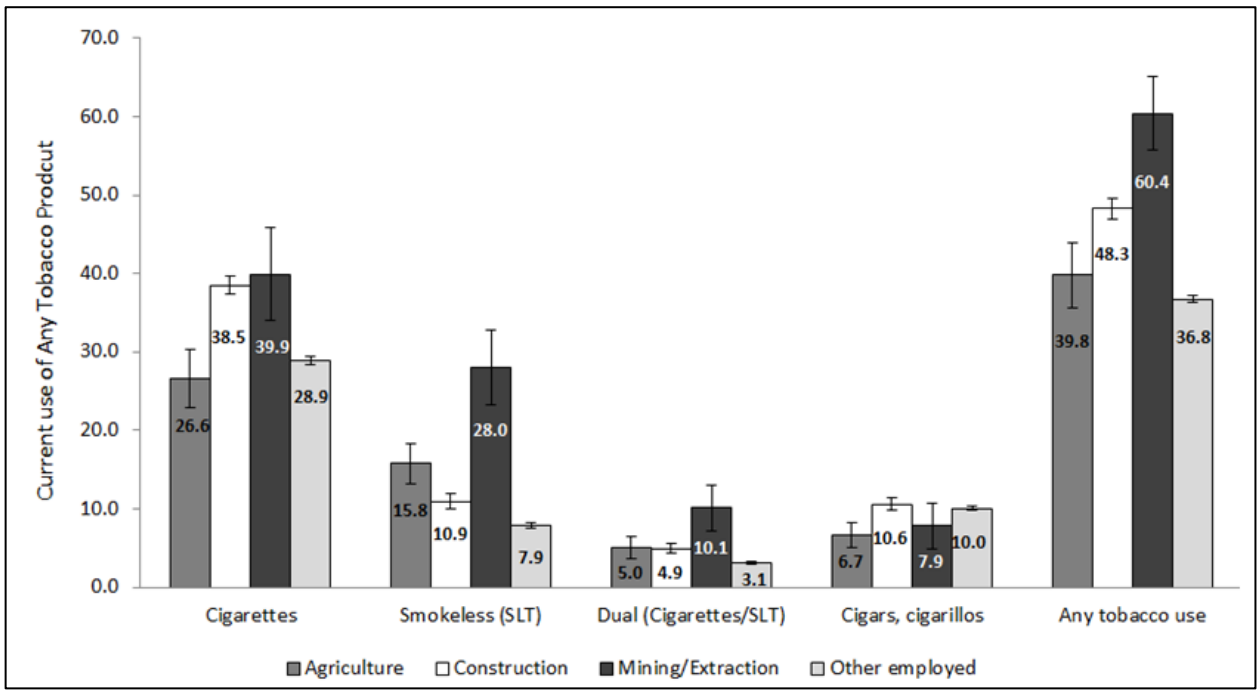

Figure 3. Prevalence of tobacco use products across multiple dusty industries from the National Survey on Drug Use and Health (NSDUH), 2006 to 2012.

Table 6. Logistic regression results of smoking behaviors by industry, adjusted for year of survey, age, race/ethnicity, education, marital status, urbanicity, health insurance, substance/tobacco use, and perceived health status.

	Current Tobacco Use					
	Cigarette		Smokeless		Dual[a]	
Industry	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Other Work	Ref	--	Ref	--	Ref	--
Agriculture	0.8	(0.6, 1.0)	2.1	(1.6, 2.6)	1.8	(1.3, 2.5)
Construction	1.2	(1.1, 1.3)	1.4	(1.3, 1.6)	1.5	(1.3, 1.8)
Extraction	1.6	(1.1, 2.2)	3.3	(2.4, 4.6)	2.6	(1.8, 3.6)

[a] Dual use indicates concurrent use of cigarettes and smokeless tobacco products.

5.1.4.4 Conclusions

In this national sample, high but variable rates of smoking and other tobacco use were observed among male workers in three dusty industries: agriculture, construction, and extraction. It is well documented that workers in these three industries are at high risk for respiratory disease from occupational mixed-dust exposure. The impact of dual tobacco use on smoking cessation is an important public health consideration. To our knowledge, the very high rate of any current tobacco use among extraction workers (60%), and the high rate among construction workers (48%) observed in this study have not been reported elsewhere.

The cross-sectional design of the study results in an inability to make inferences regarding the directionality of observed associations. The category “extraction/mining” is a heterogeneous

group, which includes extraction of aggregate materials (e.g. sand, stone), coal, and minerals as well as petroleum products.

The disparities in tobacco use identified in this study also point to opportunities for highly targeted workplace tobacco cessation programs. Future work is needed to better characterize tobacco use behaviors in blue-collar workers, especially those who are at risk of occupational dust exposure, and to determine efficacious tobacco cessation programs for polytobacco use in these workers.

5.1.5 NIOSH Surveillance Data

We completed our analysis of the NIOSH Coal Workers' Health Surveillance Program spirometry data and analyzed the relationship between lung function and radiologic category of pneumoconiosis. A total of 8,230 miners were eligible for analysis in this study. Two hundred and sixty-nine had category 1 or 2 simple CWP. Decrements in FEV_1 percent reference were nearly consistent across profusion subcategories. Clear decrements in FVC percent reference and FEV_1/FVC were also observed, although these were less consistent. Controlling for smoking status, BMI, and mining tenure, each one-unit subcategory increase in profusion was associated with decreases of 1.5% (95% CI 1.0% to 1.9%), 1.0% (95% CI 0.6% to 1.3%), and 0.6% (95% CI 0.4% to 0.8%) in FEV_1 percent reference, FVC percent reference, and FEV_1/FVC, respectively. We observed progressively lower lung function with increasing small opacity profusion. The manuscript analyzing this data has been published in the journal CHEST.[23]

We have also made significant progress on the linkage of DOL OWCP and NIOSH surveillance data. We have received IRB exemption from NIOSH and are working closely with DOL OWCP to complete this data linkage. These datasets have never been linked and should provide useful insights to understand respiratory disease progression as well as a better understanding of the characteristics of miners who are seen in both systems. This information will help inform future enhancements to both programs. In addition, this analysis will describe those characteristics of miners who show up in only one of these datasets which will provide valuable information regarding and the strengths and weaknesses of the outreach and participation in the NIOSH surveillance programs which generally target working miners, and the OWCP Black Lung Program which generally targets former/retired miners.

5.2 State-based Data Collection Systems

As part of this project, we proposed to collect and characterize the structure, content, quality and scope of existing data systems as potential sources of information on contemporary trends, distribution and determinants of miners' health, particularly cardiopulmonary health. A component of one of our specific aims was to explore the content and utility of data from four state-based workers' compensation programs (CO, IL, NJ, and WV). A discussion of our analysis from each state is detailed below.

5.2.1 Colorado

After meeting with representatives from the Colorado Division of Workers' Compensation (DWC) to discuss the scope and availability of workers' compensation data and review reports of mining-related claims (details of these reports can be found in the November 2014 Progress Report), we have concluded that the DWC database appears limited in terms of its ability to provide insight into miners' cardiopulmonary diseases. As previously reported, no medical

information is collected in the DWC database, nor does it contain information about smoking or occupational histories. Our study team concluded that the workers' compensation data in Colorado is currently of limited value in understanding miners' cardiopulmonary health due to issues with access, completeness, and quality.

5.2.2 Illinois

5.2.2.1 Illinois Workers' Compensation Data Linked to MSHA Mine Data

Our study team in Illinois has completed a final linkage of the Illinois Workers' Compensation Commission (IWCC) and MSHA company-level data in an effort to examine company-level characteristics in relation to workers' compensation claims. A manuscript based on this analysis entitled, *"Illinois Workers' Compensation Commission and MSHA Linkage study of Cardiopulmonary Claims, 1990-2010,"* has been submitted to the American Journal of Industrial Medicine. An abstract of this work was accepted by the ATS and presented at their 2015 annual conference.[24]

5.2.2.1.1 Introduction

While injury and fatality rates have steadily decreased since the 1970s, mining remains one of the most hazardous industries in the U.S. Of particular concern among mine workers is respiratory and cardiovascular injury and illness that result from exposures to occupational dust, in particular coal dust. Several mine characteristics have been identified as potential risk factors for injury and illness among mine workers including mine size, coal seam height, and mining method. Employee characteristics associated with increased risk of injury and illness include younger age, mine employment tenure, and type of work and location within the mine. Understanding how injury and illness rates vary by mine and miner characteristics is crucial to designing effective injury/illness prevention programs. The study aimed to link IWCC and MSHA data to better understand those individual- and company-level factors that are associated with cardiopulmonary injuries and illnesses in this population. Our goals for these analyses were to 1) examine the association between respiratory and CVD claims with mining employment in the IWCC data and 2) explore the associations between respiratory and CVD claims and company characteristics among mine-employees in the IWCC data.

5.2.2.1.2 Methods

Our study team identified 12,582 mining-related claims in the IWCC from 1990-2010 using a multi-step screening algorithm based on names of registered mining companies in Illinois, as reported to MSHA; keywords (e.g. coal, silica, mining, quarry); and extensive manual review. A random sample of non-mining claims from the IWCC database from 1990-2010 was selected as a comparison group. We aggregated mine-level data from MSHA's address/employment and mines databases to the company level to create company characteristics including average mine size, commodity (e.g. coal, metal/non-metal), and the use of safety programs. We achieved a 94% match rate between the IWCC data and MSHA company-level data, linked by year and company.

5.2.2.1.3 Results

A significantly higher percentage of mining claimants were male (97% vs. 71%), married (84% vs. 60%), and over 45 years of age (62% vs. 38%) compared to non-mining claimants. Mine employees had significantly elevated odds of reporting an illness or injury involving the heart and/or lungs (OR 21.2, 95% CI 16.2 – 27.6), after controlling for age and gender. Coal mine employees comprise 44-68% of all IL mine employees, but 96% of all mining-related

claims in IWCC, 1990-2010. Among mining-related claims in IWCC, mine employees of small mines, coal mines, and mines operated by a company without any safety committees in their mines were at increased odds of a heart or lung injury or illness (Table 7). Lack of detailed health information in the IWCC data prevented analyses of individual respiratory or cardiovascular diseases.

Table 7. Logistic regression results[a] for the association between individual and coal company-level characteristics and cardiopulmonary injuries and illnesses[b] among coal mine employees (n=11,347) in the Illinois Workers' Compensation Commission data, 1990-2010.

Variable	OR	95% CI
Gender		
Male	1.27	0.83 - 1.95
Female	1.00	ref.
Age *(continuous)*	1.16	1.15 - 1.17
Mine Size		
<25	7.60	4.52 - 12.76
25 - 49	4.52	2.96 - 6.91
50 - 199	4.29	3.21 - 5.75
200 - 499	2.48	1.82 - 3.37
500+	1.00	ref.
Coal Seam Height[c]	1.04	0.99 - 1.08
Safety Committee		
No	1.67	1.42 - 1.97
Yes	1.00	ref.

[a] Model controlled for year, but individual injury year estimates are not shown in the table above.
[b] All claims that specified the part of body affected as "Lung(s)" or "Heart & Lung(s)," or those that specified a nature of injury as any pneumoconioses or respiratory condition, excluding influenza.
[c] Odds ratio and 95% CI presented for 10 inch increase in seam height.

5.2.2.1.4 Conclusions

This study is one of the first to use state-based workers' compensation data to examine cardiopulmonary injuries and illnesses among mine workers in the U.S. In Illinois, mine workers have increased rates of cardiopulmonary injury and illness claims compared to non-mine workers. Small mine size and safety culture, as indicated by the presence or absence of a safety committee, contribute to increased odds of a cardiopulmonary claim among coal mine workers.

Improvements in medical, occupational, and geographic data elements to state based data systems such as the IWCC would greatly improve their utility as sources of data for epidemiologic research.

5.2.2.2 Illinois Workers' Compensation Data Linked to the MSHA Part 50 Program

Our Illinois investigators have also completed an analysis of the underreporting of chronic respiratory injuries and illnesses to the MSHA Part 50 Program. The results of that analysis are briefly summarized below. An abstract entitled, "*Completeness of Respiratory Injury and Illness Reporting in the Illinois Mining Industry: Comparing Workers' Compensation Claims to the MSHA Part 50 Program"* has been submitted to the ATS 2016 Annual Conference and is summarized below.

5.2.2.2.1 Introduction

Despite declining rates of injuries and fatalities since the 1970s, mining remains one of the most hazardous industries in the U.S. Respiratory illnesses are of particular concern among mine workers as a result of exposures to occupational fibrogenic dusts. MSHA collects data on injuries and illnesses in mines through their Part 50 Program. Injuries and illnesses are under-reported to the Part 50 Program, but the extent and pattern of under-reporting is not well understood. This study aimed to characterize under-reporting of chronic respiratory injuries and illnesses among Illinois mine employees to the MSHA Part 50 Program.

5.2.2.2.2 Methods

We used probabilistic linkage methods to match IWCC claims for mining employees (N = 6,545) to MSHA Part 50 reports (N = 9,052) from 2000 to 2013. Probabilistic linkage processes use statistical methods to estimate the likelihood of a true match between records in different databases. This likelihood (or probability) is based on the number of variables that exactly match and the variables that are close, but not exact, matches. By allowing near matches on some variables, probabilistic linkage processes offer greater flexibility and maximize the number of matches a user can make by overcoming data cleaning problems such as misspellings of names or data entry errors.

Prior to performing probabilistic linkage between the MSHA and IWCC data, we generated standardized keywords for company names in both data sets. This was done to allow the statistical software to correctly identify matched companies across the databases. Second, some companies went through restructuring, renaming, or take-overs during the study period. We wanted to use only a single company name for an entity throughout the study period, regardless of what its name was at a particular point in time. To create the keywords, we first generated a list of all company/employer names in both databases. We searched MSHA and other publicly-available data to identify current company names. For those company/employer names that we identified as not currently active, or no longer in existence, we identified their current ownership or proper name and edited their keywords to match their current syntax and spelling.

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.

We defined unreported cases as those appearing in the IWCC data that did not match to those in MSHA Part 50 data. Chronic non-respiratory and respiratory injuries/illnesses were identified through a combination of accident code, body part affected, and nature of injury. Logistic regression methods were used to evaluate the association between individual and claim-level variables and under-reporting to the MSHA Part 50 Program.

5.2.2.2.3 Results

We identified 2,347 claims of chronic injury/illness filed in the IWCC data, of which 2,097 (89%) were unreported to the Part 50 Program (Table 8). Of these chronic respiratory condition claims, 90% had resulted in a final decision, <1% were in progress or unspecified, and 9.6% were dismissed. Chronic respiratory cases (1,287) were significantly more likely to be unreported than chronic non-respiratory cases. Compared to reported claimants, unreported claimants were older (56 vs. 50 years); more likely to have used an attorney to file their IWCC claim (94% vs. 60%); less likely to be awarded any temporary total disability (TTD) or percent permanent disability (PPD); and received higher total compensation awards ($15,541 vs. $11,107). Claims for chronic respiratory injury/illness were significantly more likely to be unreported to MSHA compared to chronic non-respiratory claims (OR = 2.79, 95% CI 1.84 – 4.24), after controlling for age, use of attorney, TTD, PPD, compensation award, and time to filing.

Table 8. Distribution of individual and claim characteristics for chronic claims (N = 2,347) in the Illinois Workers' Compensation Commission data, by reporting status[a] to the MSHA Part 50 Program 2000 − 2013.

Variable	Reported (N = 250)	Unreported (N = 2097)	p-value
	N (%)[b]		
Respiratory Chronic Injury/Illness	39 (16)	1,248 (60)	<.0001
Used Attorney	150 (60)	1,970 (94)	<.0001
Male	246 (98)	2,060 (98)	0.85
Total Temporary Disability (Any)	133 (53)	123 (6)	<.0001
Percent Permanent Disability (Any)	162 (65)	1,078 (51)	<.0001
	Mean (SD)[c]		
Age in years	49.7 (10.7)	56.4 (7.2)	<.0001
	Median[d]		
Total Workers' Compensation Award	$11,107	$15,541	0.04
Time between Accident and Filing (days)	324	388	0.08

[a] IWCC cases that matched to MSHA Part 50 claims are considered "Reported" and those that did not match were considered "Unreported."
[b] Chi-square test used to test for differences in proportions across groups.
[c] T-test used to test differences in means for normally distributed data.
[d] Wilcoxon Rank Sum test used to test for differences between groups for non-normal data.

5.2.2.2.4 Conclusions

Chronic injuries/illnesses among mining employees in Illinois are markedly underreported to the MSHA Part 50 Program. Chronic respiratory conditions among miners are unreported to MSHA at a significantly higher rate than non-respiratory conditions. While the legislative mandate exists to collect data to monitor and prevent illness and injury in this population, underreporting needs to be addressed to make this data more useful.

5.2.3 New Jersey

In New Jersey, there is a small, but stable surface aggregate mining industry. From 1992 to 2011, there have been, on average, 23 stone mines (range 21 to 25) and 62 sand and gravel mines (range 57 to 70) operating each year (written communication, Linda McWilliams, NIOSH; December 2012). In that same 20-year period, NJ stone mines employed an annual average of 925 full-time equivalent (FTE) employees and sand and gravel mines employed 719 FTE employees. While the number of operating aggregate mines has remained stable over the past two decades, the number of employees and FTEs has fallen; FTEs fell from 1,921 in all aggregate mines in 1998, to a low of 1,077 FTEs in 2011.

5.2.3.1 Evaluation of New Jersey State Datasets

Our investigator at Rutgers University in New Jersey partnered with the New Jersey Department of Health and Senior Services, Consumer Environmental Occupational Health Services (NJDOH) and the New Jersey Department of Labor and Workforce Development (NJDOLWD) to conduct evaluations of multiple datasets to determine their utility for understanding miners' health status and risk factors for respiratory and other chronic diseases.

We evaluated the following datasets:

- NJDOH hospital admission and emergency department unified billing data: we assessed the occurrence of records with a location e-code (assigned to injuries in these data) that indicate the injury occurred in amine or quarry
- NJDOLWD Mining regulatory data
- NJDOH Occupational health surveillance systems
- NJDOH Fatality Assessment and Control Evaluation program
- NJDOH Census of Fatal Occupational Injuries program
- NJDOH Silicosis Registry

With the exception of the silicosis registry data, we were unable to identify miners in any of the other NJDOH datasets.

5.2.3.2 Analysis of the NJDOH Silicosis Registry

The de-identified NJDOH silicosis registry was linked to MSHA datasets through the unique MSHA mine ID in both datasets. Thirty-seven of the 54 miners identified with silicosis were linked to the MSHA mine data. MSHA injury data are only available publically from 2000 forward. Of the 122 mines in NJ, only 11 were linked to one or more of the 37 reported silicosis cases, ranging from 1 to 7 cases per mine (Table 9). The average number of FTEs per year, as well as the average number of hours worked by employees per year, was higher in mines with

one or more silicosis cases compared to mines with no cases. We did not pursue multivariate analysis due to the small number of mines with cases

Table 9. Characteristics of NJ mines identified with and without silicosis cases 2000-2012.

Silicosis Cases per Mine	All	Commodity			Employment Indicators per year			
		Stone	Sand & Gravel	Other	Average Number of FTEs		Average Number of Hours Worked	
	n	n	n		n	(sd)	n	(sd)
None	114	27	83	4	9.26	(12.07)	18,953	(27,174)
1−2	7	3	4	0	26.48	(19.14)	59,685	(46,272)
3−7	4	1	3	0	21.89	(16.24)	42,818	(30,663)
Total	125	31	90	1	10.74	(13.38)	22,215	(30,137)

We evaluated the number of inspections, citations, and injuries (standardized by FTE/year) in mines with and without silicosis cases. We found that injury rates and number of citations were highest in the mines with 1- 2 silicosis cases. The number of inspections per mine is highest in those mines with one or more cases of silicosis (Table 10).

Table 10. Number of inspections[a], citations, and injuries (standardized by FTE/year) in mines with and without silicosis cases; New Jersey 2000 to 2012.

	Number of Silicosis Cases		
Inspection Characterization	None N (SD)	1 − 2 N (SD)	3 − 7 N (SD)
Number of inspections per year	1.2 (0.5)	1.7 (0.2)	1.7 (0.1)
Total number of inspections per mine	13.1 (9.1)	21.4 (7.6)	25.0 (2.5)
Number of citations per FTE[b]	4.1 (2.7)	4.3 (1.3)	2.7 (1.2)
Number of inspection citations per FTE	3.3 (2.3)	3.6 (1.1)	2.3 (0.9)
Proposed penalty per FTE	588.1 (1017.8)	834.2 (767.0)	268.3 (267.2)
Number of injuries per FTE	0.03 (0.04)	0.07 (0.05)	0.02 (0.01)

[a] Only regular inspections included in these analyses.

[b] FTE = Full Time Equivalent employees

5.2.3.3 Analysis of Prospective Survey Data

Our dataset evaluation in New Jersey identified significant gaps in health data for NJ miners. In response, our investigators conducted a pilot project to evaluate the feasibility of adding a health survey to annual MSHA safety training. The survey was designed in collaboration with NJDOLWD, NJDOH, and mine operators to capture demographics, workplace characteristics, and use of tobacco products.

The survey was launched on March 24, 2015. We have submitted a manuscript based on this work entitled *"High cigarette and poly-tobacco use among workers in a dusty industry: New*

Jersey quarry workers" to the Journal of Environmental and Occupational Medicine, which has been accepted for publication pending revisions. As summary of that manuscript follows.

5.2.3.3.1 Introduction

Occupational dust exposure increases risk of mortality and morbidity in some groups of blue-collar workers. Occupational dust exposure and tobacco use are the primary modifiable risk factors for respiratory disease among these workers, yet there is little detailed industry-specific information about tobacco prevalence among workers in the U.S. The use of other tobacco products, either alone or in combination with other products, including cigars and e-cigarettes is also poorly characterized among U.S. workers despite the rapid increase in e-cigarette use in the general population. This study reports results from a brief survey on tobacco use and job information among New Jersey surface miners and quarry workers (henceforth quarry/mine workers).

5.2.3.3.2 Methods

Participants for this cross-sectional survey were identified when they attended compulsory annual miner safety training. The survey included questions about the respondents' socio-demographic characteristics and tobacco use. Information including the number of miners attending each session (to facilitate calculation of response rates) and the region of NJ where the training was held, i.e. north, central, and south (Figure 4) was obtained. Statistical analysis included calculation of (1) response rates, prevalence and 95% confidence intervals for survey respondents by demographic and workplace characteristics; and (2) prevalence and 95% confidence intervals for current and ever tobacco use for smoking, smokeless tobacco use, e-cigarette use, and use of one or more tobacco product (any tobacco use).

5.2.3.3.3 Results

Surveys were conducted in 14 facilities and across 19 training sessions resulting in 240 completed surveys. Most respondents were male (97.9%) and non-Hispanic white. Respondents' average age was 44.2 years old (SD 13.3) and average years working in a quarry/mine was 11.2 (SD 11.6). Most usually worked in either a sand & gravel mine (24.8%) or stone mine (49.1%). Three-quarters of respondents (75.8%; 95% CI 69.8, 81.1) reported ever using any tobacco product, and 41.7% (95% CI 35.4, 48.3) reported current tobacco use, including 28.1% who currently smoked cigarettes (Figure 5). Concurrent use of cigarettes and one or more other tobacco products was reported by 12.6% (95% CI: 8.7, 17.4) of respondents which included using smoking and: chewing tobacco (5.1%, 95% CI: 2.8, 8.5); cigars (6.8%, 95% CI: 4.1, 10.6), and e-cigarettes (4.9%, 95% CI: 2.6, 8.3). The smoking prevalence was highest among sand and gravel workers and among workers in southern NJ. Sand and gravel quarries are located throughout NJ (Figure 4).

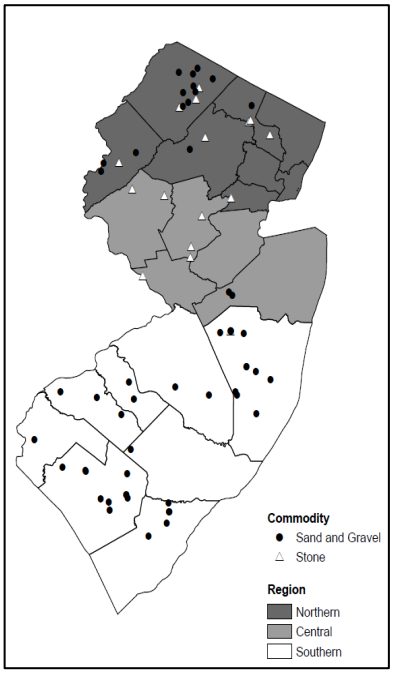

Figure 4. Active mines in New Jersey; MSHA Address/Employment and Mines data 2014.

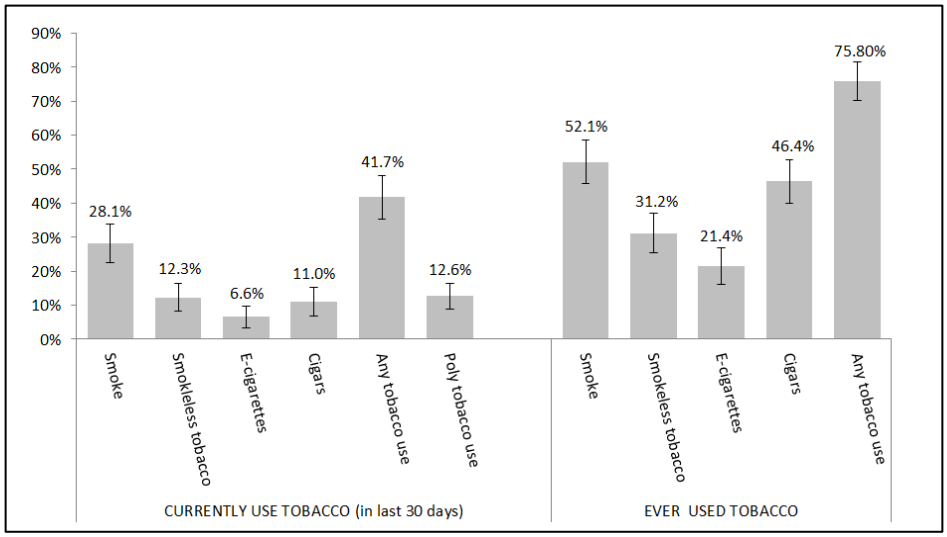

Figure 5. Prevalence of tobacco use among quarry workers and other miners; New Jersey 2015 (n=240).

5.2.3.3.4 Conclusions

National estimates of tobacco prevalence among industry groups consistently find high rates of smoking among blue-collar workers, including extraction and construction workers. In our survey, we observed high rates of smoking and smokeless tobacco use similar to those observed nationally. We also found a high prevalence of other tobacco product use including cigars and e-cigarettes as well as a high rate of any current tobacco product use.

The convenience sampling and implementation in one state may limit the generalizability of the findings to other workers in other states. Participating mine operators and their employees may differ from those who chose not to participate in terms of tobacco-use behaviors.

This study provides a snapshot of tobacco use among quarry workers, one sub-sector of U.S. extraction workers. Cigarette smoking and other tobacco use was high among these workers who may also be exposed to toxic mineral dust. Additionally, many of the workers in our study used a variety of tobacco products in combination with cigarettes, which may increase health risks. More in-depth industry-specific information is needed to successfully develop and implement tobacco-cessation programs for these workers.

5.2.4 West Virginia

5.2.4.1 West Virginia Insurance Commission

As indicated in our Interim Report, the Alpha Foundation investigators have been unable to obtain the full requested dataset from the West Virginia Insurance Commission (WVIC).

A number of external factors complicated the acquisition and evaluation of administrative datasets from the WVIC, including a prolonged drinking water emergency in Charleston, WV. There were also changes in leadership, staff, and management at the WVIC. During the extended negotiations related to obtaining the available datasets, the WVIC Legal Department staff raised a number of objections, and indicated that the request should be formatted as a Freedom of Information Act (FOIA) request. Our group subsequently sent a formal request under FOIA to access a data dictionary and a number of specific variables in a manner that would not identify individual claimants or businesses. In response to our FOIA inquiry seeking descriptive information regarding the data structure and variable elements from the data systems used by the West Virginia Workers' Compensation program, WVIC Associate Counsel provided a helpful listing of specific responses to the investigators' queries, but pointed out a number of structural, practical, and legal barriers and limitations to accessing the content of the workers' compensation data for analysis. Although initially it seemed that the barriers could be overcome, ultimately the WVIC data was not released.

We did learn several lessons from our interactions with the WVIC that may be helpful for future investigators who might hope to analyze data collected by the WVIC with the goal of evaluating factors associated with miners' health. There has been a lack of coherent data collection and archiving strategies throughout the history of the WVIC. The data was not organized in a fashion that would facilitate easy export to analytic software and instead would require huge amounts of manual labor to prepare. There was the sense that there was no mandate to use data from WVIC for public health purposes and no resources at this point to make this feasible.

We concluded that it would be important for these agencies and insurers to consider their role not only adjudicating cases, but contributing to our overall knowledge of injury and disease in these working populations. This would require them to provide data in a coherent and usable format while maintaining confidentiality. The database created from these administrative materials would have to have sufficient accuracy, breadth, and detail to permit analysis directed at identifying illness and injury trends, distributions, and determinants. The various partners in these activities will each need to allocate sufficient resources to perform these periodic analyses.

5.2.4.2 West Virginia Occupational Pneumoconiosis (WVOP) Board

After the unsuccessful attempt to obtain the full dataset from the WVIC, the project investigators have focused on obtaining a subset of data from the WVOP Board, which involved updating the clinical variables from individual miners whose pneumoconiosis claims were approved since the time of the earlier Wade report.[7] Despite initial positive interactions relating to the possibility of obtaining data from the WVOP Board, we were ultimately unsuccessful in obtaining the data from more recent claimants in order to update the analysis in the earlier Wade report.

6.0 Dissemination Efforts and Highlights

Each of the three specific aims of this proposal was intended to yield a number of actionable outcomes. Our approach to dissemination of results has focused on providing a scientific foundation for specific actions that can directly improve disease prevention and health promotion in miners as well as recommendations that will improve future collection of miner health data. As a result, we have produced manuscripts and conference presentations to share our findings with a broad range of stakeholders, including clinicians and other scientists, engineers, and public health practitioners. Below is a list of our manuscript submissions and conference presentations.

6.1 Peer reviewed publications:

1. Blackley DJ, Laney AS, Halldin CN, Cohen RA. Profusion of Opacities in Simple Coal Workers' Pneumoconiosis is Associated with Reduced Lung Function. *Chest*. 2015 148(5):1293-9.
2. Graber, JM, Worthington, K, Almberg, KS, Meng, Q, Rose, CS, Cohen, RA. High Cigarette and Poly-Tobacco Use Among Workers in a Dusty Industry: New Jersey Quarry Workers. *JOEM* 2016. (In press)
3. Graber JM, Delnevo CD, Manderski MT, Cohen, RA, Rose CS, Ahluwalia JS. Cigarettes, smokeless tobacco and poly-tobacco use in three dusty industries. *JOEM* 2016. (Accepted pending revisions)
4. Almberg, KS, Friedman, LS, Graber, JM, Rose, CS, Petsonk, EL, Harris, G, Go, L., Cohen, RA. "Cardiopulmonary Disease among Illinois Miners: Results of a Linkage Analysis with State Workers' Compensation and MSHA Data." *Am J Ind Med* 2016. (Under review)
5. Graber, JM, Manderski, MT, Cohen, RA, Almberg, KS, Rose, CS, Delnevo, CD. Tobacco Use Patterns Among US Working Age Men: High Rates in the Mining Industry and Among the Unemployed. American Thoracic Society International Conference Abstracts. American Thoracic Society; 2015:A4032-A4032. http://www.atsjournals.org.proxy.cc.uic.edu/doi/abs/10.1164/ajrccm-conference.2015.191.1_MeetingAbstracts.A4032. Accessed November 23, 2015.
6. Almberg, KS, Friedman, LS, Graber, JM, Rose, CS, Petsonk, EL, Cohen, RA. Cardiopulmonary Disease Among Illinois Miners, Results of an Analysis of State Workers' Compensation Data. American Thoracic Society International Conference Abstracts. American Thoracic Society; 2015:A1748-A1748. http://www.atsjournals.org.proxy.cc.uic.edu/doi/abs/10.1164/ajrccm-conference.2015.191.1_MeetingAbstracts.A1748. Accessed November 23, 2015.
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Conference Posters and Presentations:

1. Cohen, RA, Graber JM. (Workshop co-chairs) "Current Topics and Methods in Surveillance of Disease in Mining Populations." 24th International Epidemiology in Occupational Health (EPICOH) Conference, Chicago IL, June 2014.
2. Cohen, RA. "Excavating the Cardiopulmonary Health Effects of Mining: From National Datasets to Lung Pathology." Pulmonary Grand Rounds. National Jewish Health, February 26, 2015. Denver, Colorado.
3. Cohen, RA. "Excavating the Cardiopulmonary Health Effects of Mining: From National Datasets to Lung Pathology." West Virginia Black Lung Clinics Conference, June 3, 2015. Pipestem, West Virginia.
4. Cohen, RA. "Pneumoconiosis in the 21st Century: New Lessons from an Old Exposure." Oral presentation. National Coalition of Black Lung and Respiratory Disease Clinics National Conference, September 9, 2015. Bristol, Virginia.
5. Cohen, RA, Rose, CS, Graber, JM, Petsonk, EL, Ibrahim, N, Almberg, KS, Robinson, M, Go, LH. "Use of National and State Compensation and Surveillance Compliance Data Sets to Better Understand Miners' Health." Oral presentation. American Public Health Association Annual Conference, November 3, 2015. Chicago, Illinois.
6. Almberg, KS, Cohen, RA, Friedman, LS, Graber, JM, Rose, CS, Petsonk, EL, Swedler, DI. "Completeness of Respiratory Injury and Illness Reporting in the Illinois Mining Industry: Comparing Workers' Compensation claims to the MSHA Part 50 Program." Submitted abstract, American Thoracic Society Annual Conference 2016.
7. Cohen, RA, Graber, JM, Harris, G, Rose, CS, Almberg, KS, Go, LH, and Petsonk, EL. "Lung Function and Chest Radiographs Finding in Former U.S. Coal Miners: Results of an Analysis of Data from the U.S. Department of Labor, Division of Coal Mine Workers' Compensation." Submitted abstract, American Thoracic Society Annual Conference 2016.

6.2 Future Plans for Dissemination of Findings

1. Write up our findings of silicosis cases from New Jersey and submit to the American Journal of Industrial Medicine.
2. Report an overview of our findings to the American Occupational Health Conference to be held in Chicago in April of 2016.
3. Provide an update on our findings to representatives from MSHA and the US Department of Labor, Office of Workers Compensation at their Miners Health Study Group Meeting to be held in Washington DC on Marcy 7, 2016.
4. Provide an update on our findings to the Health Resources Services Administration Black Lung Clinics Program workshop to be held in Rockville, Md on March 8, 2016

5. Provide an update on our findings to the West Virginia Black Lung Clinics Conference to be held June 8-10, 2016 in Pipestem, WV.

7.0 Conclusions and Impact Assessment

Overall, the findings of this project highlight the great wealth of public health information that exists in these national and state occupational health datasets. That information may be augmented when careful linkages combining these data can be performed providing region- and industry-specific descriptions of the distribution, determinants, and burden of occupational illness and injury. This will allow limited resources to be focused on appropriate preventive interventions. The results from each of the sub-studies performed in this project demonstrate the current utility of this approach, and the possibilities that would exist if certain changes were made to standardize data collection and enhance the ease of linkages in the future.

Currently, on-going health surveillance is available only for active underground coal miners, and is focused on radiographic surveillance of pneumoconiosis with the recent addition of spirometry. Additional surveillance and research programs are urgently needed to elucidate the impact of the broader spectrum of respiratory disease, and to provide information on the distribution and determinants of CVD among all U.S. miners. Data on retired or inactive miners and non-coal miners is sorely lacking. Fortunately, many state and federal agencies and nongovernmental organizations have collected relevant health information from the U.S. mining population that may fill this void.

8.0 Recommendations for Future Work

The work completed under this grant has laid the groundwork for several new projects. These studies, outlined below, are focused on linking and analyzing national surveillance datasets that we identified to better understand the distribution, severity, rate of progression, as well as mortality from respiratory disease and other co-morbidities in U.S. coal miners.

8.1 Linkage of NIOSH Coal Workers' Health Surveillance Program and the DOL OWCP/DCMWC BLBP data

The DOL OWCP/DCMWC and NIOSH have programs that evaluate the health of coal mining populations in the United States. However, these agencies have different missions. NIOSH's CWHSP collects health data, primarily on active coal miners in the United States to synthesize and disseminate information about respiratory disease hazards and trends with the ultimate goal of preventing occupational respiratory disease. DOL OWCP/DCMWC administers the BLBP, which collects respiratory health information on former miners applying for disability benefits as well as health care billing information for the respiratory care of those miners awarded benefits. We have proposed linking these two databases for the purposes of supporting the missions of both agencies to improve outreach services to the coal mining population in the United States.

This linkage will provide a deeper understanding of the characteristics of miners who participate in either or both systems as well as a description of populations that are not well

captured by either program. It will allow a better characterization of the extent of coal mine dust lung disease from the time a miner is employed all the way through to their application for Black Lung benefits. We have received approval from NIOSH to link their surveillance data with data from DOL OWCP/DCMWC and are in the process of obtaining a data sharing agreement to execute this goal.

8.2 Mortality study of U.S. coal miners participating in both the DOL BLBP and the NIOSH CWHSP using National Death Index data

The second proposal for future work will build on the linkage study above. We are developing an all-cause mortality study of those coal miners who appear in both the DOL BLBP and the NIOSH CWHSP databases. We will use data obtained from the National Death Index (NDI) to ascertain the cause of death for deceased miners in this population. This information will be linked to occupational and medical history, longitudinal respiratory health information from the time they were employed through their disability evaluation for BLBP in an unprecedented study. The information gained from this project will allow our investigators to study coal mine dust lung disease and its associated morbidity in an enriched dataset enabling a more complete understanding of the health conditions affecting U.S. coal miners. The mortality data will allow a better understanding of the conditions that may be associated with workplace exposures, thus allowing focused preventive measures and improved surveillance as well as crucial information for the health benefits and preventive measures OWCP may need to provide in the future.

9.0 References

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10.0 Appendices

APPENDIX A: Search terms used to identify comorbid conditions and risk factors among BLBP benefit claimants from 2000 to 2013.

APPENDIX B: Guidelines for assigning smoking status and pack years of smoking among BLBP benefit claimants from 2000 to 2013.

10.1 APPENDIX A

Search terms used to identify comorbid conditions and risk factors among FBL benefit claimants from 2000 to 2013. Data source: USDOL OWCP/DCMWC CORS physical examination and history data.

Category and search term[a]	Count
CVD	
CVD	302
Heart	7,330
Cardio	7,133
Ischem	1,996
Myoc	2,034
MI	378
Arrhy	396
Aortic	886
Megaly	993
Pulmonale	429
Chf	652
Congestiv	2,596
Cad	518
Stent	890
Cabg	836
Bypass	1,517
Hyperten Or Htn	7,612
Hyperlip	1,323
Dyslip	238
Hyperchol	375
Coronary	7,012
Athero	1,702
Attack	370
One or more of the above terms	22,043
COPD	
COPD	8,383
Obstruct	17,397
Airway Disease	1,357
Hyperinfla	412
Emphy	5,912
Bullae	147
Bronchitis	13,317
Centriacin	144
Air Trap	468
Revers	1,116
Response	0
Bronchodi	1,443
Albuter	123
≥1 of the above terms	32,030

Category and search term[a]	Count
Other lung	
Fibrosis	3,711
Interstit	2,795
IPF	31
Fibrotic	750
Idiopa	493
≥1 of the above terms	5,806
Asthma	3,628
Obesity	
Obesity	2,802
BMI	693
Overweight	185
Obese	262
≥1 of the above terms	3,605
Cancer	
Cancer	2,742
Metast	1,303
Malig	1,158
Tumor	463
Adenocar	315
Carcino	1,733
≥1 of the above terms	5,210
≥1 of the above with term "lung"	3,727
Gender[b]	
She	323
Her	261
Female	8
Girl	2
Woman	5
Any of the above terms	460

[a] Searches were not case sensitive
[b] Many of these terms may refer to clinicians

10.2 APPENDIX B

Guidelines for assigning smoking status and pack years of smoking among BLBP benefit claimants from 2000 to 2013.

A. Smoking Status

Smoking Status Assigned	Examples of words and phrases used to assign smoking status
Never	"never smoker", "No smoking history", "has never smoked cigarettes"
Current	"continue tobacco abuse"
Former	"No longer smokes" "Past smoking"
Smoking NOS[1]	"history of smoking"; "etiology –cigarette smoking", "smoking"
Probable never smoker	"is a non smoker"; "non smoker"
Ambiguous/indefinable	"Likely tobacco abuse"; "No evidence of cigarette smoking related lung disease"; "Coal dust exposure/cigarette smoking ???"

[1]Smoking not otherwise specified. Record review indicated that the miner was smoker, but there was insufficient information to assign current or former smoking status.

B. Pack Years

Text Condition	Approach	Example
Number of pack years in the text	Abstract the number of pack years	
n+ pack years	Use 'n'	"at least 30 pack years" was entered as 30 pack years
n- pack years	Use 'n'	"at most 30 pack years" was entered as 30 pack years
A range is given for pack years	Use the midpoint of the range	"10 to 20 pack years" was entered as 15
Number of packs per day and the number of years smoked given	Multiply those two values	"smoked 2 packs per day for 10 years" = 20 pack years
N+ numbers of packs per day and the number of years smoked given	Multiply those two values	"Smoked a pack a day for at least 20 years" is 20 pack years
A range for packs per day or years given	Use the midpoint of the range	"1 to 3 packs per day for 10 years" = 20 pack years; "2 packs per day for 9 to 11 years" = 20 pack years
Detailed smoking history both packs per day and duration of smoking	Calculate pack years	"smoking history: 1970-1976, 1984-1992, 2002-2007" calculates as (76-70)+(92-84)+(7-2) = 19 pack years
Incomplete smoking history	Not included in the analysis, code as U	"smoked for 60 years,; "smoked for 30 years"; "smoked two packs per day"

Disclaimer

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