Linking Compensation and Health Surveillance Data Sets to Improve Knowledge of US Coal Miners' Health

Kirsten S. Almberg, PhD, Robert A. Cohen, MD, David J. Blackley, DrPH, Anthony S. Laney, PhD, Eileen Storey, MD, MPH, and Cara N. Halldin, PhD

Objective: Increase knowledge of US coal miners' respiratory health by linking data from the black lung benefits program (BLBP) and the coal workers' health surveillance program (CWHSP). **Methods:** BLBP claims data from 2000 through 2013 was linked to CWHSP data from 1970 through 2016. **Results:** Overall, 273,644 miners participated in CWHSP, 37,548 in BLBP, and 22,903 in both programs. Median age of miners at their time of first/only participation in CWHSP was 28 and 32 years, respectively. BLBP claimants were older (median age 59). Thirty-nine percent of BLBP claimants had not participated in CWHSP. The relative contributions of states to participation differed between CWHSP and BLBP. For example, Kentucky miners accounted for 18% of CWHSP participants, but 36% of BLPB participants. **Conclusions:** Many BLBP claimants never appeared in CWHSP, indicating missed opportunities for secondary prevention.

Occupational exposure to coal mine dust is associated with a broad spectrum of respiratory morbidity, including coal workers' pneumoconiosis (CWP), lung function impairment,[1,2] and chronic obstructive pulmonary disease (COPD).[3] These together with other diseases are encompassed by the term coal mine dust lung disease (CMDLD).[4] Despite substantial progress in reducing CWP in coal miners following implementation of the Federal Coal Mine Health and Safety Act of 1969, the trend has reversed in recent years.[5] Particularly disturbing is the increased incidence of rapidly progressive pneumoconiosis (RPP)[6] and progressive massive fibrosis (PMF), the most severe form of CWP, now being seen in relatively young coal miners (median age 53 years).[7,8]

Miners exposed to coal mine dust can develop significant lung function impairment[4] even in the absence of radiologic changes consistent with CWP.[9,10] Additionally, a recent study found prevalence of CWP and impaired lung function to be higher among former coal miners when compared with active miners from a similar time period, controlling for mining tenure. This suggests that some forms of CMDLD may progress following cessation of dust exposure,[11] underscoring the importance of monitoring the health of former miners.

From the Environmental and Occupational Health Sciences Division, School of Public Health, University of Illinois at Chicago, Chicago, Illinois (Dr Almberg, Dr Cohen); Respiratory Health Division, Surveillance Branch, National Institute for Occupational Safety and Health, Morgantown, West Virginia (Dr Almberg, Dr Cohen, Mr Blackley, Dr Laney, Dr Storey, Dr Halldin).

Source of Funding: This research was supported by an internal National Occupational Research Agenda (NORA) grant from the National Institute for Occupational Safety and Health and a grant from the Alpha Foundation for the Improvement of Mining Safety and Health, Inc. The views, opinions and recommendations addressed herein are solely those of the authors and do not imply any endorsement by the Alpha Foundation, its Directors and staff.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Mention of product names does not imply endorsement by NIOSH/CDC.

All authors have no conflicts of interest to declare.

Address correspondence to: Kirsten S. Almberg, PhD, 1603 W. Taylor Street (MC923), Chicago, IL 60612 (almberg@uic.edu).

DOI: 10.1097/JOM.0000000000001084

Federal agencies, including the Mine Safety and Health Administration (MSHA), the Energy Information Administration, the Health Resources and Services Administration, the National Institute for Occupational Safety and Health (NIOSH), and the Department of Labor (DOL) Division of Coal Mine Workers' Compensation (DCMWC) collect data on the characteristics and/or health of US coal miners. However, no comprehensive surveillance of miners' health exists, as these agencies have different missions, target populations, and data collection goals. NIOSH and the DOL collect miner's individual respiratory health information and perform clinical testing as part of their respective missions.

NIOSH administers the coal workers' health surveillance program (CWHSP) for active miners. The CWHSP was originally mandated by the Federal Coal Mine Health and Safety Act of 1969 (amended by the Federal Mine Safety and Health Act of 1977) and began operation in 1970. The primary purpose of the CWHSP is secondary prevention of CMDLD.[12] The program is designed to detect early radiographic CWP in active miners and prevent the progression to disabling disease by allowing miners to exercise their right to work in locations with lower dust exposure.[13] Coal miners are offered a chest radiograph (CXR) at approximately 5-year intervals at no cost to themselves. Participation in the CWHSP is open to all surface and underground coal miners on a voluntary basis and has fluctuated over the program's 50 years history.[14,15]

DOL operates the black lung benefits program (BLBP) and administers claims filed under the Black Lung Benefits Act of 1969. The Act provides compensation to coal miners who are totally disabled by pneumoconiosis arising out of coal mine employment and to certain miners' survivors. The Act also provides eligible miners with medical services and supplies needed to treat their pneumoconiosis.[16] Since 1970, the DOL Division of Coal Mine Workers' Compensation has paid over $46 billion in BLBP benefits.[17] Data from the BLBP have only recently been analyzed for public health purposes,[18] and have never before been linked to other data sets.

A recent investigation by NIOSH found a cluster of 60 cases of clinic-identified PMF in Kentucky which exceeded the burden of disease identified through surveillance of active miners by CWHSP,[19] suggesting that multiple databases containing health information on coal miners may be necessary to fully understand the burden of respiratory disease in this population. This study links miners' respiratory health information from the CWHSP and BLBP and identifies workers appearing in only one or both data sets, highlighting gaps in program participation and our CMDLD knowledge base.

METHODS

Data Sources and Study Participants

This study used health surveillance data collected for CWHSP and health data used to adjudicate benefits claims from the BLBP. A Memorandum of Understanding was established between DOL and NIOSH for access to BLBP claims made between January 1, 2000 and December 31, 2013, allowing for a linkage of CWHSP and BLBP data. We included all CWHSP data from 1970

through 2016 to maximize the potential for linking to individuals in the BLBP data (2000 to 2013), who are likely applying for benefits at the end of their mining careers. The study was approved by the NIOSH institutional review board.

Coal Workers' Health Surveillance Program Database

The CWHSP data contain demographic information such as age, sex, and race/ethnicity, and work histories for previous mining positions. The CWHSP also contains the results of a standardized International Labour Office (ILO) pneumoconiosis classification of each CXR by independent NIOSH B Readers.[20] Full characteristics of the CWHSP data have been previously described in detail.[21,22] The Enhanced Coal Workers' Surveillance Program (Enhanced Program) began in 2005 and provides lung function testing (spirometry) according to the American Thoracic Society criteria.[23] Lung function data includes FEV_1, FVC, FEV_1/FVC ratio; additional data collected from the miner prior to spirometry testing include height, weight, smoking status (former/current/never), and respiratory symptom information.[22]

Black Lung Benefits Program Databases

The DOL Division of Coal Mine Workers' Compensation maintains demographic, work history, medical testing, and benefits data on all BLBP claimants. These data include miner's name, social security number (SSN), date of birth, and residence at time of filing, the mining work history as years of coal mine employment (CME) claimed and verified (DOL examiners verify years of employment using social security earnings data). In addition, the BLBP data contain the location (state), employer, and date of the claimant's last coal mine employment as well as the status of the BLBP claim. The BLBP does not collect data on claimant sex or race. The clinical data contain detailed information from the miners' medical disability examinations, including the dates and ILO Classification of CXRs, and results of pre- and post-bronchodilator spirometry, arterial blood gases at rest and with exercise, and physical examination findings.

Data Analysis

BLBP and CWHSP data were linked using SSN. We restricted our analysis of CWHSP participants to those born in or after 1910, allowing the linkage to be inclusive of almost all miners found in CWHSP who applied for BLBP benefits after the year 2000. After excluding duplicate SSNs ($n = 11$) and miners born before 1910 ($n = 2240$), we included 273,644 miners from the CWHSP in analyses. We computed basic demographic and geographic descriptive statistics to characterize this population by age, coal mining tenure, and location. All calculations of age and tenure in the BLBP were based on claims by living miners only. We evaluated miner characteristics associated with non-participation in either CWHSP or BLBP by analyzing miners who appeared in only one of the two data sets compared with those who appeared in both programs. To assess the significance of differences in observed comparisons, we used chi-squared tests for categorical variables and *t* tests for continuous variables. We also examined the geographic distribution of miners who appeared in one or both of the data sets to examine differences in program participation across states.

RESULTS

During 1970 to 2016, 273,644 miners participated in the CWHSP. Twenty-eight percent of miners in the CWHSP participated only at the time of initial employment to obtain a CXR. These CXRs are obtained before or within 30 days of starting employment.[24] These miners appear in the CWHSP data set with no reported coal mine tenure and only one CXR. The mean age of miners that participated only once in the CWHSP, either as an initial employment examination or at some point later in their mining career, was 34.6 (standard deviation [SD] 12.8). For miners with more than one encounter with the CWHSP, the mean age of miners at the time of first participation was 31.3 (SD 11.2) and was 41.2 (12.5) at the time of their last encounter with the CWHSP. Excluding initial employment participants who have no tenure information, the median self-reported coal mining tenure of miners in the CWHSP was 13.8 (range 0–89) years (Table 1).

There were 48,841 claims in the BLBP database from 2000 to 2013, representing 37,548 unique miners. Most claims, initial and repeated, were filed by a living miner ($n = 31,576$; 65%), the

TABLE 1. Distribution of Demographic and Occupational Characteristics of US Coal Miners Participating in Either the Coal Workers' Health Surveillance Program (CWHSP) From 1970 Through 2016 or the Department of Labor Black Lung Benefits Program (BLBP) From 2000 Through 2013

	CWHSP Participants* $n = 273,644$	BLBP Claimants $n = 37,548$
Initial employment only *n* (%)	75,311 (27.5)	–
Race *n* (%)		
Non-Hispanic White	198,284 (72.4)	–
Non-Hispanic Black	5,618 (2.1)	–
Other	2,751 (1.0)	–
Missing	66,991 (24.5)	–
Sex *n* (%)		
Male	230,783 (84.3)	–
Female	6,662 (2.4)	–
Missing *n* (%)	36,199 (13.2)	–
Age at only encounter†		
Mean (SD)	34.6 (12.8)	–
Median	32	–
Range	15–92	–
Missing *n*	1	–
Age at first encounter‡		
Mean (SD)	31.3 (11.2)	59.3 (9.1)
Median	28	59
Range	15–75	23–112
Missing *n*	0	22
Age at last encounter‡		
Mean (SD)	41.2 (12.5)	66.4 (9.8)
Median	41	66
Range	17–91	29–100
Missing *n*	0	4
Number of CXR encounters		
Mean (Median)	1.7 (1)	1.2 (1)
Range	1–28	1–9
Missing *n*	18	
Coal mining employment (yrs)§		
Mean (SD)	13.8 (12.1)	19.5 (10.0)
Median	10	19
Range	0–89	0–51
Missing	0	788 (2.1)
Captured in both datasets *n* (%)	22,903 (8.4)	22,903 (61.0)

CXR, chest radiograph; SD, standard deviation; "–", indicates where data are not available.

*Restricted to those born in 1910 or after.

†Among CWHSP, age at radiograph for miners participating only once in the program ($n = 162,028$).

‡Age at first and last radiograph for miners appearing more than once in the CWHSP ($n = 111,597$). Among BLBP claimants, age at initial BLBP claim for living miners ($n = 20,402$).

§Coal mining employment calculations exclude initial employment participants in the CWHSP ($n = 75,311$), as they have 0 years of coal mine employment at time of participation. Among BLBP claimants, verified coal mine employment at last or only BLBP claim.

remainder (35%) by a surviving spouse or child. The mean age of BLBP living miner claimants at the time of their initial or only claim was 59.3 (SD 9.1) and 66.4 (SD 9.8) years at the time of their last claim, if they had more than one, with a mean verified mining tenure of 19.5 (SD 10.0) years. The median number of CXRs submitted to the BLBP by miners was one (Table 1).

A total of 22,903 miners appeared in both programs. Thirty-nine percent of miners filing BLBP claims had not previously participated in the CWHSP. A higher proportion of miners appearing in both programs were non-Hispanic white (84%) compared with those appearing in the CWHSP only (71%; χ^2 $P < 0.0001$). Eighty-nine percent of miners appearing in both programs were men, compared with 84% of those who only participated in the CWHSP; however, a large proportion (14%) of miners participating in only the CWHSP had missing data on sex. Miners appearing in both programs participated in the CWHSP more often than those participating in the CWHSP alone (Table 2; t test $P < 0.0001$).

Geography

Miners employed in 25 states participated in the CWHSP from 1970 through 2016, while the BLBP received claims from miners last working in 38 states during 2000 to 2013. Sixty percent of miners were working in the states of West Virginia (26.4%), Kentucky (18.5%), and Pennsylvania (15.0%) at the time of their last or only CWHSP encounter. The majority of miners applying for BLBP benefits last worked in Kentucky (35.6%), West Virginia (25.9%), and Virginia (9.0%). Of the miners appearing in both programs, nearly three fourths last worked in Kentucky (34.5%), West Virginia (28.5%), and Virginia (9.5%) (Table 3). A majority (88%) of miners worked in the same state at the time of filing their BLBP claim as the state in which they were working at the time of their last CWHSP encounter.

DISCUSSION

This unique study linking two sources of coal miners' health data has provided some insights into the strengths and weaknesses of these two programs. The combined data facilitate investigation into factors associated with participation and non-participation in either or both programs. Miners who participate in the CWHSP tend to participate only once, and at a relatively young age (mean age of first) or only encounter between 31 and 35 years. For those that appear more than once in the CWHSP, the difference in median age between the first and last encounter is 13 years (age 28 and age 41), somewhat longer than the median duration of coal mine employment of 10 years. Those miners applying for BLBP benefits do so about 20 years later (mean age 59). A large proportion (39%) of miners applying for BLBP benefits had never participated in the CWHSP while actively mining, demonstrating missed opportunities for secondary prevention.

The geographic distribution of participation in the two programs is also revealing. Two thirds of miners who participated in both programs were from Kentucky and West Virginia. While the proportion of miners participating in each program in West Virginia was comparable between the two programs, the proportion participating in the CWHSP in Kentucky was only half that of the BLBP. This difference could reflect many factors that were not measurable in this study. For instance, more miners from Kentucky may become ill enough to consider applying for BLBP; there may be a difference in the knowledge of the BLBP in Kentucky; differences in state compensation benefits may play a role; and/or miners may perceive possible disincentives for participation in surveillance that vary by state.[19] Further study is important given that the central Appalachian coal fields have been identified as an area with significant rates of rapidly progressive and advanced disease.[6,7,25–27]

This linkage examined data from different time periods between the two programs. BLBP claims data from 2000 through 2013 were linked to CWHSP data from 1970 through 2016. Some miners appearing in the CWHSP who were awarded BLBP benefits prior to 2000 will not appear to be captured by both programs despite potentially participating in both. Similarly, while some miners participating in the CWHSP after 2013 did link to BLBP claimants, we expect that most miners participating in surveillance after 2013 would not be captured in the claims data from 2000 to 2013. A primary goal was to identify miners that appear only in the benefits process without any prior participation in surveillance efforts. We expanded the years of surveillance data used in the linkage process to maximize the potential for identifying miners captured by both programs.

TABLE 2. Distribution of Demographic and Surveillance Encounter Characteristics Among US Coal Miners Appearing in the CWHSP or BLBP Only Compared With Those that Appear in Both Programs, 1970 to 2013. The CWHSP Data are Restricted to those Born After Jan 1, 1910 ($n = 273,644$)

Variable	CWHSP and BLBP *n* (%)	CWHSP Only *n* (%)	BLBP Only *n* (%)
Total *n*	22,903	250,741	14,645
Initial employment only	2,431 (10.6)	72,880 (29.1)	–
Race			
Non-Hispanic White	19,285 (84.2)	178,999 (71.4)	–
Non-Hispanic Black	877 (3.8)	4,741 (1.9)	–
Other	173 (0.8)	2,578 (1.0)	–
Missing	2,568 (11.2)	64,423 (25.7)	–
Sex			
Male	20,457 (89.3)	210,326 (83.9)	–
Female	232 (1.0)	6,430 (2.6)	–
Missing	2,214 (9.7)	33,985 (13.6)	–
Age at only encounter*			
Mean (median)	35.3 (34)	34.6 (31)	–
Range	16–89	15–92	–
Missing	0 (0.0)	18 (0.01)	–
Age at first encounter†			
Mean (median)	30.1 (28)	31.5 (28)	60.2 (60)
Range	17–72	15–75	24–102
Missing	1 (0.0)	0 (0.0)	5 (0.07)
Age at last encounter‡			
Mean (median)	42.5 (43)	41.0 (41)	68.2 (69)
Range	17–91	17–88	29–100
Missing	0 (0.0)	0 (0.0)	1 (0.02)
Number of CXR encounters			
Mean (median)	2.3 (2)	1.7 (1)	1.2 (1)
Range	1–14	1–28	1–7
Coal mine employment (yrs)§			
Mean (median)	14.0 (12)	13.7 (10)	16.0 (10.4)
Range	0–60	0–89	0–50
Missing	0	0	283 (1.9)

CXR, chest radiograph; SD, standard deviation; "–", indicates where data are not available.

*Among CWHSP, age at radiograph for miners participating only once in the program, including initial employment participants (CWHSP and BLBP $n = 8,784$; CWHSP only $n = 153,262$).

†Age at first CWHSP radiograph for miners appearing in both datasets ($n = 14,118$) or the CWHSP only ($n = 97,479$). Age at first CWHSP encounter based only on those miners with more than one CWHSP chest radiograph. Age at first or only BLBP claim ("BLBP Only") is based on living miners only ($n = 7,558$).

‡Age at last CWHSP radiograph for miners appearing in both datasets ($n = 14,118$) or the CWHSP only ($n = 97,479$). Age at last CWHSP encounter based only on those miners with more than one CWHSP chest radiograph. Age at last BLBP claim ("BLBP Only") is based on living miners only ($n = 5,784$).

§Coal mining employment calculations exclude initial employment participants in the "CWHSP Only" and "CWHSP and BLBP" groups, as they have 0 years of coal mine employment at time of participation in the CWHSP. Among "BLBP Only" claimants, verified coal mine employment at last or only BLBP claim.

TABLE 3. State in Which Coal Miners Appearing in the CWHSP From 1970 Through 2016 and the BLBP From 2000 Through 2013 Worked at Time of their Last Surveillance Chest Radiograph or at the Time of their First BLBP Claim

State	All CWHSP *n* (%)	All BLBP *n* (%)	Miners in Both Programs *n* (%)
West Virginia	72,294 (26.4)	9,737 (25.9)	6,532 (28.5)
Kentucky	50,518 (18.5)	13,366 (35.6)	7,910 (34.5)
Pennsylvania	41,075 (15.0)	2,159 (5.7)	1,282 (5.6)
Illinois	22,462 (8.2)	1,889 (5.0)	1,386 (6.1)
Virginia	21,134 (7.7)	3,374 (9.0)	2,185 (9.5)
Ohio	12,360 (4.5)	1,302 (3.5)	692 (3.0)
Colorado	11,758 (4.3)	165 (0.4)	125 (0.5)
Alabama	10,173 (3.7)	2,563 (6.8)	1,565 (6.8)
Utah	9,731 (3.6)	295 (0.8)	254 (1.1)
Indiana	5,452 (2.0)	439 (1.2)	118 (0.5)
Wyoming	3,103 (1.1)	129 (0.3)	21 (0.1)
Texas	2,331 (0.9)	*	0 (0.0)
Tennessee	1,761 (0.6)	1,041 (2.8)	245 (1.1)
New Mexico	1,640 (0.6)	107 (0.3)	32 (0.1)
Montana	825 (0.3)	32 (0.1)	*
Arizona	606 (0.2)	93 (0.2)	44 (0.2)
Maryland	511 (0.2)	39 (0.1)	12 (0.1)
North Dakota	434 (0.2)	*	0 (0.0)
Other	678 (0.2)	225 (0.6)	*
Missing	4,798 (1.8)	583 (1.6)	493 (2.2)
Total	273,644	37,548	22,903

"Other" category includes Alaska, Arkansas, California, District of Columbia, Florida, Georgia, Idaho, Iowa, Kansas, Louisiana, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Oklahoma, South Carolina, Vermont, Washington. Data was aggregated due to low cell counts.

*Frequencies <10 are suppressed.

This linkage provides the first comprehensive data set to date on miners who participate in both programs. For this initial linkage, few restrictions were made in order to maximize the potential for miners appearing in both programs to be linked. Consequently, there are some outlier observations included for age and coal mine tenure. However, it does not appear that these outliers have greatly affected the descriptive statistics of the groups. Also, this linkage includes many miners who completed much of their mining tenure before CWHSP was initiated in 1970. Still, the dataset provides relevant, useful information.

The BLBP database lacks demographic data, such as sex and race/ethnicity of claimants which can be added from linked CWHSP data, although these data elements were missing for a proportion of CWHSP participants (13% missing sex; 25% missing race/ethnicity). These variables are not collected in a systematic way in the BLBP data, but are important in any analysis of respiratory outcomes in this population. Conversely, the CWHSP database does not include data on arterial blood gases and pre- and post-bronchodilator pulmonary function tests (PFTs) and has spirometry results only for participants in the Enhanced Program.

The linkage of these data sets indicates that the current CWHSP captures relatively young coal miners with relatively short mining tenures. Comparing the two datasets suggests that increased surveillance efforts are needed among older, more experienced miners, with a focus on Central Appalachia.

ACKNOWLEDGMENTS

The authors would like to acknowledge the work of Janet Hale, Anita Wolfe, and the Coal Workers' Health Surveillance Program staff. They additionally acknowledge the work of Michael Chance, Gerald Delo, Tracey Teague, and Bennett Stewart of the Department of Labor Division of Coal Mine Workers' Compensation.

REFERENCES

1. Attfield MD, Hodous TK. Pulmonary function of U.S. coal miners related to dust exposure estimates. *Am Rev Respir Dis*. 1992;145:605–609.
2. Seixas NS, Robins TG, Attfield MD, Moulton LH. Longitudinal and cross sectional analyses of exposure to coal mine dust and pulmonary function in new miners. *Br J Ind Med*. 1993;50:929–937.
3. Kuempel ED, Wheeler MW, Smith RJ, Vallyathan V, Green FHY. Contributions of dust exposure and cigarette smoking to emphysema severity in coal miners in the United States. *Am J Respir Crit Care Med*. 2009;180:257–264.
4. Petsonk EL, Rose C, Cohen R. Coal mine dust lung disease. New lessons from an old exposure. *Am J Respir Crit Care Med*. 2013;187:1178–1185.
5. Laney AS, Attfield MD. Coal workers' pneumoconiosis and progressive massive fibrosis are increasingly more prevalent among workers in small underground coal mines in the United States. *Occup Environ Med*. 2010;67:428–431.
6. Antao VC dos S, Petsonk EL, Sokolow LZ, et al. Rapidly progressive coal workers' pneumoconiosis in the United States: geographic clustering and other factors. *Occup Environ Med*. 2005;62:670–674.
7. Blackley DJ, Halldin CN, Laney AS. Resurgence of a debilitating and entirely preventable respiratory disease among working coal miners. *Am J Respir Crit Care Med*. 2014;190:708–709.
8. Wade WA, Petsonk EL, Young B, Mogri I. Severe occupational pneumoconiosis among West Virginian coal miners: one hundred thirty-eight cases of progressive massive fibrosis compensated between 2000 and 2009. *Chest*. 2010;139:1458–1462.
9. Wang ML, Beeckman-Wagner L-A, Wolfe AL, Syamlal G, Petsonk EL. Lung-function impairment among US underground coal miners, 2005 to 2009: geographic patterns and association with coal workers' pneumoconiosis. *J Occup Environ Med Am Coll Occup Environ Med*. 2013;55:846–850.
10. Blackley DJ, Laney AS, Halldin CN, Cohen RA. Profusion of opacities in simple coal worker's pneumoconiosis is associated with reduced lung function. *Chest*. 2015;148:1293.
11. Halldin CN, Wolfe AL, Laney AS. Comparative respiratory morbidity of former and current US coal miners. *Am J Public Health*. 2015;105:2576–2577.
12. Centers for Disease Control and Prevention National Institute for Occupational safety and Health. CDC—Coal Workers' Health Surveillance Program—NIOSH Workplace Safety and Health Topic; 2016. Available at: https://www.cdc.gov/niosh/topics/cwhsp/default.html (accessed Dec 22, 2016).
13. Title 42 C.F.R. Public Health. §37. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=78267829dd6935b5d1e3cb372d39e65f&node=42:1.0.1.3.21&rgn=div5#se42.1.37_13 (accessed Dec 30, 2015).
14. Laney AS, Attfield MD. Examination of potential sources of bias in the US coal workers' health surveillance program. *Am J Public Health*. 2014;104:165–170.
15. Centers for Disease Control and Prevention National Institute for Occupational Safety and Health. CWXSP: Estimated number of actively employed workers at underground mines and number of miners examined, 1970-2006; 2008. Available at: https://wwwn.cdc.gov/eworld/Data/CWXSP_Estimated_number_of_actively_employed_workers_at_underground_mines_and_number_of_miners_examined_1970-2006/347 (accessed Dec 22, 2016).
16. The Black Lung Benefits Act of 1969 Title 30 U.S.C. §§901–945; 1981. Available at: http://uscode.house.gov/view.xhtml?path=/prelim@title30/chapter22/subchapter4&edition=prelim. Accessed May 19, 2016.
17. U.S. Department of Labor—Office of Workers' Compensation Programs (OWCP)—Division of Coal Mine Workers' Compensation (DCMWC)—Black Lung Program Statistics. Available at: https://www.dol.gov/owcp/dcmwc/statistics/TotalBenefitsPayment.htm (accessed May 19, 2016).
18. Cohen RA, Graber JM, Harris G, et al. *Spirometry and chest radiographs in US coal miners: analysis of data from the federal black lung program. B24. occupational medicine.* American Thoracic Society; 2016 , A2996. Available at: http://www.atsjournals.org.proxy.cc.uic.edu/doi/abs/10.1164/ajrccm-conference.2016.193.1_MeetingAbstracts.A2996 (accessed May 19, 2016).
19. Blackley DJ, Crum JB, Halldin CN, Storey E, Laney AS. Resurgence of progressive massive fibrosis in coal miners—Eastern Kentucky, 2016. *MMWR Morb Mortal Wkly Rep*. 2016;65:1385–1389.

20. Centers for Disease Control and Prevention National Institute for Occupational Safety and Health. CDC—Chest Radiography: B. Reader Information for Medical Professionals—NIOSH Workplace Safety and Health Topic; 2016. Available at: http://www.cdc.gov/niosh/topics/chestradiography/breader-info.html (accessed Dec 4, 2016).
21. Attfield MD, Althouse RB. Surveillance data on US coal miners' pneumoconiosis, 1970 to 1986. *Am J Public Health*. 1992;82:971–977.
22. Laney AS, Weissman DN. The classic pneumoconioses: new epidemiological and laboratory observations. *Clin Chest Med*. 2012;33:745–758.
23. Miller MR. Standardisation of spirometry. *Eur Respir J*. 2005;26:319–338.
24. Centers for Disease Control and Prevention National Institute for Occupational Safety and Health. CDC—Coal Workers' X-ray Surveillance Program—NIOSH Workplace Safety and Health Topic; 2016. Available at: https://www.cdc.gov/niosh/topics/cwhsp/cwhsp-xray.html (accessed Dec 22, 2016).
25. Laney AS, Petsonk EL, Attfield MD. Pneumoconiosis among underground bituminous coal miners in the United States: Is silicosis becoming more frequent? *Occup Environ Med*. 2010;67:652–656.
26. Suarthana E, Laney AS, Storey E, Hale JM, Attfield MD. Coal workers' pneumoconiosis in the united states: regional differences 40 years after implementation of the 1969 Federal Coal Mine Health and Safety Act. *Occup Environ Med*. 2011;68:908–913.
27. Laney AS, Petsonk EL, Hale JM, Wolfe AL, Attfield MD. Potential determinants of coal workers' pneumoconiosis, advanced pneumoconiosis, and progressive massive fibrosis among underground coal miners in the United States, 2005–2009. *Am J Public Health*. 2012;102(Suppl):S279–S283.