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BRIEF REPORT

Assessment of pneumoconiosis in surface coal miners after implementation of a national radiographic surveillance program, United States, 2014–2019

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Abstract

Background: Pneumoconiosis can occur in surface coal miners. The Coal Workers' Health Surveillance Program (CWHSP) has only included surface coal miners as part of its regular disease surveillance since 2014. This analysis identifies the prevalence of pneumoconiosis among working surface coal miners participating in the CWHSP since their initial inclusion, through 2019.

Methods: Working surface coal miners who had chest radiographs through the CWHSP from January 1, 2014 through December 31, 2019 were included in this analysis. Demographic information, mining tenure and occupation, and radiographic classifications according to the International Labour Office system were included from each miner's most recent encounter with the CWHSP. Prevalence ratios were calculated comparing the prevalence of the disease by region and occupation by log-binomial regression.

Results: Pneumoconiosis was present in 109 (1.6%) surface coal miners, including 12 miners with progressive massive fibrosis, the most severe form of the disease. After taking surface mining tenure into account, surface miners in Central Appalachia (prevalence ratio [PR], 3.2; 95% confidence interval [CI], 2.2–4.7) and surface miners who worked as a driller or blaster (PR, 2.1; 95% CI, 1.3–3.5) were at increased risk of pneumoconiosis.

Conclusion: The occurrence of pneumoconiosis in surface coal miners supports including them within a systematic respiratory health surveillance program. The current surveillance findings are consistent with past findings of pneumoconiosis, particularly silicosis, in surface mining occupations such as drilling and blasting.

KEYWORDS
coal mining, epidemiology, occupational health, pneumoconiosis, silicosis

1 | INTRODUCTION

The resurgence of severe pneumoconiosis in underground coal miners in the United States over the past 15 years has been well documented.[1–4] Increasing evidence in the form of case reports, clinic-based investigations, and targeted surveillance efforts has revealed that the burden of pneumoconiosis in modern US coal miners is not isolated to underground workers but also occurs in surface miners.[4–6] Both underground and surface coal miners can be exposed to excessive amounts of respirable coal mine dust which,

with sufficient exposure, causes pneumoconiosis.[7] Coal mine dust is composed of coal dust and other mineral dust, such as respirable crystalline silica dust from rock containing quartz. Inhalation of respirable crystalline silica dust can lead to a form of pneumoconiosis called silicosis which, like other pneumoconioses, is incurable and can cause substantial morbidity and even mortality. A comprehensive evaluation of pneumoconiosis among US surface coal miners has previously not occurred because the legislation[8] establishing medical monitoring for coal workers' respiratory health only specified surveillance for working underground coal miners. The 1969 Coal Mine Health and Safety Act specifically targeted underground miners because the common opinion in the 1960s was that surface miners were at low risk of occupational lung disease and the overall population-based burden of respiratory illness in surface miners was negligible. However, over the past 50 years, National Institute for Occupational Safety and Health (NIOSH) has conducted periodic surveys of surface miners and each has identified pneumoconiosis, identifying specific jobs (highwall drillers) and specific regions (Central Appalachia) shouldering a disproportionate amount of the disease.[5,6,9–14]

In 1972 and 1973, the US Public Health Service conducted an assessment examining 1438 surface coal miners to determine the prevalence of radiographically defined pneumoconiosis.[11] Among that cross-section, 59 individuals (4%) showed some evidence of pneumoconiosis and 7 (0.5%) had severe disease (International Labour Organization [ILO] small opacity major category 2 or greater, or presence of a large opacity). In the context of the time, this burden of disease was considered of little consequence as the corresponding prevalence of pneumoconiosis in actively working underground coal miners was nearly 35%. In the face of these radiographic findings, NIOSH concluded "surface coal miners show little roentgenographic evidence of the development of pneumoconiosis" and "the low concentrations of respirable dust in US surface mines mitigate against the development of (pneumoconiosis) in surface miners."

In April of 1979, a 34-year-old male was admitted to hospital with a six-month history of progressive dyspnea.[9] Chest radiography revealed an alveolar filling pattern bilaterally in the lower lung fields. A chest radiograph from 2 years prior was available and was classified as normal. A lung biopsy revealed extensive interstitial fibrosis and silicoproteinosis. Within 10 months, the patient had radiographically defined progressive massive fibrosis (PMF; bilateral conglomerate mass lesions, tracheal distortion, and pleural thickening) and died 26 months after presentation. Occupational history revealed work as a rotary drill operator at a surface mine from 1975 to 1979. Following this sentinel case, NIOSH investigated nine other drill crew workers from the same company. Two of the nine had silicosis. This investigation led NIOSH to conclude "the development of pneumoconiosis in these subjects suggests that the annual personal dust sample failed to reflect true exposure to silica" and "the belief that only coal miners who work underground have an appreciable risk of developing pneumoconiosis needs to be modified."[9] NIOSH then conducted a re-evaluation of the 1972 Public Health Service findings and highlighted a number of limitations of the original analysis ultimately concluding "further epidemiological research is particularly needed on anthracite workers, but also bituminous workers who have elevated silica exposures, such as highwall drillers."[13]

To address those concerns, NIOSH conducted radiographic screening of 1236 Pennsylvania surface miners in 1996–1997, identifying silicosis in 83 (6.7%).[10] Of particular note is that silicosis prevalence increased as drilling tenure increased, from 4.7% in miners reporting no drilling experience to 46% in miners reporting more than 20 years of drilling. In collaboration with the Mine Safety and Health Administration (MSHA), during 1999–2002, NIOSH evaluated radiographs from MSHA's Miners' Choice Program.[14] This program was established to determine the prevalence of pneumoconiosis among working underground and surface miners. This study was the first to highlight regional differences in pneumoconiosis prevalence, including higher rates of pneumoconiosis among surface miners in Central Appalachia compared with those in the rest of the United States.

During 2010–2011, NIOSH conducted surface miner screening in 16 states using a mobile examination unit and again identified pneumoconiosis and PMF in surface miners and found that miners in the Central Appalachia bituminous coal fields were at significantly greater risk.[6] This prompted a follow-up investigation of the eight surface miners with PMF and no history of underground mining identified in that survey.[5] All eight worked the majority of their careers in drilling and blasting and based on the medical and occupational histories it is clear that their PMF was from excessive inhalation of respirable crystalline silica dust.

As early as 1984, NIOSH researchers recommended that pneumoconiosis screening should be extended to surface coal miners.[13] In 2014, MSHA issued a final rule enabling NIOSH to expand radiographic screening to include all US surface coal miners.[15] In the last 6 years, surface coal miners working at all active US surface coal mines have had the opportunity to participate in the NIOSH-administered Coal Workers' Health Surveillance Program (CWHSP). The objectives of this report are to describe the prevalence of pneumoconiosis in US surface coal miners participating in the CWHSP since the implementation of the 2014 rule.

2 | METHODS

Data for analysis come from the CWHSP and include information on working surface coal miners who participated in the CWHSP from January 1, 2014 to December 31, 2019. Information on working tenure (specified by employment at a surface or underground mine at the time of screening), age, sex, region where the miner worked, jobs held during their mining tenure, and radiographic classification data were derived from each surface miner's most recent CWHSP encounter. The presence of small opacities (profusion ≥ 1/0 according to the International Labour Office Classification of Radiographs of Pneumoconiosis)[16] and/or large opacities (PMF defined as the presence of large opacities >1 cm) was determined using chest

radiograph as described previously.[14] The Central Appalachian region was defined as the following states: Kentucky, Virginia, and West Virginia. The following MSHA occupation codes were used to identify those miners who reported ever working as a driller or blaster at a surface mine: blaster (307), coal drill operator and helper (333 and 334), rock driller (356), and highwall driller operator and helper (383 and 384).

All analysis, including prevalence ratios (PRs) comparing the prevalence of the disease by region and occupation calculated using log-binomial regression, was completed in SAS 9.4.

3 | RESULTS

During January 1, 2014 to December 31, 2019, 11,255 surface miners participated in the CWHSP. After removing 4465 miners with zero years of surface mining tenure and only an initial radiograph taken upon entry into the coal mining industry on file, 6790 surface miners remained for analysis. The majority of these surface miners were male (93.4%), and 86.3% were White, 9.5% were American Indian or Alaska Native, 2.4% were black, and 0.2% were Asian, with race information unavailable for 109 individuals. The median surface mining tenure was 11 years, while the median combined surface and underground mine tenure was 12 years. The majority of surface miners (91.3%) reported no underground mining tenure. For surface miners with underground tenure, miners in Central Appalachia worked on average 10.3 years underground and those working outside of Central Appalachia worked on average 8.1 years underground. The 2-year average difference in underground mining tenure did not result in a meaningful difference in overall working tenure and subsequent exposure. For Central Appalachian miners, the median surface mining tenure was 21 years, while miners working outside of Central Appalachia had a median surface mining tenure of 11 years.

Of the 6790 working surface miners, 109 miners (1.6%; Table 1) showed radiographic evidence of pneumoconiosis, including 12 with PMF. Of the 935 surface miners working in Central Appalachia, 44 (4.7%) had radiographic evidence of pneumoconiosis, while among the 5855 working in the United States outside of Central Appalachia, 65 (1.1%) had evidence of pneumoconiosis. Prevalence of pneumoconiosis in Central Appalachia was 4.2 times higher compared with the rest of the United States (unadjusted PR, 4.2; 95% confidence interval [CI] 2.9–6.2), and this difference remained significant even after adjusting for surface mining tenure (adjusted PR, 3.2; 95% CI, 2.2–4.7; Table 1).

Of the 12 surface miners with evidence of PMF, 6 were working in Central Appalachia and 6 elsewhere in the United States (unadjusted PR, 6.2; 95% CI, 2.0–19.4). After adjusting for surface mining tenure, miners working in Central Appalachia had greater than three times the prevalence of PMF compared with those working elsewhere in the United States (adjusted PR, 3.7; 95% CI, 1.2–11.4).

Among the 6742 working surface miners with occupational history available, 413 (6.1%) had ever worked as a driller or blaster at a surface operation. Among those who had ever worked as a driller or blaster, 17 (4.1%) had evidence of pneumoconiosis and 6 (1.4%) had evidence of PMF. Compared with those miners who had never worked as a driller or blaster and controlling for surface mining tenure, these miners had a twofold greater prevalence of pneumoconiosis (adjusted PR, 2.1; 95% CI, 1.3–3.5; Table 1) and had an over ninefold greater prevalence of PMF (adjusted PR, 9.0; 95% CI, 2.9–27.9).

4 | DISCUSSION

Periodic assessments of the respiratory health of surface miners have been conducted in the United States for the last 50 years. The findings from the latest assessment of the respiratory health of actively working US surface coal miners are remarkably similar to findings from assessments conducted in decades past. In addition to the current health findings, our recent analysis of 36 years of compliance sampling data[17] led us to the same paradoxical conclusion that Parobeck and Tomb[12] reported in 1974—the majority of dust samples collected at the US surface mines are at or below the

TABLE 1 Prevalence ratios for pneumoconiosis by region and occupation among working surface coal miners participating in the CWHSP (*N* = 6790), 2014–2019

	Pneumoconiosis						
US surface miners	***N***	***n***	**%**	**PR (unadjusted)**	**95% CI**	**PR (adjusted)[a]**	**95% CI**
Central Appalachia[b]	935	44	4.7	4.2	2.9–6.2	3.2	2.2–4.7
US excluding Central Appalachia	5855	65	1.1				
Ever drillers/blasters[c]	413	17	4.1	2.9	1.7–4.8	2.1	1.3–3.5
Never drillers/blasters[c]	6329	91	1.4				

Abbreviations: 95% CI, 95% confidence interval; CWHSP, Coal Workers' Health Surveillance Program; PR, prevalence ratio.

[a]PR adjusted by surface mining tenure.

[b]Central Appalachia includes Kentucky, Virginia, and West Virginia.

[c]Forty-eight surface miners did not have a detailed occupational history available.

applicable standard even though medical surveillance findings are consistent with surface miners in certain occupations being overexposed to respirable dust including respirable crystalline silica. Taken as a whole, these surveillance findings, recent clinic-based investigations (which identified surface miners with advanced disease including PMF) and the MSHA inspector-collected compliance sampling findings are consistent with pneumoconiosis in surface coal miners being caused by overexposure to respirable dust containing quartz (a type of respirable crystalline silica).[1,4,17]

In a large sample of the US surface coal miners, 109 (1.6%) had pneumoconiosis and there was significantly more disease in Central Appalachia compared with the rest of the United States, even after adjusting for tenure. The higher prevalence of the disease among surface miners in Central Appalachia corresponds to sampling data which shows that surface coal mines in this region consistently have higher respirable dust, respirable quartz, and percent quartz in their samples when compared with the rest of the United States.[17] Miners who had worked as a driller or blaster had a significantly higher prevalence of disease compared with those who had never held these jobs, which also corresponds to the surface mine sampling data and previous studies identifying surface miners with PMF as primarily having worked as drillers or blasters.[5,6,10,10,17]

The inclusion of surface miners in periodic radiographic and pulmonary health screening through the CWHSP in 2014 was clearly warranted. Based upon quarterly coal mine operators' reports to MSHA, which provide the total number of surface miners employed, the surface miners who participated in the CWHSP over the 6-year study period represent 34% of the workforce. As the majority of the working surface coal miners do not participate in this surveillance, the case count of pneumoconiosis in this study is likely underestimated. The inclusion of surface miners in the CWHSP is still in its infancy. Therefore, it is unclear whether surface miner participation rates in health screening and in MSHA's Part 90 program, which conveys the right to transfer to a less dusty position at the mine to miners with radiographic evidence of pneumoconiosis, will be similar to the participation rates observed in underground coal miners.[18] NIOSH will continue to monitor participation patterns in surveillance for surface miners as the program matures.

Pneumoconiosis is a chronic, progressive disease. The expansion of the CWHSP to include surface miners and the subsequent identification of pneumoconiosis, including very severe disease, underscores the importance of health surveillance for all coal miners during and after their careers. Lifelong health surveillance for workers exposed to crystalline silica and/or coal mine dust has previously been recommended within a joint World Health Organization/ILO document.[19] Pneumoconiosis can continue to progress after miners' working exposure ceases, and lifelong respiratory health surveillance would likely provide a more complete picture of the prevalence of the disease in the United States. Even so, the present analysis is still informative in identifying that pneumoconiosis, including PMF, still occurs among surface miners. The continued occurrence of this preventable disease must not be accepted as inevitable for the next generation of miners.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John D. Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Noemi B. Hall analyzed and interpreted the data, led writing of the article, and takes responsibility for its content. Cara N. Halldin designed the study, assisted with interpreting data, and writing the article. David J. Blackley assisted with interpreting data and writing the article. A. Scott Laney conceptualized the study, assisted in study design, data interpretation, and writing.

DATA AVAILABILITY STATEMENT

Data are available on request.

ETHICS APPROVAL AND INFORMED CONSENT

The CWHSP is a surveillance program with non-research designation, and is exempt from NIOSH Human Subjects Review Board approval (11-DRDS-NR03).

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