Data Linkage, PMF Trends, and Mortality Studies of U.S. Coal Miners

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Utility of Linking Datasets to Enhance Understanding of Coal Miners' Health

1. Linkage of Illinois workers' compensation and MSHA data
   - *Increased odds of respiratory or cardiovascular injury/illness among coal mine employees compared to other mine employees; higher odds of these injuries/illnesses at smaller mines; safety committees are protective*
   - *The Part 50 Program did not capture 66% of WC cases from 2001 to 2013; chronic injuries or illnesses were more likely to be unreported*
2. Linkage study of Coal Worker's Health Surveillance Program (CWHSP) and Department of Labor (DOL) Federal Black Lung Program benefits data
   - *39% of miners applying for BLBP benefits had never participated in surveillance while actively mining*

Utility of Linking Datasets (continued)

3. Progression of radiographic disease and lung function impairment absent further exposure
   - *3.7% of coal miners with no evidence of PMF at the time of initial CXR developed PMF by the time of their final CXR*
   - *26.9% of former coal miners with normal lung function at first FBLP claim had accelerated lung function decline at time of second testing absent further exposure*
4. Resurgence of progressive massive fibrosis from 1970 – 2016
   - *Hot off the press*
5. Mortality studies of U.S. coal miners
   - *In progress*

Resurgence of Progressive Massive Fibrosis in U.S. Coal Miners Filing for Federal Black Lung Program Benefits

- Data from surveillance of active miners and from individual black lung clinics indicate an increase in prevalence rates of CWP and progressive massive fibrosis (PMF)

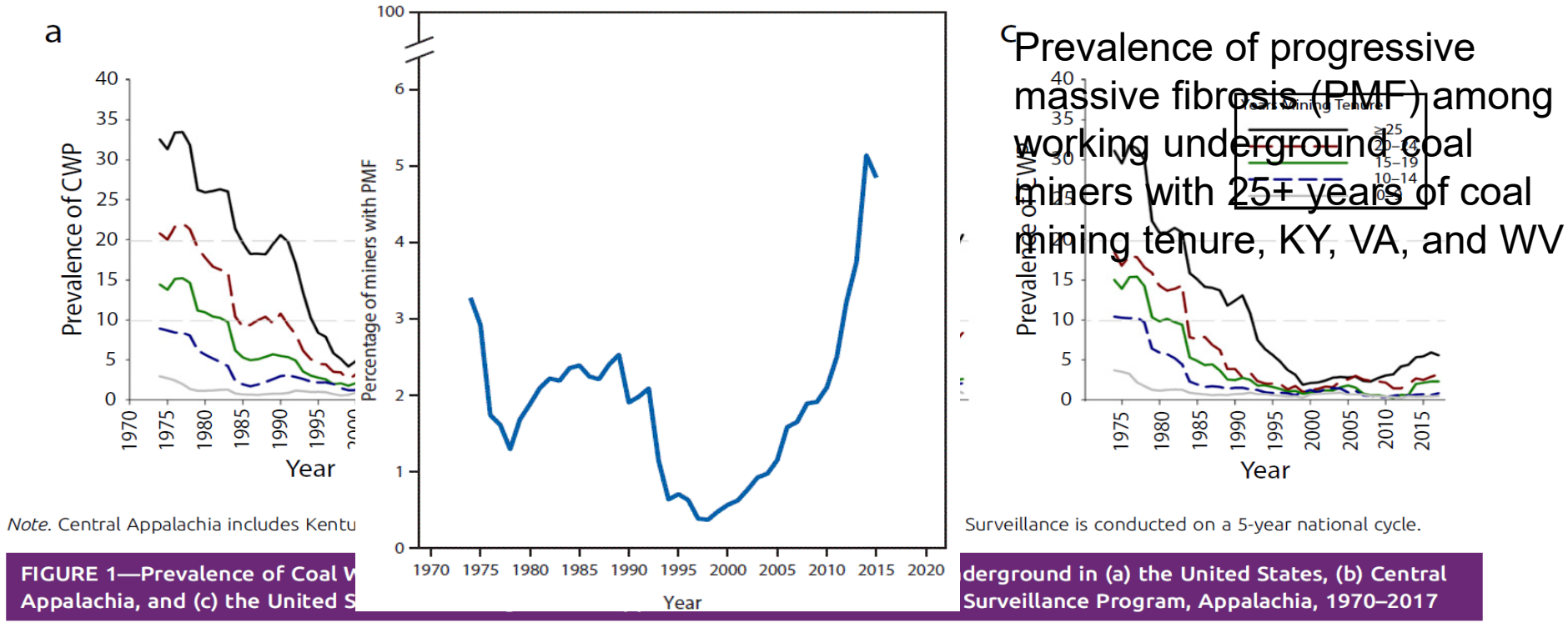

FIGURE 1—Prevalence of Coal W… derground in (a) the United States, (b) Central Appalachia, and (c) the United S… Surveillance Program, Appalachia, 1970–2017

Prevalence of progressive massive fibrosis (PMF) among working underground coal miners with 25+ years of coal mining tenure, KY, VA, and WV

Blackley DJ, Crum JB, Halldin CN, Laney AS. Resurgence of Progressive Massive Fibrosis in Coal Miners — Eastern Kentucky, 2016. MMWR Morb Mortal Wkly Rep 2016;65:1385–1389.

Blackley DJ, Halldin CN, Laney AS. Continued Increase in Prevalence of Coal Workers' Pneumoconiosis in the United States, 1970-2017. Am J Public Health. 2018;108(9):1220-1222.

Resurgence of Progressive Massive Fibrosis in U.S. Coal Miners

- The prevalence of PMF among former miners is less well understood
- The U.S. DOL operates the Federal Black Lung Program and administers claims filed for black lung benefits and makes a determination, which includes information on the presence of PMF as well as the presence of totally disabling pulmonary impairment based on medical evidence submitted by the miner
- This study is the first to report trends in the proportion of former U.S. coal miners with PMF using data from the Federal Black Lung Program.
- These data represent an additional source of information, *independent of national surveillance data*, on the burden of PMF among former U.S. coal miners.

Methods

PMF cases: Claims for DOL Federal Black Lung Program benefits from 341,176 former coal miners between 1970–2016 were evaluated. Approved claims where determinations of PMF were made for miners with between 5–60 years of coal mine employment (CME) were included.

Analyses:

- Compared age and years of CME among PMF cases and non-cases
- Conducted a time-trend analysis of PMF cases nationally and by state and identified significant changes in trends over time
- Calculated the annual percent change (APC) in proportion of Federal Black Lung Program claimants with PMF
- Characterized the severity of disease on chest radiographs submitted for PMF cases using the ILO large opacity classification of A, B, or C

Results

- 4,679 unique cases of PMF were identified between 1970–2016
- PMF cases were younger and had longer coal mine employment than non-cases
- Geographic distribution of PMF cases differed from non-cases
  - 84% of PMF cases last worked as a miner in WV, KY, PA, or VA, despite only 62% of all claims originating from these states. The annual proportion of claimants with PMF increased significantly from 1970 – 2016 in each of these states.
- Distribution of large opacities among PMF cases with a chest radiograph was 915 (56%) with category A; 548 (34%) with category B; and 158 (10%) with category C
  - 40% of PMF cases had low small opacity profusion scores (category one)

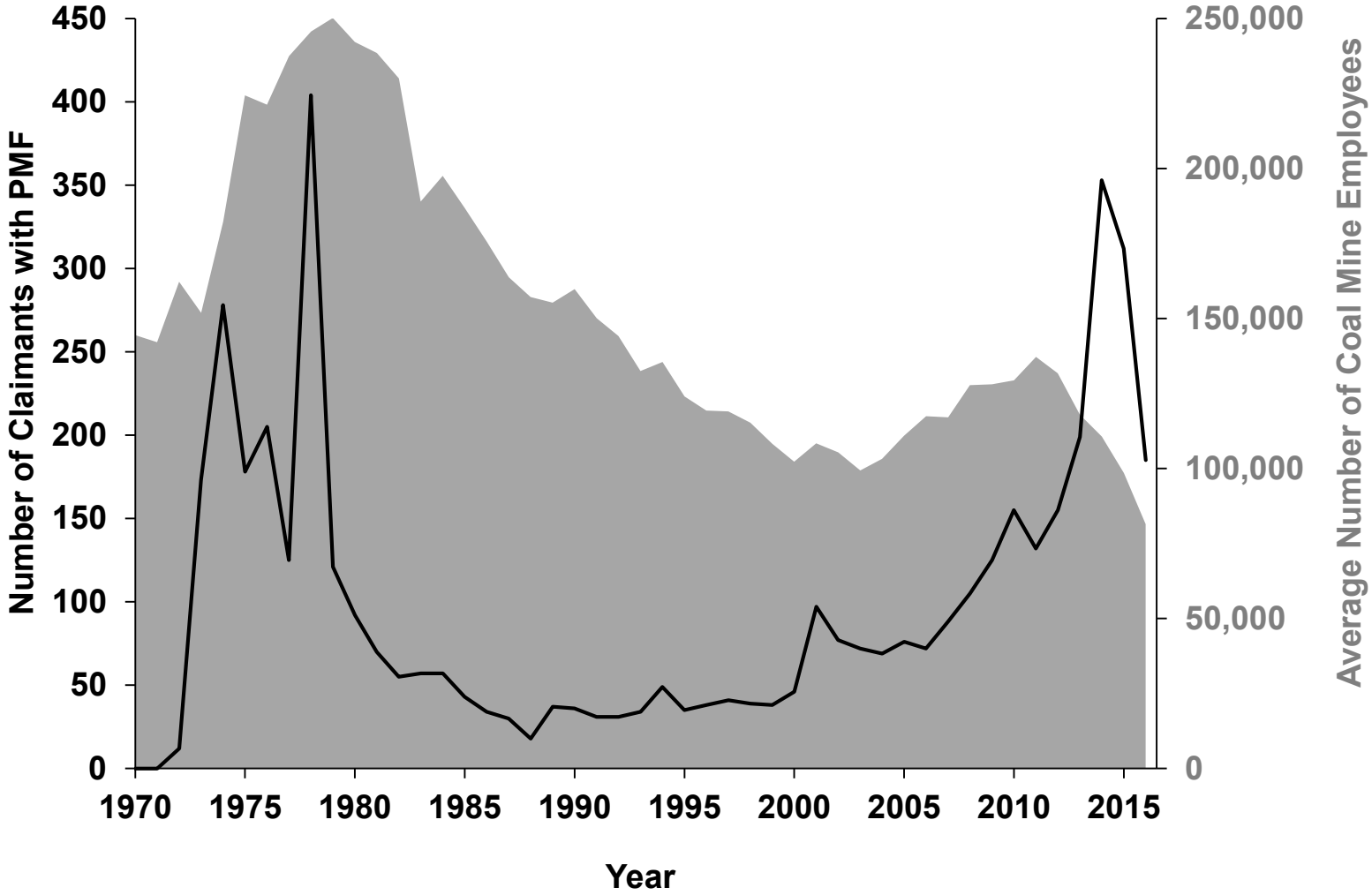

Figure 1. Number of miners filing for Federal Black Lung Program benefits that were found to have a determination of progressive massive fibrosis (PMF) compared to average annual coal mine employment, 1970–2016. The number of claimants with PMF from 1970–1972 are combined due to small numbers. Office workers are included in employment totals from 1973–1977. Data sources: U.S. DOL, OWCP, DCMWC; U.S. DOL, MSHA; and the EIA.

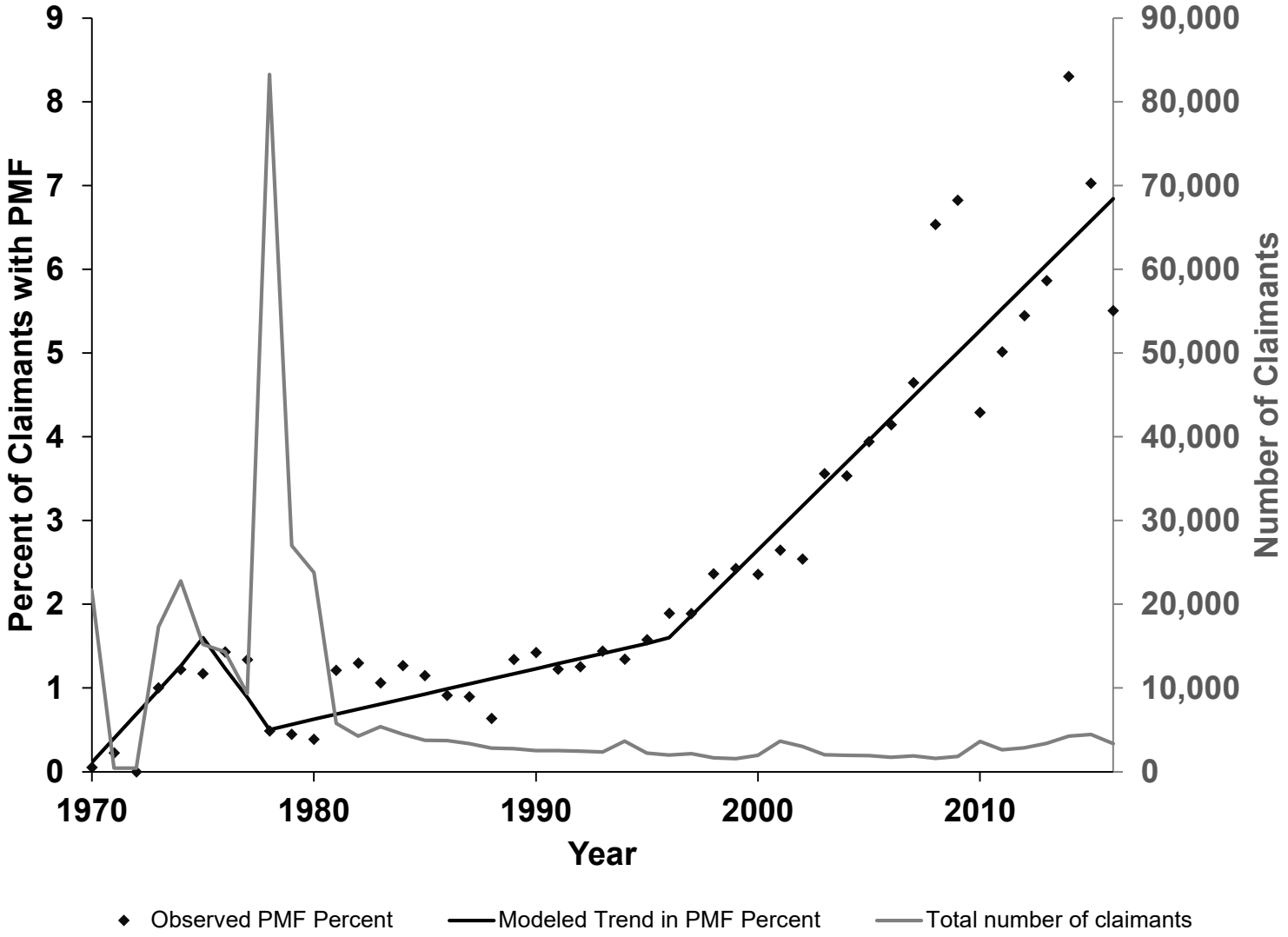

Figure 2. Number of claimants for Federal Black Lung Program benefits and the percentage of these claimants that received a determination of PMF during their claim process, 1970–2016. Observed and Joinpoint regression model results are displayed. Data restricted to those miners with between 5 and 60 years of coal mine employment. Data source: U.S. DOL, DCMWC.

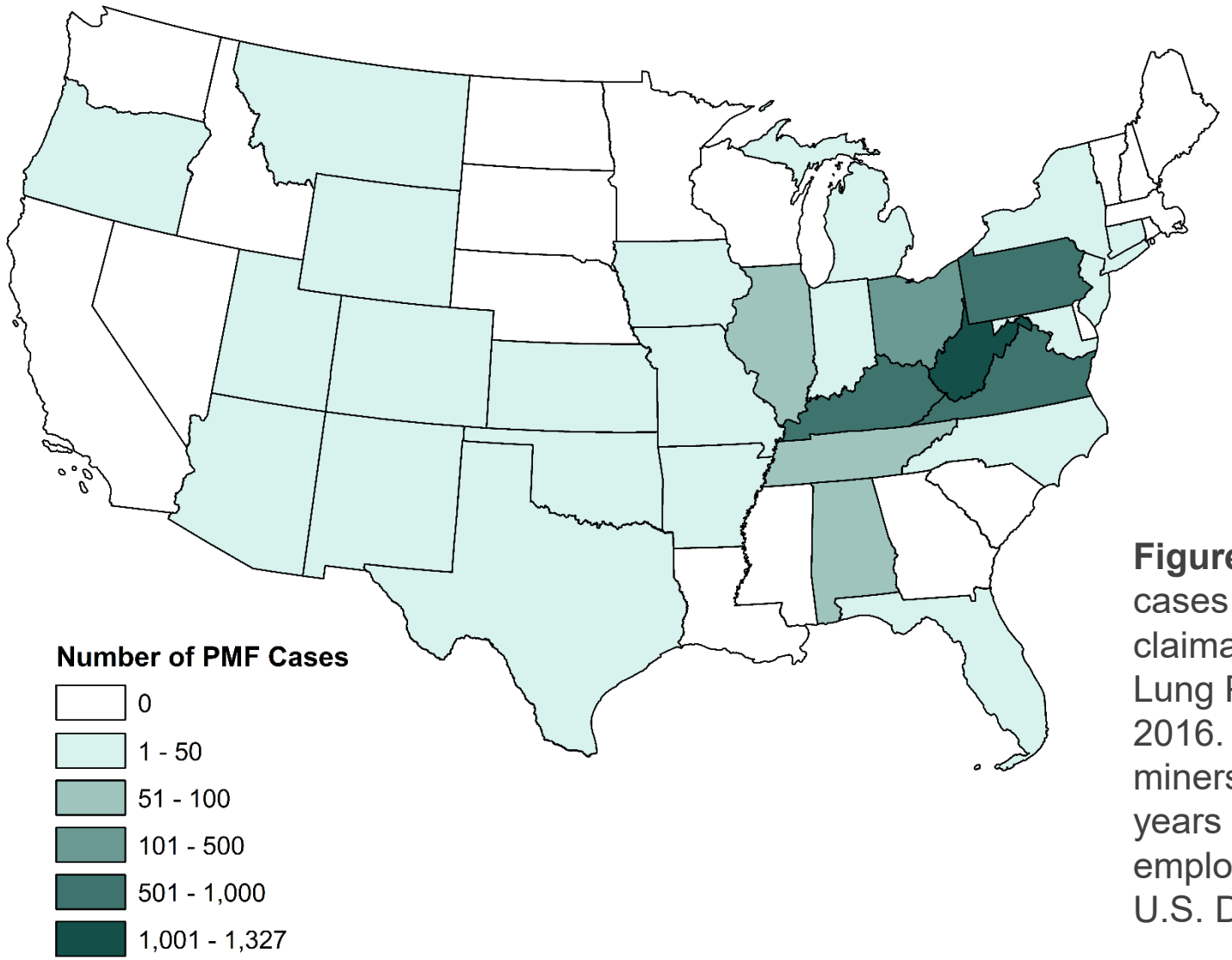

Figure 3. Total number of PMF cases by state among claimants for Federal Black Lung Program benefits, 1970 – 2016. Data restricted to those miners with between 5 and 60 years of coal mine employment. Data source: U.S. DOL, DCMWC.

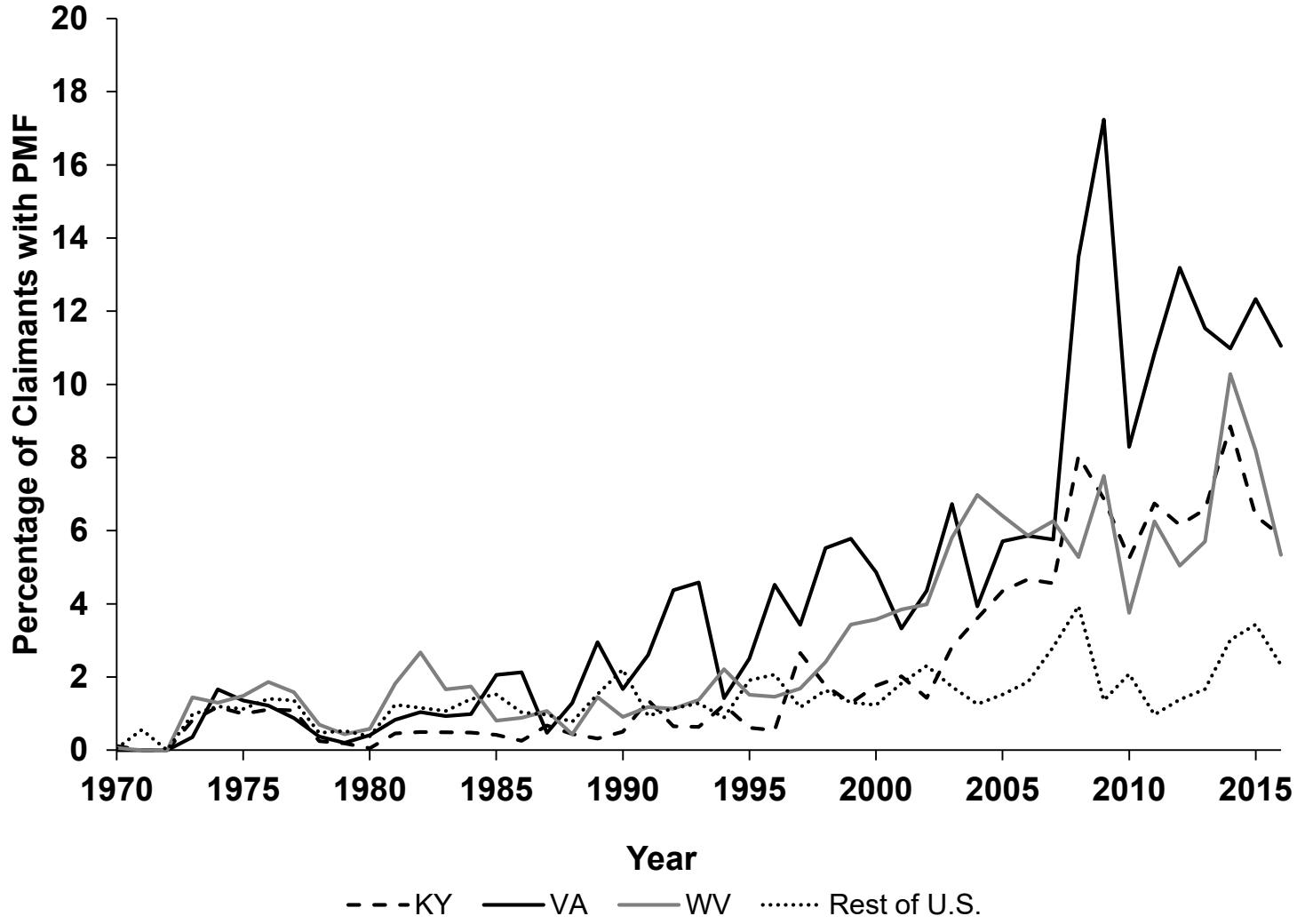

Figure 4. Percent of claimants Federal Black Lung Program benefits that received a determination of PMF during their claim process in the central Appalachian states of Kentucky, Virginia, and West Virginia compared to the rest of the U.S., 1970–2016. Data restricted to those miners with between 5 and 60 years of coal mine employment. Data source: U.S. DOL, DCMWC.

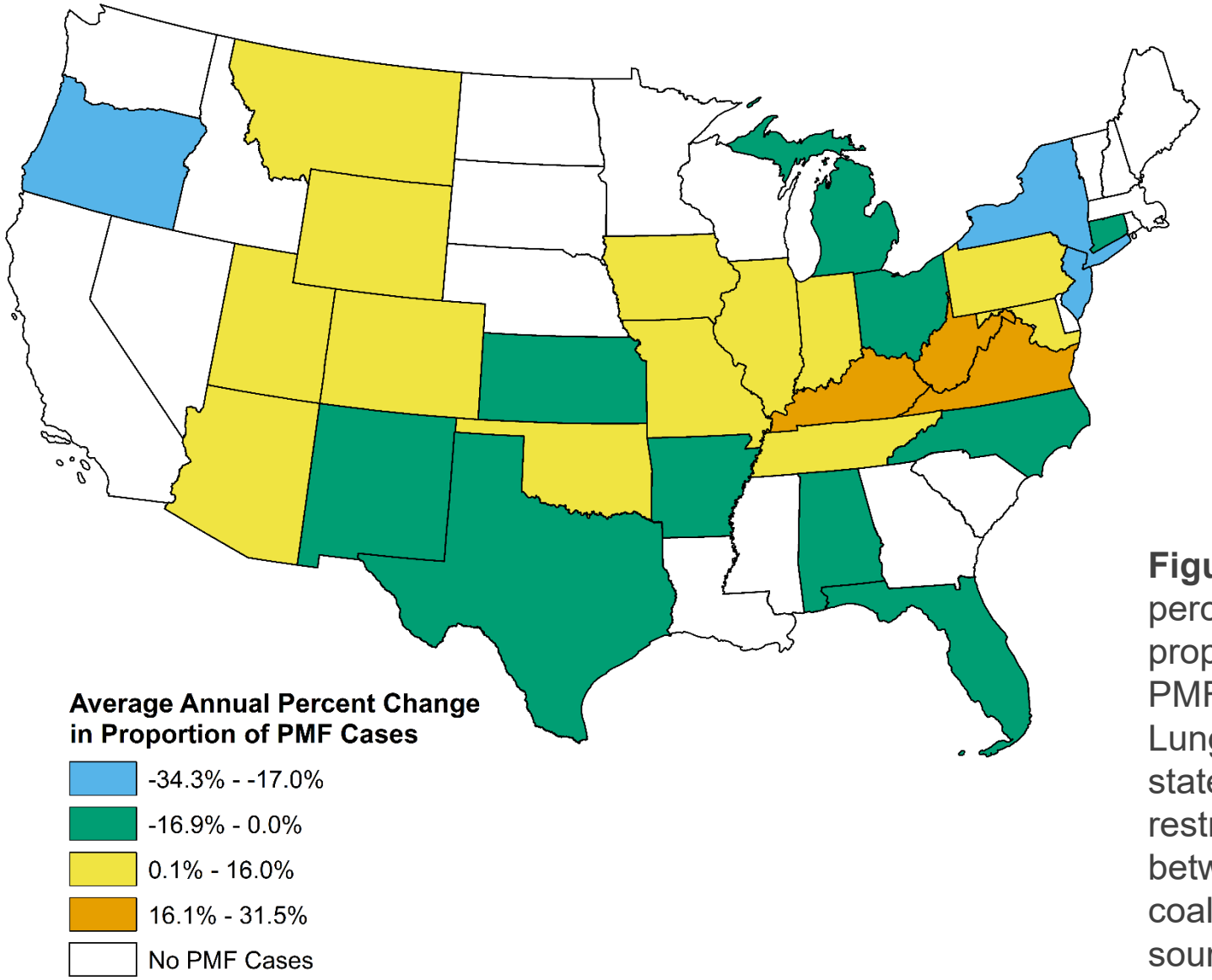

Figure 5. Average annual percent change in the proportion of coal miners with PMF among Federal Black Lung Program claimants by state, 1970 –2016. Data restricted to those miners with between 5 and 60 years of coal mine employment. Data source: U.S. DOL, DCMWC.

Major Findings and Implications

- The frequency and proportion of PMF in former U.S. coal miners applying for Federal Black Lung Program benefits has significantly increased from 1970–2016, with a significantly accelerated rate of increase since 1996.
- We identified 2,474 cases of PMF in the 21 years from 1996–2016 which is > 10x the number identified in working miners by the Coal Workers' Health Surveillance Program (n=225).
- Rise in PMF cases has occurred amidst declining workforce numbers and stable new claim rates
- Changes in mining processes associated with increased mechanization; mining thin-seam coal; and increases in silica exposure could be contributing to this increase
- Most PMF cases were among claimants working in the central Appalachian states of KY, VA, and WV
- Highlights the continuing need for effective primary and secondary prevention of dust-related lung disease in U.S. coal miners as well as *importance of following workers after they have left the industry*

Mortality Studies of Coal Miners

- National Study of Coal Workers' Pneumoconiosis (NSCWP) – U.S.
- Cohort of 9,078 U.S. underground coal miners underwent surveys and medical examinations between 1969-1971
- Cumulative dust exposure calculated from combination of gravimetric samples and detailed work histories

- NSCWP findings after 9 years of follow-up:
  Increased mortality risk from pneumoconiosis, chronic bronchitis and emphysema
  Increased mortality risk with increasing radiographic profusion of opacities
  Smoking, coal rank, cumulative exposure, and age important risk factors

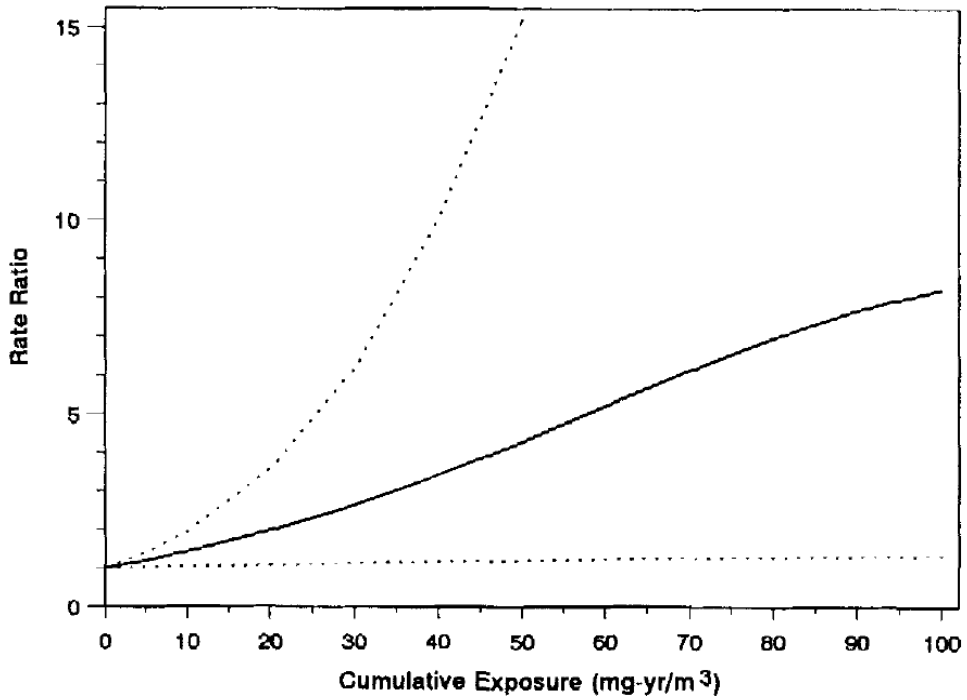

Fig. 2. Mortality rates for chronic bronchitis or emphysema as underlying or contributing causes of death by cumulative exposure to respirable coal mine dust (based on Cox proportional hazards model in Table V; dotted lines represent 95% CI estimates).

Kuempel ED, Stayner LT, Attfield MD, Buncher CR. Exposure-response analysis of mortality among coal miners in the United States. Am J Ind Med. 1995;28(2):167-184.

NSCWP findings after 23 years of follow up:

- Elevated mortality from nonviolent causes, non-malignant respiratory diseases (NMRD), and accidents among coal miners
- Elevated mortality as coal rank increases – highest mortality among anthracite and Appalachian miners
- Mortality risk increased with increasing radiographic profusion and with increasing dust concentrations

- Examined effects of cumulative dust exposure and coal rank on risk of death from ischemic heart disease (IHD)
- Risk of IHD mortality increases across quartiles of cumulative dust exposure categories; strongest effects in Appalachia

Attfield MD, Kuempel ED. Mortality among U.S. underground coal miners: a 23-year follow-up. Am J Ind Med. 2008;51(4):231-245.

Landen DD, Wassell JT, McWilliams L, Patel A. Coal dust exposure and mortality from ischemic heart disease among a cohort of U.S. coal miners. Am J Ind Med. 2011;54(10):727-733.

NSCWP findings after 37 years of follow up:

- Assessed risk of death from CWP, COPD, and lung cancer in relation to cumulative dust and silica exposures
- Excess mortality from COPD, CWP, some regions lung cancer
- Mortality from CWP modified by region (highest in high coal rank regions)
- Increased mortality risk from COPD among non-smokers
- Increased mortality risk from lung cancer

Graber JM, Stayner LT, Cohen RA, Conroy LM, Attfield MD. Respiratory disease mortality among US coal miners; results after 37 years of follow-up. Occup Environ Med. 2014;71(1):30-39.

Pneumoconiosis Field Research Study – U.K.

- Cohort of >50,000 British miners from underground mines, enrolled in 1950s
- Outcomes: lung and stomach cancers, COPD and chronic bronchitis, TB, cardiovascular disease, NMRD
- Findings after 47 years of follow-up:
  - Mortality from most outcomes elevated only after ~30 years follow up
  - Death from CWP increases with increasing dust exposure
  - Increased mortality from stomach cancer and COPD
  - Increased risk of death from lung cancer associated with quartz exposure

Miller BG, MacCalman L. Cause-specific mortality in British coal workers and exposure to respirable dust and quartz. Occup Environ Med. 2010;67(4):270-276.

Current Mortality Study

- Mortality follow up on any coal miner who participated in the CWHSP and who filed for federal benefits
  - Cause of death data from 1979 to the present (National Death Index)
  - Largest population of U.S. coal miners in a mortality study to date
  - Increased power to analyze rare outcomes such as cancers
- Currently analyzing national data on >35,000 deceased miners from the DOL database
  - CWHSP mortality follow up in progress with NDI

Current Mortality Study

- Outcomes of interest:
  1. Mortality rates over time
     a. Previous studies have shown decreasing mortality rates from CWP and silicosis
     b. Possible reversal in the wake of increasing rates of PMF
     c. Geographic differences in burden of disease expected to be reflected in mortality rates by state
  2. All cause mortality, compared to general population, as well as workers from comparable industries
  3. Non-malignant respiratory diseases: pneumoconioses, emphysema and/or chronic bronchitis
  4. Malignant diseases: lung and stomach cancers
  5. Accidents/violent causes of death
  6. Ischemic heart disease, cardiovascular diseases

In Summary

- We can learn more about the health of U.S. coal miners through the linkage and integration of multiple data sets containing health and employment data
  - Non-traditional data sets are important for the full picture
- The trends observed in recent studies of CWP and PMF suggest exposures may be higher than we understand them to be from dust monitoring data
- Mineralogic analysis of dust exposures is critical for understanding what is driving these trends
- Important to increase participation in surveillance while miners are actively working, but health surveillance of former miners is critical for understanding true burden of disease
- Imperative to increase research collaboration with clinics, who house important health data on miners

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Table 1. Characteristics of miners applying for Federal Black Lung Program benefits who received a determination of progressive massive fibrosis (PMF) during their claim process compared to those who did not receive a PMF determination, 1970–2016. State is determined by the last state in which the miner was employed as a coal miner.

	PMF Claimants (n = 4,679)		Non-PMF Claimants (n = 336,497)		
Claim Characteristic	**N**	**%**	**N**	**%**	**p-value***
Claim Type					
Living Miner	4,350	93.0	288,158	85.6	<.0001
Living Survivor	329	7.0	48,339	14.37	
Age of miner† (*mean, SD*)	61.6	9.7	62.3	10.3	<.0001
Coal mine employment‡ (*mean, SD*)	23.0	9.9	18.9	10.3	<.0001
State/Region§					
West Virginia	1,327	28.4	67,213	20.0	<.0001
Kentucky	945	20.2	49,266	14.6	
Pennsylvania	935	20.0	69,445	20.6	
Virginia	714	15.3	22,791	6.8	
Eastern	306	4.7	27,135	8.1	
Interior	109	2.3	25,259	7.5	
Western	65	1.4	8,387	2.5	
Unknown	278	5.9	67,001	19.9	

* P-values are from Chi-square tests for categorical variables and from t-tests for continuous variables.

† Age of miner at time of filing a claim for federal black lung benefits.

‡ Coal mine employment, in years, verified by the U.S. Department of Labor.

§ Eastern region includes the states of AL, CT, DC, DE, FL, GA, MA, MD, ME, NC, NH, NJ, NY, OH, TN, RI, SC, and VT. Interior region includes the states of AR, IA, IL, IN, KS, LA, MI, MN, MO, MS, ND, NE, OK, SD, TX, and WI. Western region includes the states of AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, and WY.