Occupational Lung Diseases: Pneumoconiosis

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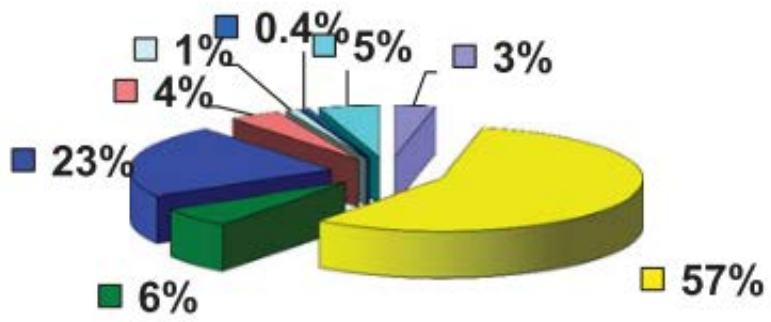
Department of Public Health

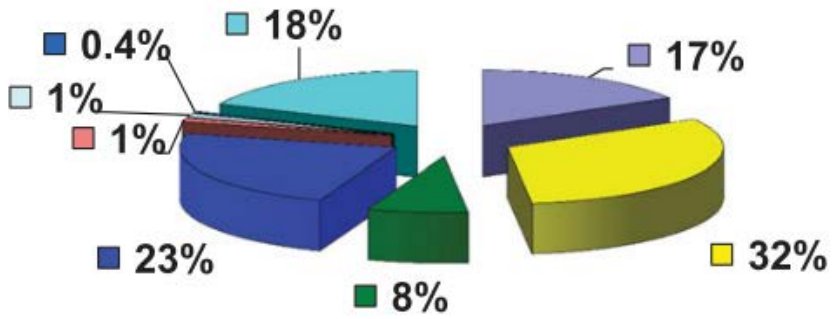
Occupational diseases

- Globally, 5–7% of fatalities are attributable to work-related illnesses and occupational injuries
- 2.3 million occupational related deaths each year, worldwide



Communicable diseases
Cancers
Respiratory Diseases
Circulatory diseases
Mental Disorders
Digestive system diseases
Genitourinary system
Accidents and violence

Developed Countries



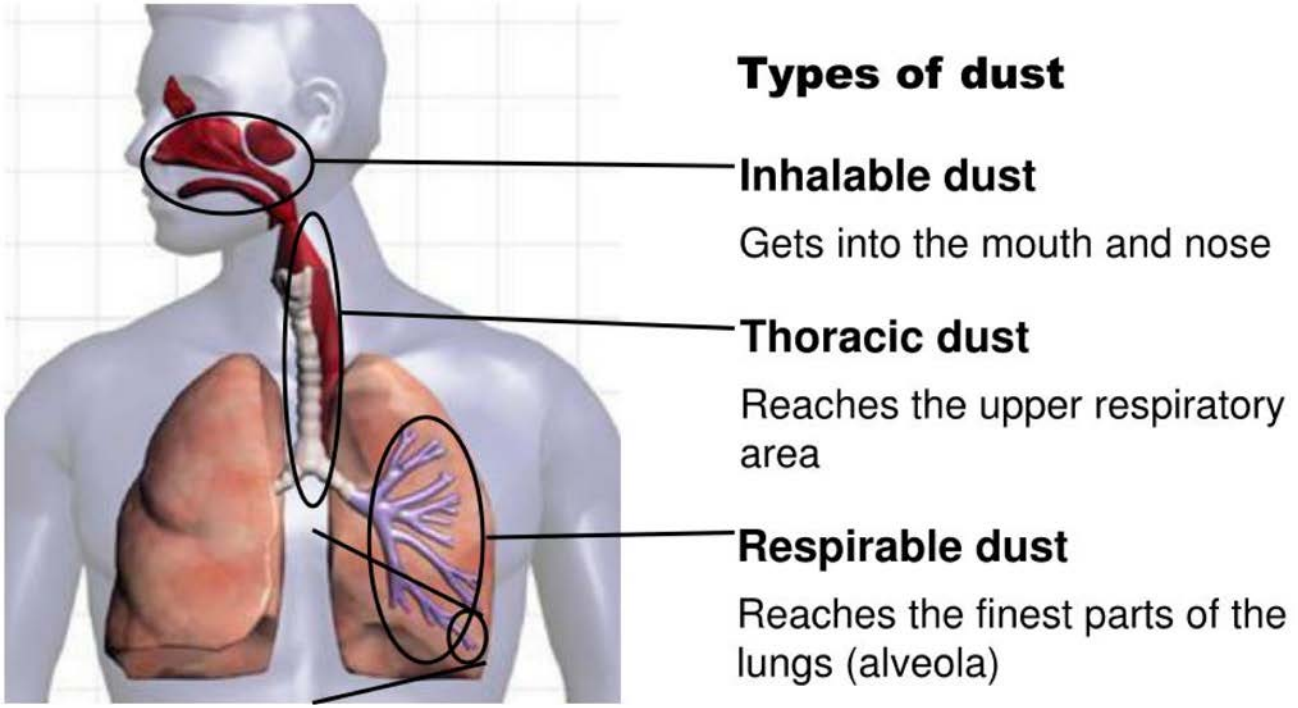
Communicable diseases
Cancer
Respiratory Diseases
Circulatory diseases
Mental Disorders
Digestive system diseases
Genitourinary system
Accidents and violence

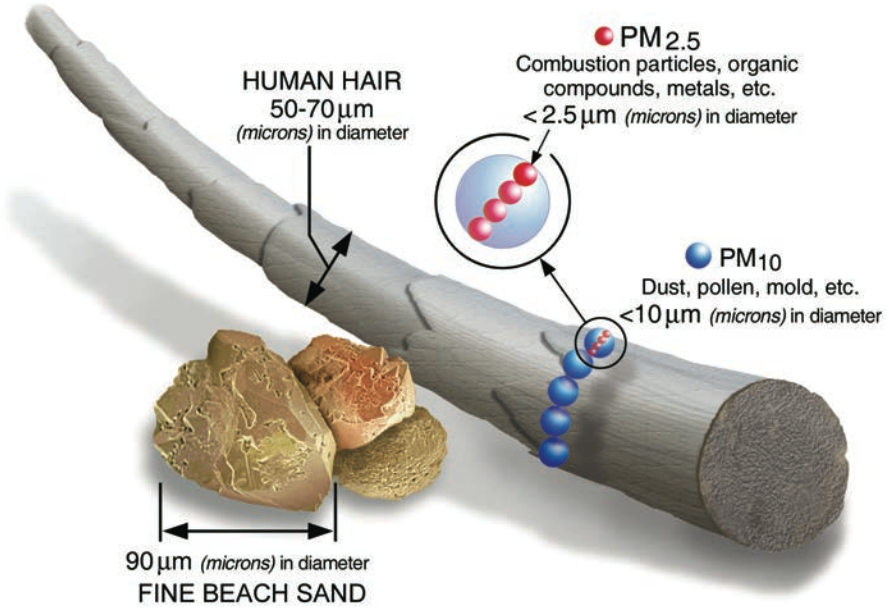
Developing Countries

(Sources: Hämäläinen P, Takala J, Saarela KL; TUT, ILO, EU-OSHA, 2008).

Dust in workplaces

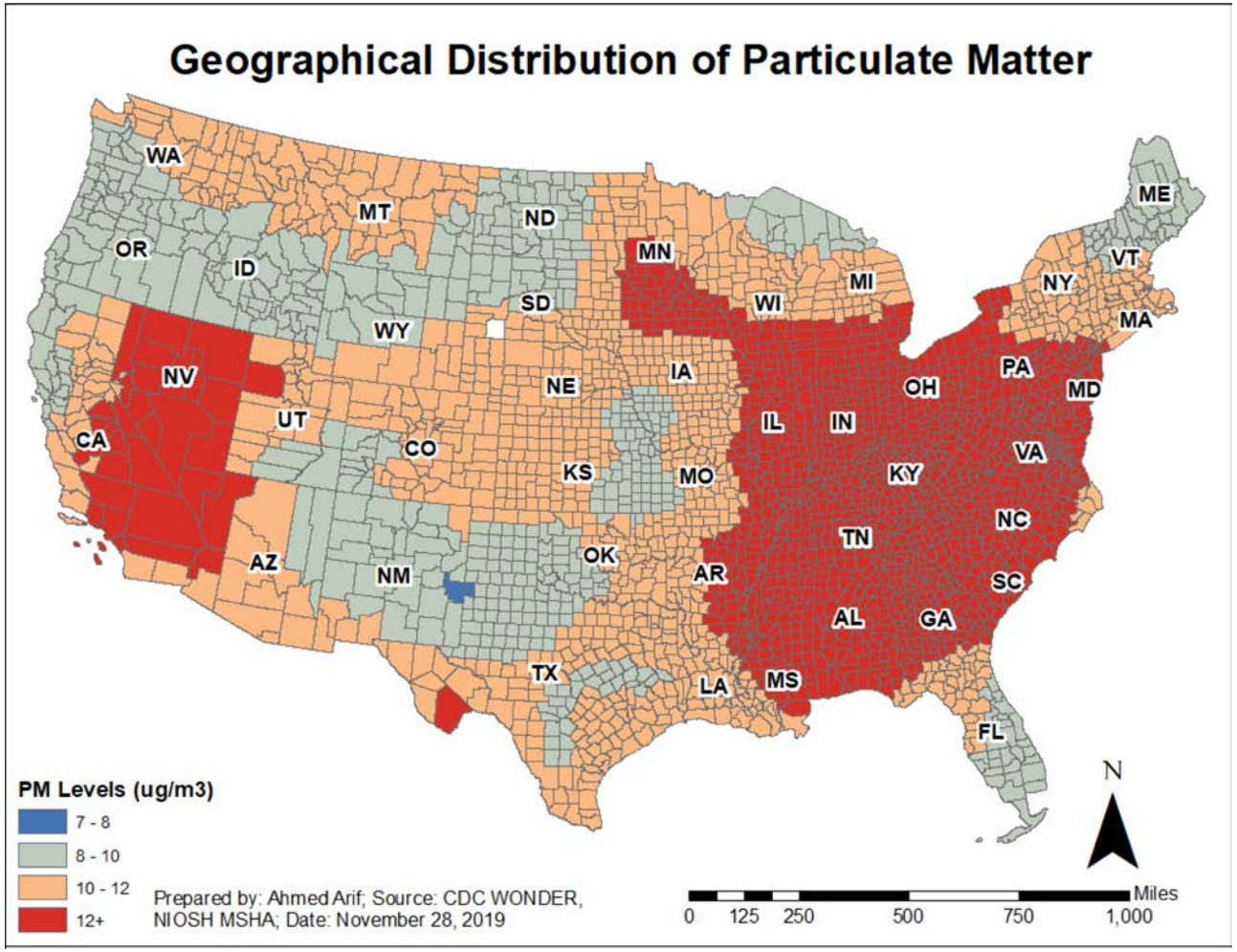
- Workplace hazard
- Particulate pollution
- Inhalable particles- PM_{10}
- Respirable particles-$PM_{2.5}$



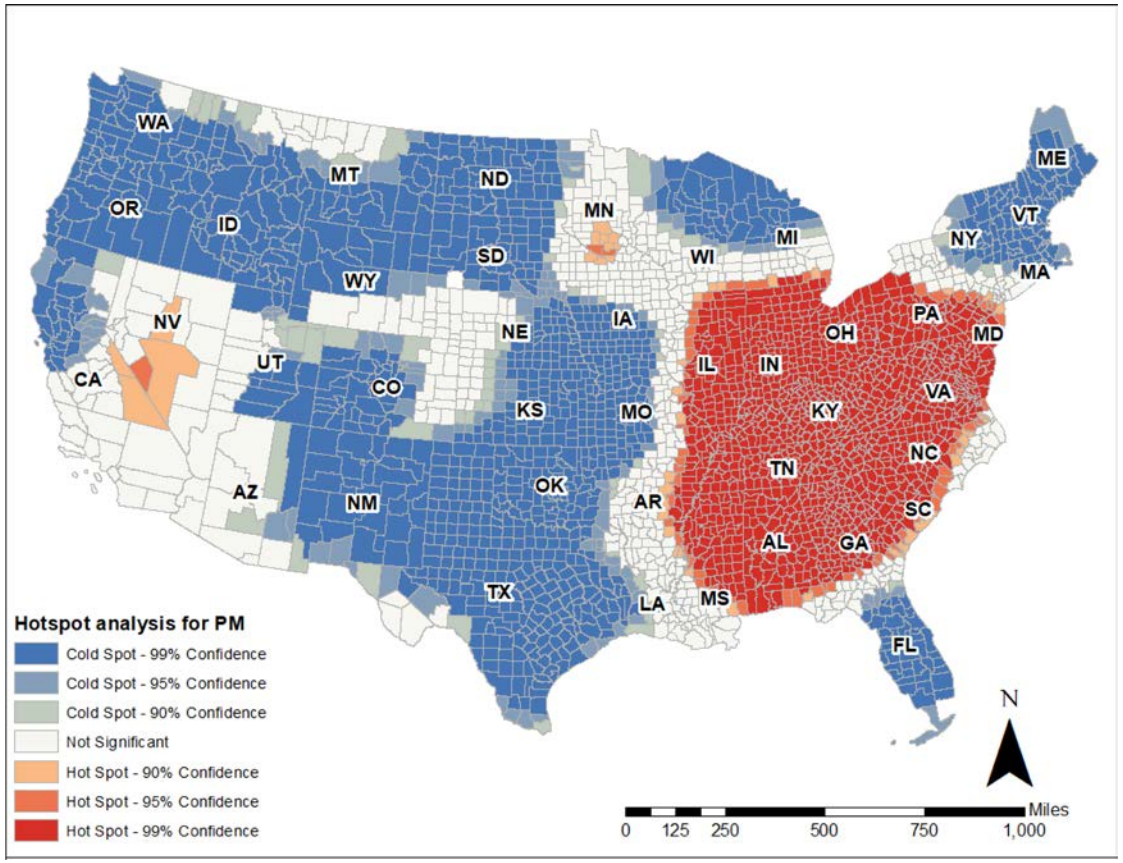


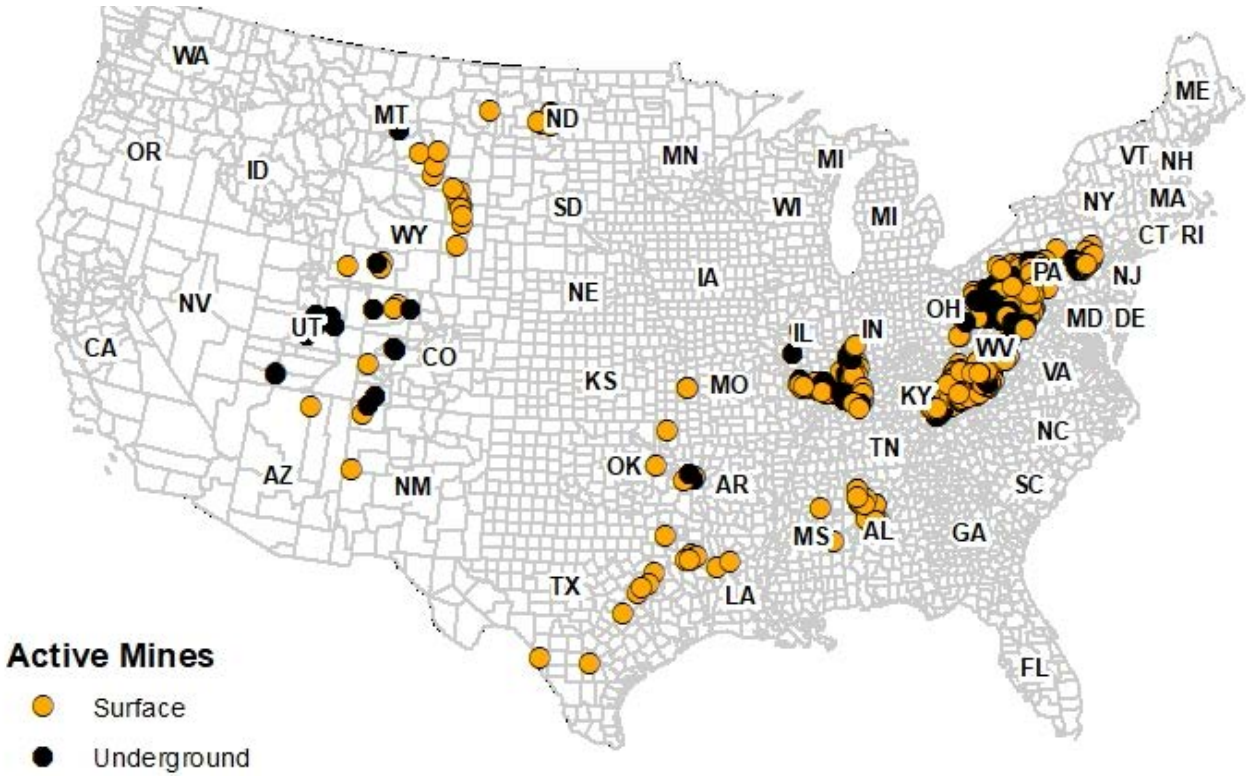
- Premature death
- Coronary heart disease
- COPD
- Asthma
- Cancer


Particle pollution can affect your health. What causes it?
Factories
Cars and Trucks
Construction Sites



Hotspot analysis of Particulate Matter ($PM_{2.5}$, ug/m^3)




WA
OR
CA
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OH
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MS
AL
GA
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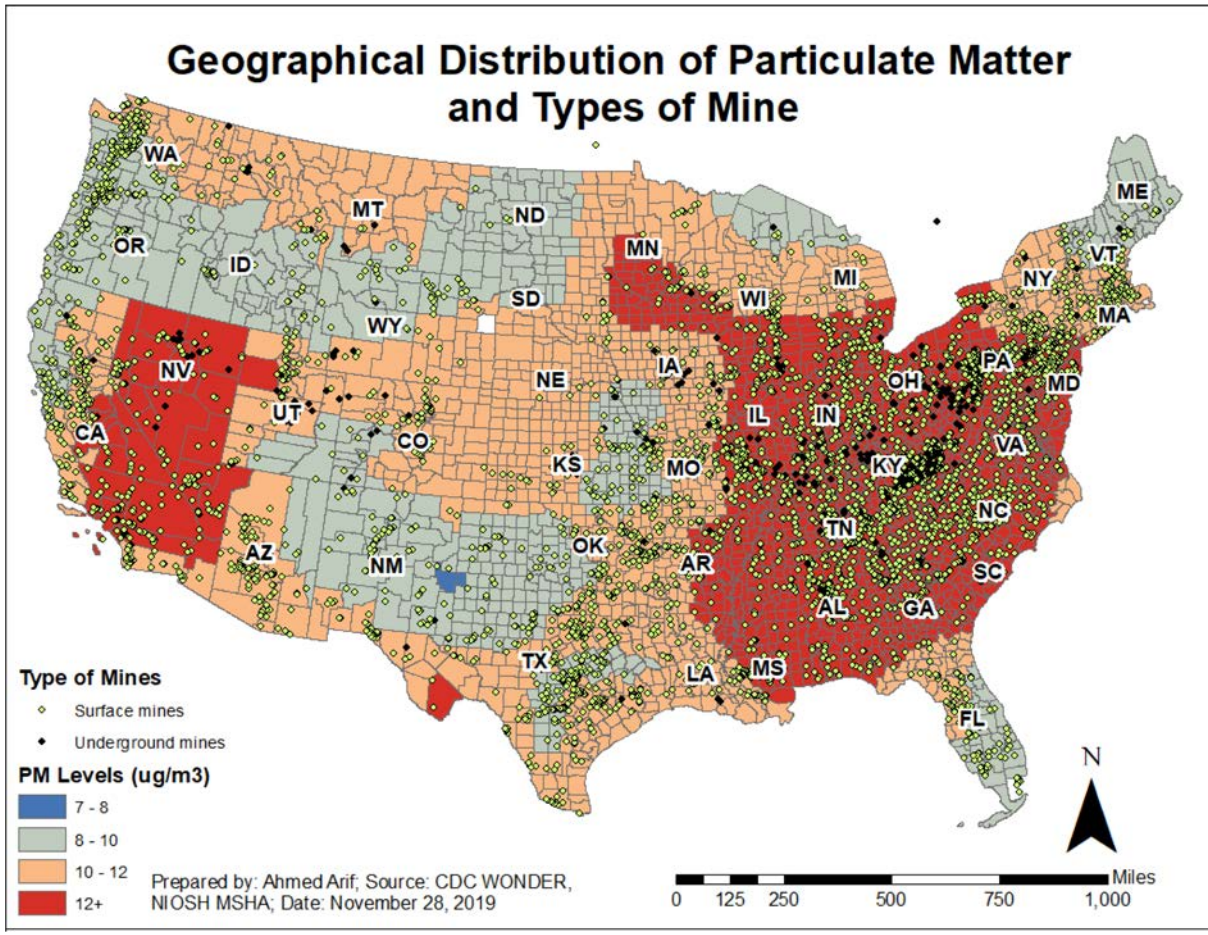
WV
PA
NY
VT
NH
ME
MA
CT
RI
NJ
MD
DE
Active Mines
Surface
Underground


Geographical Distribution of Particulate Matter and Types of Mine
Type of Mines
Surface mines
Underground mines
PM Levels (ug/m3)
7 - 8
8 - 10
10 - 12
12+
Prepared by: Ahmed Arif; Source: CDC WONDER, NIOSH MSHA; Date: November 28, 2019
N
0 125 250 500 750 1,000 Miles

Classification

- Exposure to organic dust
  - Byssinosis
  - Asthma
  - Agricultural dust
- Exposure to inorganic dust
  - Silica
  - Coal dust
  - Asbestos
  - Beryllium

Obstructive lung diseases

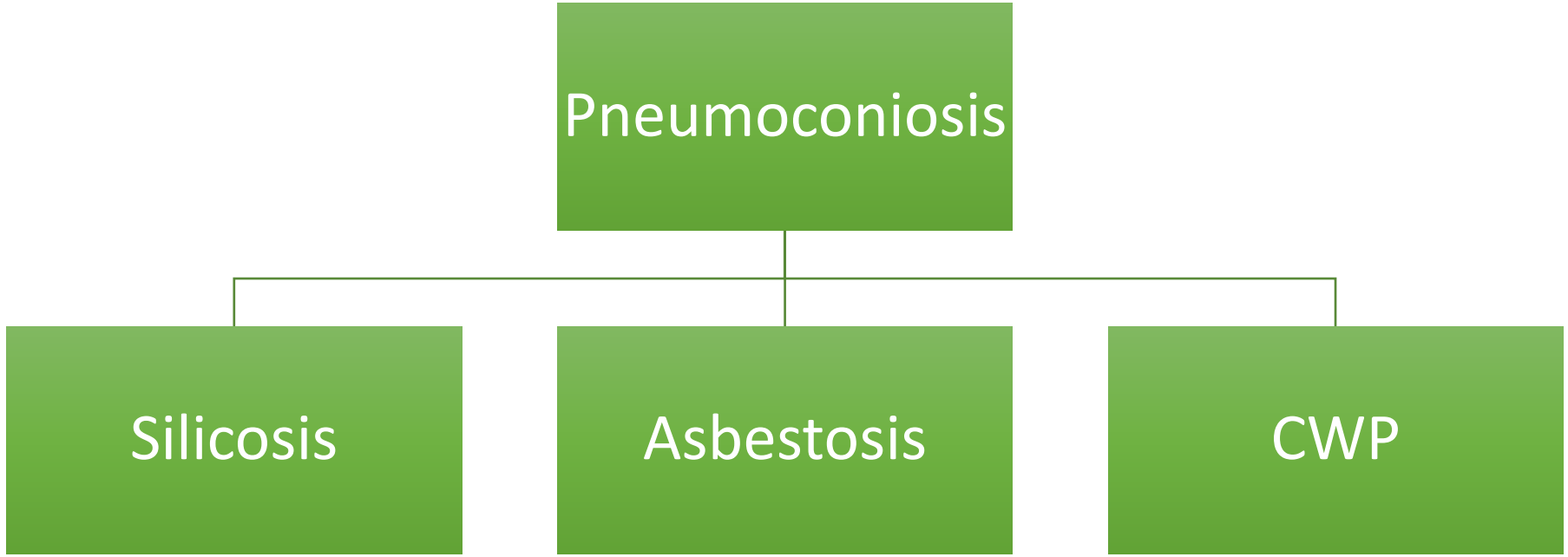
- Byssinosis
- COPD

Restrictive lung diseases

- Asbestosis
- Silicosis
- Coal workers' pneumoconiosis

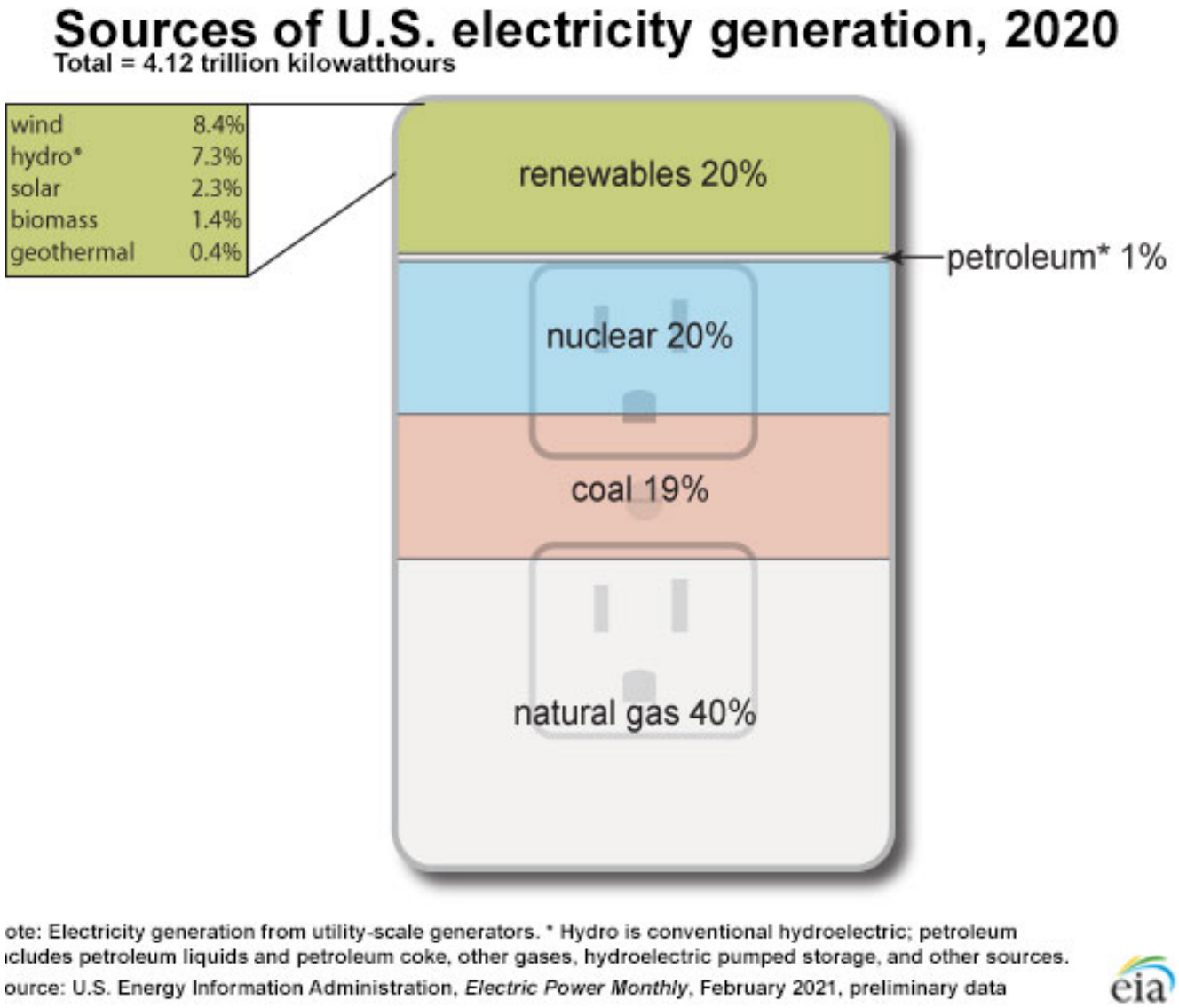
Pneumoconiosis

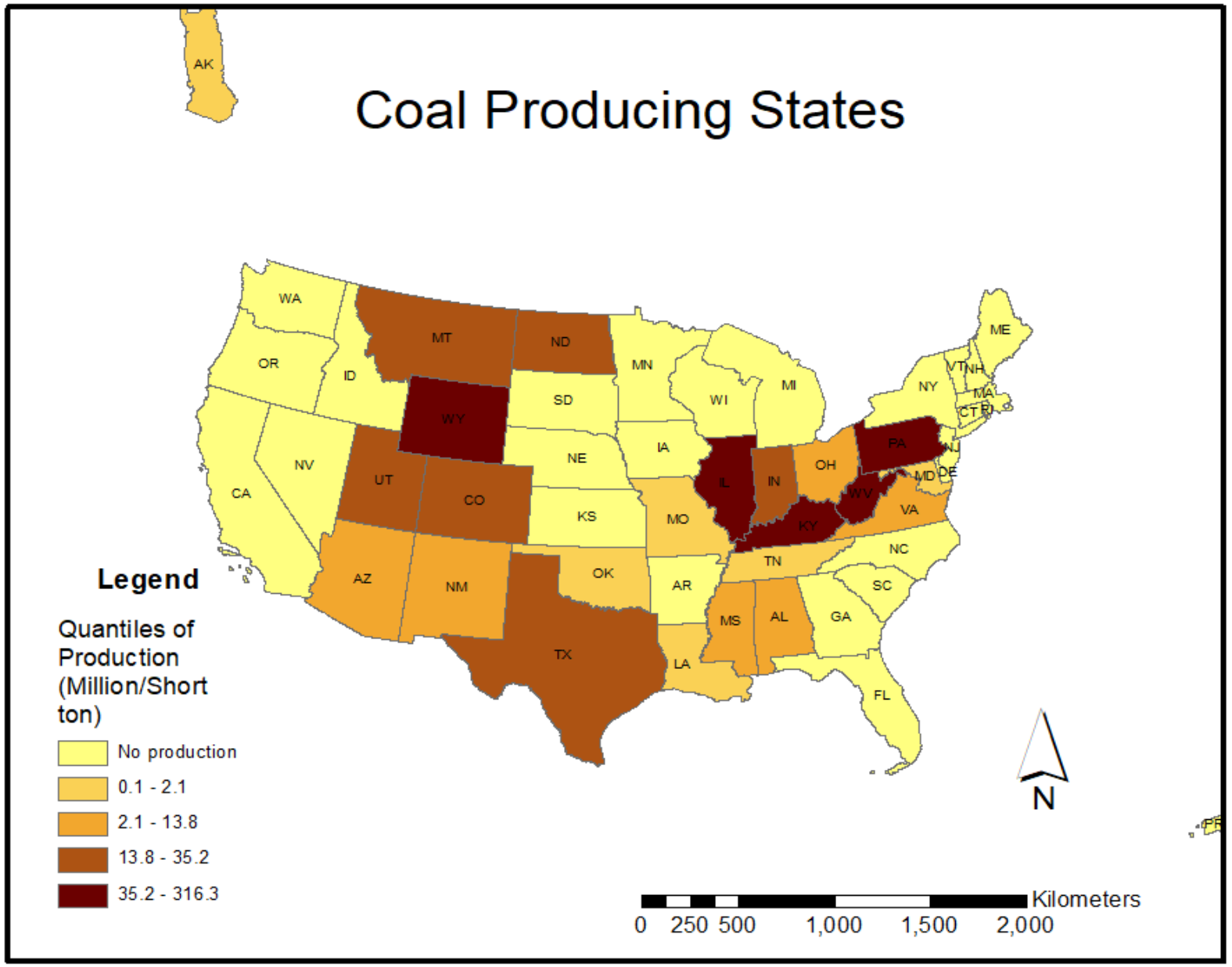
The pneumoconioses are a group of interstitial lung diseases caused by workplace exposure and the inhalation of dusts



Coal

- More than 8140 million tons (Mt) produced worldwide
- Top three coal producers
  - China – 3708 Mt
  - India – 761 Mt
  - U.S. – 728 Mt

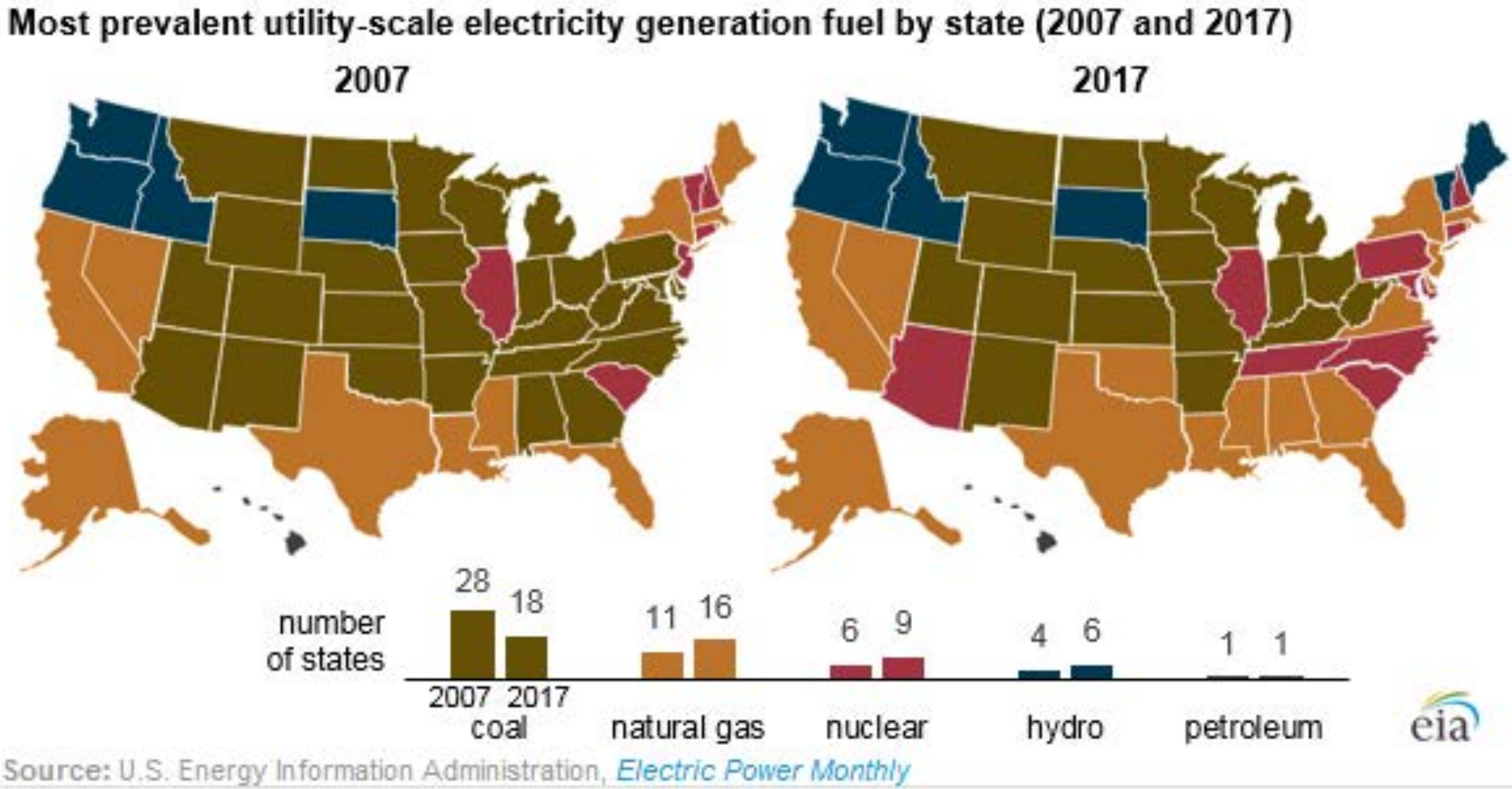




Source: US Energy Information Administration, State Energy Data System (SEDS): 2017

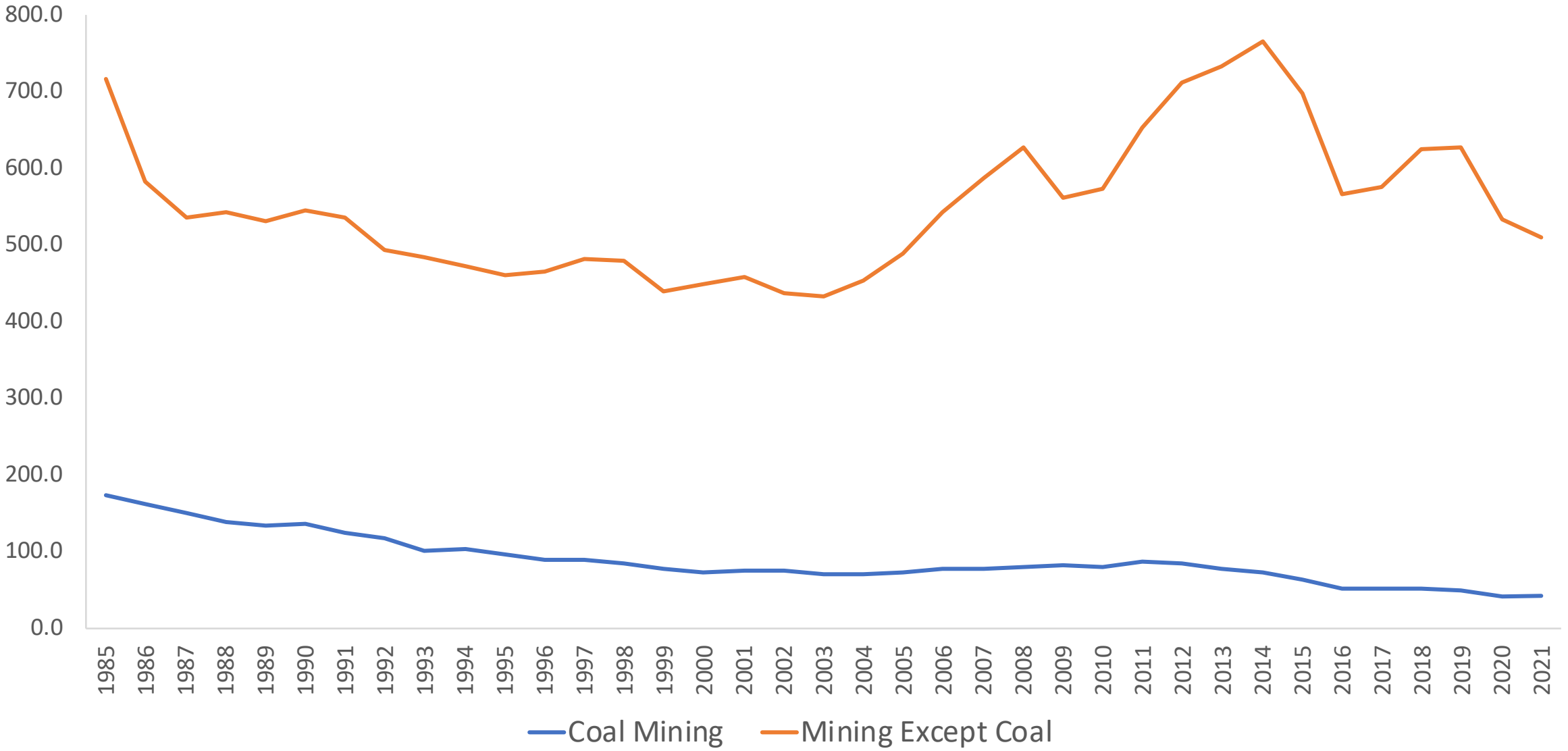
1. Wyoming:
2. West Virginia
3. Pennsylvania
4. Illinois
5. Kentucky

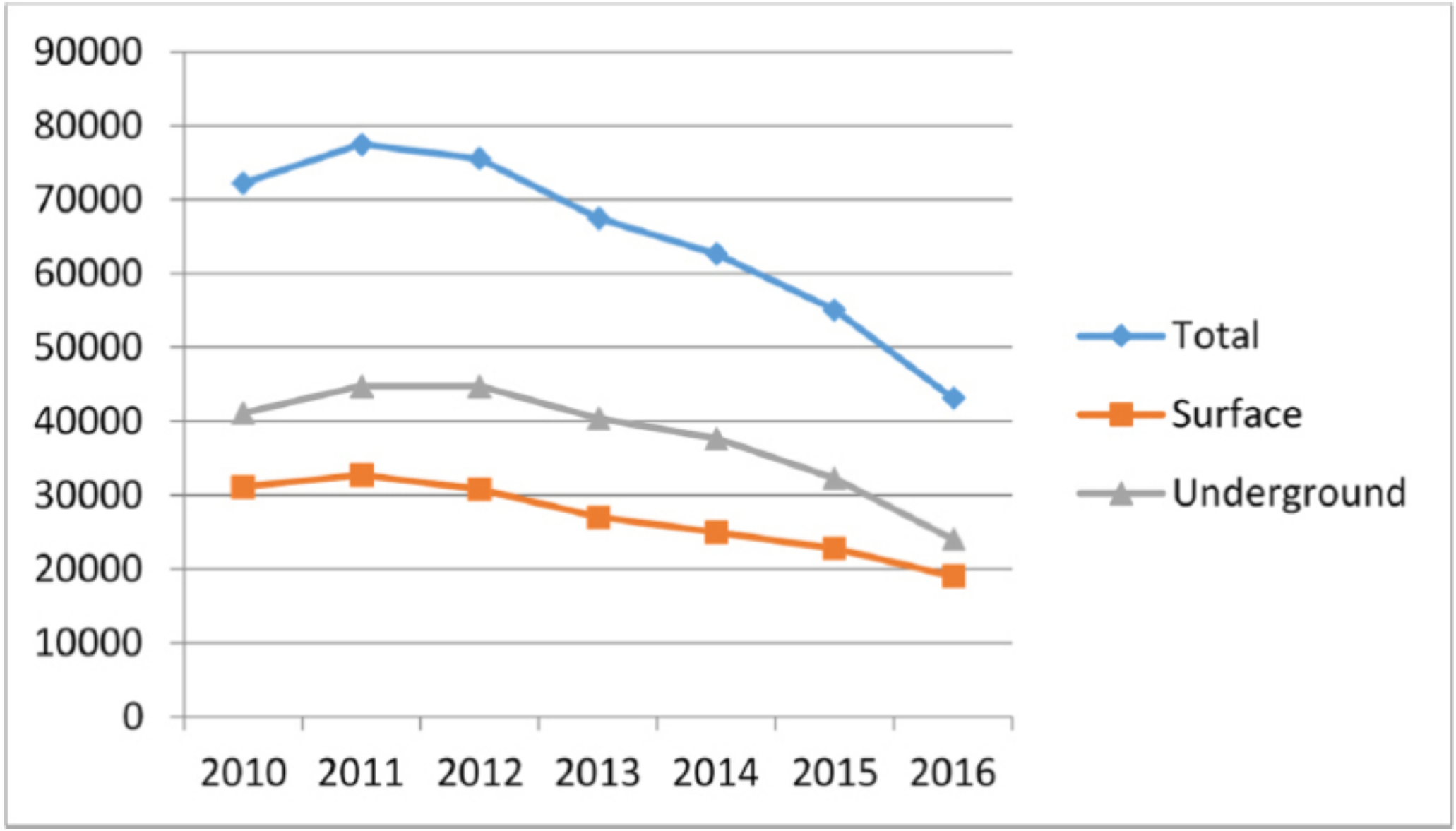
Coal is the most-used electricity generation source in 18 states; natural gas in 16



https://www.eia.gov/todayinenergy/detail.php?id=37034

All employees, thousands, seasonally adjusted, BLS

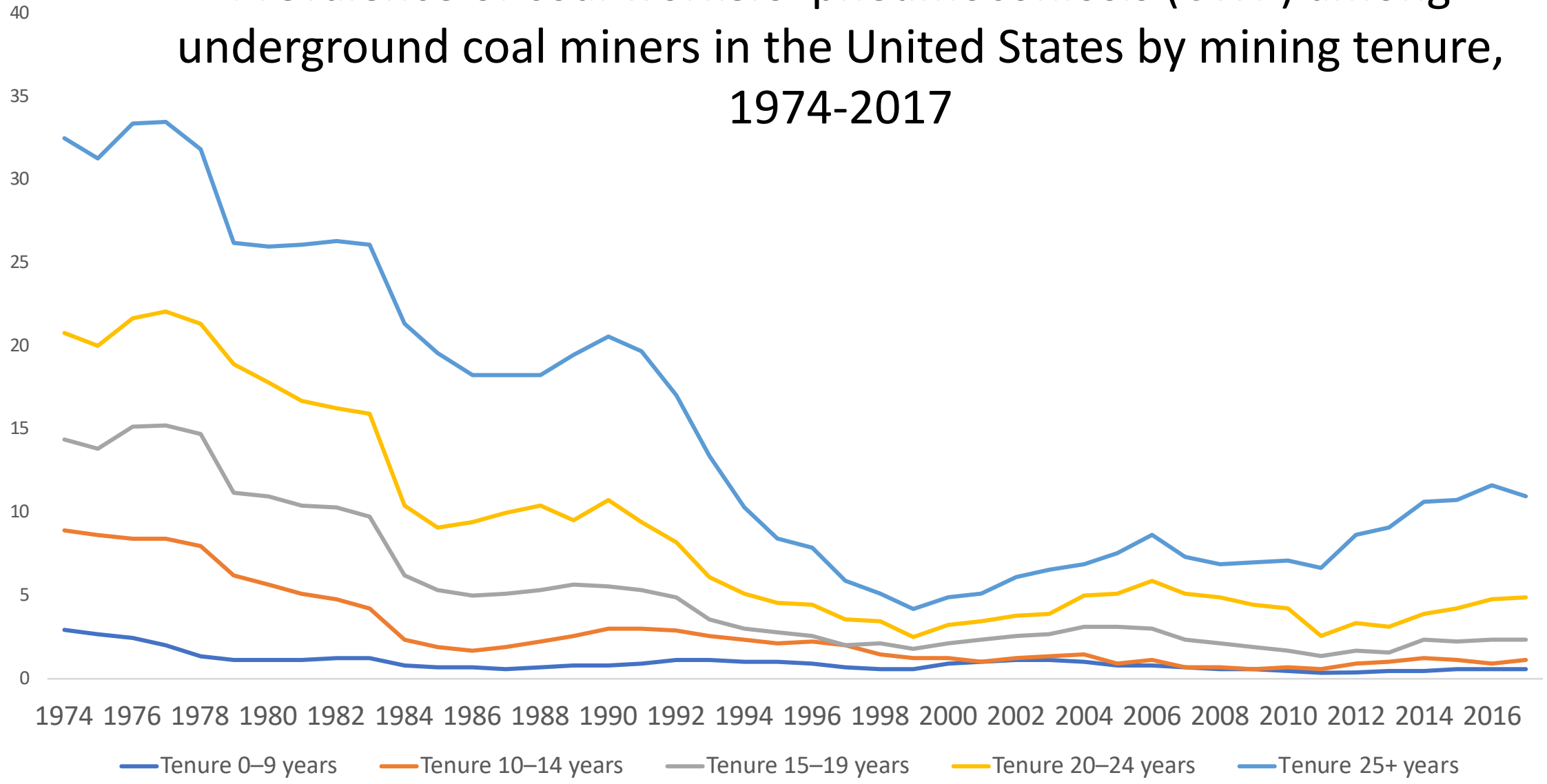




Number of miners employed in coal mines: total and by mining method, 2010-2017.
SOURCE: Data from MSHA, 2017.

https://www.ncbi.nlm.nih.gov/books/NBK531861/

Prevalence of coal workers' pneumoconiosis (CWP) among underground coal miners in the United States by mining tenure, 1974-2017



Data are presented as a 5-year moving average. Surveillance is conducted on a 5-year national cycle.
DATA SOURCE: NIOSH Coal Workers' Health Surveillance Program (CWHSP)

Mining and Pneumoconiosis

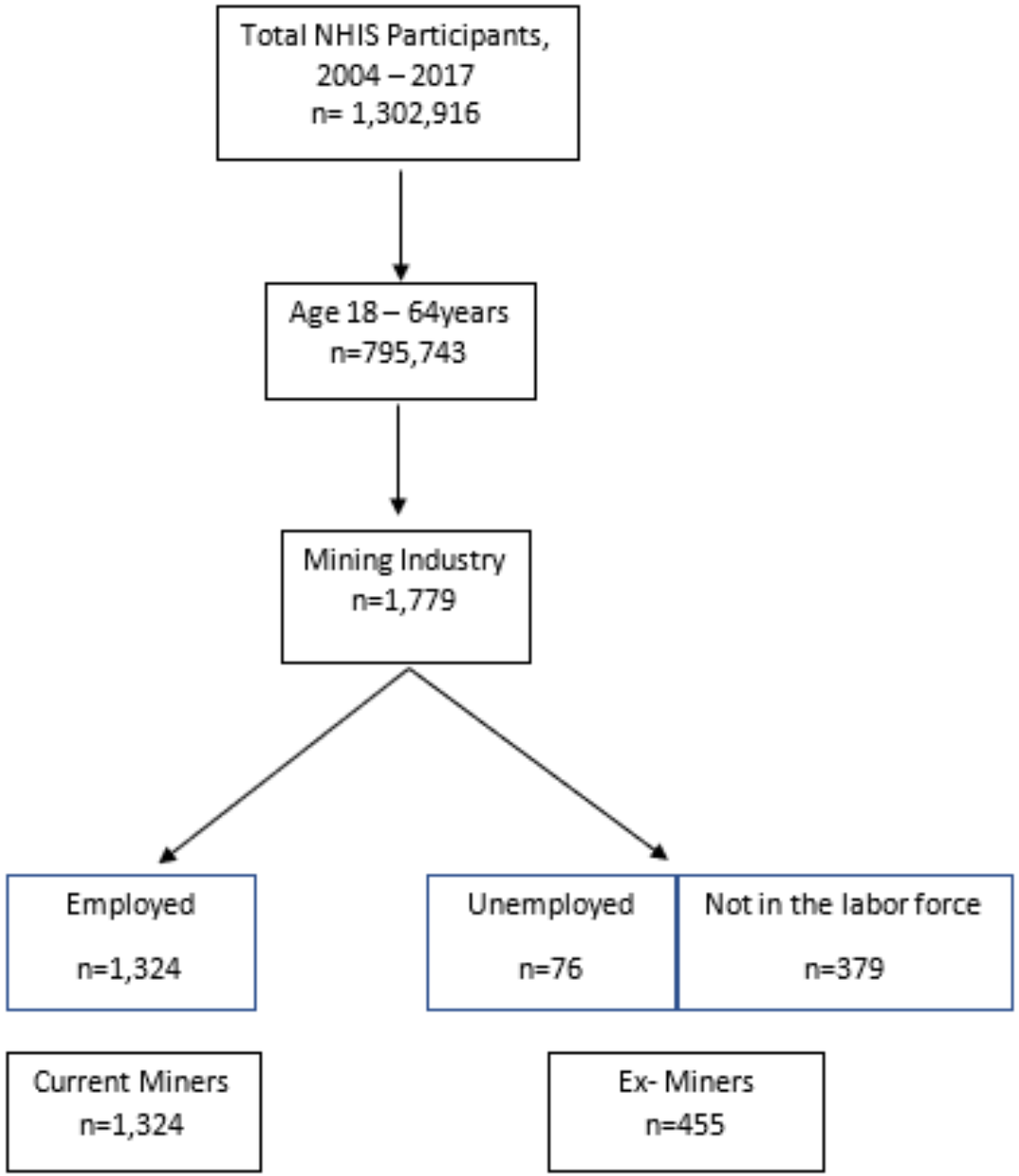
- National health interview survey
  - Working age adults 18 years-64 years
  - Working in the mining industry
  - Ex-miners 2004-2017
  - Mortality 1986-2014

- Medicare beneficiaries
  - 65 years and older
  - Diagnosis of ICD-9-CM 500-505
  - Healthcare utilization
  - Mortality
  - 2011-2014

National Health Interview Survey

- Longest ongoing household interview survey in the US.
- Conducted since 1957
- Multistage area probability sampling design
- 2004-2017
- Aged 18 and 64 years (n=795,743).
- Starting 2004, Census Bureau started assigning industry codes based on the North American Industrial Classification System (NAICS).
- IPUM-NHIS harmonized cross time comparison

Flowchart of selection of the final analytical sample



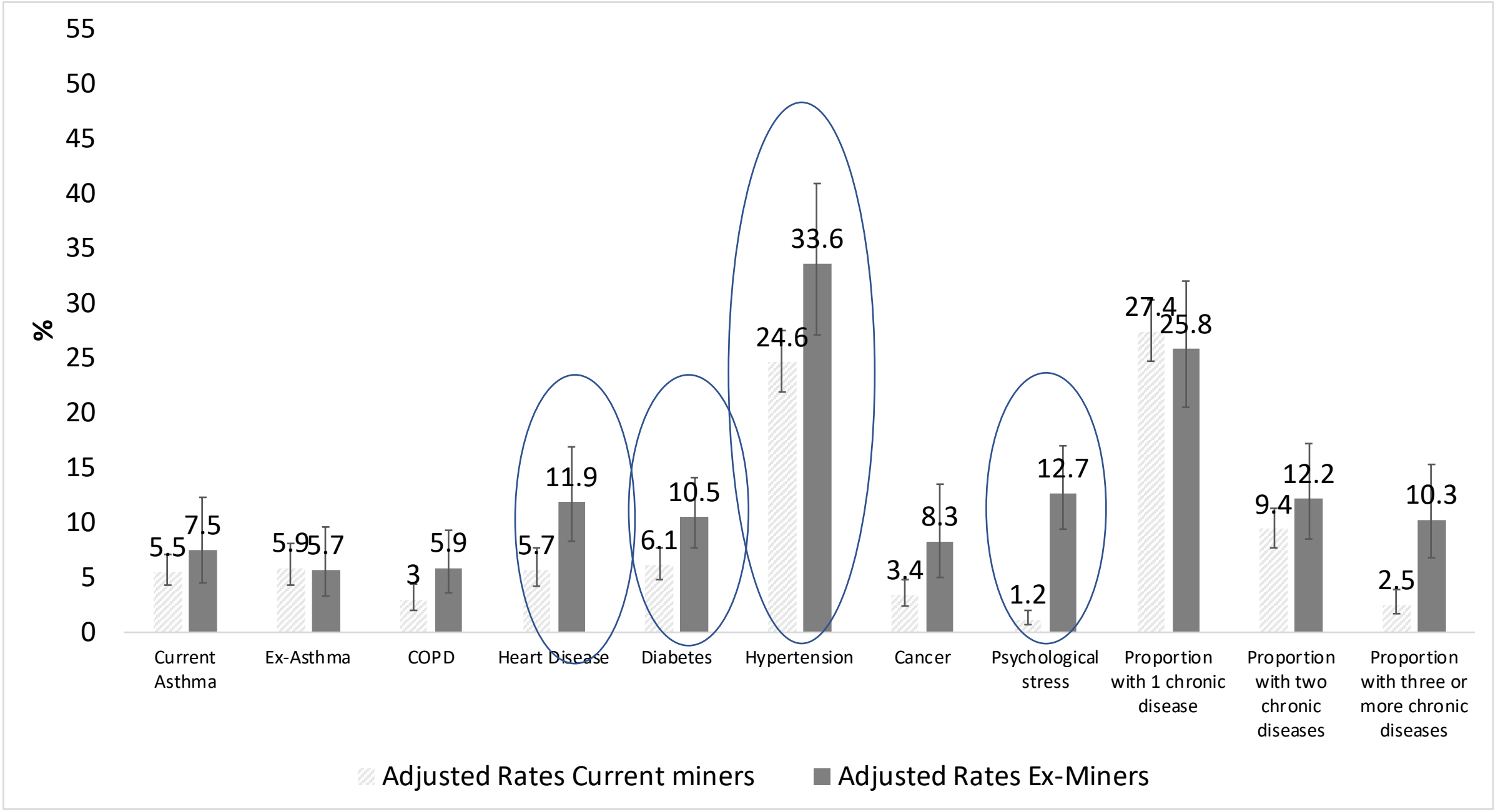
The Prevalence of Chronic Diseases Among Current and Ex-Miners in the United States

Ahmed A. Arif, PhD and Oluwaseun Adeyemi, MBChB, MPH

Objective: To determine and compare the prevalence and odds of chronic diseases among ex- and current miners. **Methods:** Fourteen-year pooled data from the National Health Interview Survey between 2004 and 2017 were analyzed. Ex- and current miners ages 18 to 64 years were defined based on employment status at the time of National Health Interview Survey (NHIS) interview. We calculated age-adjusted prevalence rates and odds ratios of association of chronic diseases. The analysis was adjusted for respondent's age, sex, race, marital status, poverty–income ratio, health insurance, and smoking status. **Results:** Ex-miners have significantly increased prevalence of most chronic diseases. The age-adjusted prevalence and the adjusted odds of heart disease, cancer, hypertension, diabetes, and psychological stress were significantly higher among ex-miners as compared with current miners. **Conclusions:** Ex-miners have worse health outcomes that may persist for years after leaving the mining industry.

TABLE 1. Weighted Prevalence of the Sociodemographic Characteristics of Current and Ex-Miners

Variable	Current Miners		Ex-Miners	
	Unweighted *n*	Weighted %	Unweighted *n*	Weighted %
Age groups				
18–24 yrs	102	8.3	19	4.4
25–34 yrs	391	30.2	59	12.5
35–49 yrs	440	32.3	97	23.6
50–64 yrs	391	29.2	280	59.6
Sex				
Female	198	15.5	82	16.8
Male	1126	84.5	373	83.2
Race/ethnicity				
NH White	1186	90.6	394	86.9
NH Black	63	4.7	42	8.8
Other/Multi-Race	75	4.7	19	4.3
Marital status				
Married	777	58.3	226	51.4
Widowed	32	2.6	16	3.8
Divorced/Separated	220	16.3	120	23.4
Never married	292	22.8	91	21.3
Poverty income ratio				
At or above	1197	90.0	316	69.0
Below	33	2.3	98	19.9
Unknown	94	7.8	41	11.1
Health insurance coverage status				
Has insurance	1187	89.8	332	74.3
Has no insurance	136	10.2	136	25.7
Smoking status				
Non-smoker	700	52.5	166	36.4
Former smoker	278	20.6	126	28.5
Current smoker	333	26.9	162	35.1



Arif, A.A., & Adeyemi, O. (2020). The Prevalence of Chronic Diseases Among Current and Ex-Miners in the United States. *Journal of Occupational and Environmental Medicine, 62*(3), 227-231.

TABLE 2. Odds Ratios of Chronic Diseases Among Ex-Miners

Outcome Variables	Univariate Analysis (Unadjusted Odds Ratio) (95% CI)	Adjusted Odds Ratio* (95% CI)
Asthma†		
Current asthma	1.61 (1.05–2.47)	1.58 (0.95–2.63)
Ex-asthma	0.86 (0.48–1.53)	0.74 (0.40–1.37)
COPD	3.39 (1.79–6.43)	2.01 (0.96–4.23)
Heart disease	3.59 (2.48–5.21)	2.34 (1.52–3.61)
Diabetes	2.96 (2.05–4.26)	1.96 (1.24–3.10)
Hypertension	2.62 (2.00–3.41)	1.71 (1.22–2.41)
Cancers	2.89 (1.81–4.62)	1.93 (1.10–3.38)
Psychological stress	10.60 (5.72–19.66)	8.79 (4.43–17.46)
Number of chronic diseases†		
One chronic disease	1.56 (1.10–2.20)	1.09 (0.73–1.62)
Two chronic diseases	3.08 (1.97–4.81)	1.79 (1.06–3.03)
Three or more chronic diseases	8.65 (5.13–14.61)	4.79 (2.69–8.55)

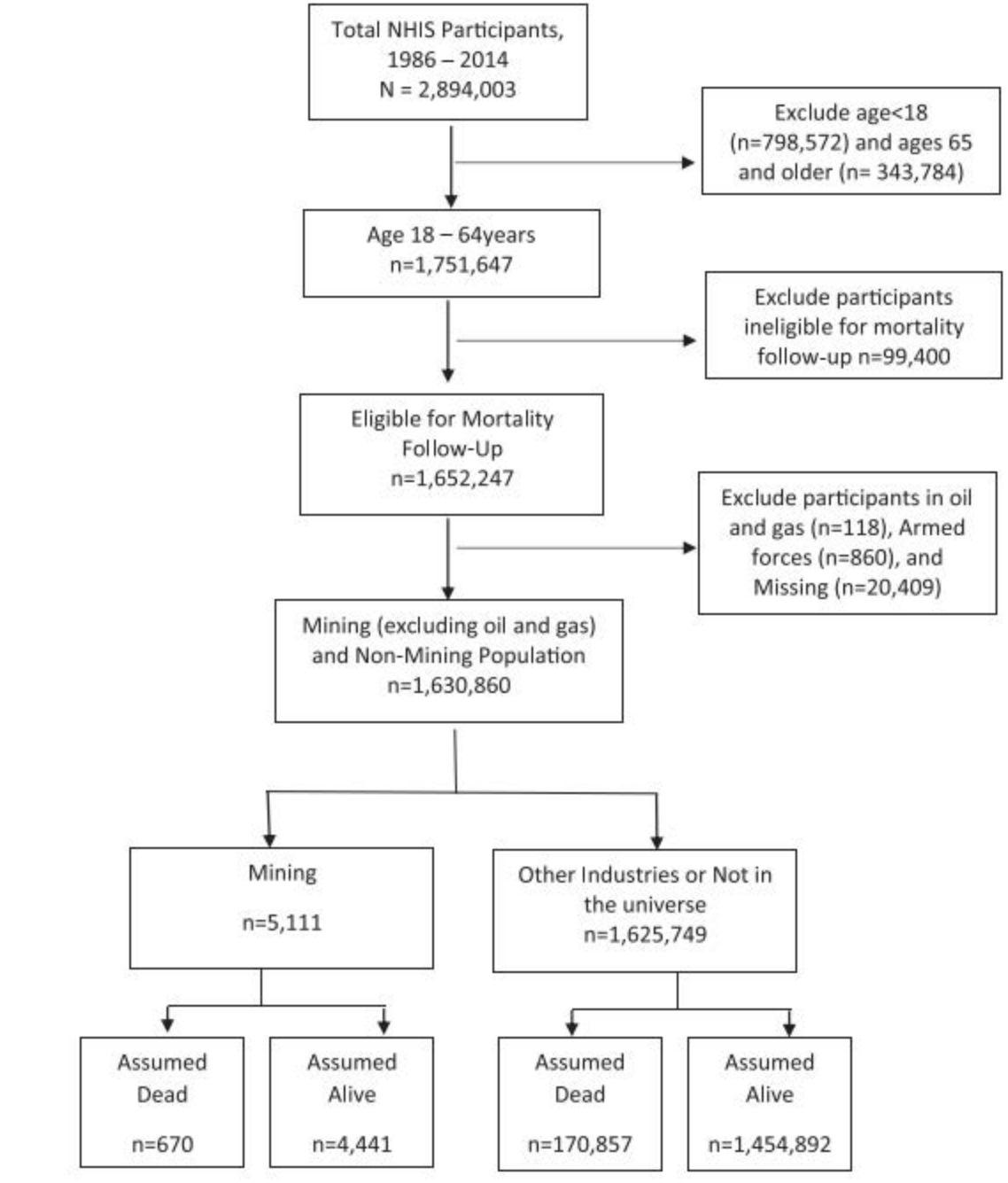
CI, confidence interval; COPD, chronic obstructive pulmonary disease.

*The model is controlled for age, sex, race, poverty threshold, health insurance, and smoking status.

†Multinomial logistic regression was performed.

NHIS linked mortality file

- NCHS has linked NHIS data with death certificate records from the National Death Index (NDI).
- Public-use Linked Mortality Files (LMF) are available for 1986-2014
- Pooled 29 years of data from 1986 to 2014
- 18-64 years & eligible for mortality follow-up
- Underlying causes of death from diseases of the heart, malignant neoplasm, chronic lower respiratory diseases, accidents (unintentional injuries), and chronic kidney diseases
- Standardized mortality ratio



Selection of study participants, National Health Interview Survey—Linked Mortality File, 1986-2014

Mortality among workers employed in the mining industry in the United States: A 29-year analysis of the National Health Interview Survey—Linked Mortality File, 1986-2014

Ahmed A. Arif MBBS, PhD | Oluwaseun Adeyemi MBChB, MPH

Abstract

Background: Working in the mining industry increases the risk of chronic diseases and mortality. We investigated overall and cause-specific mortality rates among workers employed in the mining sector in the United States.

Methods: We pooled 29 years of National Health Interview Survey (NHIS) public-use data from 1986 to 2014, with mortality follow-up until 31 December 2015. We grouped respondents into the mining and nonmining sectors based on the responses given at the time of the NHIS interview. We compared the overall and cause-specific mortality rates using standardized mortality ratios (SMR) and 95% confidence interval (CI) adjusted for the competing cause of death.

Results: From 1986 to 2014, an estimated 14 million deaths were recorded among subjects eligible for mortality follow-up. Of these, an estimated 50,000 deaths occurred among those working in the mining sector. A significantly higher overall mortality (SMR = 1.26, 95% CI: 1.17-1.36), and mortality from heart diseases (adjusted SMR = 1.56, 95% CI: 1.31-1.83), cancer (adjusted SMR = 1.30, 95% CI: 1.14-1.48) and unintentional injuries (adjusted SMR = 1.41, 95%CI: 1.03-1.85) were observed among those employed in the mining sector. When the analyses were restricted to men, only the SMRs for heart disease and cancer remained statistically significant. No elevated SMR for deaths from chronic lower respiratory disease was observed in the study.

Conclusion: Workers employed in the mining sector have a significantly increased total death rate and death rates from heart disease, cancer, and unintentional injuries.

TABLE 2 Standard mortality rates by causes of death in mining industry for miners ages 18 and 64 y and eligible for mortality follow-up, NHIS 1986-2014

Cause of mortality	Observed death counts[a]	Expected number of deaths[b]	Standardized mortality ratio (95%CI)[c]	Adjusted expected death counts[d]	Adjusted standard mortality ratio (95%CI)[e]
Chronic lower respiratory disease	22	23.77	0.93 (0.58-1.35)	24.64	0.89 (0.56-1.30)
Heart diseases	137	84.60	1.62 (1.36-1.90)	87.71	1.56 (1.31-1.83)
Diabetes	15	18.13	0.83 (0.46-1.30)	18.80	0.80 (0.45-1.25)
Hypertension	67	52.94	1.27 (0.98-1.59)	54.88	1.22 (0.95-1.53)
Cancer	224	166.06	1.35 (1.18-1.53)	172.16	1.30 (1.14-1.48)
Chronic kidney disease	9	7.65	1.18 (0.53– 2.07)	7.93	1.13 (0.51-2.00)
Unintentional injuries	45	30.79	1.46 (1.07-1.92)	31.93	1.41 (1.03-1.85)
All causes of deaths[f]	670	530.62	1.26 (1.17-1.36)		
Residual causes of death[g]	190	163.95	1.16 (0.99-1.33)		

Arif, A. A., & *Adeyemi, O. (2020). Mortality among workers employed in the mining industry in the United States: A 29-year analysis of the National Health Interview Survey-Linked Mortality File, 1986-2014. *Am J Ind Med.* 63(10), 851-858. Doi:10.1002/ajim.23160

Summary - NHIS

- Age-adjusted prevalence and odds of heart diseases, diabetes, hypertension, cancer, and psychological stress were significantly higher among ex-miners as compared to current miners.
- There was a statistically significant excess deaths from heart disease, cancer, and unintentional injuries.
- Deaths from all causes of mortality were 26% higher among miners as compared to the general population

Medicare Limited Dataset (LDS) administrative claims data

- Medicare beneficiaries represent 16% of the total U.S. population or approximately 51 million individuals covered under Part A (hospital) and B (outpatient services).

- The LDS includes a set random sample of 5% of the Medicare population

Purpose of the study

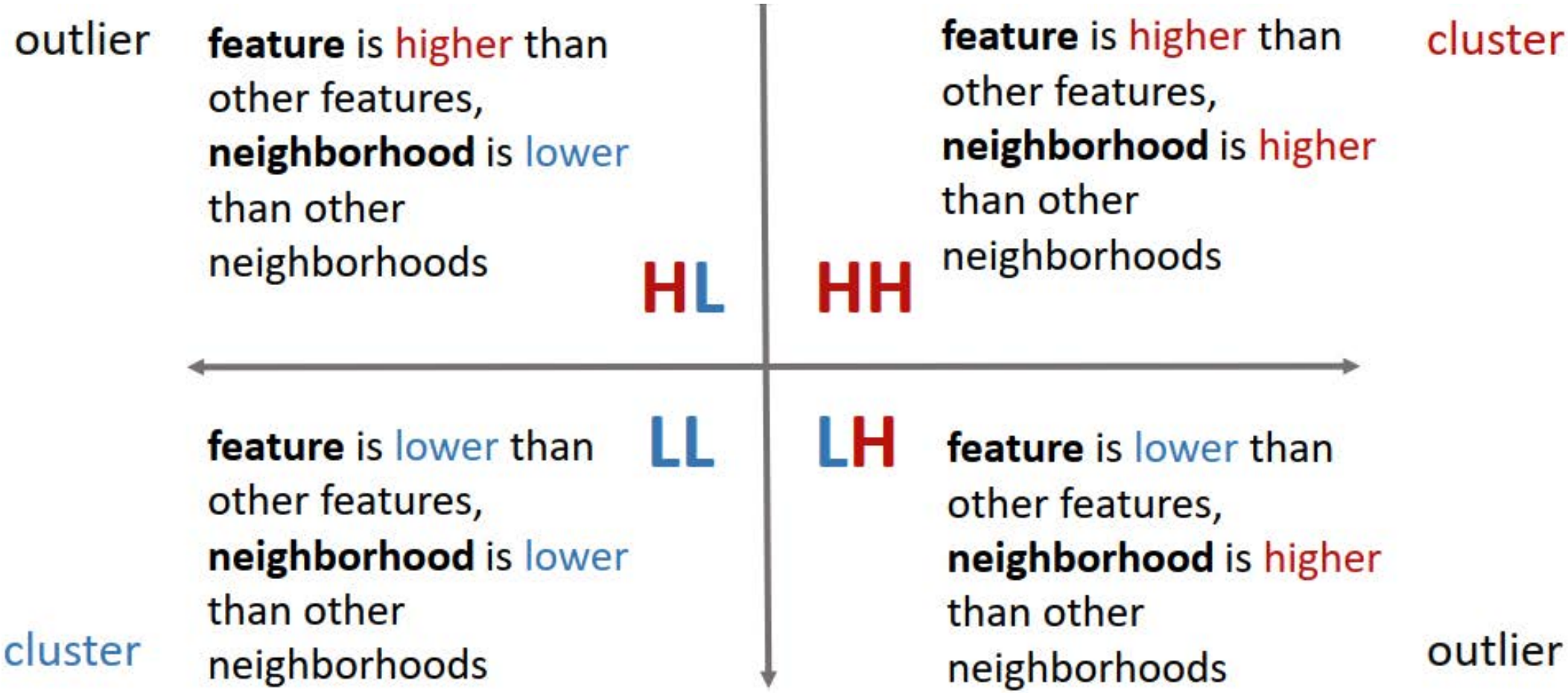
- To examine the geographical distribution & conduct hotspot analysis of health care utilization patterns among Medicare beneficiaries with CWP and other pneumoconiosis.
- To determine and compare the county-level prevalence of CWP using Medicare data in seven contiguous states with high mining activity, including Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia.
- Estimate the risk of mortality from Pneumoconiosis

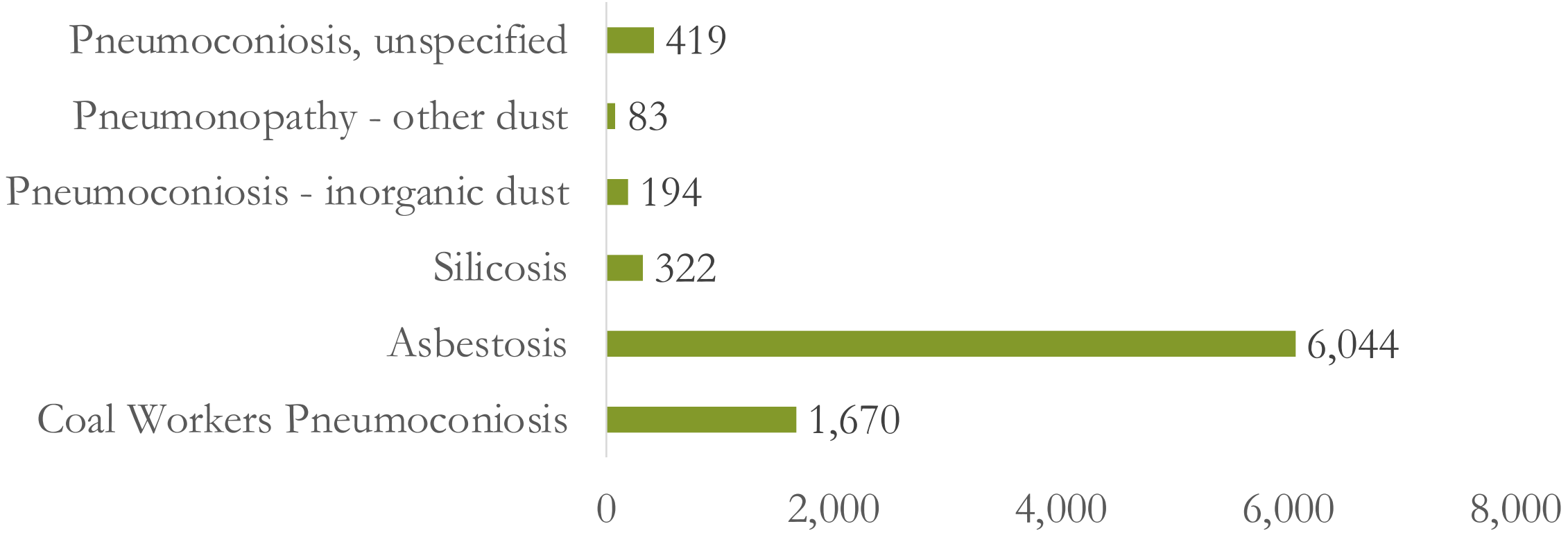
Inclusion Criteria

ICD-9-CM Code	Description
500	Coal workers' pneumoconiosis
501	Asbestosis
502	Pneumoconiosis due to other silica or silicates
503	Pneumoconiosis due to other inorganic dust
504	Pneumonopathy due to inhalation of other dust
505	Pneumoconiosis, unspecified

- Diagnosis of ICD-9-CM 500-505
- Study period of January 1, 2011 through December 31, 2014.
- The date of first diagnosis of CWP served as the patient's index date.
- If the patient did not have a diagnosis of CWP then the date of first diagnosis of 501-505 served as the index date.

Identifying Clusters
High/Low Clustering (Getis-Ord General Gi*)




Pneumoconiosis, unspecified
419
Pneumonopathy - other dust
83
Pneumoconiosis - inorganic dust
194
Silicosis
322
Asbestosis
6,044
Coal Workers Pneumoconiosis
1,670
0
2,000
4,000
6,000
8,000

Results

Table 2. Demographic Characteristics of Medicare Beneficiaries with CWP and Other Related Pneumoconiosis in Medicare LDS Claims Data from 2011 to 2014.

	CWP		Other Related Pneumoconiosis	
	Patients (N = 1,657)	Total Utilization (N = 35,771)	Patients (N = 6,968)	Total Utilization (N = 152,171)
Individual characteristic	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Gender				
Male	1,300 (78)	28,392 (79)	6,175 (89)	133,774 (88)
Female	357 (22)	7,379 (21)	793 (11)	18,397 (12)
Age group				
<= 64	374 (23)	9,033 (25)	511 (7)	14,248 (9)
65 and older	1,283 (77)	26,738 (75)	6,457 (93)	137,923 (91)
Race[a]				
White	1,481 (90)	31,728 (89)	6,261 (91)	135,693 (90)
Back	110 (7)	2,935 (8)	490 (7)	11,968 (8)
Other	53 (3)	854 (2)	154 (2)	3,186 (2)

Arif AA, Owusu C, Paul R, Blanchette CM, Patel RP, Borders TF. *Spatial Analysis of Health Care Utilization among Medicare Beneficiaries with Coal Workers' Pneumoconiosis and Other Related Pneumoconiosis*. Lexington, KY: Rural and Underserved Health Research Center; 2021.

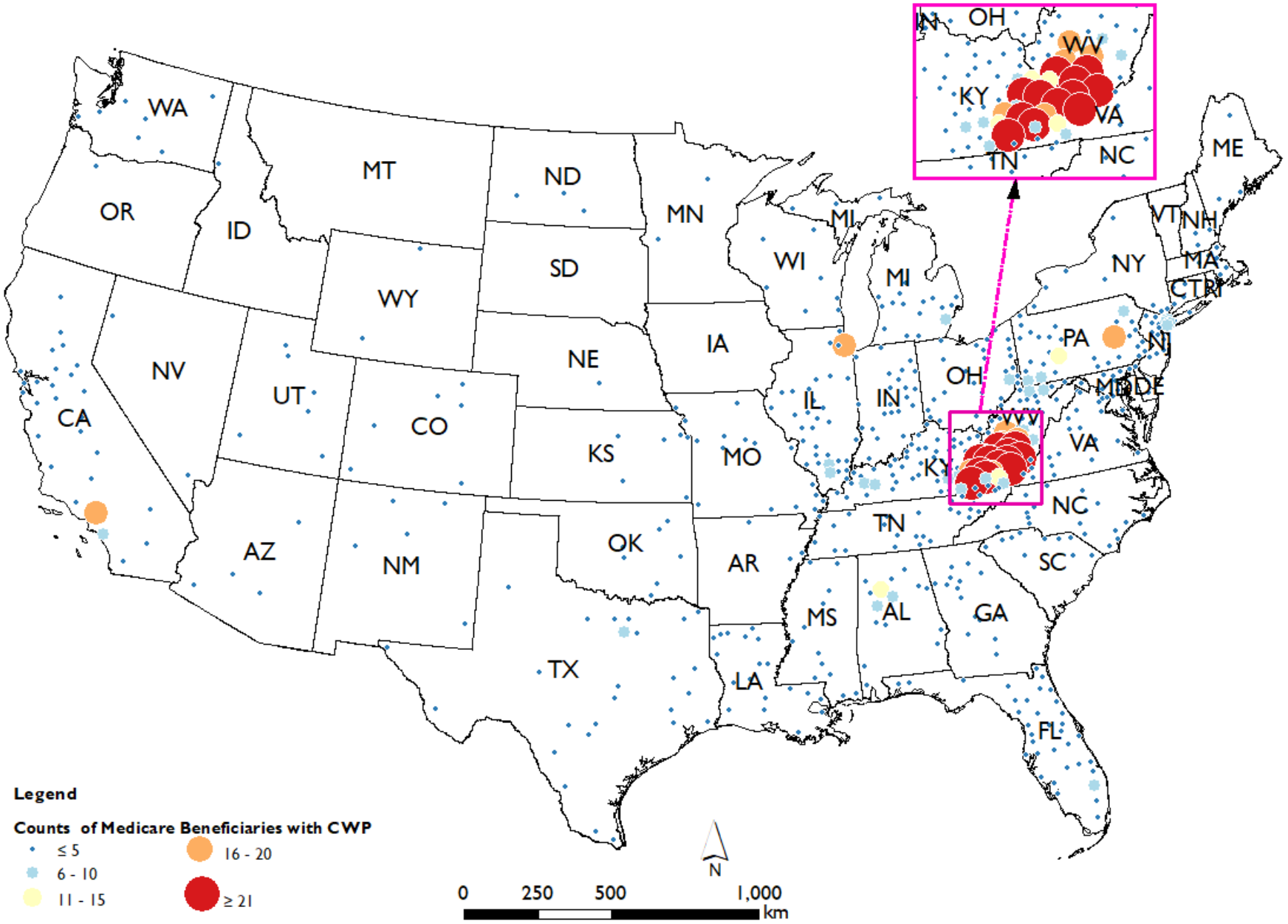
Table 3. Counts, Percentages, and Health Care Utilization Rates (per 1,000) of Medicare Beneficiaries with CWP in Medicare LDS Claims Data from 2011 to 2014.

	CWP (N=1,657)		Health Care Utilization Rates per 1,000
State	**n**	**%**	**Mean**
Kentucky	320	19.3	185
West Virginia	285	17.2	276
Virginia	163	9.8	66
Pennsylvania	102	6.2	15

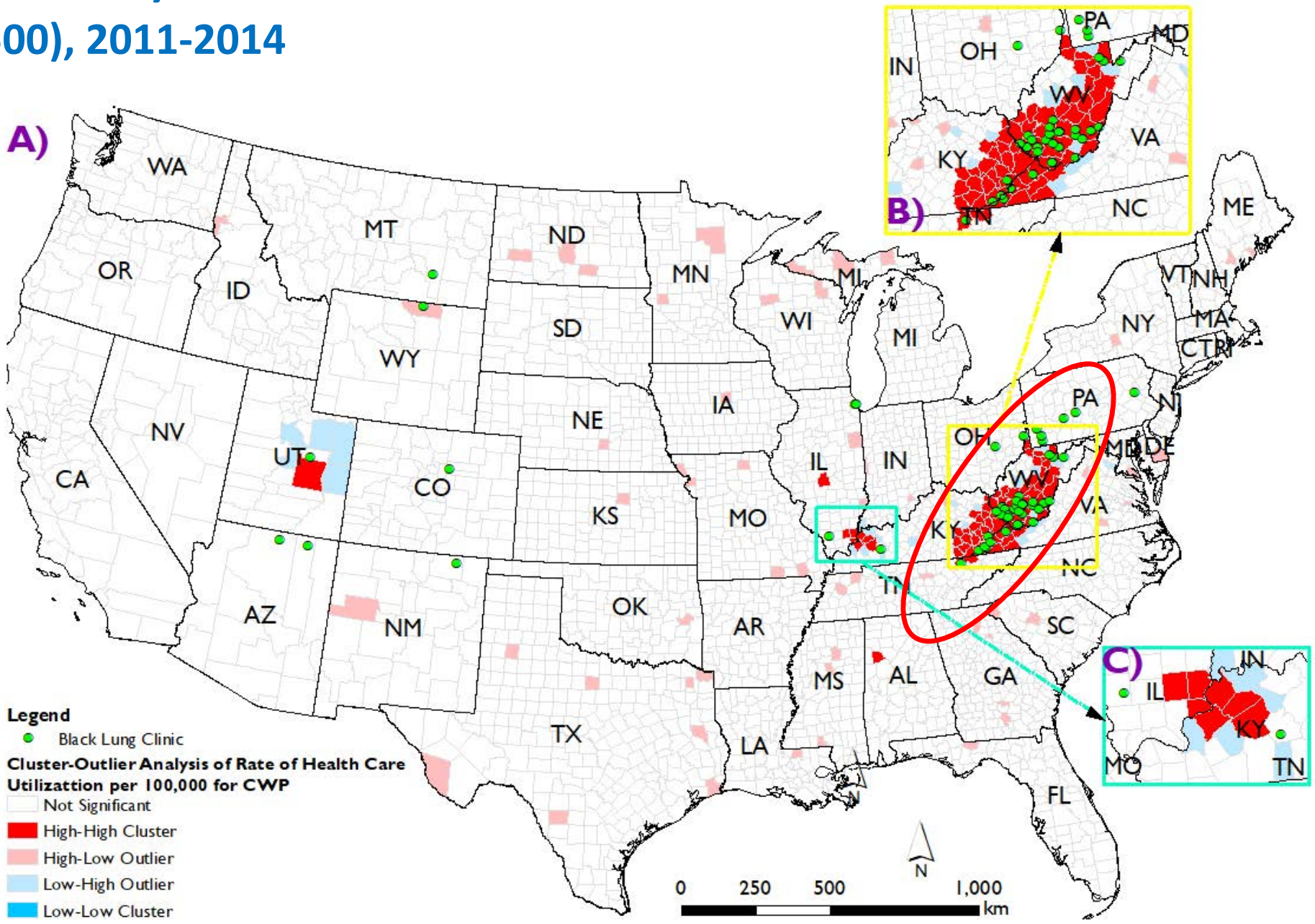
Table 4. Counts, Percentage, and Health Care Utilization Rates (per 1,000) of Medicare Beneficiaries with Other Related Pneumoconiosis in Medicare LDS Claims Data from 2011 to 2014.

	Other Related Pneumoconiosis (N=6,968)		**Health Care Utilization Rate per 1,000**
State	**n**	**%**	**Mean**
Florida	481	6.9	60
Texas	479	6.9	63
New Jersey	439	6.3	138
New York	408	5.9	61

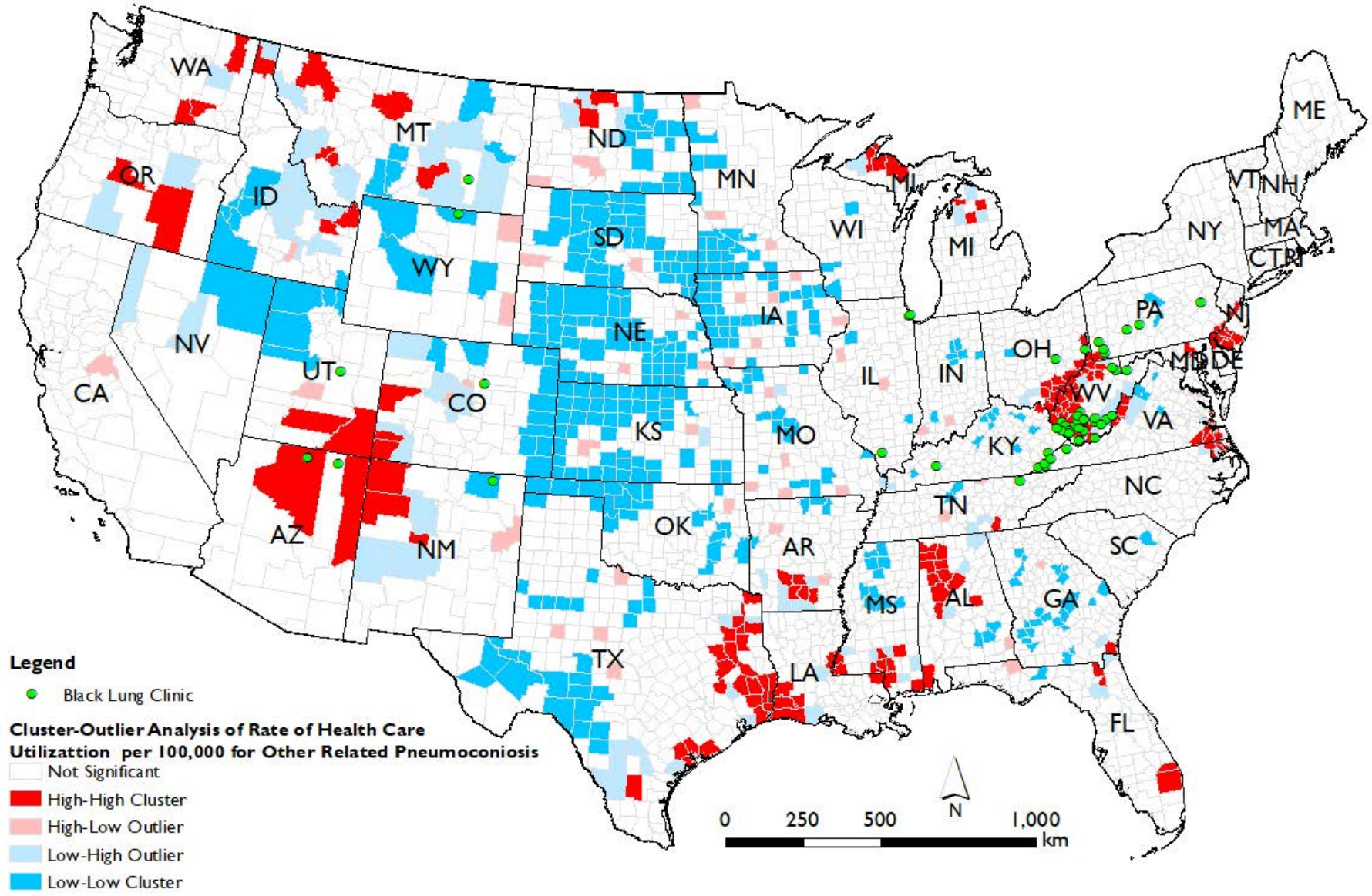
Counts of Beneficiaries with CWP (ICD-9 CM 500), 2011-2014, Contiguous United States



Cluster-outlier Analysis of Annual Rate of Health Care Utilization for CWP (ICD-9 CM 500), 2011-2014



Cluster-outlier Analysis of Annual Rate of Health Care Utilization for Other Related Pneumoconiosis (ICD-9 CM 501–505), 2011-2014



RESEARCH ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Estimating the prevalence and spatial clusters of coal workers' pneumoconiosis cases using medicare claims data, 2011-2014

Ahmed A. Arif MBBS, PhD[1] | Rajib Paul PhD[1] | Eric Delmelle PhD[2] | Claudio Owusu MA[2] | Oluwaseun Adeyemi MBChB, MPH[1]

Methods

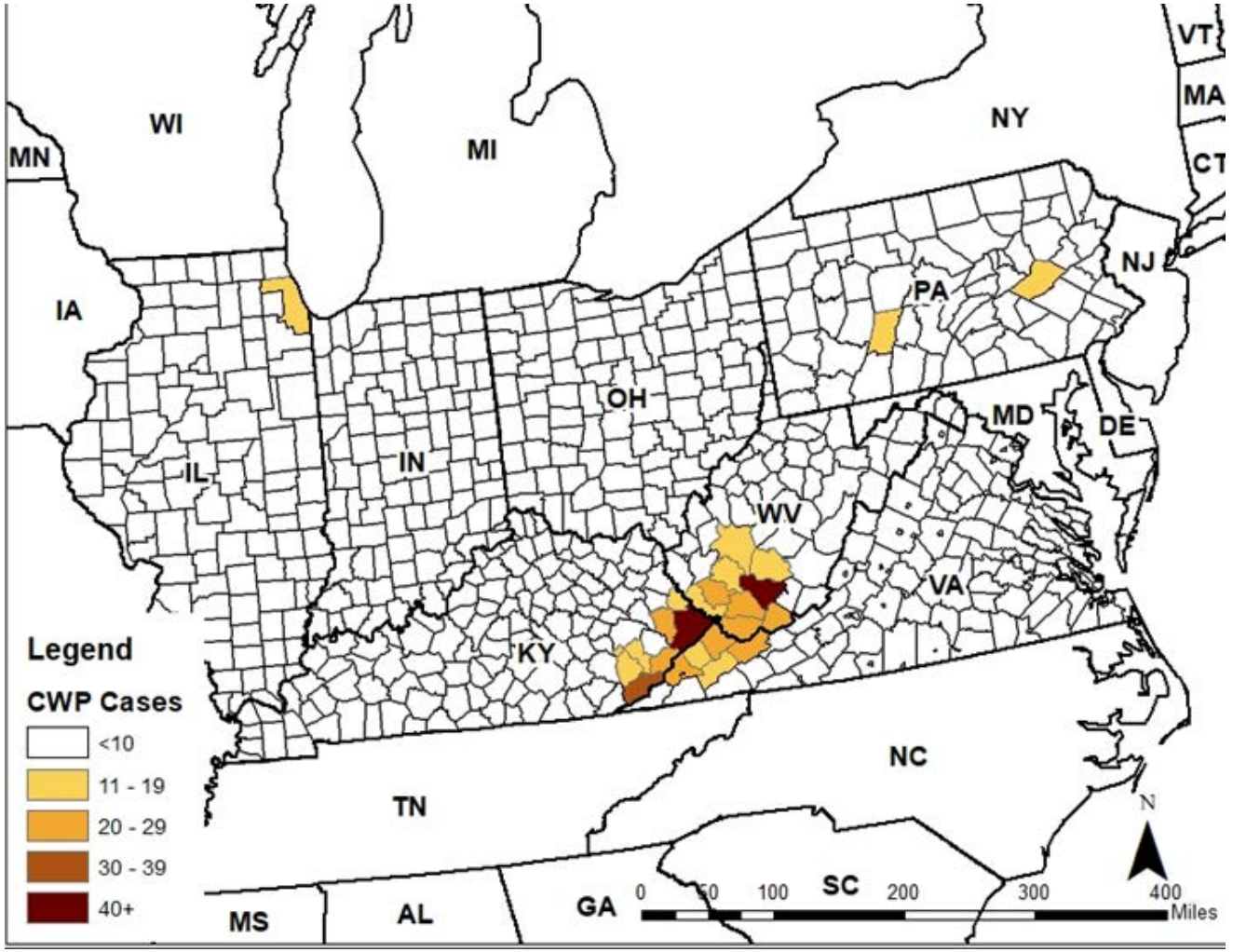
- Medicare Claims Limited Data set (LDS)
- Outcome: diagnosis of ICD-9-CM 500 (CWP)
- Sociodemographic variables (ACS): % males 65 years and above, % population with income below the, federal poverty level, and % non-Hispanic Whites
- Rurality: RUCA codes
- Proximity to mining activity: 10-mile radius around each mining facility
- Restricted our data to seven states, including Illinois, Indiana , Kentucky, Ohio, Pennsylvania, Virginia, and West Virginia
- Aggregated the data by county and state FIPS code

Statistical Analysis

- Descriptive measures: including interquartile range (IQR), means, medians, and maximum value.
- Crude prevalence rates of CWP
- Negative binomial regression – CWP count as outcome

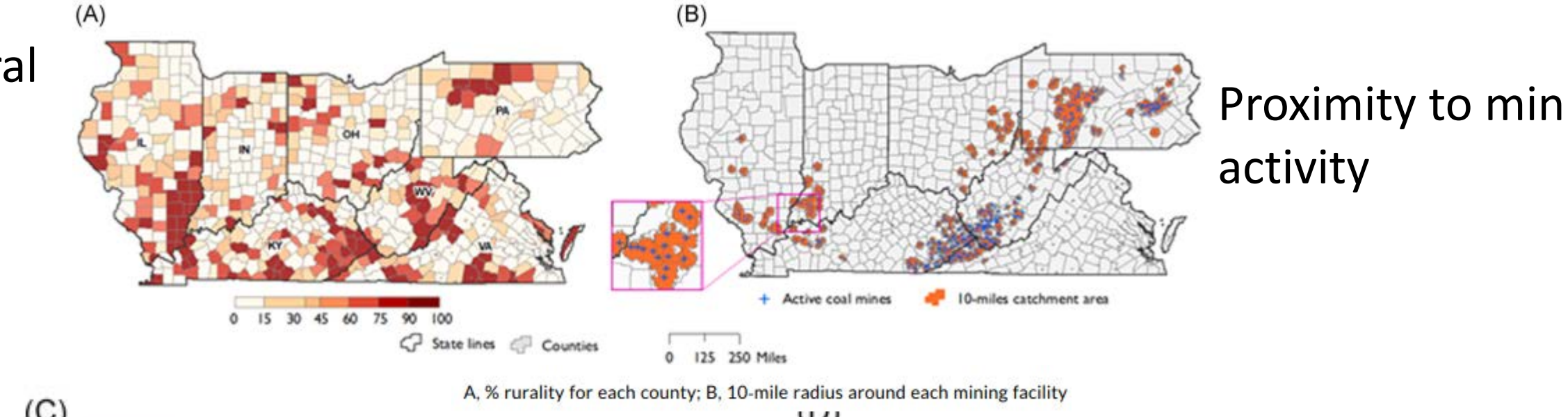
Count of CWP by State

State	Unweighted Count
Kentucky	320
West Virginia	285
Virginia	162
Pennsylvania	102
Illinois	70
Ohio	53
Indiana	29
Total	1021



Arif, A. A., Paul, R., Delmelle, E., *Owusu, C., & *Adeyemi, O. (2020). Estimating the prevalence and spatial clusters of coal workers' pneumoconiosis cases using medicare claims data, 2011-2014. *Am J Ind Med*, 63(6), 478-483. doi:10.1002/ajim.23104

Rural



Proximity to mining activity

A, % rurality for each county; B, 10-mile radius around each mining facility

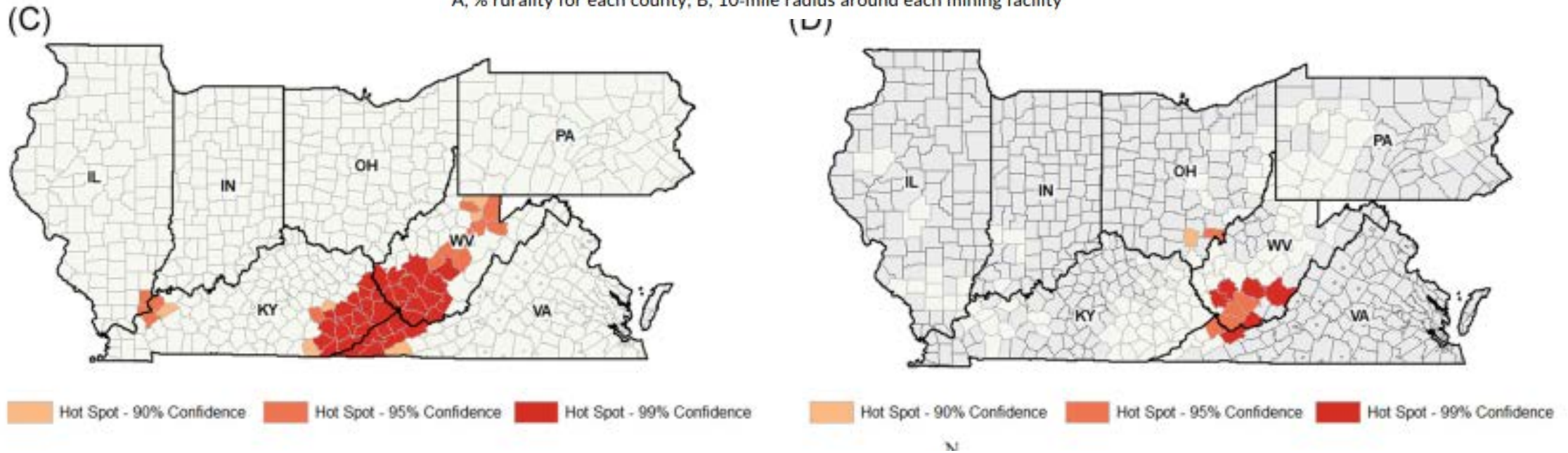


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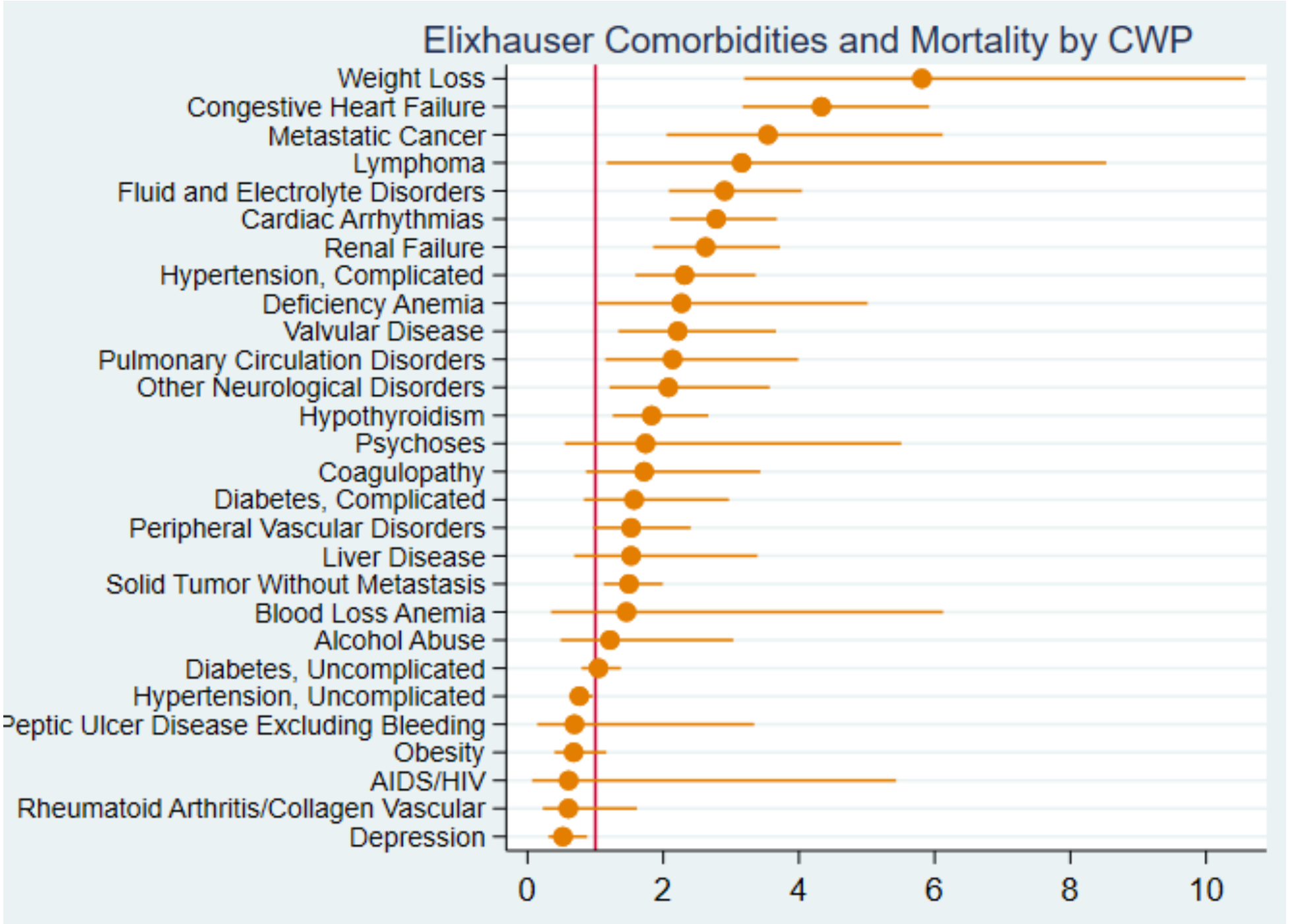
TABLE 2 Unadjusted and adjusted rate ratios of the county-level factors associated with CWP using negative binomial regression analysis

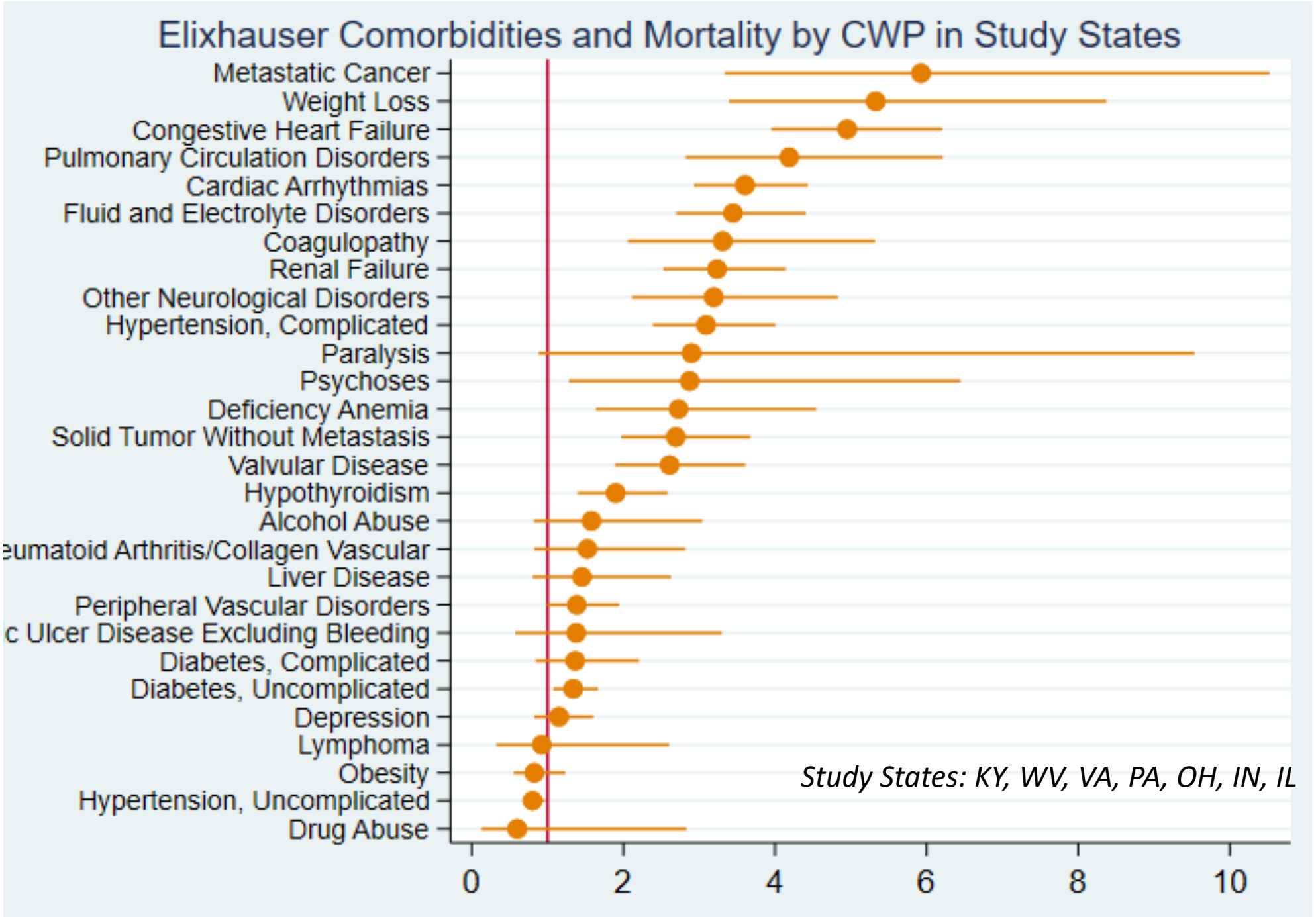
Variables	Unadjusted Rate ratios (95% CI)	Adjusted Rate ratios (95% CI)*
% Population living below poverty level	1.25 (1.21-1.29)	1.15 (1.12-1.18)
Areal proportion within 10 miles of mines	1.08 (1.01-1.08)	1.04 (1.03-1.05)
% Males	1.11 (1.02-1.21)	1.04 (0.98-1.11)
% Whites	0.98 (0.97-1.00)	0.99 (0.97-1.00)
% Rural	3.28 (2.22-4.84)	1.45 (1.04-2.01)

*Adjusted simultaneously for all variables in the table, and in addition to county-wise number of underground mines.

CWP & Mortality

- Determine whether Medicare beneficiaries with Coal workers' pneumoconiosis have a higher risk of mortality as compared to beneficiaries with other types of pneumoconiosis
- Determine the role of silicosis in mortality among Medicare beneficiaries


Elixhauser Comorbidities and Mortality by CWP
Weight Loss
Congestive Heart Failure
Metastatic Cancer
Lymphoma
Fluid and Electrolyte Disorders
Cardiac Arrhythmias
Renal Failure
Hypertension, Complicated
Deficiency Anemia
Valvular Disease
Pulmonary Circulation Disorders
Other Neurological Disorders
Hypothyroidism
Psychoses
Coagulopathy
Diabetes, Complicated
Peripheral Vascular Disorders
Liver Disease
Solid Tumor Without Metastasis
Blood Loss Anemia
Alcohol Abuse
Diabetes, Uncomplicated
Hypertension, Uncomplicated
Peptic Ulcer Disease Excluding Bleeding
Obesity
AIDS/HIV
Rheumatoid Arthritis/Collagen Vascular
Depression
0
2
4
6
8
10


Elixhauser Comorbidities and Mortality by CWP in Study States
Metastatic Cancer
Weight Loss
Congestive Heart Failure
Pulmonary Circulation Disorders
Cardiac Arrhythmias
Fluid and Electrolyte Disorders
Coagulopathy
Renal Failure
Other Neurological Disorders
Hypertension, Complicated
Paralysis
Psychoses
Deficiency Anemia
Solid Tumor Without Metastasis
Valvular Disease
Hypothyroidism
Alcohol Abuse
eumatoid Arthritis/Collagen Vascular
Liver Disease
Peripheral Vascular Disorders
c Ulcer Disease Excluding Bleeding
Diabetes, Complicated
Diabetes, Uncomplicated
Depression
Lymphoma
Obesity
Hypertension, Uncomplicated
Drug Abuse
0
2
4
6
8
10
Study States: KY, WV, VA, PA, OH, IN, IL

	Odds ratio of Mortality	
	All	**Study States[1]**
	Odds ratio (95% confidence interval)	**Odds ratio (95% confidence interval)**
Model 1: adjusted for age	1.20 (1.06-1.36)	1.32 (1.10-1.59)
Model 2: adjusted for age, race, sex	1.24 (1.09-1.41)	1.31 (1.09-1.57)
Model 3: adjusted for age, race, sex, comorbidities[2]	1.23(1.07-1.41)	1.35 (1.02-1.66)

[1] *KY, WV, VA, PA, OH, IN, IL*
[2] *Elixhauser comorbidities*

	All	Study Sites
CWP	1,668	1,020[1]
Silicosis	322	95
Other	6,701	1,498

[1] *KY, WV, VA, PA, OH, IN, IL*

	Odds ratio of Mortality Study States[1]	
	CWP	**Silicosis**
	Odds ratio (95% confidence interval)	**Odds ratio (95% confidence interval)**
Model 1: adjusted for age	1.35 (1.13-1.64)	1.46 (0.91-2.34)
Model 2: adjusted for age, race, sex	1.35 (1.12-1.62)	1.48 (0.92-2.36)
Model 3: adjusted for age, race, sex, comorbidities[2]	1.40 (1.14-1.73)	1.58 (0.95-2.62)

[1] KY, WV, VA, PA, OH, IN, IL
[2] Elixhauser comorbidities

Summary

- Ex-miners remains at risk of chronic diseases including COPD, hypertension, heart disease, psychological stress, and CWP.
- Miners have significantly elevated risk of death from heart disease, cancer, and unintentional injuries.
- Significant spatial clustering of CWP cases in Kentucky, Virginia, and West Virginia
- Significantly elevated prevalence rates of CWP in Appalachian counties
- County-level poverty rates, catchment areas, and rurality were significantly associated with CWP.
- Medicare beneficiaries with CWP & Silicosis have higher odds of mortality as compared to beneficiaries with other types of pneumoconiosis
- Risk of secondary exposure needs to be evaluated in future studies.

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Questions