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Patterns of Pneumoconiosis Mortality in Kentucky: Analysis of Death Certificate Data

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Background *Mortality rates associated with total pneumoconiosis, including coal worker's pneumoconiosis (CWP), have remained elevated.*
Methods *2003–2013 pneumoconiosis mortality data obtained from National Center for Health Statistics and 2011–2013 Kentucky death certificates were analyzed.*
Results *Total pneumoconiosis mortality rates showed significant linear decreases in West Virginia, Pennsylvania, Kentucky, and the U.S. from 2003 to 2013; Pennsylvania and Kentucky had comparable rates in 2003 but while Pennsylvania rates significantly decreased ~3.0 deaths/million annually, Kentucky rates decreased only 0.5/million annually. Kentucky and Pennsylvania CWP fatality rates were also comparable in 2003 but while Pennsylvania rates decreased 82% over the study period, Kentucky rates decreased only 26%. Kentucky pneumoconiosis deaths primarily occurred in white Appalachian males in-hospital. Diseases leading to pneumoconiosis death were largely respiratory and cardiovascular, with autopsies rarely performed.*
Conclusions *Coal worker environmental exposure protection should be enhanced and pneumoconiosis surveillance improvements, including enhanced management of comorbid conditions like COPD, should be considered.* Am. J. Ind. Med. 58:1075–1082, 2015. © 2015 Wiley Periodicals, Inc.

KEY WORDS: mortality rates; pneumoconiosis; coal worker's pneumoconiosis; comorbid conditions; autopsies

INTRODUCTION

Over the past three decades, overall US mortality rates of the occupational lung disease, pneumoconiosis, have decreased [Centers for Disease Control and Prevention, 2014]. Pneumoconiosis refers to a group of respiratory illnesses that are related to inhalation of mineral dusts and fibers. The primary types of pneumoconiosis are coal workers' pneumoconiosis resulting from inhalation of coal dust, silicosis from inhalation of crystalline silica, and asbestosis from inhalation of asbestos fibers. The description and classification of pneumoconiosis types for epidemiological studies and medical screening is based on the International Labor Organization [ILO, 2011] classification of radiographs of pneumoconioses. Clinically, pneumoconiosis may be hard to detect due to the long latency period between exposure and onset of illness. There are currently no options to cure individuals with pneumoconiosis and in severe cases that progress to chronic respiratory failure, lung transplantation may be the only curative treatment option [Hayes et al., 2012].

Geographically, elevated rates of pneumoconiosis have been observed in the regions of eastern Kentucky, western Virginia, southern West Virginia, and eastern Pennsylvania, relative to U.S. rates, and rates seen in other coal mining areas. Due to the coal mining workforce in Kentucky, employing over 11,000 individuals, primarily in the Eastern

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and Western Kentucky coal fields, most pneumoconiosis in Kentucky is coal worker pneumoconiosis (CWP) or "black lung disease" [Wang et al., 2013]. CWP in Kentucky has been linked to mine size, with employees in small mines having a 2.1 times higher prevalence of CWP and 37% higher prevalence of abnormal spirometry when compared to those in large mines. Additionally, progressive massive fibrosis (PMF), a severe fatal form of CWP, is seen in 2.4% of small mine miners compared to 1.1% of large mine miners [Blackley et al., 2014].

The prevalence of pneumoconiosis in Appalachian regions has been increasing in recent years, despite stringent regulations following the 1969 Federal Coal Mine Safety and Health Act. PMF was nearly eradicated in coal mines only 15 years ago with a prevalence of only 0.08% for those who participated in the Coal Worker Health Surveillance Program (CWHSP). However, in Appalachian miners, the prevalence of PMF reached 3.23% in 2012 [Blackley et al., 2014], reflecting the need for additional efforts in order to adequately protect Kentucky coal miners. There has not only been an increase in prevalence, but also in the severity of pneumoconiosis for younger miners with less cumulative exposure. In a study done on underground coal miners from 2005 to 2009, when compared to 12 other states, miners in Kentucky, Virginia, and West Virginia, had a greater risk of advanced CWP (RR = 8.1), progressive massive fibrosis (RR = 10.5), and r-type opacities(RR = 7.7), in younger miners with less mining tenure [Laney et al., 2012].

In addition to the relationship between coal mining and pneumoconiosis, exposures in mines may be related to a number of non-malignant respiratory diseases such as chronic bronchitis, emphysema, and chronic airway obstruction [Petsonk et al., 2013]. A 23 year follow-up study of 8,899 working coal miners showed elevated mortality from nonmalignant respiratory diseases, even among miners who did not smoke. However, there were not excess mortalities associated with lung and stomach cancers. While lung cancer rates were not elevated, there may have been other factors making lung cancer harder to detect in this population [Attfield and Kuempel, 2008]. This is in contrast to a German study of coal miners which showed an increase in stomach cancer related to coal worker pneumoconiosis [Morfeld et al., 1997]. Pneumoconiosis may also exacerbate symptoms in those who have COPD. A study published in *La Clinica Terapeutic* found that patients admitted to the hospital with acute exacerbation of COPD (AECOPD) who also had complicated CWP had significantly longer hospitalizations [Ornek et al., 2013]. Because of the relationship between coal mining and a number of other respiratory and non-respiratory ailments, CWP may play a role in the onset, severity, progression, and subsequent health outcomes of other diseases from exposure in mines.

Due to the severity of the disease and the health burden on states like Kentucky, the Coal Workers' Health Surveillance Program, a surveillance program under the National Institute for Occupational Safety and Health (NIOSH), recently expanded (2014) to cover surface miners, in addition to underground coal miners. This expansion came as a result of the Mine Safety and Health Administration's (MSHA) final ruling on exposure to coal dust, which also resulted in lowering coal dust standards [Mine Safety and Health Administration, 2014].

This study has two parts. The first part is a trend analysis of Kentucky total pneumoconiosis and CWP mortality rates compared to overall U.S. and other coal mining state rates to better understand the total health burden and public health implications of pneumoconiosis. The second part is a three-year descriptive analysis (years 2011–2013) with four objectives: (1) identification of demographic characteristics of Kentucky resident pneumoconiosis deaths; (2) identification of comorbid conditions when pneumoconiosis was listed as the underlying or contributing disease of death; (3) identification of death certifier type, autopsy performance and location of death; and (4) comparison of pneumoconiosis mortality between Kentucky Appalachian and non-Appalachian coal mining regions.

METHODS

Trend Analysis Methods

Data for Kentucky, West Virginia, Pennsylvania, and U.S. pneumoconiosis mortality, 2003–2013, were obtained from the National Center for Health Statistics' Multiple Cause of Death files, available from CDC's Wide-ranging Online Data for Epidemiologic Research (WONDER) online query system [CDC WONDER, 2015]. The Multiple Cause of Death data are based on death certificates for U.S. citizens filed in the fifty states and the District of Columbia. All death certificates in the U.S. have a single underlying cause of death (UCOD) and up to 20 additional contributing causes (multiple causes) of death, coded according to the guidelines of the Tenth Revision of the International Classification of Disease (ICD-10) for standardized classification and grouping [World Health Organization, 2010]. The World Health Organization defines the underlying cause of death as the disease responsible for initiating the events preceding death or the circumstances directly involved in the outcome of the fatal injury. For the purpose of this study, the following ICD-10 codes were utilized for case selection as an underlying or a contributing cause of death: J60 (coal workers' pneumoconiosis), J61 (pneumoconiosis due to asbestosis and other mineral fibers), J62 (pneumoconiosis due to dust containing silica), J63 (Pneumoconiosis due to other inorganic dusts), J64 (Unspecified pneumoconiosis), J65 (Pneumoconiosis associated with tuberculosis), J66

(Airway disease due to specific organic dust). "Total pneumoconiosis" was defined as a death with an underlying or a contributing cause of death in the range J60-J66 [Council of State and Territorial Epidemiologists, 2014]. Age-adjusted mortality rates for 15 years of age and older residents of Kentucky, West Virginia, Pennsylvania, and the U.S., 2003–2013 were calculated. Trends in Kentucky rates were compared to West Virginia and Pennsylvania, two of the other top coal producing states in this region of the country, as well as to the overall U.S. rates. A trend analysis utilizing a least-square method was performed in Microsoft Excel to determine the significance of the changes in pneumoconiosis rates over the study period. Statistical significance was determined at a level of significance at 0.05. R-squared was used to check the goodness of fit.

Descriptive Analysis of 2011–2013 Kentucky Pneumoconiosis Deaths

A retrospective analysis of deaths from or with pneumoconiosis was performed over a 3 year period, from 2011 to 2013, using Kentucky Office of Vital Statistics death certificate data for Kentucky residents, 15 years of age or older. Electronic death certificate data were provided by the Kentucky Cabinet for Health and Family Services, Office of Vital Statistics. The Kentucky Office of Vital Statistics death certificate records are a subset of the NCHS multiple causes of death files and represent death certificates for Kentucky residents and out-of-state residents who died in Kentucky. Each death certificate record contains all the information listed on the actual death certificate, supplemented by the ICD-10 underlying and multiple causes of death codes that were assigned by the NCHS coding process. We identified the Kentucky residents who had died with some form of pneumoconiosis during the study period as indicated by the underlying or multiple cause of death associated with the death certificate (ICD-10 underlying or multiple causes of death in the range J60-J66).

Relevant information from the electronic death certificate records was used for descriptive analysis by gender, race, and industry that the individual worked in. Additionally, death certificate information included whether a physician or a coroner certified the death as well as whether a subsequent autopsy was performed. Frequencies and rates of pneumoconiosis deaths were calculated by region of residency (Appalachian *vs*. non-Appalachian Kentucky regions). According to the Appalachian Regional Commission's classification, 54 Eastern Kentucky counties are part of the Central Appalachian Region (Appalachian Regional Commission, 2015). Average ages at time of death from total pneumoconiosis and from CWP were compared between Appalachian and non-Appalachian regions using a two-sample t-test. A least-square regression analysis was performed to determine the significance of the changes in the average age at death over the study period.

North American Industry Classification System (NAICS) codes were used to identify industries. Mining refers to all deaths related to Metal Mining, Coal Mining, Oil and Gas Extraction, and Mining and Quarrying of Nonmetallic Minerals, Except Fuels. Frequencies of deaths for "All Other industries" included: Agriculture, Forestry, & Fishing, Construction, Manufacturing, Transportation, Communication, Electric, Gas & Sanitary Services, Wholesale Trade, Retail Trade, Finance, Insurance & Real Estate, Services, and Public Administration.

This study was performed at the Kentucky Injury Prevention and Research Center (KIPRC), a joint entity between the University of Kentucky, College of Public Health and the Kentucky Department for Public Health. This study was part of the Kentucky Occupational Safety and Health Surveillance program, and was approved by the University of Kentucky Institutional Review Board.

RESULTS

Historical Trends in Mortality Rates From or Due to Pneumoconiosis, 2003–2013

Table I shows the age-adjusted rates for total pneumoconiosis deaths for residents of Kentucky, West Virginia, Pennsylvania, and the U.S., who were 15 years of age or older at the time of the death, 2003–2013. Total pneumoconiosis age-adjusted mortality rates showed significant linear decreases in West Virginia (P-value < 0.0001), Pennsylvania (P-value < 0.0001), Kentucky ($P = .01$), and the U.S. (P-value < 0.0001) from 2003 to 2013 (Fig. 1). The total pneumoconiosis fatality rate in West Virginia decreased from 132 deaths/million residents in 2003 to 68.3/million in 2013, a 48% decrease, but still more than 10 times above the 2013 U.S. total pneumoconiosis mortality rate of 6.8/1 million. The average annual decrease in West Virginia was 6 deaths per 1 million residents over the study period. Pennsylvania and Kentucky had comparable total pneumoconiosis mortality rates in 2003 at 36.3/1million in Kentucky and 37.2/1million in Pennsylvania. The Pennsylvania total pneumoconiosis age-adjusted fatality rate significantly decreased approximately 3 deaths per million residents annually over the study period while Kentucky rates decreased only 0.5/ 1 million annually over the study period.

Similar results were observed for CWP age-adjusted mortality rates (Fig. 2). From 2003 to 2013, there was a significant linear decrease in West Virginia ($P < 0.0001$, $R^2 = 0.89$), Pennsylvania ($P < 0.0001$, $R^2 = 0.93$), Kentucky ($P < 0.04$, $R^2 = 0.39$), and the U.S. ($P < 0.0001$, $R^2 = 0.95$).

TABLE I. Age-Adjusted Pneumoconiosis and CWP Mortality Rates in Kentucky, West Virginia, Pennsylvania, and US, 2003–2013, Ages 15 and Over

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kentucky											
Pneumoconiosis[a]	36.3	35	34.6	33.2	29.7	26.3	26.2	27.8	31.9	29.1	28.4
CWP[a]	26.9	23.3	24.2	23.8	19.7	19.7	19.3	21.2	22.4	22.4	19.9
West Virginia											
Pneumoconiosis[a]	132	124	118	121	99.7	104	96.8	90.8	80.6	68.7	68.3
CWP[a]	84.4	79.8	62.7	81.3	63.9	59.7	55	50	41	33	37.3
Pennsylvania											
Pneumoconiosis[a]	37.2	34.1	25.8	25.4	20.3	20.7	16.4	14.3	13.9	12.4	11.1
CWP[a]	23.4	20.2	15.2	15.3	10.8	8.9	8.4	7.3	6.1	4.3	4.1
United States											
Pneumoconiosis[a]	11.6	11	10.4	9.7	9.1	8.8	8	8	7.2	6.8	6.8
CWP[a]	3.4	3.1	2.8	2.8	2.2	1.9	1.9	1.9	1.6	1.4	1.3

[a]Age-adjusted mortality rates per 1 million residents, ages 15 and over.

The CWP rate in West Virginia decreased from 84.4/million in 2003 to 37.3/million in 2013, a 56% decrease over the 11-year period, but still higher than Kentucky, Pennsylvania, and overall U.S. rates. Similar to total pneumoconiosis fatality rates, CWP fatality rates were comparable in Kentucky and Pennsylvania in 2003 (26.9/million and 23.4/million, respectively) but Pennsylvania rates decreased 82% over the study period while Kentucky rates decreased only 26% (Table I). Resident CWP death numbers significantly decreased approximately 5 per million residents in West Virginia and by 2 per million in Pennsylvania, annually. In contrast, Kentucky CWP rates showed an average annual decrease of less than 1 CWP death per 1 million residents.

Descriptive Analysis of 2011–2013 Kentucky Pneumoconiosis Deaths

Demographics and number of deaths

The Kentucky Office of Vital Statistics files identified 330 Kentucky residents who died from or due to pneumoconiosis from 2011 to 2013. There were 125 deaths where pneumoconiosis was listed as the underlying disease associated with the death, including 85 CWP, 9 asbestosis, 5 silicosis, and 26 unspecified pneumoconiosis (data not shown). There were a total of 237 death certificates for Kentucky residents listing specifically death from or due to CWP, 33 from or due to asbestosis, 7 from or due to silicosis, less than 5 due to other inorganic or organic dust, and the remaining were unspecified pneumoconiosis deaths (data not shown). Nearly all of the pneumoconiosis deaths were in males (98%); almost all deceased were white (99%) (data not shown). The average age at death from pneumoconiosis in Kentucky significantly decreased from 2011 to 2012 then remained the same in 2013 (P-value = 0.035) (Table II). Mining was most frequently listed as the industry associated with death (78%) compared to all other industries listed on the death certificates (22%).

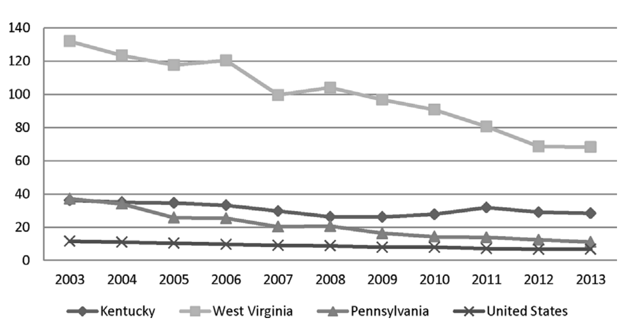

FIGURE 1. Total pneumoconiosis mortality rates in WV, PA, and US, 2003–2011, and in KY, 2003–2013.

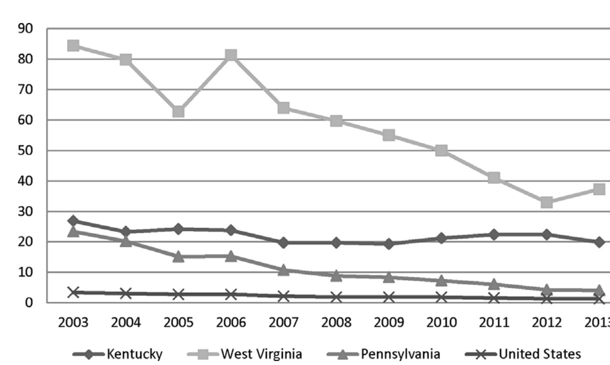

FIGURE 2. Coal worker's pneumoconiosis mortality rates in KY, 2003–2013, and in WV, PA, and US, 2003–2013.

TABLE II. Kentucky Residents Pneumoconiosis Deaths by Demographic Characteristics, 2011–2013, Ages 15 and Over

	2011	2012	2013
Total Pneumoconiosis			
Number of Deaths[a]	114	108	108
Coal Workers Pneumoconiosis			
Number of Deaths[b]	79	83	75
Average Age at Death from Pneumoconiosis (years)			
Kentucky	76.9	73.9	73.8
Appalachian Region	75.7	73.5	73.9
Non-Appalachian Region	80.8	77.3	73.6
Average Age at Death from CWP (years)			
Kentucky	76.1	74.2	74.2
Appalachian Region	75.5	73.6	74.4
Non-Appalachian Region	78.9	83.8	73.4
Pneumoconiosis Deaths (Rates) by Region[c]			
Appalachian	87(90.2)	97(100.9)	84(87.4)
Non-Appalachian	27(10.6)	11(4.3)	24(9.3)
Coal Workers Pneumoconiosis Deaths (Rates) by Region[c]			
Appalachian	66(68.4)	78(81.1)	61(63.5)
Non-Appalachian	13(5.1)	5(1.9)	14(5.4)
Industry Numbers (%)			
Mining	90(79%)	92(85%)	75(69%)
All other	24(21%)	16(15%)	33(31%)

[a]Kentucky Office of Vital Statistics death certificate files were missing data for 9 of the 339 Kentucky residents who died from or due to pneumoconiosis according to NCHS Multiple Cause of Death data, 2011–2013; Kentucky Office of Vital Statistic death certificate files for 2011–2013 are considered provisional and subject to change.
[b]Kentucky Office of Vital Statistics death certificate files were missing data for 8 of the 245 Kentucky residents who died from or due to CWP according to NCHS Multiple Cause of Death data, 2011-2013; Kentucky Office of Vital Statistic death certificate files for 2011–2013 are considered provisional and subject to change.
[c]Crude death rates were calculated as number of pneumoconiosis deaths per 1 million residents 15 years of age or older; rates based on less than 20 deaths are considered unreliable and should be interpreted with caution.

Appalachian versus non-Appalachian

The Appalachian areas of Kentucky experienced a greater number of deaths (268 of the 330 pneumoconiosis deaths, 2011–2013) and higher crude mortality rates due to pneumoconiosis than the non-Appalachian region of the state (Table II). Additionally, deaths from CWP were greater in the Appalachian region, accounting for 205 of the 237 CWP deaths, 2011–2013. Appalachian region had significantly higher mortality rates from total pneumoconiosis and from CWP than the non-Appalachian region of the state. The 2013 crude mortality rates from pneumoconiosis and CWP were 87.4/1million and 63.5/1million, respectively, for Appalachia, compared to 9.3/1million and 5.4/1million for non-Appalachia. The number of deaths from asbestosis over the three year period was similar between Appalachia and non-Appalachia, with 18 and 15 deaths, respectively but the Kentucky non-Appalachian region has population 3 times the population of the Appalachian region. There were less than five deaths from silicosis in the non-Appalachian region and 6 silicosis deaths in Appalachian Kentucky during the study period.

The average age of death from or with pneumoconiosis in Appalachian region in 2011 was 75.7 years, significantly lower (P-value = 0.0365) than the average age of 80.8 years in the non-Appalachian region, but the difference disappeared by 2013 when the average ages were 73.9 years in the Appalachian region and 73.6 years in the non-Appalachian region (P-value = 0.9029) (Table II). No significant difference in the average age of death from CWP was found between Appalachian and non-Appalachian regions for any of the three years of the study. The average age for CWP deaths was 74.5 years in the Appalachian region vs. 78.7 years in the non-Appalachian region for years 2011-2013 (P-value = 0.1823).

Causes of death due to pneumoconiosis

Of the 125 deaths where pneumoconiosis was considered the underlying cause of death, the immediate cause of death was primarily due to respiratory diseases; specifically, respiratory failure (46), COPD (42), pneumoconiosis (22), CWP (12), and pneumonia (26) (Fig. 3). There were 23 deaths where the immediate cause of death involved the

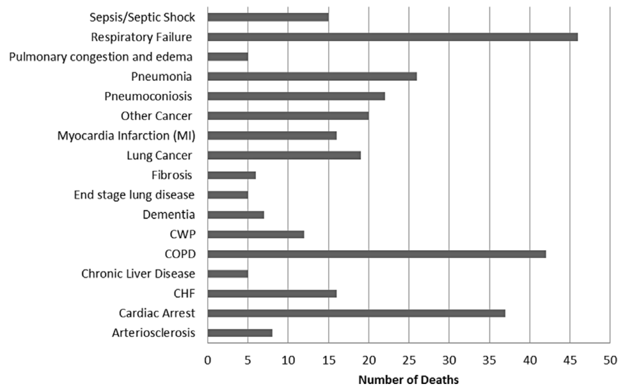

FIGURE 3. Immediate cause of death when pneumoconiosis was the underlying or contributing disease in Kentucky, 2011–2013.

heart. Of the 330 total cases where pneumoconiosis was an underlying or contributing cause of death, the immediate cause of death was largely due to respiratory conditions, with 46 deaths from respiratory failure and 42 from COPD. However, there were also a large proportion of heart-related deaths, with 37 from cardiac arrest, as well as various forms of cancer (39), specifically lung cancer (19), listed as the immediate cause of death.

Location of death, autopsies performed, and certifier of death

The percentage of pneumoconiosis deaths in hospital decreased every year from 2011 to 2013. The second most common location of death was the patient's residence (36%), which slightly increased from 2011 to 2013 (Table III). The percentage of pneumoconiosis patients who died in a nursing home/ long-term care facility was 8% in 2013. A physician certified the pneumoconiosis death 84% of the time. This proportion stayed relatively the same over the 3 year period. In the majority of the cases, those who certified the death did not perform an autopsy over the 3 year period. Autopsies to confirm the suspected cause or causes of death were performed on 12% of the decedents in Kentucky over the three year period (Fig. 4).

TABLE III. Location of Pneumoconiosis Deaths in Kentucky, 2011–2013

	2011[a]	2012[a]	2013[a]	Avg
Location				
In-Patient	62(54%)	53(49%)	42(39%)	52.3(47%)
Residence	37(33%)	42(39%)	41(38%)	40.0(36%)
Nursing Home/ Long-term Care	b	b	9(8%)	5.7(5%)
ED/Outpatient	5(4%)	b	6(6%)	b
Hospice	b	5(5%)	b	b
Other	b	b	c	b

[a]Kentucky death certificate data for years 2011–2013 are considered provisional and subject to change.
[b]Numbers <5 were suppressed according to state data management policy.
[c]Number was suppressed to conform to state data management policy so that small numbers <5 cannot be determined.

DISCUSSION

Pneumoconiosis white male demographic results are similar to previous findings by Attfield and Kuempel [2008] and Wang et al. [2013] pertaining to race and gender most affected by pneumoconiosis. The average age of death due to pneumoconiosis significantly decreased from 2011 to 2012 in Kentucky then remained the same in 2013. This result may suggest that workers are being diagnosed with severe forms of pneumoconiosis at younger ages, and young miners with less mining tenure may be at heightened risk for the development of pneumoconiosis [Laney et al., 2012].

Of all deaths associated with pneumoconiosis, CWP was the most frequent cause among decedents in Kentucky. However, it is important to note that, while the number of silicosis deaths from 2011 to 2013 only averaged 2.33 deaths per year in Kentucky, a number of deaths from crystalline silica exposure may have been miscategorized as coal workers' pneumoconiosis or other respiratory diseases, or could have been undercounted. There is evidence that silicosis and asbestosis may be underestimated in high-risk non-mining occupations [Goodwin et al., 2003].

West Virginia and Pennsylvania showed significant linears decreases ($P < 0.05$) in mortality rates from 2003 to 2013. Kentucky rates also decreased over the study period but at a much slower rate (less than 1 death per 1 mill residents annually). This is despite increases in disease surveillance and safety regulations in the last couple of decades, as well as a declining coal mining workforce in Kentucky, with a reported 15.5% decrease in Kentucky coal

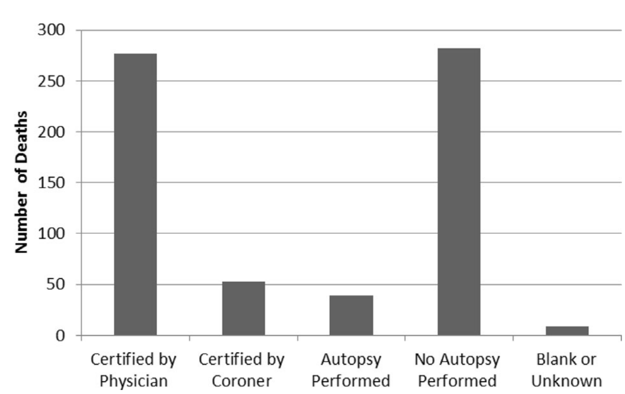

FIGURE 4. Autopsies performed and certification of pneumoconiosis deaths in Kentucky, 2011–2013.

mining jobs in 2013 alone [Patrick et al., 2014]. The slower rate of decrease in Kentucky total pneumoconiosis deaths may be a reflection of increased employment in the coal mining industry a few decades ago since there is a long lag time between industrial exposure and a pneumoconiosis diagnosis. The slower rate of decrease could also be due to the more recent mining of thinner coal seams in Kentucky that contain more rock intrusions that may increase exposure to silica. Third, regulatory coal dust standards were not as stringent a couple of decades ago. The coal dust standard was recently lowered from 2.0 mg per cubic meter to 1.5, and more research studies are needed in the future to determine if the lower exposure standard will reduce the prevalence and mortality from CWP.

Identifying the immediate medical cause of death with pneumoconiosis as an underlying or contributing disease is important for a number of reasons. Pneumoconiosis may increase the risk or exacerbate other respiratory diseases, heart diseases, and certain forms of cancer [Morfeld et al., 1997; Petsonk et al., 2013]. Respiratory failure was the most frequent immediate cause of death with pneumoconiosis as an underlying disease or contributing disease. A focus on prevention of respiratory failure, like noninvasive ventilation in patients with pneumoconiosis, may be an important factor in preventing respiratory health complications or death [Nava et al., 2005]. We also found that individuals who were diagnosed with pneumoconiosis frequently died of COPD. Although the association between COPD and pneumoconiosis is unclear [Meijers et al., 1997], there is a known association between exposure to coal dust and COPD [Santo Tomas, 2011]. Prevention of respiratory failure may be especially important for individuals who died at home (36%).

When pneumoconiosis was a contributing disease, individuals died of heart-related causes 23% of the time. While our study was not designed to determine an association between pneumoconiosis and death from heart disease, a study by Landen and Wassell [2011] found an association between mortality from ischemic heart disease in individuals with CWP. Our study results may signify the need for close heart function monitoring in patients with pneumoconiosis. Cancer (all forms) was the immediate cause of death in 12% of the cases, with lung cancer being the most common type, when pneumoconiosis was a contributing disease. A positive causal relationship was found between diffuse interstitial fibrosis (DIF), which is caused by pneumoconiosis, and lung cancer [Katabami et al., 2000]. Healthcare providers who have observed significant DIF in patients with pneumoconiosis should routinely monitor these patients for early detection of lung cancer. In addition, lung cancer concerns for miners should not be limited only to miners who regularly smoke. Coal dust and crystalline silica exposure in miners may be associated with an increased risk of mortality from lung cancer, even in miners who don't smoke [Graber et al., 2014].

Autopsies were performed on 12% of the individuals who died from or with pneumoconiosis between 2011 and 2013, higher than the 5% average autopsy percentage in the total general population in Kentucky. Autopsies can confirm or refute previous diagnoses, or lead to new diagnoses or previously unknown causes of death. For a disease like silicosis that has historically been misclassified [Goodwin et al., 2003], increased performance of autopsies on pneumoconiosis deaths may be important in identifying specific forms of pneumoconiosis diseases and preventing undercounting of silicosis mortality cases. While we were unable to determine if the different forms of pneumoconiosis have been adequately identified or undercounted in this study of pneumoconiosis mortality cases, performing autopsies on all pneumoconiosis cases may help determine if mortality rates for certain forms of pneumoconiosis such as silicosis are underreported.

Limitations

As is the case with any study involving death certificates, there are a number of limitations. First, clinicians may not list all of the individual's ailments on the death certificate. If pneumoconiosis was a contributing disease but the individual died of causes that the clinician believed were not associated with this particular disease, this may not be included, which could cause deaths from or with pneumoconiosis to be underreported. Death certificate data depends on correct diagnosis of a particular ailment. Because pneumoconiosis has such a long latency period between exposure and onset of illness, death could be attributed to a number of other more common respiratory conditions, potentially causing underreporting of pneumoconiosis. This could especially be the case for an individual who worked in a coal mine early on in their adult life and then retired in a different industry. Misclassification of ICD-10 diagnosis codes may also be a limiting factor.

CONCLUSIONS

Despite the overall negative trend for pneumoconiosis mortality in Kentucky and the U.S., there is a continued need for pneumoconiosis prevention efforts with improved workplace safety programs to prevent exposure to inorganic dusts known to cause pneumoconiosis in Appalachian states such as Kentucky, West Virginia, and Pennsylvania. Although the respirable coal dust standards were recently lowered by MSHA, it is still unknown if this change will be an effective approach to a re-emerging problem. While lowering the coal dust standards is a step in the right direction, it will also require complete compliance of the coal industry, as well as ensuring active participation by employees in federal disease surveillance programs to detect pneumoconiosis symptoms early and avoid fatal disease progression. Kentucky should ensure that healthcare providers are properly educated on pneumoconiosis and related diseases in order to accurately diagnose and treat symptoms, especially for those with co-morbid conditions. Mortality numbers and rates provide a snapshot of pneumoconiosis in Kentucky but other state-based data sources that assess morbidity (e.g., emergency department visits, inpatient hospitalizations) will be useful for pneumoconiosis surveillance, along with federal surveillance programs like the CWHSP. Continued pneumoconiosis trend analyses are needed to determine if the burden of pneumoconiosis will be further reduced in the next several years.

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