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Original Research

Cancer mortality rates in Appalachian mountaintop coal mining areas

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Abstract

Background: Mountaintop coal mining is associated with greater levels of environmental disturbance compared to other mining types, and with significant health disparities. We examined the association between cancer mortality rates in three types of counties in central Appalachia: those with mountaintop coal mining (MTM), those with other surface or underground mining, and those with no coal mining.

Methods: Linear regression was used to conduct county-level analyses to determine the association between age-adjusted cancer mortality rates and MTM mining for two periods of time: 1999-2002 and 2003-2007. County-level covariates included smoking, health care access, adult obesity, poverty, and education.

Results: Mortality rates for leukemia and for lung, colon, and bladder cancer in MTM counties were significantly greater than those in non-mining areas in 2003-2007 (lung cancer mortality rates were also significantly greater than non-mining areas in 1999-2002). Kidney cancer mortality rates in MTM areas were marginally significantly greater ($p < .06$) than those in non-mining counties in 2003-2007.

Conclusions: Mortality rates from lung, colon, bladder, and kidney cancer and leukemia are significantly associated with MTM mining areas (vs. non-mining counties) in 2003-2007. Results may indicate either that exposures to water and air pollutants from MTM activity have accumulated, or that contamination in MTM counties may have worsened in more recent years in conjunction with increases in the extent of this activity.

INTRODUCTION

This paper examines the association between age-adjusted cancer mortality rates and mountaintop coal mining (MTM) in Central Appalachia, an area noted for both socioeconomic disparities as well as excess morbidity and mortality rates [1]. Appalachia is the largely rural, mountainous region of the eastern United States that extends from southern New York to northeastern Mississippi. Appalachia is the only area of the United States with MTM, a form of surface mining used in steep terrain that removes forests and uses explosives to remove rock and soil above and between coal seams. The rubble from this process is dumped into adjacent valleys that often contain headwater streams. MTM is widespread in Central Appalachia in portions of West Virginia, Kentucky, Virginia and Tennessee [2]. MTM acreage has increased from 77,000 acres in 1985 to 272,000 acres in 2005, a 250 percent increase [3]. MTM creates large-scale impairment of surface water and groundwater and significant disturbances in local air quality [4-8]. The Environmental Protection Agency (EPA) estimates that 816,000 acres of largely forested land has been directly impacted by MTM over the years 1992-2012 [2].

MTM is distinct from other forms of surface or underground mining in its environmental impacts. Mountaintop mining requires the use of explosives containing ammonium-nitrate and diesel fuel, and results in the release of coal dust and fly rock containing sulfur compounds, fine particulates with metals, and nitrogen dioxide [6,9]. Evidence indicates elevated levels of respirable ambient particulate matter, sulfur dioxide, nitrous oxide, benzene, carbon monoxide, and polycyclic aromatic hydrocarbons in areas proximate to coal extraction, processing and transportation [9,10]. Recent studies of health outcomes in these coal-mining areas indicate elevated levels of respiratory and cardiovascular chronic disease in Appalachian coal-mining communities [11,13].

Dumping excess rock and soil into adjacent valleys results in greater impairment of surface and ground water than other mining forms [4]. Thousands of miles of streams are buried from the dumping of rubble in valley fills. Water emerging from the base of these fills contains elevated levels of sulfates and some metals compared to reference streams [5]. Ground water in mining areas has elevated levels of sulfate, calcium, magnesium, bicarbonate ions, selenium, arsenic, and hydrogen sulfide compared to non-mined areas [4,5,14-17]. Additional water contamination occurs as a result of the coal washing process, which uses chemical formulas containing surfactants, flocculants and other agents to prepare coal for use in combustion. The result of this process is the creation of slurry that is stored in surface ponds that can leach into ground water, or is injected underground into old mining spaces. Drinking water from domestic wells in coal mining areas has been shown to have levels of arsenic [16,17], thallium, selenium, cadmium, beryllium, barium, antimony, and lead [17] at levels that pose human health concerns.

Air and water pollutants that result from MTM include some that are known or possible carcinogens. Arsenic in water is a risk for lung, bladder, kidney, liver, and skin cancer [18-21]. Radon is associated with an increased risk of lung cancer [18,19]. Air pollution is a risk factor for lung cancer [18, 22-24] and perhaps for other cancers; however, the exact pollutants and cancers are not well-understood [18]. Cancers other than lung cancer that result from air pollution show mixed effects; but some effects have been seen for leukemia, and for cancers of the bladder, uterus, prostate, colon, stomach, and esophagus [18-20]. Cadmium exposure has been associated with risk of kidney cancer [25-26] as well as lung cancer. Nickel, beryllium, and chromium VI are linked to lung cancer [20]. Iron and selenium have been found to be higher in polyp vs. control tissue [27]. Diesel exhaust may increase the risk of bladder cancer [28]. Multiple studies point to a correlation between benzene exposure and breast and leukemia cancer risks [29-32].

Evidence regarding the health of coal-mining communities indicates elevated levels of chronic disease and mortality rates for adults residing in these communities compared to non-mining communities [11-13,33,34]. A recent study found elevated risk of low-birth-weight deliveries in coal-mining communities [35]. These studies have examined mining without regard to whether the mining was MTM or other types. (Other types of mining include underground mining and surface mining that do not involve the use of explosives or stream destruction to the extent that MTM does.) A more recent study found significantly higher birth-defect prevalence rates specifically in MTM areas vs. non-mining areas for six of seven defect categories [36], and other studies have shown higher rates of cardiovascular disease mortality [37], and lower health-related quality of life, specifically in MTM settings [38]. Finally, a recent survey of adults in two West Virginia communities, one proximate to MTM activity and the other in a non-mining area, found significantly higher self-reported cancer rates in the MTM community after controlling for age, sex, smoking, occupational history, and family cancer history [39].

This study extends current research comparing mortality rates for 23 types of cancers in MTM vs. non-mining counties in the four states that comprise central Appalachia for two time periods: 1999 through 2002, and 2003 through 2007. Given 1) epidemiological evidence on health problems in MTM areas; 2) evidence of water and air disturbance resulting specifically from MTM compared to other surface and underground mining; and 3) evidence that pollutants from coal extraction and processing include known or possible carcinogens, we hypothesize that cancer mortality rates in Appalachia will be greater in MTM areas relative to other mining areas and to non-mining areas after controlling for other risk factors. Because of the temporal delay that would take place between exposure and cancer mortality, and because MTM activity became widespread only in the mid to late 1990s [3], we also hypothesize that MTM-related mortality effects will be stronger in the more recent time period compared to the older period. New contributions of the current study over previous research include the comparison of early versus late time periods, the focus on MTM rather than coal mining in general, and the inclusion of multiple cancer types.

MATERIALS AND METHODS

Design

We conducted a retrospective, county-level ecological analysis of secondary data to examine age-adjusted cancer mortality rates from 1999-2007 for all counties in the four states where MTM activity occurs, including Kentucky, Tennessee, Virginia, and West Virginia (Figure 1). These four states include counties that are designated as Appalachian as well as counties outside the Appalachian region. All MTM occurs within Appalachia, but Appalachia also includes other counties with other mining types, and counties with no mining. Counties with MTM were compared to counties with other forms of coal mining, and to counties with no mining. Independent variables included health risks (detailed below) and residential location in mountaintop mining, other mining, or non-mining county. Analyses divide the time period into earlier (1999-2002) and later (2003-2007) intervals to examine whether cancer-MTM relationships were stronger in the later period than in the earlier period.

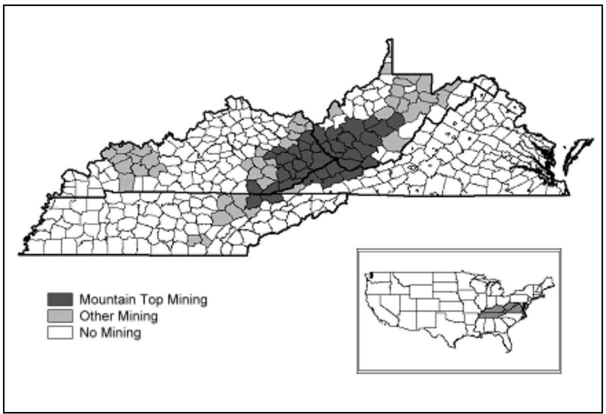

Figure 1. Coal mining areas in Central Appalachian states, 1999-2007

Data

Data on county-level cancer mortality rates were obtained from the Centers for Disease Control and Prevention's (CDC) ICD 10-113 diagnostic groups. Mortality rates reflect deaths in the county of residence, are expressed per 100,000 population and are age-adjusted using the 2000 US standard population [40]. Annual age-adjusted rates were found for the period 1999-2007, which corresponds to the period of time available at the time of data retrieval from the CDC website in which ICD-10 codes were used.

Cancer rates were examined separately for all of the diagnostic groups reported. Table 1 lists the code numbers and diagnostic groups studied, and the age-adjusted mortality rates for the three county groups (MTM, other coal mining, and non-mining).

We developed three coal-mining dichotomous variables to classify each county based on the presence and type of mining: MTM county, other mining county, or non-mining county. MTM is defined as a surface mining site crossing a ridge or mountain peak, and either a) spanning a minimum of 210 acres including 40 acres of removed ridge top, or b) spanning 40 to 320 acres and containing a minimum of 10 to 40 acres of ridge top.[3] To determine MTM areas, county-level coal mining tonnage production data from the Department of Energy, Energy Information Administration (EIA) [41] were overlaid on a map of surface mining areas in central Appalachia based on satellite imagery last updated in 2005 [3]. A county was classified as an MTM county if the county met the above criteria at any point over the study period. Other mining counties were those that contained other surface or underground coal mining but not MTM, and counties with no mining was the referent variable. These designations were based on mining activity that occurred for 1999-2007.

Data from the 2006 Area Resource File and other sources were used to measure covariates. Variables included the county smoking rate; county metropolitan vs. non-metropolitan status; percent male population; the number of active, non-federal primary care physicians per 1,000 population; the adult obesity rate; percent of the population below the federal poverty level; percent of the population who were African American, Native American, and Hispanic; and percent of adults with college or higher education. Poverty rate was the average of the years 2000-2002. Smoking prevalence in each county was obtained from Behavioral Risk Factor Surveillance System (BRFSS) data based on surveys conducted in 2003 and 2006, supplemented with additional county estimates based on review of state public health department websites. Adult obesity rates for each county were taken from the US Department of Agriculture (USDA) Food Atlas, which in turn is based on BRFSS survey and US Census estimates for the years 2006-2008. Rural-urban continuum codes from the USDA were used to categorize counties into metropolitan (codes 1-3) or non-metropolitan (codes 4-9) areas based on 2003 designations. Other indicators (gender, per capita physicians, racial/ethnic variables, and education) were from the 2000 US Census. These variables were selected to represent competing cancer risks; for example,smoking and obesity are well-established as cancer risks, and cancer mortality rates are higher among men than women.

Analysis

Age-adjusted cancer mortality rates were linked with mining data and covariates at the county level. Descriptive summaries of study variables were found, distributional characteristics of variables were examined, and bivariate correlations were calculated to examine the data for multicollinearity. Total age-adjusted cancer mortality rates were found for each year and each mining type. Age-adjusted mortality rates for each cancer type were statistically compared across mining groups before controlling for other risks, and again with other risks controlled. The risk variables themselves were also statistically compared across the mining groups. Group means were tested using F-tests with post-hoc corrections for Type I error.

Linear regression analyses were used to determine the association of age-adjusted cancer mortality rates with the two primary coal mining dichotomous variables (MTM [yes or no]; other mining [yes or no]), with non-mining counties as the referent, controlling for other risk variables. Regression models were run separately for each cancer type and for earlier versus later years. The early years included 1999-2002, and the later years included 2003-2007. Statistical Analysis Software (SAS) version 9.2 was used for all analyses. Statistical significance is set at p<0.05, although findings that are marginally significant at p<0.1 are also included.

RESULTS

There were a total of 403 counties with complete data for the study. Of these, 321 were non-mining, 45 had coal mining but not mountaintop mining, and 37 had mountaintop mining.

Table 1 shows age-adjusted cancer mortality rates per 100,000 population in Kentucky, Tennessee, Virginia, and West Virginia for the combined years 1999-2007. Rates are presented in Table 1 separately for the three county groups, and are age-adjusted but not yet adjusted for other variables. The following cancer types were significantly higher in MTM counties versus the non-mining referent counties: colon, liver, lung, cervix, leukemia, and total cancer. Total cancer and lung cancer were also significantly higher in MTM counties versus other mining counties, and in other mining counties versus the non-mining referent.

Table 2 shows socioeconomic and behavior covariates for subsequent regression analyses. This table statistically compares covariates across the three county groups. It may be seen that MTM counties are characterized by a number of socioeconomic and behavioral risks at higher levels than other mining and non-mining groups. Compared to the non-mining referent, MTM populations had higher smoking rates, higher poverty rates, lower college education levels, and higher adult obesity rates. MTM counties had smaller percentages of African American and Hispanic populations compared to non-mining counties, and were less likely to be designated as metropolitan.

Table 1. ICD-10 113 Cancer Diagnosis Groups: Annual Age-Adjusted Mortality Rates 1999-2007 per 100,000 in Kentucky, Tennessee, Virginia, and West Virginia, by County Group (Mountaintop Mining, Other Mining, or No Mining). Figures are mean mortality rates with standard deviations in parentheses.

ICD-10 113 Group	Description	Mountaintop Mining (N=37)	Other Mining (N=45)	No Mining (N=321)
		Mean (SD)	Mean (SD)	Mean (SD)
20	Lip, oral cavity and pharynx	3.01 (1.41)	2.94 (1.13)	2.90 (1.40)
21	Esophagus	3.75 (1.48)	4.46 (1.80)	4.35 (1.58)
22	Stomach	4.04 (1.63)	3.59 (1.35)	3.73 (1.73)
23	Colon, rectum, and anus [1]	23.01 (3.92) [2]	21.13 (3.37)	20.85 (4.06)
24	Liver and intrahepatic bile ducts [1]	5.19 (1.95) [2]	4.57 (1.63)	4.34 (1.59)
25	Pancreas	10.45 (2.29)	10.03 (2.39)	10.75 (2.75)
26	Larynx	1.96 (1.14)	1.62 (0.73)	1.56 (1.12)
27	Lung, bronchus, and trachea [1]	88.37 (15.00) [2,3]	75.46 (13.46) [2]	68.03 (12.51)
28	Skin	3.01 (1.36)	3.06 (1.16)	3.23 (1.36)
29	Breast	14.83 (3.03)	14.38 (3.11)	14.39 (3.36)
30	Cervix uteri [1]	2.03 (1.24)	1.61 (1.07)	1.56 (1.05)
31	Corpus uteri and uterus	2.28 (1.14)	2.32 (1.20)	2.24 (1.19)
32	Ovary	4.91 (1.24)	4.95 (1.63)	5.14 (1.73)
33	Prostate	9.96 (2.27)	10.39 (3.04)	10.85 (2.91)
34	Kidney and renal pelvis	4.66 (1.58)	4.75 (1.65)	4.40 (1.55)
35	Bladder	5.02 (1.69)	4.29 (1.48)	4.37 (1.81)
36	Meninges, brain and other parts of central nervous system	4.70 (1.38)	4.59 (1.64)	4.48 (1.80)
38	Hodgkins disease	0.48 (0.43)	0.47 (0.48)	0.44 (0.52)
39	Non-Hodgkins lymphoma	7.53 (2.01)	8.19 (2.36)	7.52 (2.18)
40	Leukemia [1]	8.51 (2.04) [2]	7.73 (1.48)	7.60 (2.03)
41	Multiple myeloma and immunoproliferative neoplasms	3.80 (1.45)	4.18 (1.59)	4.17 (1.80)
42	Other and unspecified malignant neoplasms of lymphoid, hematopoietic and related tissue	0.05 (0.13)	0.05 (0.16)	0.02 (0.09)
43	All other and unspecified malignant neoplasms [1]	28.12 (6.09) [2]	26.25 (5.20)	24.58 (4.54)
--	Total [1]	244.87 (20.88) [2,3]	225.52 (20.18) [2]	216.10 (20.41)

1. F-test comparing group means significant at p<.05
2. Post-hoc means test significantly different from non-mining referent at p<.05
3. Post-hoc means test significantly different from other mining group at p<.05

Table 2. Descriptive statistics for independent variables in regression models, by mining group.

Variables	Mountaintop Mining (N=37)	Other Mining (N=46)	No Mining (N=321)
Interval Variables	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Percent of smokers in county [1]	30.6 (4.2) [2,3]	29.0 (3.7) [2]	26.9 (4.1)
Percent males in county	49.2 (1.0)	49.5 (1.4)	49.7 (1.9)
Percent county population below federal poverty level [1]	23.3 (4.9) [2,3]	18.2 (5.6) [2]	13.3 (4.7)
Percent of county population African American [1]	2.0 (2.7) [2]	2.4 (4.2) [2]	11.5 (14.5)
Percent of county population Hispanic [1]	0.6 (0.1) [2]	0.9 (0.7) [2]	2.0 (2.7)
Percent of county population Native American	0.2 (0.1)	0.2 (0.1)	0.3 (0.4)
Primary care physicians per 1,000 county population	1.3 (0.9)	1.3 (1.5)	1.5 (1.9)
Percent of county population with college degree [1]	9.2 (2.8) [2]	11.0 (4.5) [2]	15.6 (9.4)
Percent of adult county population who are obese [1]	32.6 (2.5) [2,3]	30.9 (1.8) [2]	29.6 (2.4)
Categorical Variable	**N (%)**	**N (%)**	**N (%)**
Metropolitan county [1]	5 (14) [2]	14 (30) [2]	156 (49)

1. F-test comparing group means significant at p<.05
2. Post-hoc means test significantly different from non-mining referent at p<.05
3. Post-hoc means test significantly different from other mining group at p<.05

Table 3. Regression coefficients for age-adjusted cancer mortality rates for MTM, other mining, and non-mining counties (reference group), controlling for other risk variables including smoking rates, metro vs. non-metro, percent males, poverty rate, percent African American, percent Hispanic, percent Native American (referent = Caucasian), primary care physicians per 1,000 population, percent with college education, and percent obese adults.

Cancer and Mining Types	1999-2002	2003-2007
	Coefficient (Std. Error)	**Coefficient (Std. Error)**
Kidney and renal pelvis		
MTM County	-.737 (.511)	.837 (.445)*
Other Mining County	.263 (.417)	.353 (.363)
Stomach		
MTM County	. 935 (.482)**	-.377 (465)
Other Mining County	-.424 (.394)	.283 (.380)
Lung, bronchus, trachea		
MTM County	10.30 (2.60)***	4.89 (2.44)**
Other Mining County	l.80 (2.12)	-.496 (2.00)
Colon, rectum, anus		
MTM County	l.54 (l.25)	3.00 (.99) ***
Other Mining County	-0.07 (1.02)	1.09 (.814)
Bladder		
MTM County	.259 (.571)	1.33 (.438)***
Other Mining County	.050 (.467)	-.046 (.357)
Leukemia		
MTM County	.464 (.671)	1.102 (.554)**
Other Mining County	.209 (.548)	.050 (.453)
Esophagus		
MTM County	-.552 (.503)	.095 (.433)
Other Mining County	-.132 (.411)	.776 (.353)**
Liver and intrahepatic bile ducts		
MTM County	.518 (.484)	.511 (.453)
Other Mining County	.788 (.395) **	-.343(.370)
Cervix uteri		
MTM County	.699 (.325)**	-.407 (.303)
Other Mining County	-.054 (.265)	-.175 (248)

*p < .06; **p < .05; ***p<.01

Table 3 reports multiple regression results for 1999-2002 and for 2003-2007, for all age-adjusted cancer mortality rates that were significant in either of the two time periods, and for either of the mining types. (Cancer types listed in Table 1 that are not included in Table 3 did not show significant mining effects.) Coefficients show significance relative to the excluded referent variable--counties with no coal mining. Covariates controlled for county-level data related to smoking rates, poverty, college education levels, obesity levels, racial/ethnicity categories, percent male population, rural-urban status, and supply of primary care physicians.

As shown in Table 3, age-adjusted cancer mortality rates (further adjusted using covariates) for lung, colon, bladder, leukemia, and kidney (at $p<.06$) were significantly associated with MTM counties in the second time period (2003-2007), relative to counties with no coal mining. Mortality rates for counties with other mining types were not significantly different from non-mining counties for these cancer types. Four of these cancer types (colon, bladder, leukemia, and kidney) became significantly associated with MTM mining in the second time period, but were not significant in the first time period (1999-2002). Lung cancer mortality rates were significantly greater in MTM areas vs. non-mining areas in both the first and second time period.

Cervix uteri, and stomach (at $p<.06$) mortality rates were significantly greater in MTM areas vs. non-mining areas in the first time period, with other mining areas not significantly different from non-mining areas. Finally, significantly higher mortality rates were found in counties with other coal mining but not MTM mining for: (1) liver and intra-hepatic bile ducts for the first time period; and (2) esophageal cancer for the second time period.

Although not shown in the Table, in both periods poverty was significantly associated with cancer of the esophagus, stomach, lung, and cervix. Lower education levels were significantly associated with esophagus, colon, and lung cancers. Other significant associations included smoking and lung cancer; percent African American and esophagus and stomach cancer; percent Hispanic and colon cancer; percent male and stomach cancer and leukemia; lower supply of primary care and colon cancer; and percent obese and leukemia.

The relative magnitude of the MTM coefficients indicates that the significant MTM effects were sometimes stronger, and sometimes not, compared to other covariates. For lung cancer, the strongest p values were found for smoking, poverty, and lack of college education, followed by MTM. For leukemia, obesity and percent male populations were strongest, followed by MTM. MTM effects had the strongest p values for kidney, colon, and bladder cancer.

The interpretation of the significant regression coefficients for MTM areas was based on an increase of annual deaths per 100,000 persons, adjusting for other variables. For example, in the case of kidney and renal pelvis cancers, the coefficient indicates .837 excess deaths per 100,000 for this cancer type annually in the years 2003-2007. As the population of MTM areas totals about 1.3 million people, this equates to approximately 11 additional deaths from this cancer every year over what would be expected from age and other risks. Likewise, the coefficient for lung cancer equates to approximately 64 excess annual deaths in MTM areas after control for other risks.

A final analysis was conducted for the five cancer types that showed an MTM effect for 2003-2007 in Table 3 (results not shown). This analysis repeated the regression analyses with the same covariates, with the only change that the "other mining county" was used as a referent so that MTM could be compared to other mining. Among the five cancer types, the difference between MTM and other mining was significant for bladder cancer ($p<.0042$), and lung cancer ($p<.05$) and marginally significant for leukemia ($p<.08$) and colorectal cancer ($p<.08$). The difference between MTM and other mining was not significant for kidney cancer.

DISCUSSION

Cancer rates for five types (lung, colon, bladder, leukemia, and kidney) were significantly greater in MTM areas versus no mining areas in the period 2003-2007, after controlling for other risks. Four of these cancers were not significant in the first period (1999-2002), but became significant in the second period. Only two cancers were significant in other mining areas but not in MTM areas: liver cancer in the earlier period, and cancer of the esophagus in the later period. There were also 14 types of cancer that were not significantly related to either form of mining in either period; most of these cancer types are uncommon in general populations.

Thus, out of 10 significant cancer rate measures comprising two periods, eight measures were significant for MTM areas, while only two measures were significant for other mining areas, relative to the non-mining referent. Further, four of the cancers that were not significant in the first period for MTM became significant in the later period. Higher lung cancer mortality rates were significantly related to MTM in both periods. In addition, there was evidence that mortality from leukemia, as well as lung, bladder, and colorectal cancer, were higher in MTM areas compared to areas where other types of mining take place. Results suggest stronger associations between MTM activity and cancer mortality in more recent years. Because cancer mortality can take place years or even decades after exposure, the findings may underestimate future morality effects, as MTM mining has expanded in the 2000s compared with the 1990s.

There is evidence showing that 1) MTM pollutants can persist in environments for long periods [4,42] and that 2) the footprint of MTM activity on the landscape has increased over time [2,3]. These two findings suggest that the environmental impacts from mountaintop mining, which include known carcinogens, may be contributing to the observed higher cancer mortality rates in the region over time.

Because direct environmental exposure data are not available for this study, we rely on an ecologic design using the type of mining in each county as a proxy for environmental exposure. Findings are therefore correlational and suggestive. In addition, there may be unmeasured factors associated with residence in a county with mountaintop mining that increase cancer mortality risk. Future research is needed to increase geographic specificity and to test individual-level exposure-outcome relationships over time. Finally, because most covariates were taken from the 2006 Area Resource Fine, the time period does not exactly match the period of the mortality observations.

The National Institutes of Health cite Appalachia as a priority area for reducing and eliminating health disparities. The relationship between poverty and health disparities has been well documented. Until recently, health studies related to coal-mining areas focused on the miners themselves. A growing body of research has found that residence in coal mining areas is associated with higher probabilities of poor health outcomes [11-13,33-38]. For example, a recent study found a significantly higher incidence of birth defects in Central Appalachian mining counties, vs. non-mining counties, with MTM counties having the highest birth defect prevalence rates across six of seven defect categories [36]. Another recent study found significantly higher poverty rates and greater age-adjusted mortality rates in coal mining areas, with these rates being the highest in MTM areas [43].

Work to eliminate Appalachian disparities will require a focus on the central Appalachian mountaintop mining region. Residents of these areas face a constellation of socioeconomic, behavioral and environmental risks to health. While more work on individual-level environmental exposures is needed, studies conducted thus far suggest that reasonable and prudent efforts should be taken to reduce environmental risks in MTM areas. These efforts include effective monitoring and enforcement of air and water quality standards, and ending MTM practices unless they can be demonstrated to meet adequate environmental quality standards [4]. Such efforts can mean significant health care savings in the medium-to-longer run, and significant improvements in quality of life.

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