JOURNAL OF HD RP

Journal of Health Disparities Research and Practice
Volume 4, Number 3, Spring 2011, pp. 44-53

Poverty and Mortality Disparities in Central Appalachia: Mountaintop Mining and Environmental Justice

Michael Hendryx, PhD, West Virginia University

ABSTRACT

Objectives. This study investigated the associations between poverty rates, Appalachian mountaintop coal mining, and age-adjusted total mortality rates to determine if persons exposed to this form of mining experience greater poverty and higher death rates compared to other types of mining or other areas of Appalachia.

Methods. Mortality rates, poverty rates, Appalachian designation and mining activity were examined for counties in Kentucky, Tennessee, Virginia and West Virginia (N=403). Linear least squares models tested for annual group differences from 2000-2007 in total and child poverty, and total mortality, based on mining type and Appalachian location. Nested linear models accounting for state-level effects were used to determine whether mountaintop mining and poverty were associated with mortality rates controlling for other risks.

Results. Mountaintop mining areas had significantly higher mortality rates, total poverty rates and child poverty rates every year compared to other referent counties of these states. Both poverty and mountaintop mining were independently associated with age-adjusted mortality rates in nested models.

Conclusions. Persons living in MTM areas experience persistently elevated poverty and mortality rates. Higher mortality is independently associated with both poverty and MTM, the latter effect suggestive of a possible environmental contribution from mining activities. Efforts to reduce longstanding health disparities in Appalachia must focus on those areas where disparities are concentrated: the Appalachian coalfields.

Key Words: environmental justice; Appalachia; coal mining; mortality; poverty

BACKGROUND

The relationship between poverty and population health disparities including premature mortality is well established (Shaw & Smith, 2006). For example, a recent study found that poverty had a larger impact on reducing quality-adjusted life years than more traditional public health and health services variables including smoking, obesity, binge drinking, and health insurance (Muennig, Fiscella, Tancredi, & Franks, 2009). There is increasing recognition in the United States and internationally for the critical need to focus public health efforts on the fundamental determinates of population health including socioeconomic disadvantage (Aday, 2005).

The Appalachian region of the United States contains all of West Virginia and parts of 12 other states extending from southern New York to northern Mississippi, and has a population of almost 25 million people (ARC, 2007). Persons living in Appalachia are known to experience adverse health outcomes at greater rates compared to national averages (Barnett, Halverson, Elmes, & Braham, 2000; Wingo, et al., 2008) and this disparity is due in part to socioeconomic disadvantage (Hendryx & Ahern, 2009). The National Institutes of Health recognizes Appalachia as a priority area in efforts to reduce and eliminate health disparities (Zerhouni & Ruffin, 2002).

Coal has been mined in Appalachia since the 1700s. Within the last approximately 30 years, a form of surface coal mining called mountaintop mining (MTM) has become widespread in parts of central Appalachia including areas of Kentucky, West Virginia, Virginia and Tennessee, with most of this activity occurring since 1995 (Skytruth, 2009). Surface mining as a percent of total mining has correspondingly increased over this time (Freme, 2008). The MTM process involves stripping vegetation and topsoil from ridges and peaks, using explosives to remove up to hundreds of feet of rock above and between the coal seams, and disposing of excess rock into adjacent valleys. MTM has deforested approximately 2,000 square miles, and permanently buried 2,000 miles of Appalachian headwater streams (EPA, 2010; McQuaid, 2009). The evidence is strong that MTM is highly polluting to the air and water of local environments during and after mining activity (EPA, 2010; Hitt & Hendryx, 2010; McAuley & Kozar, 2006; Palmer, et al., 2010; Pond, Passmore, Borsuk, Reynolds, & Rose, 2008).

One motivating factor in the attractiveness of this form of mining for coal companies is the reduced labor costs of surface MTM sites relative to underground mines. Surface coal mines require fewer employee hours per ton of coal than underground mines (Freme, 2008). Corresponding to an increase in surface mining practices, the number of mining jobs in Appalachia has declined by more than 50% between 1985 and 2008 (Freme, 2008). These declining economic opportunities place the population at greater risk for layoffs, job loss (with corresponding multiplier effects through local economies), and poverty.

Appalachian health disparities are well recognized but not all Appalachians are exposed to the same socioeconomic or environmental risks. Previous studies have documented health disparities in mining areas of Appalachia in general or in West Virginia specifically (e.g., Hendryx, 2008; Hendryx & Ahern, 2008; 2009; Hendryx, O'Donnell & Horn, 2008; Hitt & Hendryx 2010; Hendryx & Zullig, 2009) but these studies have not examined effects specific to MTM. The current study examines whether the Appalachian subpopulation residing in MTM areas experiences greater poverty risks than other areas, and whether both poverty and MTM risks are related to health outcomes as measured by mortality rates. Results of the study have implications for efforts to reduce disparities and promote environmental justice for a vulnerable population.

METHODS

Design. The study is an analysis of the associations among county-level poverty rates, coal mining, and mortality rates for the four-state region of Kentucky, Tennessee, Virginia and West Virginia. Some but not all of the counties in the four states included in this study are in Appalachia.

Appalachian counties were defined by Appalachian Regional Commission designations in place in 2006. Some analyses, described below, examine trends over the years 2000-2007, and some analyses collapse mortality rates across years.

Data and Variables. Coal mining data were obtained from the Energy Information Administration (EIA) (Freme, 2008) and from satellite imagery to identify MTM areas (Skytruth, 2009). Coal mining activity was recorded from the EIA for the years 2000-2007 based on any coal mining (surface or underground) over that time. MTM occurs in a contiguous geographic area that includes parts of southern West Virginia, eastern Kentucky, western Virginia, and eastern Tennessee. MTM is identified from satellite imagery as a surface mining site that crosses over a ridge or mountain peak, and that either 1) spans at least 320 acres including at least 40 acres of removed ridge top or 2) spans 40-320 acres and contains at least 10-40 acres of ridge top (Skytruth, 2009). A county was classified as an MTM county regardless of the number or size of MTM sites or whether the site was historical or active over the study period. The satellite imagery was last updated in 2005. Each county was thus classified into one of three groups: MTM county, coal-mining county but outside the MTM area, or non-mining county. Figure 1 presents a map of the four state area with county mining designations.

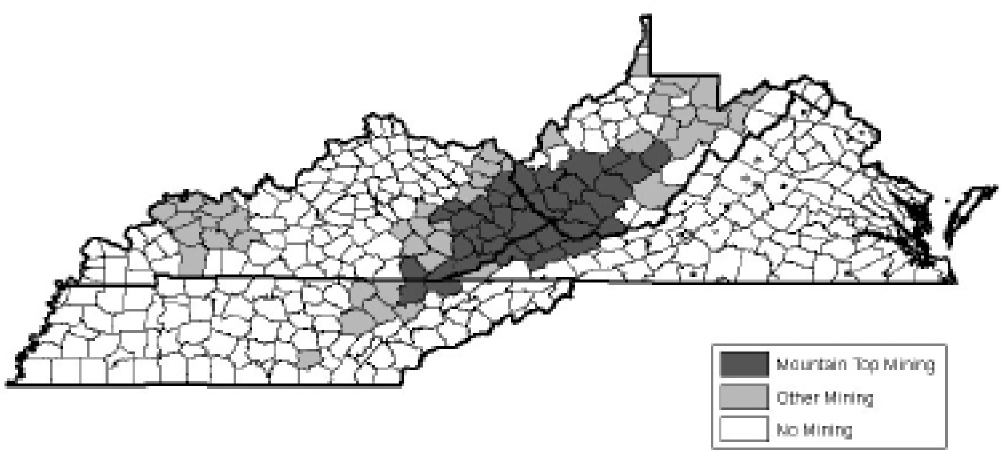

Figure 1. Coal mining areas in Central Appalachian states, 2000-2007.

The primary focus of the study was on poverty and MTM. However, I examined a set of additional covariates as well. The choice of which covariates to include was based on previous research on this topic, and on additional prior evidence that the selected variables (poverty, high school and college education rates, smoking rates, African American race, metropolitan setting, and obesity rates) exert the strongest influences on population health outcomes including mortality (Muennig, et al., 2009; Woolf, Johnson, & Geiger, 2006; Woolf, Johnson, Phillips, & Philipsen, 2007). I did not include other race or ethnicity groups in addition to African Americans because of small population sizes of these groups in most parts of these states.

Poverty and other demographic data were taken from the 2008 Area Resource File (ARF, 2008) which in turn is based on US Census data and Census estimates. Poverty rates included those for the entire population, and rates specific to children aged 0-17, for each year 2000-2007. Education rates and percent African American population were based on 2000 Census data. Metropolitan status (yes/no) was taken from the ARF based on US Department of Agriculture (USDA) rural-urban continuum codes in place in 2003. Adult smoking rates were obtained from Behavioral Risk Factor Surveillance System (BRFSS) survey data for 2003 and 2006 as reported on the BRFSS website (CDC, 2007) and on state-specific public health department websites. Adult obesity rates as measured in 2007 were obtained from the USDA's Food Atlas (USDA, 2010).

Total age-adjusted mortality rate per 100,000 was found for the years 2000-2007 from CDC public data (CDC, 2008). Rates were age-adjusted to the US Standard 2000 population. Mortality from all internal causes was included; mortality from external causes (injury, homicide, and suicide) was excluded.

I included poverty for the period of time 2000-2007 because earlier poverty figures were calculated differently on the ARF and did not seem consistent when compared to more recent figures, and 2007 was the most recent year available. I included mortality for the period 2000-2007 to begin with the same year as the poverty data and ending with the most recent data available on the CDC public database. I included mining data for 2000-2007 to coincide with these other data. There were eight counties that had small amounts of non-MTM mining in the years 1994-1999 but no mining during 2000-2007; these counties were classified into the non-mining group for the current study. The timing for the various measures are not the same, but were collected to represent the same time period as much as possible given data availability.

Two alternative classifications of counties were created to examine mining-related effects. The first consisted of three groups: MTM counties, other coal mining counties, and the remaining non-mining counties. The second consisted of three groups: the same MTM counties (all of which are in Appalachia), other Appalachian counties, and the remaining non-Appalachian counties. These alternatives provide a test of MTM effects relative to 1) other mining and 2) general Appalachian effects. Although most mining in these four states occurs in Appalachia, there is a non-Appalachian mining area in western Kentucky, and there are areas of Appalachia without coal mining.

Analysis. Analyses included least squares models using the SAS GLM (General Linear Models) procedure to examine total and childhood poverty rates each year for the years 2000-2007 by county groups, and to examine total age-adjusted mortality rates for the years 2000-2007 by county groups. Overall F values were found for each year and each comparison, followed by post-hoc Ryan-Einot-Gabriel-Welsch multiple range tests to compare the three group means controlling for Type I error.

The second major analysis examined total age-adjusted mortality as the dependent variable, with mining and poverty as the primary independent variables of interest, controlling for other covariates. Mining was treated as a categorical variable (MTM, other mining, and non-mining as the referent.) These models were run using SAS Proc Mix, with mining as a random variable nested within a fixed state effect. This nested structure allows for possible within state correlated effects that may relate to state differences in environmental or health policies. A sandwich estimator was used to calculate robust standard errors. Prior to conducting these models, covariates were examined for multicollinearity and high-school education was dropped from further analysis because it correlated highly with poverty. Models examined the mean age-adjusted mortality rate for the combined years 2000-2007 in relation to MTM county (yes/no), non-MTM mining county (yes/no), total mean poverty rate for the years 2000-2007, percent African American, adult obesity rate, adult smoking rate, college education rate, and county designation as metropolitan or non-metropolitan. Three models were examined. Model 1 included only MTM and non-MTM mining as the independent variables, Model 2 added poverty, and Model 3 added other covariates.

RESULTS

A total of 403 counties with complete data on the measures of interest were included in the analysis. Divided into groups on the basis of mining, there were 37 MTM counties, 44 other mining counties, and 322 non mining counties. Divided into groups based on Appalachian status, there were the same 37 MTM counties in Appalachian areas, 148 other Appalachian counties and 218 non-Appalachian counties.

Poverty rates in the MTM areas were significantly higher in every year 2000-2007 compared to other areas (Table 1). This was true for both total and child poverty rates, and when the comparisons were based on other mining or on other Appalachian areas. Age-adjusted mortality rates were also significantly higher every year 2000-2007 in MTM areas for both comparisons (Table 1). The model F value for every test was significant at $p<.0001$, and group differences described in the Table were based on post-hoc means tests controlling for Type I error rates. Figure 2 provides an example of one of these results over time, for the data at the bottom of Comparison 1 concerning mortality rates for MTM, other mining, and non-mining counties; this figure shows that non-MTM areas were not different from non-mining counties, but illustrates the significantly higher annual mortality rates present in MTM areas compared to both other groups.

Table 1. Demographic Characteristics (n=141).

Comparison 1: MTM vs Other-Mining vs Non-Mining								
	2000	2001	2002	2003	2004	2005	2006	2007
Adult poverty rate								
MTM	22.8**	23.5**	23.4**	22.1**	23.3**	26.8**	25.5**	25.4**
Other-mining	17.7	18.6	18.4	17.8	19.0	21.3	20.7	20.9
Non-mining	12.9	13.4	13.7	13.4	14.0	15.3	15.3	15.3
Child poverty rate								
MTM	30.9**	30.6**	32.7**	33.0**	32.0**	37.4**	35.0**	34.6**
Other-mining	24.5	25.1	26.0	26.1	26.1	29.4	28.7	28.8
Non-mining	18.1	17.9	18.6	19.4	18.9	21.2	21.1	21.2
Mortality rate per 100,000								
MTM	1023*	1037*	1041*	1021*	987*	991*	986*	950*
Other-mining	950	926	931	923	877	892	854	833
Non-mining	917	895	894	891	844	853	820	810
Comparison 2: MTM vs Other Appalachian vs Non-Appalachian								
	2000	2001	2002	2003	2004	2005	2006	2007
Adult poverty rate								
MTM	22.8**	23.5**	23.5**	22.2**	23.3**	26.8**	25.5**	25.4**
Other-Appalachian	16.1	16.8	16.8	16.1	17.0	19.1	19.0	18.9
Non-Appalachian	11.8	12.1	12.5	12.5	13.0	14.0	13.9	14.0
Child poverty rate								
MTM	30.9**	30.6**	32.7**	33.0**	32.0**	37.4**	35.0**	34.6**

Other-Appalachian	22.3	22.7	23.3	23.8	23.2	26.5	26.4	26.1
Non-Appalachian	16.5	16.1	16.9	17.8	17.4	19.2	19.1	19.4
Mortality rate per 100,000								
MTM	1023*	1037*	1041*	1021*	987**	991**	986*	950*
Other-Appalachian	924	900	912	911	869	883	840	823
Non-Appalachian	919	893	890	883	834	841	814	806

* MTM significantly higher (p<.05) than other two groups, and other two groups not significantly different from each other.

** All three groups significantly different (p<.05) from each other.

Figure 2. Age-adjusted mortality rates per 100,000 for the years 2000-2007 for counties in MTM areas, other mining, and non-mining counties, Kentucky, Tennessee, Virginia and West Virginia.

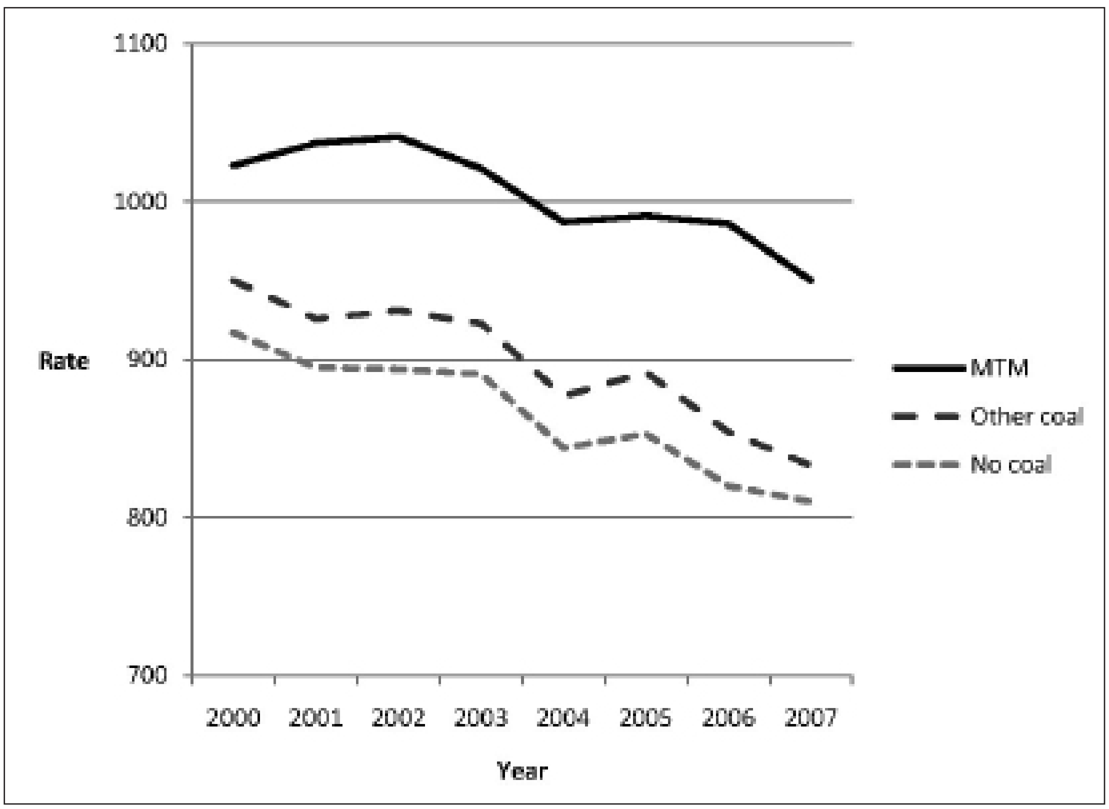

Table 2 shows the results of the nested linear models with robust standard errors. In Model 1, MTM was associated with significantly higher mortality rates compared to the non-mining referent, but other mining areas were not different from the referent. When the significant effect of poverty was added to Model 2, the effect of MTM was reduced but remained significant. Adding additional covariates in Model 3 did not alter the significant effects of MTM and poverty. Although not shown in Table 2, comparing MTM to the Appalachian and non-Appalachian groups also resulted in significantly higher MTM mortality rates in all three models.

Table 2. Model results for total age-adjusted mortality per 100,000 in relation to mountaintop mining (MTM) activity, poverty, and other covariates, for Kentucky, Tennessee, Virginia and West Virginia (N=403).

	Model 1		Model 2		Model 3	
Independent variable	Coefficient (standard error)	P<	Coefficient (standard error)	P<	Coefficient (standard error)	P<
Mountaintop mining (MTM)	127.2 (18.3)	.0001	51.3 (18.4)	.022	63.0 (13.8)	.002
Mining in non-MTM areas	28.2 (23.4)	.26	-12.8 (14.9)	.42	-4.5 (10.1)	.67
Poverty rate			8.8 (1.7)	.0001	6.2 (0.8)	.0001
Smoking rate					0.6 (1.2)	.63
Obesity rate					2.7 (1.2)	.03
Percent African American					1.2 (0.1)	.0001
Percent with college education					-3.4 (0.3)	.0001
Metropolitan county					18.3 (3.0)	.0001

DISCUSSION

Poverty is concentrated in MTM areas of central Appalachia compared to other types of mining activity, to other counties in central Appalachia, and to the non-Appalachian portion of these states. The higher mortality rates present in non-MTM areas compared to non-mining areas can be attributed in part to poverty, but both poverty and MTM activity contribute unique variance to understanding mortality disparities present in central Appalachia. This study does not attempt to determine whether MTM activity causes poverty, though the effects of MTM on such factors as depressed property values, employment declines and volatility, and foregone alternative economic opportunities have been previously identified (Burns, 2007; Freme, 2008; Wood, 2005). Rather, the study establishes the simple fact that MTM areas have higher poverty. Thus, residents of these areas are faced with the combined risks of differential exposures to potential environmental hazards in the context of socioeconomic vulnerability.

Limitations of the study include those imposed by the county-level ecological design. Data were not available on individual MTM exposures in relation to poverty status or mortality. However, some writers have argued that, from an environmental justice perspective, it is not necessary to prove direct causal links between specific environmental exposures and disease outcomes, and that evidence at a community level of compound disadvantages imposed by poor environmental conditions, poverty, and other factors, is sufficient to invoke action to improve those communities (Kriebel, et al., 2001; Wakefield & Baxter, 2010).

Another limitation concerns temporal and other imperfections in the data. Most covariates were measured only at a single point, such as 2000 Census data, and so do not precisely correspond with mortality observations. The temporal and spatial relationship between MTM activity and mortality is inexact as well; for example, some of the MTM activity took place years before the mortality observations, although the correct temporal specification between possible exposure and subsequent mortality is not clear and some lag would be expected, although in other cases exposure could lead to acute exacerbation of an existing illness over a short time. MTM was coded as a simple yes/no variable regardless of its scope within a county. To the extent that MTM affects air and water quality, those effects may cross county boundaries. All of these considerations (including MTM at smaller scales, including older and newer MTM activity, and cross-county MTM effects) would be expected to make observed MTM effects conservative.

The lack of significance of the smoking variable in the regression model partly reflects its overlap with other covariates but also suggests that smoking rates were imprecisely measured. (In other analyses, results not shown, I found that smoking rates were significantly higher in MTM areas versus other groups, and so to the extent that this higher smoking variability has been captured, MTM effects remained significant after controlling for the higher smoking rates measured there.)

Biological mechanisms by which pollution from MTM may impact health are not assessed in this study, and in general are poorly understood. Given the evidence for impaired air and water quality involving multiple chemicals (e.g., explosive chemicals, diesel fuels, silica, coal itself and its trace elements), and the evidence for health disparities that include multiple disease states including cancer, heart disease, lung disease, and kidney disease (Hendryx, O'Donnell, & Horn, 2008; Hendryx 2008), it may be that exposure effects vary across settings; one community may be faced with toxic dust from explosives and overburden at an MTM site, while another may experience contaminated water from coal processing or mine drainage. It remains an important next research step to identify personal level exposures, doses, and resulting biological impacts.

Previous research on health disparities in relation to Appalachian coal mining has usually examined mining regardless of its type (that is, combining surface and underground), and has focused on mining either throughout Appalachia or in West Virginia (e.g., Hendryx, 2009; Hendryx & Ahern, 2008, 2009; Hendryx & Zullig, 2009). The current study is one of few to examine effects specific to MTM areas in the several central Appalachian states. The results show that not all areas of Appalachia experience the same health disparities. Disparities are concentrated in the portion of central Appalachia where MTM occurs. The National Institutes of Health has targeted Appalachia as part of the national effort to reduce and eliminate disparities based on race, socioeconomic status, rural or urban setting, region, and other variables (Zerhouni & Ruffin, 2002). To achieve the national goal of eliminating Appalachian disparities, efforts must concentrate on reducing and eliminating disparities specifically in the central Appalachian MTM region.

For these efforts to succeed, we will need to address both socioeconomic and potential environmental risks faced by area residents. Persons exposed to environmental risks are more likely to experience adverse health consequences when they are already vulnerable due to other risks, such as those imposed by poverty (Evans & Kantrowitz, 2002). Even in the face of uncertainty regarding individual-level environmental exposures, prudent and reasonable efforts to reduce environmental risks can include stricter monitoring and enforcement of air and water quality standards, and restrictions on MTM practices to ensure that they occur only when adequate environmental quality standards can be met during mining and post-mining reclamation activities. Efforts to reduce poverty can include economic diversification and job creation programs; investments in K-12, vocational, college, and adult education; and modifications to tax structures to divert public dollars to geographic areas of greatest needs. These efforts become even more important when we consider that coal reserves in central Appalachia are expected to peak and production to enter permanent decline within the next few years (Milici, 2006; Ruppert, 2001), further reducing coal's economic contributions to the region.

REFERENCES

Aday, L. A. (2005). *Reinventing Public Health.* San Francisco: Jossey Bass.

ARC (2007). Appalachian Regional Commission. Retrieved 09-25-10, from http://www.arc.gov/index.jsp.

ARF (2008). *Area Resource File.* Rockville, MD: U.S. Department of Health and Human Services Health Resources and Services Administration, Bureau of Health Professions.

Barnett, E., Halverson, J. A., Elmes, G. A., & Braham, V. E. (2000). Metropolitan and non-metropolitan trends in coronary heart disease mortality within Appalachia, 1980-1997. *Annals of Epidemiology, 10,* 370-379.

Burns, S. S. (2007). *Bringing Down the Mountains.* Morgantown: West Virginia University Press.

CDC (2007). Behavioral Risk Factor Surveillance System. Retrieved 09-24-10, from http://www.cdc.gov/brfss/index.htm.

CDC (2008). Compressed Mortality File. Retrieved 05-10-10, from http://wonder.cdc.gov/mortSQL.html.

EPA (2010). EPA issues comprehensive guidance to protect Appalachian communities from harmful environmental impacts of mountaintop mining. Retrieved 09-26-10, from http://yosemite.epa.gov/opa/admpress.nsf/e77fdd4f5afd88a3852576b3005a604f/4145c96189a17239852576f8005867bd!OpenDocument.

Evans, G. W., & Kantrowitz, E. (2002). Socioeconomic status and health: the potential role of environmental risk exposure. *Annual Review of Public Health, 23,* 303-331.

Freme, F. (2008). Coal Industry Annuals / Annual Coal Reports. Retrieved 05-19-08, from http://www.eia.doe.gov/cneaf/coal/page/acr/backissues.html.

Hendryx, M. (2009). Mortality from heart, respiratory, and kidney disease in coal mining areas of Appalachia. *International Archives of Occupational and Environmental Health, 82,* 243-249.

Hendryx, M., & Ahern, M. (2008). Relations between health indicators and residential proximity to coal mining in West Virginia. *American Journal of Public Health, 98,* 669-671.

Hendryx, M., & Ahern, M. (2009). Mortality in Appalachian coal mining regions: the value of statistical life lost. *Public Health Reports, 124,* 541-550.

Hendryx, M., O'Donnell, K., & Horn, K. (2008). Lung cancer mortality is elevated in coal-mining areas of Appalachia. *Lung Cancer, 62,* 1-7.

Hendryx, M., & Zullig, K. (2009). Higher coronary heart disease and heart attack morbidity in Appalachian coal mining regions. *Preventive Medicine, 49,* 355-359.

Hitt, N., & Hendryx, M. (2010). Ecological integrity of streams related to human cancer mortality rates. EcoHealth, *published on-line 04-02-10.*

Kriebel, D., Tickner, J., Epstein, P., Lemons, J., Levins, R., Loechler, E. L., et al. (2001). The precautionary principle in environmental science. *Environmental Health Perspectives, 109,* 871-876.

McAuley, S. D., & Kozar, M. D. (2006). *Ground-water quality in unmined areas and near reclaimed surface coal mines in the northern and central Appalachian coal regions, Pennsylvania and West Virginia.* Scientific Investigations Report 2006-5059. Reston, VA: US Geological Survey.

McQuaid, J. (2009). Mountaintop mining legacy: destroying Appalachian streams. Yale University, Environment 360. Retrieved 09-26-10, from http://e360.yale.edu/content/feature.msp?id=2172.

Milici, R. C. (2006). *Production trends of major U.S. coal-producing regions.* Reston, VA: US Geological Survey.

Muennig, P., Fiscella, K., Tancredi, D., & Franks, P. (2009). The relative health burden of selected social and behavioral risk factors in the United States: implications for policy. *American Journal of Public Health, online ahead of print, e1-e7.*

Palmer, M. A., Bernhardt, E. S., Schlesinger, W. H., Eshleman, K. N., Foufoula-Georgiou, E., Hendryx, M., et al. (2010). Mountaintop mining consequences. *Science, 327,* 148-149.

Pond, G. J., Passmore, M. E., Borsuk, F. A., Reynolds, L., & Rose, C. J. (2008). Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. *Journal of the North American Benthological Society, 27,* 717-737.

Ruppert, L. F. (2001). *Chapter A - Executive Summary - Coal resource assessment of selected coal beds and zones in the northern and central Appalachian basin coal region.* (No. 1625-C). Reston, VA: US Geological Survey.

Shaw, M., D., D., & Smith, G. D. (2006). Poverty, social exclusion, and minorities. In M. Marmot & R. G. Wilkinson (Eds.), *Social Determinants of Health, 2nd Edition.* (pp. 196-223). Oxford: Oxford University Press.

Skytruth (2009). Mountaintop removal mining, Part 1: Measuring the extent of mountaintop removal in Appalachia. Retrieved 04-21-10, from http://blog.skytruth.org/2009/12/measuring-mountaintop-removal-mining-in.html.

USDA (2010). Your food environment atlas. US Department of Agriculture. Retrieved 06-08-10, from http://www.ers.usda.gov/foodatlas/.

Wakefield, S. E. L., & Baxter, J. (2010). Linking health inequality and environmental justice: articulating a precautionary framework for research and action. *Environmental Justice, 3*(3), 95-102.

Wingo, P. A., Tucker, T. C., Jamison, P. M., Martin, H., McLaughlin, C., Bayakly, R., et al. (2008). Cancer in Appalachia, 2001-2003. *Cancer, 112,* 181-192.

Wood, L. E. (2005). Trends in national and regional economic distress: 1960-2000. Washington DC: Appalachian Regional Commission.

Woolf, S. H., Johnson, R. E., & Geiger, H. J. (2006). The rising prevalence of severe poverty in America: a growing threat to public health. *American Journal of Preventive Medicine, 31,* 332-341.

Woolf, S. H., Johnson, R. E., Phillips, R. L., & Philipsen, M. (2007). Giving everyone the health of the educated: an examination of whether social change would save more lives than medical advances. *American Journal of Public Health, 97,* 679-683.

Zerhouni, E. A., & Ruffin, J. (2002). *Strategic research plan and budget to reduce and ultimately eliminate health disparities.* Volume I: Fiscal Years 2002-2006. Bethesda MD: National Institutes of Health.

Michael Hendryx, PhD

Department of Community Medicine, West Virginia University

Address correspondence to: Michael Hendryx, PhD, Associate Professor, Department of Community Medicine, School of Medicine, West Virginia University, PO Box 9190, Morgantown, WV 26506; (304) 293-9206; mhendryx@hsc.wvu.edu