Social Determinants of Health Impacting Obesity, Diabetes Mellitus and Death Due to Injury in West Virginia and Virginia Coal Counties

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ABSTRACT

Recent publications have associated the environmental impacts of mountain top coal mining in Appalachia with increased prevalence of chronic conditions such as obesity (OB) and comorbidities, i.e., diabetes mellitus (DM), heart diseases, cancers, and kidney diseases. Our previous review and subsequent study findings on chronic health conditions in coal communities in Central Appalachia indicated regional differences in lifestyle behaviors and sociodemographic factors. Programs targeting specific geographic areas can benefit using evidence based knowledge to implement interventions with measureable goals to reduce localized and persistent rates of chronic diseases. The objective of this cross-sectional study was to identify distinguishing social determinants of health affecting OB and DM in coal producing counties in West Virginia (WV) and Virginia (VA). Percent OB and DM and sociodemographic data on various factors were obtained from *County Health Rankings* (RWJF 2015) for the year 2012 for coal producing counties in WV (n = 31) and VA (n = 7). An analysis of external causes of death (NJ) served as a control for chronic health conditions. There were no significant differences in WV and VA county averages for coal production, DM, NJ, population, income, unemployment, poverty, persons over age 65, rurality, annual health care costs, and smoking. The significant differences noted were a higher OB rate in WV coal counties (33.94 ± 3.0, mean standard deviation) compared to VA coal counties (30.86 ± 2.27) (p = 0.02). The coal producing counties in VA had lower educational attainment

in the population over 25, with 73 ± 4.7 percent with at least a high school education vs. WV rates of 79.9 ± 6.9 percent (p = 0.02). Likewise, 16.29 ± 0.49 percent of the population was uninsured in VA coal counties and 18.9 ± 1.8 percent uninsured in WV ($p<0.001$). Pearson's correlations indicated that seven sociodemographic factors correlated with NJ, six correlated with OB and four with DM. Consistently, unemployment and adult smoking positively correlated to OB, DM and NJ. Coal production was not correlated to OB, DM or NJ.

In conclusion, health disparities continue to persist in coal production counties. Unemployment and smoking cessation were two factors identified to include in future intervention programs to benefit coal counties in WV and VA. Education with a focus on health literacy may benefit VA coal communities, and in WV counties weight reduction and strategies to improve rates of uninsured are suggested to benefit coal county residents. Our findings add support for multidisciplinary health care teams to engage local residents in prevention and self-managed care in communities with persistent health disparities.

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INTRODUCTION

Economic and health disparities were formally recognized in Appalachia in the 1960's yet, regrettably, have persisted over time. While poverty and overall mortality rates have improved since the concept of the Appalachian Regional Commission was proposed by President John F. Kennedy, they still hover above United States (U.S.) averages, most notably in Central Appalachia (ARC 2015).

Others have speculated that persons living in Central Appalachia near mountaintop removal coal mining experience higher rates of poor health outcomes than those in communities farther away. Reported were causative relationships between coal production and increases in total mortality (Hendryx 2011); lung cancer (Hendryx et al. 2008); cardiovascular disease (Esch and Hendryx 2011); kidney disease (Hendryx 2009); elevated morbidity rates (Christian et al. 2011); poor self-reported health (Zullig and Hendryx 2011); self-reported respiratory symptoms and chronic obstructive lung disease (Hendryx and Luo 2015); and depression (Hendryx & Innes-Wimsatt 2013). Admittedly, the authors state that the study limitations include no biochemical mechanism identified, no direct measures of exposures, non-experimental study designs, use of observational data and county rather than individual level data, as well as use of self-reported survey responses -- some with low response rates, i.e., 37% of responses missing when asking for self-reported body weights (Hendryx 2013).

In our review of the literature through 2012 and in a number of subsequent studies we reported on a need for varied investigator perspectives, stronger study protocols and clarification of reported contradictory findings (Meacham et al. 2012; Meacham et al. 2013; Borak et al. 2012; Salipante-Zaidel and Borak 2010; Buchanich et al. 2014). Continually building in the literature is support for lifestyle behaviors and sociodemographic factors as the more direct route to addressing health disparities in Appalachia, specifically obesity (OB) a comorbidity and often predisposing condition for many chronic diseases (Khaodhiar et al. 1999; Hall et al. 2014).

Investigators have identified a number of factors beyond coal important to health in these communities: a need for improved access to care, education, cultural sensitivity, understanding and managing multiple morbidities and family inclusion (Blackley 2011; Denham et al. 2007; Denham et al. 2010; Denham et al. 2011; McGarvey et al. 2011; Schoenberg et al. 2011; The Economist 2015). Encouraging are reports of improved health and economic status over time. VA counties in Appalachia have improved mortality rates for selected conditions such as heart diseases and stroke since the 1960's (Meacham et al. 2014 unpublished). Buchanich et al. (2014) reported improvements in decade averages between 1950 and 2000 in total mortality in WV coal mining and non-coal mining matched controls from the surrounding region and no association between mortality and coal production.

While attempting to identify factors contributing to improvements in total mortality covariants have been carefully followed, i.e., obesity and a number of sociodemographic indicators. For example, Buchanich et al. (2014) indicated significantly higher rates of obesity and poverty for WV coal counties relative to comparison counties. Others noted higher rates of poverty and obesity associated with mortality and no association with coal production (Borak et al. 2012). Another recent publication included an analysis of total mortality and specific causes of death at the county level in coal producing and comparison counties in WV and VA (Woolley et al. 2015). Only two of the selected demographic descriptors differed: percent high school education based on 2000 data and percent obese based on 2004 between coal counties compared to non-coal counties (education, 71.2 (range 50-84) vs 61.4 (range 53-68)($p < 0.05$) and obese, 29.0 (range 25-36) vs. 24.7 (23-26) $p < 0.001$). Later this distinction between obesity in WV coal and comparison counties was lost in a study using 2007 data but obesity was again, negatively correlated to education and income (2000 data) (Talbott et al. 2015).

While both coal mining areas of WV and VA continue to have higher mortality rates relative to comparison counties, a striking finding was the poorer mortality outcomes in coal mining counties of VA. A recent cross section study geographically confined to southwest VA noted obesity rates and most socioeconomic factors did not differ in coal producing and non-coal producing counties in southwest VA using 2012 data. Reported were a lower educational attainment and a higher rate of death due to injuries for coal counties. In non-coal counties, as the percent OB increased educational attainment decreased and percent poverty, older age and unemployment increased (Meacham et al. 2015, in press).

The following study of factors affecting chronic disease outcomes specifically focused on OB and DM focused on coal producing counties in WV and VA and assessed associated social determinants of health.

METHODOLOGY

The cross-sectional study design of county level data targeted coal producing counties in WV and VA (Figure 1). WV counties included Barbour, Boone, Braxton, Brooke, Clay, Fayette, Gilmer, Grant, Greenbrier, Harrison, Kanawha, Lincoln, Logan, Marion, Marshall, Mason, McDowell, Mercer, Mineral, Mingo, Monongalia, Nicholas, Ohio, Preston, Raleigh, Randolph, Tucker, Upshur, Wayne, Webster, and Wyoming. VA counties included Buchanan, Dickenson, Giles, Lee, Russell, Tazewell, and Wise. Data were reported for environmental factors, coal production, demographics, economic and other variables using current information available. Total annual county coal production, including underground and surface mining reported as thousands of short tons, for these counties was compared using a two-sample t-test (EIA 2015) (Table 1). For the year 2012, demographics were reported as county annual or averaged year means and standard deviations for per capita income in U.S. dollars, and percent of unemployment for

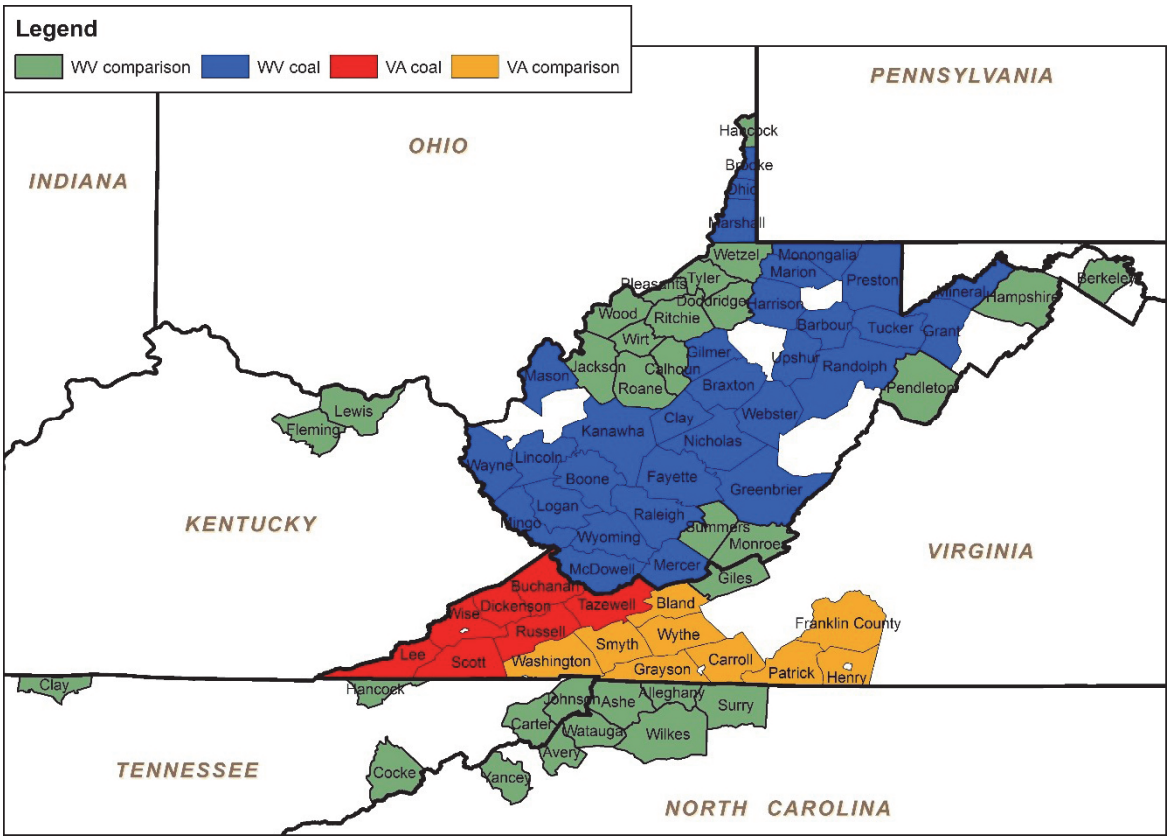

Figure 1: West Virginia and Virginia counties representing coal production and comparison counties identified for our previous study (Woolley et al., 2015). In the current study only West Virginia coal production counties (n=31, blue) and Virginia coal production counties (n=7, red) were included for analysis.

persons ages 25 to 64. For the years 2008 to 2012 education was reported as a percent of U.S. average for adults 25 years of age and over with a high school diploma, and poverty reported as a percent of the U.S. average for persons below the federal poverty level (ARC 2015).

Data also were reported for OB, DM and NJ. Obesity was reported as the percent of the adult population (age 20 and older) with a body mass index (BMI) greater than or equal to 30 kg/m^2. The percent of the population considered diabetic was obtained by survey responses to the question, "Has a doctor ever told you that you have diabetes?" Gestational diabetes was excluded (RWJF 2014). Death rates due to injury was the annual death rate from intentional and unintentional injury per 100,000 population. Deaths included were those with an underlying cause of injury including intentional injury (suicide firearm, homicide firearm, and suicide suffocation) and unintentional injury (motor vehicle traffic, poisoning, and falls) (RWJF 2014).

Annual county averages for OB, DM, and NJ were obtained for the year 2012 and for selected socioeconomic factors: estimated health care costs, age of individuals 65 years and over, percent of the population identifying as non-Hispanic, rural, uninsured, and smoking (RWJF 2015). Estimates of health care costs reflected price-adjusted Medicare spending (Parts A and B) per enrollee in a given county. Census population estimates were used for demographic information on the percent of the population over age 65, non-Hispanic Whites, and those considered living in a rural setting. The percent of those uninsured was determined in VA as those under age 65 that lack health care coverage. The measure for

Table 1. Comparison of coal production and select factors associated with health in West Virginia and Virginia coal producing counties

	WV Coal Counties[a]		VA Coal Counties[b]		
Variable	**Mean**	**SD**	**Mean**	**SD**	**P-value[c]**
Coal production, 2012, thousand short tons, n=28	4297	4882	2709	2826	0.28
Diabetes mellitus, 2012, %	13.3	1.79	12.3	0.76	0.16
Obesity, 2012, %	33.9	2.98	30.9	2.27	0.02[d]
Injury deaths, 2012, per 100,000	94.6	29.7	112.7	23.4	0.17
Population, 2012, n=28	39803	36291	28731	12104	0.44
Per capita income, 2012, $	32364	5096	31523	2592	0.68
Unemployment, 2012, %	8.4	2.09	7.9	0.87	0.62
Poverty average, 2008-2012, %	19.5	3.87	20.8	3.87	0.47
High school diploma average, 2008–2012, %	79.9	6.93	73.0	4.69	0.02[d]
Age, >65 years, 2012, %	17.5	2.07	17.5	1.39	0.96
Rural, 2012, %	67.5	24.36	80.4	21.49	0.20
Annual health care cost/person, 2012, $	9958	1121	10864	972	0.06
Uninsured, 2012, %	18.9	1.8	16.3	0.49	0.001[d]
Adult smoking, 2012, % (n=6)	26.8	5.46	27.7	4.7	0.71

Data sources: EIA –county coal production (2012); *County Road Maps and Health Rankings* (RWJF 2014); ARC (2015)

[a] WV mean and standard deviations (SD), counties n=31 unless otherwise indicated when not available for all counties
[b] VA means and SD, counties n=7 unless otherwise indicated when not available for all counties
[c] p-values were for t-tests and equal variances were assumed except for coal production
[d] $p < 0.05$, significant differences between WV and VA coal counties

smoking was the percent of adults currently smoking and who reported ever smoking at least 100 cigarettes (RWJF 2014). Paired-t tests and Pearson correlation coefficients were determined for OB, DM and NJ for WV and VA coal counties combined (N=38) and the environmental variables selected (Table 2). Variables not listed in Table 2 were not found to have correlation coefficients that reached significance. Statistical significance was set, *a priori*, at $p < 0.05$ for paired t-test analyses and Pearson correlation coefficient calculations.

RESULTS

Table 1 depicts no statistically significant differences in WV and VA coal counties for measures of coal production, diabetes mellitus, death due to injury, county population, per capita income, unemployment, poverty, older age, rurality, health care costs and smoking. Differences noted were a statistically significant higher obesity rate (percent) in WV coal counties (33.94 ± 3.0) compared to VA coal counties (30.86 ± 2.27) ($p = 0.02$) and statistically significant lower educational attainment (percent) in VA coal counties (73 ± 4.7) compared to WV coal counties (79.9 ± 6.9) ($p = 0.02$). Likewise, 16.29 ±

Table 2. Factors with statistically significant Pearson correlation coefficients for obesity, diabetes mellitus, and death due to injury selected from all factors analyzed in coal producing counties in WV and VA

A. Obesity (percent) and (Variable)	**Correlation coefficient, *r* =**	***p* ≤**
Injury deaths, 2012, per 100,000	0.38	0.02
Per capita income, 2012	-0.43	0.01
Unemployment, 2012, %	0.43	0.01
Uninsured, 2012, %	0.40	0.01
Adult smoking, 2012, %	0.46	0.00
Diabetes mellitus, 2012, %	0.53	0.01
B. Diabetes mellitus (percent) and (Variable)	**Correlation coefficient, *r* =**	***p* ≤**
High school diploma average, 2008 – 2012, %	-0.37	0.02
Unemployment, 2012, %	0.53	0.00
Adult smoking, 2012, %	0.33	0.05
Injury deaths, 2012, per 100,000	0.50	0.01
C. Injury deaths, 2012, per 100,000 and (Variable)	**Correlation coefficient, *r* =**	***p* ≤**
Per capita income, 2012	-0.32	0.05
High school diploma average, 2008 – 2012, %	-.0.75	0.00
Unemployment, 2012, %	0.47	0.00
Poverty average, 2008-2012, %	0.54	0.00
Annual health care cost/person, 2012, $	0.45	0.01
Rural, 2012, %	0.45	0.01
Adult smoking, 2012, % (n=6)	0.69	0.00

0.49 percent of the population was uninsured in VA coal counties and 18.9 ± 1.8 percent uninsured in WV (p = 0.001). Of the factors selected for analysis, unemployment rates and smoking prevalence were significantly correlated to all three health conditions assessed: OB, r = 0.43, p = 0.01, r = 0.46, p = 0.00, respectively; DM, r = 0.53, p = 0.00, r = 0.33, p = 0.05, respectively; and NJ, r = 0.47, p = 0.00, r = 0.69, p = 0.00, respectively (Table 2). Additionally, significant Pearson's correlation coefficients were positive for OB for NJ (r = 0.38, p = 0.02), uninsured (r = 0.4, p = 0.01), and DM (r = 0.53, p = 0.01) and negatively correlated to per capita income (r = -0.43, p = 0.01). For DM a positive correlation was reported for NJ (r = 0.50, p = 0.01) and a negative correlation reported for educational attainment (r = -0.37, p = 0.02). For NJ, again, negative correlations were noted for per capita income (r = -0.32, p = 0.05) and educational attainment (r = -0.75, p = 0.00). NJ were positively correlated with poverty (r = 0.54, p = 0.00), health care costs (r = 0.45, p = 0.01) and rurality (r = 0.45, p = 0.01). Coal production was not statistically significantly associated with any of the health conditions assessed.

DISCUSSION

WV coal counties had higher rates of reported OB and higher rates of unemployment, higher rates of educational attainment and higher rates of uninsured persons than VA coal counties. Only a higher educational attainment reported for WV coal counties would intuitively be perceived as influencing the

better overall mortality trend reported in our previous study for WV coal counties compared to VA coal counties (Woolley et al. 2015).

The remaining 11 factors considered, coal production and ten social determinants of health did not differ between WV and VA coal counties. A detailed analysis comparing unadjusted and adjusted factors was published by Buchanich et al. (2014) who examined mortality patterns and adjusted for potential confounding factors using a larger number of counties. The scope, number and selection of counties differed in the two studies but both report similar findings regarding health outcomes in coal and non-coal counties. Buchanich et al (2014) concluded total and all external mortalities do not seem to be related to coal production in Appalachia, yet suggested additional study of cancer specific deaths.

An unexpected finding was the positive correlation between a number of the factors and death due to injury in coal producing counties in WV and VA. Initially, death due to injury was thought to be a condition serving as a control for chronic disease assessment. Half of the sociodemographic factors assessed were significantly correlated to death due to injury, but not coal production. This finding, consistent with the previous study (Buchanich 2014) continues to highlight the increasing trend in mortality due to injuries. In recent years these counties have been the focus of considerable attention regarding mental health and substance abuse. Jonas et al. (2012) examined connections between drug use and individual social capital in rural Appalachian Kentucky. The results suggested that in regions with marked economic disparities such as rural Appalachia, drug (i.e., OxyContin™) related activities may increase social capital, in essence serving as a form of currency, among drug users. State initiatives have placed a high priority on addressing mental health and substance abuse, including nicotine, to improve health and prosperity in southwest Virginia (Healthy Appalachian Institute, 2009).

LIMITATIONS

There are several limitations to consider. A small number of counties were included for the purpose of the study objective, thus, further multiple regression analysis would have been inappropriate. Health is the product of both genetic and environmental factors, although genetic factors were not considered in this study. The usefulness of BMI measures is often debated. Self-reported survey responses to health, i.e., body weight and height, are not as reliable as actual measures. Self-reported weight and height survey responses for BMI calculations generally underestimate obesity. However, BMIs are considered reliable and valid self-reported measures that also serve as ‘proxy’ measures for healthiness of food habits and exercise. Many reputable national descriptive epidemiological studies rely on self-reported survey responses and are comparable over time and place when consistently administered (CDC BRFSS 2015). Although individual data would be preferred, county level data are more commonly available and easier to obtain. This study did not collect data on children or report on gender, both known to be important in obesity prevention intervention design.

CONCLUSIONS

Health disparities present in coal production counties in WV and VA have persisted for over half a century. While previous researchers have presented many causative factors, controversy continues and solutions remain an enigma, eluding positive identification to direct health intervention programs and policies. Attempts to improve chronic diseases in recent years may be ‘losing ground' to the troubling increases in mental health diagnoses. An interdisciplinary team of health care professionals may benefit from these findings when structuring interventions to improve both physical and mental health in coal counties in VA and WV.

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