Relations Between Health Indicators and Residential Proximity to Coal Mining in West Virginia

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We used data from a survey of 16 493 West Virginians merged with county-level coal production and other covariates to investigate the relations between health indicators and residential proximity to coal mining. Results of hierarchical analyses indicated that high levels of coal production were associated with worse adjusted health status and with higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease, hypertension, lung disease, and kidney disease. Research is recommended to ascertain the mechanisms, magnitude, and consequences of a community coal-mining exposure effect. (*Am J Public Health.* 2008;98:669–671. doi:10.2105/AJPH.2007.113472)

TABLE 1—Health Status and Rates of Disease Among Adults (N = 16 493), by County Coal-Production Levels: West Virginia, 2001

	County Coal Production[a]				
	0 Tons	≤3.9 Million Tons	≥4.0 Million Tons	*P*	Bonferroni *P*
Health status,[b] mean score	2.62	2.68	2.85	<.001	.002
Any cardiopulmonary disease, %	13.5	13.8	15.9	<.001	.007
Lung disease, %					
Any lung disease	4.2	4.6	5.7	<.001	.007
Chronic obstructive pulmonary disease	1.6	1.5	2.1	.05	.85
Asthma	2.6	2.6	3.1	.27	.999
Black lung	0.3	0.7	0.8	<.001	.003
Heart disease or stroke, %					
Any heart disease	10.4	10.6	12.3	.004	.068
Hypertension	5.6	5.5	7.6	<.001	.002
Congestive heart failure	0.9	0.7	0.6	.17	.999
Arteriosclerosis	0.3	0.4	0.3	.57	.999
Cardiovascular disease	1.3	1.2	1.4	.90	.999
Stroke	0.5	0.4	0.6	.41	.999
Angina or coronary disease	5.4	5.6	5.4	.87	.999
Diabetes, %	6.2	5.7	7.0	.043	.73
Kidney disease, %	0.4	0.4	1.0	<.001	.002
Cancer, %	2.3	1.8	2.2	.26	.999
Arthritis or osteoporosis, %	5.5	5.4	6.4	.069	.999

[a]The division of coal production at 4 million tons groups coal-producing counties approximately in half. The effects of coal production on health are usually still present when the division occurs at 3 million tons or 2 million tons, but a division at 4 million tons resulted in a better fit of observed-to-expected level 2 residuals in the Table 2 hierarchical models. The category "≤3.9 million tons" does not include 0 tons as a measure.
[b]Score was based on self-reported health (1 = "excellent"; 6 = "very poor").

The United States has 27% of known coal reserves,[1] and as many as 153 new coal-fired power plants are scheduled for operation by 2030.[2,3] Pressure to increase coal mining is likely to intensify because of concerns about nuclear power, energy security, and peak global oil production.[4–6] Increased coal demand may exacerbate negative health effects of coal-mining activities, including occupational hazards of coal mining,[7,8] air pollution from burning coal,[9] health consequences of carbon dioxide–caused climate change,[10,11] and community exposure to mining activities. We examined whether coal mining in West Virginia is related to poorer health status and incidence of chronic illness. We sought to find whether coal mining effects may result only from socioeconomic correlates of mining such as income or education or whether effects persist after controlling for such factors, which would suggest possible environmental exposure problems.

Quantitative research on health consequences of residential proximity to coal mining is limited to a few studies of respiratory illness conducted in Great Britain. One study found no effect of coal mining,[12] but others found elevated risks.[13–15]

METHODS

In 2001, the West Virginia University Institute for Health Policy Research conducted a telephone survey of adults 19 years and older (N=16 493; minimum number per county=235). The response rate was 55%. We used 2000 US Census data to weight survey respondents to match the age, gender, income, education, and insurance status demographics of the state.

Dependent variables included self-reported health (scored 1="excellent" to 6="very poor") and the presence or absence of specific chronic health conditions.

We obtained 2001 coal production figures from the West Virginia Geological and Economic Survey,[16] including the short tons of coal mined from each county in both underground and surface mines. Coal production was not normally distributed, so we divided county coal production into 3 dummy variables: (1) no production, (2) up to 3.9 million tons, and (3) 4.0 million tons or greater.

County-level covariates included smoking and obesity rates from the West Virginia Department of Health and Human Resources, percentage of the population below the poverty level from US census data, and a measure of social capital.[17] Person-level covariates included age, gender, income, education, and presence or absence of health insurance.

We analyzed whether health measures were associated with unadjusted coal production categories. Then we examined whether coal effects persisted after accounting for other person- and county-level variables with person-level HLM 6.03[18] multilevel modeling: linear modeling for health status and nonlinear REML Bernoulli modeling for the dichotomous presence of chronic illness. The intercept effect was random, and other effects were fixed. Results are reported for final population estimates with robust standard errors.

RESULTS

As coal production increased, health status worsened, and rates of cardiopulmonary disease, lung disease, cardiovascular disease, diabetes, and kidney disease increased (Table 1). Within larger disease categories, specific types of disease associated with coal production included chronic obstructive pulmonary disease (COPD), black lung disease, and hypertension.

Dependent variables at $P<.10$ from Table 1 (non-Bonferroni corrected) were carried forward for the multilevel analyses (Table 2). The highest level of mining (≥4.0 million tons) predicted greater adjusted risk for cardiopulmonary disease, lung disease, hypertension, black lung disease, COPD, kidney disease, and poorer adjusted health status.

We considered the possibility that results reflected current or former coal miners living in the area. Almost all coal miners are men. The finding for black lung disease likely reflects a miner's effect, supported by the result that women are at lower risk. The only other illness for which men as a group had higher risk was the general cardiopulmonary category. We conducted an additional multilevel model (results not shown) separately for women for this category; the effects of the coal production variable remained significant.

TABLE 2—Hierarchical Model Results for Health Status and Rates of Disease Among Adults (N = 16 493): West Virginia, 2001

Model	Coal Variables Only[a]	Full Models[b]
Worse health status,[c] b (SE)		
≤3.9 million tons of coal	0.057 (0.052)	0.024 (0.039)
≥4.0 million tons of coal	0.205 (0.066)	0.094 (0.032)
Cardiopulmonary disease, OR (95% CI)		
≤3.9 million tons of coal	1.029 (0.924, 1.147)	1.006 (0.910, 1.113)
≥4.0 million tons of coal	1.204 (1.033, 1.405)	1.119 (1.002, 1.249)
Lung disease, OR (95% CI		
≤3.9 million tons of coal	1.117 (0.931, 1.340)	1.085 (0.904, 1.303)
≥4.0 million tons of coal	1.385 (1.138, 1.685)	1.297 (1.048, 1.605)
Chronic obstructive pulmonary disease, OR (95% CI)		
≤3.9 million tons of coal	0.969 (0.596, 1.577)	0.909 (0.582, 1.419)
≥4.0 million tons of coal	1.559 (1.069, 2.272)	1.637 (1.061, 2.526)
Black lung or external agent, OR (95% CI)		
≤3.9 million tons of coal	2.256 (1.273, 3.998)	2.254 (1.255, 4.047)
≥4.0 million tons of coal	2.608 (1.548, 4.392)	2.655 (1.602, 4.402)
Cardiovascular disease, OR (95% CI)		
≤3.9 million tons of coal	1.016 (0.908, 1.137)	0.994 (0.890, 1.110)
≥4.0 million tons of coal	1.186 (1.016, 1.384)	1.106 (0.990, 1.236)
Hypertension, OR (95% CI)		
≤3.9 million tons of coal	0.967 (0.826, 1.133)	0.956 (0.820, 1.116)
≥4.0 million tons of coal	1.371 (1.153, 1.631)	1.299 (1.130, 1.493)
Kidney disease, OR (95% CI)		
≤3.9 million tons of coal	0.792 (0.420, 1.495)	0.764 (0.397, 1.470)
≥4.0 million tons of coal	2.147 (1.371, 3.362)	1.698 (1.016, 2.837)
Diabetes, OR (95% CI)		
≤3.9 million tons of coal	0.928 (0.807, 1.068)	0.898 (0.773, 1.042)
≥4.0 million tons of coal	1.135 (0.911, 1.414)	1.008 (0.864, 1.176)
Arthritis or osteoporosis, OR (95% CI)		
≤3.9 million tons of coal	1.030 (0.878, 1.210)	0.994 (0.844, 1.170)
≥4.0 million tons of coal	1.233 (1.021, 1.488)	1.097 (0.901, 1.335)

Note. OR = odds ratio; CI = confidence interval. The category "≤3.9 million tons" excludes 0 tons as a measure.
[a]Includes only the 2 level-2 dummy variables measuring tons of coal mined, where zero coal mined is the reference category. Fifty-five counties were measured.
[b]Full models include adjustment for respondent age (19–25, 26–34, 35–44, 45–54, 55–64, 65–74, ≥75 years), gender, income (<$30 000, ≥$30 000), education (less than high school, high school, some college, college graduate or higher), health insurance (yes or no), county poverty rate, smoking rate, obesity rate, and social capital. Other analyses not shown here explored various ways to categorize age and income, with no substantive effects on results. Analyses also were conducted limited to persons 45 years and older, and coal effects persisted for all response variables except kidney disease. N = 16 493 for level-1 variables and 55 for level-2 variables.
[c]Score was based on self-reported health (1 = "excellent"; 6 = "very poor"). For the coal-only model, the ≥4.0 million tons variable is significant at $P<.004$; for the full model, it is significant at $P<.005$.

DISCUSSION

Among West Virginia adults, residential proximity to heavy coal production was associated with poorer health status and with higher risk for cardiopulmonary disease, chronic lung disease, hypertension, and kidney disease, after we controlled for covariates.

Limitations of the study included the ecological design and the possibility that unmeasured variables confounded with coal mining, such as individual smoking behavior or occupational exposure, contributed to poorer health. Second, the survey response rate was imperfect, potentially limiting generalizability, although responses were weighted to census data. Third, county of residence provides an imperfect estimate of people's proximity to mining sites. Fourth, the format of the chronic disease questions likely resulted in an underreporting of disease. Fifth, the nonspecific cancer measure may have been too crude to detect effects, if they existed. The third through fifth limitations may have resulted in underestimating coal-mining effects.

For illnesses that were associated with coal effects, the literature supports the hypothesis that the risk for these illnesses increases with exposure to coal byproducts. Toxins and impurities present in coal have been linked to kidney disease[19–23] and to hypertension and other cardiovascular disease.[24–28] The effects also may result from the general inflammatory or systemic consequences of inhaled particles.[29] Effects may be multifactorial, a result of slurry holdings that leach toxins into drinking water[30] and air pollution effects of coal mining and washing.[15,31,32]

Our study serves as a screening test to examine whether coal mining poses a health risk for adults living near the mining sites. Confirmatory tests should be undertaken to establish mechanisms of action, magnitude, and health consequences of an exposure effect. ■

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This brief was accepted August 16, 2007.

Contributors

M. Hendryx originated the study, collected and analyzed the data, and led the writing of the brief. M.M. Ahern contributed to study conceptualization, analyses, and writing.

Human Participant Protection

This was an analysis of anonymous, secondary data sources, and institutional review board approval was not required.

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