Mortality in Appalachian Coal Mining Regions: The Value of Statistical Life Lost

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SYNOPSIS

Objectives. We examined elevated mortality rates in Appalachian coal mining areas for 1979–2005, and estimated the corresponding value of statistical life (VSL) lost relative to the economic benefits of the coal mining industry.

Methods. We compared age-adjusted mortality rates and socioeconomic conditions across four county groups: Appalachia with high levels of coal mining, Appalachia with lower mining levels, Appalachia without coal mining, and other counties in the nation. We converted mortality estimates to VSL estimates and compared the results with the economic contribution of coal mining. We also conducted a discount analysis to estimate current benefits relative to future mortality costs.

Results. The heaviest coal mining areas of Appalachia had the poorest socioeconomic conditions. Before adjusting for covariates, the number of excess annual age-adjusted deaths in coal mining areas ranged from 3,975 to 10,923, depending on years studied and comparison group. Corresponding VSL estimates ranged from \$18.563 billion to \$84.544 billion, with a point estimate of \$50.010 billion, greater than the \$8.088 billion economic contribution of coal mining. After adjusting for covariates, the number of excess annual deaths in mining areas ranged from 1,736 to 2,889, and VSL costs continued to exceed the benefits of mining. Discounting VSL costs into the future resulted in excess costs relative to benefits in seven of eight conditions, with a point estimate of \$41.846 billion.

Conclusions. Research priorities to reduce Appalachian health disparities should focus on reducing disparities in the coalfields. The human cost of the Appalachian coal mining economy outweighs its economic benefits.

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The Appalachian region of the United States has long been associated with severe socioeconomic disadvantages.[1–3] These disadvantages translate to poor public health outcomes including elevated morbidity and mortality rates for a variety of serious, chronic conditions, such as diabetes, heart disease, and some forms of cancer.[4–6] The problems are so severe and persistent that the National Institutes of Health (NIH) has included Appalachia among its target priorities for the reduction and elimination of health disparities.[7]

Coal mining constitutes a major economic activity in some portions of Appalachia.[8] As with Appalachia in general, the region's coal mining areas have been linked to socioeconomic disadvantages.[1,9,10] Appalachian areas where economic disadvantage has been most persistent over time are those characterized by low economic diversification, low employment in professional services, and low educational attainment rates.[2] These features are characteristic of tobacco- and coal-dependent economies.[11] Rural economies dependent on sole-source resource extraction are vulnerable to employment declines and market fluctuations.[12]

Based on social disparities models[13,14] that link poor health to socioeconomic disadvantage, one would expect to see elevated morbidity and mortality in mining areas resulting from the socioeconomic disadvantages that are prevalent in these areas. Recent empirical studies have indeed confirmed that health disparities exist in coal mining regions of Appalachia compared with other areas of the region or the nation, including elevated mortality rates for total causes, lung cancer, and some chronic illnesses.[15–19] These studies showed that mortality is related to higher poverty, lower education levels, and smoking behavior, and also suggested that environmental pollution from the mining industry is a contributing factor.

The reliance on coal mining in some areas of Appalachia constitutes a de facto economic policy: coal is mined because it is present and because there is a market for it. However, other economic policies could be developed if reliance on this resource was not in the best interest of the local population. This study evaluated the costs and benefits associated with the Appalachian coal mining economy. We first estimated the number of excess annualized deaths in coal mining areas for the period 1979 through 2005 and converted those estimates to monetary costs using value of statistical life (VSL) figures from prior research.[20–23] Then, we compared VSL costs with an estimate of the economic benefits of coal mining to test whether the economic benefits of coal mining in Appalachia exceeded the estimated VSL costs.

METHODS

Design

This study retrospectively investigated national mortality rates for the years 1979–2005. The level of analysis was the county (n=3,141). We compared four groups: counties in Appalachia with levels of coal mining above the median, Appalachian counties with levels of mining below the median, non-mining counties in Appalachia, and other counties in the nation. The study, an analysis of anonymous, secondary data sources, met university Internal Review Board standards for an exception from human subjects review.

Data

We obtained publicly available mortality data for 1979 through 2005 from the Centers for Disease Control and Prevention (CDC). These data measure county-level mortality rates per 100,000, age-adjusted using the 2000 U.S. standard population.[24] We examined total mortality rates for all causes, and included all ages.

We obtained coal employment and production data from the Energy Information Administration (EIA),[25] measured as tons of coal mined in every county every year for the years 1994–2005. The EIA does not provide county-specific data prior to 1994. For the current study, we defined coal mining areas as counties with any amount of coal mining during those years. For some analyses, we divided coal mining counties into those with higher or lower amounts of mining based on a median split of production figures. In most cases, counties that mined coal in one year did so in most or all years, due simply to the presence of economically minable coal in the county. However, we placed seven counties that had small amounts of mining prior to 1997 and no mining after that time with the non-mining counties to focus the analysis on areas with more contemporary mining, as some analyses were limited to the period 1997–2005. There is also considerable historical evidence that Appalachian counties characterized by coal mining during recent years were also coal mining areas in previous years and decades,[1,26–28] so we used mining during the 1994–2005 period as a proxy for mining during the entire study period.

We obtained data on county socioeconomic characteristics from the 2005 Area Resource File[29] and the Appalachian Regional Commission.[30] Area Resource File data were in turn drawn from U.S. Census data and were based either on the 2000 Census or on multi-year estimates when available. We used these data to compare coal mining areas with other areas using the following categories: median household income (the mean for 2000–2002), poverty rates (the mean for

2000–2002), 2000 high school and college education rates, and 2000 unemployment rates. We obtained smoking rates from Behavioral Risk Factor Surveillance System survey results from CDC,[31] supplemented with additional data found by reviewing all 50 states' public health websites.

We calculated estimates for the VSL based on prior VSL research conducted by U.S. regulatory agencies.[20–23] VSL estimates were based on trade-offs between risks (e.g., probability of mortality from breathing polluted air) and money (e.g., the cost of reducing that risk), and provided a reference point to assess the benefits of risk-reduction efforts. VSL estimates are used by government agencies such as the Environmental Protection Agency (EPA), Food and Drug Administration, and others to conduct cost-benefit analyses of pollution control policies or other public benefit programs. The two estimates that we used in the current study were (*1*) the calculated mean VSL of $3.8 million per life across 18 U.S. regulatory agency studies reported by Viscusi and Aldy and (*2*) the EPA estimate of $6.3 million to represent environmental policies pertinent to the current investigation.[23] We measured both of these estimates in 2000 dollars, and converted them to 2005 dollars as described further in this article.

We estimated the economic benefit of coal mining from a 2001 report of the direct, indirect, and induced economic contributions of the coal mining industry in Appalachia.[32] This report was based on earnings and coal production in 1997. Direct contributions include earnings from coal company employees, including laborers and proprietors; indirect and induced contributions include earnings by other sectors based on multiplier effects of the industry (e.g., supplies purchased locally by coal companies and coal company employee expenditures on other goods and services). We made adjustments to reflect the 4.35% mean annual increase in the Consumer Price Index between 1997 and 2005, and the 11% decline in Appalachian coal mining employment during the same time period.

In addition to these economic benefits, some states imposed coal severance taxes that provided additional economic input to these states.[32] West Virginia, for example, imposed a 5.0% coal severance tax on the sales price per ton, the tax in Kentucky was 4.5%, and in Tennessee it was $0.20 per ton. In contrast, states also provided various tax incentives related to the coal industry: Maryland, Ohio, and Virginia provided a corporate tax credit of $3.00 per ton for burning indigenous coal, and the credit in Kentucky was $2.00 per ton. Alabama and Virginia provided tax incentives to coal companies to increase production. The final estimate of economic contributions included the adjusted sum of the indirect, direct, and induced contributions, plus the net contributions of the severance tax, minus the tax credits.

Analysis

We analyzed the data using SAS® 9.1.3.[33] We tested mean group differences using least squares linear models. Where indicated, post-hoc Type I error corrections used the Ryan-Einot-Gabriel-Welsch Multiple Range Test. We conducted ordinary least squares multiple regression models with age-adjusted mortality as the dependent variable and mining, socioeconomic, and demographic indicators as independent variables to identify mining effects independently of other effects. We converted unadjusted and covariate-adjusted annual mortality rates to excess number of deaths in mining areas using census population data, and then multiplied these figures by the VSL estimates to find a range of the economic cost of coal mining, which we then compared with the estimated economic benefit.

There is evidence that some health impacts from economic and environmental disadvantage occur in the short term,[34–37] but that other effects are delayed.[38,39] Discounting future costs is one way to account for delayed effects; however, discounting has proponents[23,40,41] and detractors,[36] and there are unknowns in the choice of time periods, discount rates, and uncertainties of how people value future health benefits.[42] Nevertheless, we conducted a discount analysis based on previous research that used a 10-year, 3% discount rate to study cancer mortality;[38] we selected a 2% discount to recognize that not all health impacts would be delayed. We compared the 2005 benefits of coal mining with future discounted VSL costs using eight scenarios, including lower or higher VSL, unadjusted or adjusted covariate analysis, and Appalachia or the nation as the comparison group.

RESULTS

Socioeconomic characteristics

Table 1 presents socioeconomic indicators and age-adjusted mortality rates for four groups of counties: Appalachian counties with levels of mining above the median, Appalachian counties with levels of mining below the median, Appalachian counties with no mining, and the rest of the nation. Significant post-hoc differences between groups were corrected for Type I error at $p<0.05$. Coal mining areas fared significantly worse on all indicators compared with non-mining areas of Appalachia and/or the nation. These conditions worsened as levels of mining increased: the highest levels of unemployment and lowest incomes

Table 1. Socioeconomic measures and annual age-adjusted mortality from 1979 to 2005 for four groups

Socioeconomic measure	*Appalachian counties with coal mining above the median*[a]	*Appalachian counties with coal mining below the median*[a]	*Non-mining Appalachian counties*	*Rest of nation*	*P-value*
Number	70	69	274	2,728	
Median household income[b]	$28,287	$30,614	$33,078	$36,622	0.0001
Poverty rate[c]	18.0	16.5	14.5	13.3	0.0001
Percent of adults with high school education[d]	69.8	71.3	71.5	78.3	0.0001
Percent of adults with college education[b]	11.2	12.6	13.8	17.0	0.0001
Unemployment rate[e]	7.0	6.0	5.0	4.7	0.0001
Age-adjusted mortality per 100,000[f]	1,049.0	1,007.3	985.6	932.7	0.0001

[a]The median split refers to mining counties with greater than, or less than, the median tons of coal mined during the combined years 1994–2005; this median figure is 7,785,000 tons.

[b]Higher coal mining was significantly different from all groups; lower coal mining was significantly different from the nation.

[c]Both coal mining locations were significantly different from others.

[d]All three Appalachian groups were significantly different from the nation.

[e]Higher coal mining was significantly different from all groups, and lower coal mining was significantly different from all groups.

[f]Higher coal mining was significantly different from all groups, and both other Appalachian groups were significantly different from the nation.

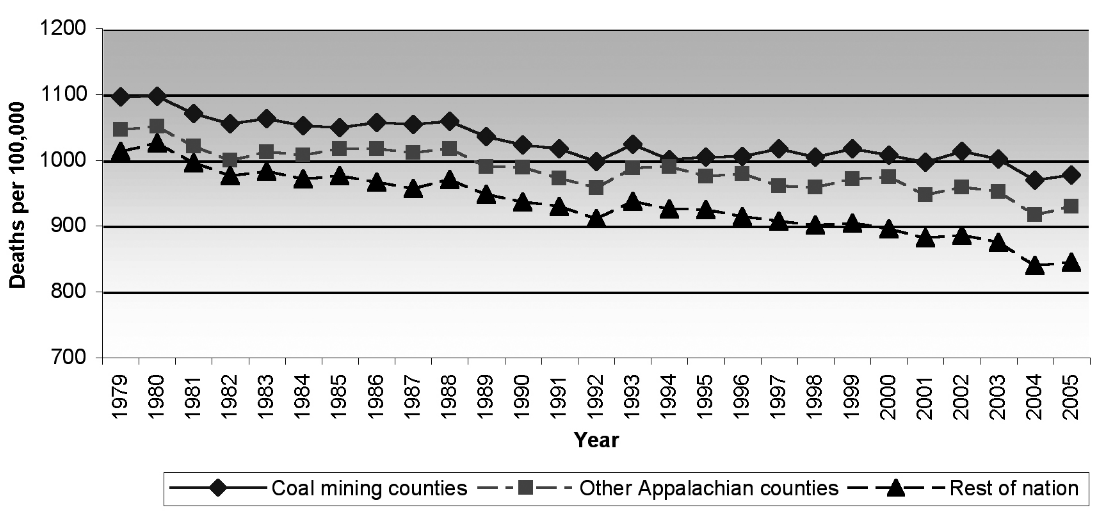
were located in the areas where the heaviest mining activity took place. For two indicators, poverty and unemployment, the disparity was unique to mining areas; that is, an Appalachian disparity compared with the nation did not exist outside of coal mining areas. Age-adjusted mortality was highest in areas of heaviest coal mining.

Reductions in employment in the industry over time indicated the poor economic conditions of mining areas. The number of coal miners in Appalachia declined from 122,102 to 53,509 between 1985 and 2005. This decline corresponded to increases in mechanized mining practices and the growth of surface mining, which requires fewer employees than underground mining per ton mined.[43]

Age-adjusted mortality rates

The Figure presents the age-adjusted total mortality rates for three groups of counties for 1979 through 2005. We combined higher and lower levels of mining for this analysis. Significant main effects were present for time ($F=869.8$, $p<0.0001$) and county group ($F=23.6$, $p<0.0001$), and for the interaction of time and group ($F=24.8$, $p<0.0001$). (Mortality rates are sometimes studied using log normal distributions; we repeated this test on the log values of mortality rates

Figure. Total age-adjusted mortality per 100,000 for the years 1979–2005, by county group



and still found significant main effect and interaction terms at the same levels of *p*-values.) Historic trends showed declining mortality rates for all groups, but coal mining areas had the highest rates for every year. Non-mining areas of Appalachia had intermediate rates. The time $\times$ group interaction indicated that the gap between non-Appalachian counties and both other county groups increased; this increasing gap became most evident in 1997 and subsequent years as shown in the Figure. As illustrated, the mean gap between coal mining areas and the nation in the first five years (1979–1983) was 77.6 excess deaths per 100,000 and increased to 126.0 excess deaths per 100,000 during the last five years (2001–2005). The trend between coal mining areas and other areas of Appalachia was more complex, as the gap between these groups of counties declined prior to 1997, but has increased since then.

Across all years, the mean number of excess age-adjusted deaths in mining relative to non-mining areas of Appalachia was 42.74 per 100,000. The population of the coal mining regions of Appalachia was 9,301,033, based on the mean of the U.S. Census figures for 1980, 1990, and 2000. Multiplying deaths per 100,000 (42.74) by the population in 100,000 units (93.01) resulted in an excess of 3,975 annualized deaths in coal mining areas of the region compared with the rest of Appalachia.

When we limited the analysis to the more recent period, 1997–2005, we found the number of excess annualized deaths to be 4,432. (This estimate used only the 2000 U.S. Census population for Appalachia to best match the mortality time period.) If mortality rates in coal mining areas were equal to the nation outside Appalachia, the number of annualized averted deaths would be 8,840 for the period 1979–2005, and 10,923 for the period 1997–2005.

Covariate-adjusted mortality

Regression models examined two time periods: 1979–2005 and 1997–2005. For each time period, one model used national data and one was limited to Appalachian counties. The results of all four analyses indicated that higher age-adjusted mortality was independently related to coal mining counties in Appalachia after controlling for smoking rates, rural-urban location, percent male population, supply of primary care doctors, a regional South variable, poverty, race/ethnicity, and education. We selected these covariates to be consistent with other research on this topic.[16–19] We considered income and percentage of the population without health insurance, but then dropped them because of their high correlation with poverty. The covariates were themselves correlated with mortality. For example, we linked higher mortality with poverty, lower education, smoking, and higher percentages of African American and Native American populations.

The model for the national analysis across all years is summarized in Table 2; other models were similar. As shown, the coefficient for the mining effect after controlling for covariates was 31.06. Multiplied by the population of mining areas, this translated to 2,889 excess deaths. In other words, of the 8,840 excess age-adjusted deaths found in mining areas, 2,889 remained after accounting for smoking, race, poverty, physician

Table 2. Regression model results[a] to estimate total age-adjusted mortality per 100,000 for 1979–2005 from mining, socioeconomic, and other variables: a national analysis

Variable	*Unstandardized coefficient*	*Standard error*	*P-value*
Intercept	1,047.57	45.42	0.0001
Mining (yes/no)	31.06	7.46	0.0001
Appalachia (yes/no)	−2.57	4.96	0.6100
Smoking rate	3.08	0.44	0.0001
Rural-urban continuum code	−9.19	0.56	0.0001
Percent male population	−0.29	0.69	0.6800
Primary care physicians per 1,000	7.25	1.17	0.0001
South region of U.S. (yes/no)	24.01	4.04	0.0001
Poverty rate	5.24	0.41	0.0001
Percent African American	1.82	0.13	0.0001
Percent Native American	2.90	0.18	0.0001
Percent nonwhite Hispanic	−1.50	0.14	0.0001
Percent Asian American	−0.81	0.62	0.2000
Percent with high school education	−2.03	0.32	0.0001
Percent with college education	−3.34	0.28	0.0001

[a]Model F=355.67 (degree of freedom = 14, 3,125), $p<0.0001$; adjusted R^2 = 0.61

supply, education, and other variables. We also found this adjusted estimate for the number of excess deaths for the other three models, as shown in Table 3.

Estimated costs and benefits of coal mining

The assessment of the coal mining industry in Appalachia resulted in an estimate of the 1997 economic contribution valued at $6.5 billion.[32] This estimate included direct, indirect, and induced earnings impacts. To the extent that employment in the mining industry has experienced a downward trend,[43] future declines in employment would reduce this impact estimate. Comparing the economic report with EIA figures[25] indicated an 11% decrease in employment in Appalachian coal mining from 1997 to 2005. We adjusted the impact estimate, which was based on employment figures, downward by 11% to account for this decrease in employment. However, we increased the estimate based on the mean 4.35% annual increase in the Consumer Price Index between 1997 and 2005. The resulting contribution of the coal mining industry in 2005 dollars may be estimated at $7.798 billion. State income from coal severance taxes added about $458 million to coal's economic contribution to the region in 2005 dollars, and tax credits reduced this amount by about $168 million, for a final total of $8.088 billion.

We used two VSL estimates: $3.8 million and $6.3 million per life.[23] We based these figures on 2000 dollars. Adjusting for the mean 4.60% annual increase in the Consumer Price Index between 2000 and 2005 resulted in VSL estimates of $4.67 million and $7.74 million expressed in 2005 dollars. Table 3 summarizes the estimates of the human cost of Appalachian coal mining by multiplying these VSL estimates with the estimates of excess deaths during varying time periods and comparison groups. The analysis is presented for both unadjusted and adjusted deaths. In the unadjusted analysis, resulting estimates ranged from $18.563 billion to $84.544 billion, all of which were higher than the estimate of the beneficial economic impact of coal mining for the region. To identify a point estimate, we used the lower VSL estimate of $4.67 million, selected the more recent time interval 1997–2005, and selected the mortality difference between coal mining areas and the nation based on the fact that the NIH goal is to equate health in Appalachia to the nation. Using this estimate, we determined the cost associated with coal mining in Appalachia as $50.01 billion per year.

After adjusting for other mortality risks, the VSL analysis continued to show excess costs relative to the economic benefits of mining. Estimates ranged from $8.236 billion to $18.166 billion. In the case of adjusted estimates, using the higher EPA VSL figure of $7.74 million was defensible because adjusted deaths more likely reflected environmental health impacts of mining; the resulting point estimate was $18.166 billion per year.

Discount analysis

Table 4 summarizes the results of the discount analysis. This analysis used as the starting point the 2005 benefits of coal mining and the 1997–2005 estimate of excess deaths to reflect more current conditions. A 2% 10-year discount resulted in future VSL costs that exceeded current benefits for seven of eight scenarios. The only exception was for the smaller VSL that compared mining areas with other Appalachian areas adjusted for all covariates. Social disparity models indicated the importance of both socioeconomic and environmental variables and, therefore, the appropriateness of an unadjusted analysis: all four unadjusted results showed discounted VSL costs exceeding current benefits, with a point estimate

Table 3. Unadjusted and adjusted costs of coal mining by VSL estimate and comparison group

	Cost estimates in billions for excess deaths in coal mining areas in comparison with other Appalachian counties and the nation, by time period			
VSL	*Appalachia, 1979–2005*	*Appalachia, 1997–2005*	*Nation, 1979–2005*	*Nation, 1997–2005*
Unadjusted				
$4.67 million	$18.563	$20.697	$41.283	$51.010
$7.74 million	$30.766	$34.304	$68.422	$84.544
Number of excess unadjusted annual deaths	3,975	4,432	8,840	10,923
Adjusted				
$4.67 million	$8.236	$8.491	$13.492	$10.923
$7.74 million	$13.646	$14.071	$22.361	$18.166
Number of excess adjusted annual deaths	1,763	1,818	2,889	2,347

VSL = value of statistical life

Table 4. Discounted VSL costs in billions of dollars based on a 10-year 2% discount rate[a]

	Cost in billions compared with Appalachia		Cost in billions compared with the nation	
Discounted VSL	*Unadjusted*	*Adjusted*	*Unadjusted*	*Adjusted*
$3.83 million	$16.979	$6.965	$41.846	$8.991
$6.35 million	$28.141	$11.543	$69.356	$14.902

[a]Results are for two VSL estimates, for adjusted and unadjusted effects, and for comparisons with non-mining Appalachia and the nation.

VSL = value of statistical life

of $41.846 billion under the same assumptions used to select the non-discounted point estimate.

DISCUSSION

Age-adjusted mortality rates were higher every year from 1979 through 2005 in Appalachian coal mining areas compared with other areas of Appalachia or the nation. We found the highest mortality rates in areas with the highest levels of mining. Over time, the gap in mortality rates between coal mining areas and other areas of Appalachia and the nation has increased. The disparity became particularly noticeable after 1996. Consistent with social disparities models,[13,14] the results of the current regression analyses and other research suggest that poverty, low education level, smoking behavior, and environmental pollutants are among the factors that lead to higher mortality rates in coal mining areas.[15,18,19] Higher mortality may also be due in part to conditions of elevated stress[44] caused by economic disadvantage and environmental degradation. The results suggest, but do not prove, that a coal mining-dependent economy is the source of these continuing socioeconomic and health disparities. The call by NIH for research to reduce and eliminate Appalachian health disparities should focus on eliminating disparities in the coalfields.

Previous research that examined specific forms of mortality in coal mining areas found that chronic forms of heart, respiratory, and kidney disease, as well as lung cancer, remained elevated after adjusting for socioeconomic and behavioral factors.[16,18,19] Elevated adjusted mortality occurred in both males and females, suggesting that the effects were not due to occupational exposure, as almost all coal miners are men. These illnesses are consistent with a hypothesis of exposure to water and air pollution from mining activities. There is evidence that the coal mining industry is a significant source of both air and water pollution.[45–50] In the current study, the adjusted VSL costs indicate that the potential environmental impacts of mining exceed the economic benefits of mining.

Eliminating the mortality disparity in coal mining areas would result in savings of an estimated 3,975 to 10,923 lives per year based on choice of comparison group. The results of the unadjusted analysis showed that the corresponding VSL estimates outweighed the economic benefits of coal mining by up to an order of magnitude, and the point estimate outweighed the benefits of mining by a factor of six.

Discounting the majority of VSL costs 10 years into the future still resulted in costs that exceeded benefits in seven of eight tests. Social disparities models indicated that socioeconomic disadvantage should not be "adjusted away"; all four unadjusted tests showed future costs exceeding current benefits.

Socioeconomic disadvantage is a powerful cause of morbidity and premature mortality.[51–53] Coal mining regions have higher unemployment and poverty rates compared with the rest of Appalachia or the nation, and this economic disadvantage appears to be a contributing factor to the poor health of the region's population. Areas with especially heavy mining have the highest unemployment rates in the region, contrary to the common perception that mining contributes to overall employment. The weakness of local coal-dependent economies is also evident from census data showing that migration has resulted in population loss from mining areas relative to non-mining areas. For example, coal mining counties in West Virginia experienced a mean net loss of 639 people to migration between 1995 and 2000, compared with a mean net migration gain of 422 people in non-mining counties.[54]

We limited the calculation of costs and benefits to those occurring in the Appalachian mining industry. For example, we did not include benefits such as the economic productivity resulting from coal combustion in factories nor the costs of premature deaths from air pollution caused by burning coal in those factories.[39] We intentionally limited the analysis to an assessment of the costs and benefits of the coal mining industry for the people of Appalachia.

We selected the VSL estimates that we used from studies by government agencies to reflect costs and benefits of policies for the population at large. We excluded VSL estimates derived from labor market studies, which typically result in higher mean VSLs for working-age populations, so that all people, regardless of age, were included at equal value. Although studies have generally confirmed that the VSL declines with age, regulatory policies to improve environmental health also have disproportionate benefits for the elderly.[23] The U.S. federal government has established that age discrimination (discounting the life value of older people) in VSL estimates is contrary to official policy.[22]

Limitations

First, despite the significant associations between coal mining activity and both socioeconomic disadvantage and premature mortality, it cannot be stated with certainty that coal mining causes these problems. It is not possible to determine what the economic and public health outcomes would be in these areas in the absence of mining. However, given the literature on the impacts of social disparities and the previously documented problems of coal-dependent economies, such a causal link seems likely.

Second, we had no direct measures of environmental pollutants to determine what role they play in excess mortality. We concluded that such an impact was possible given the results of the regression models and previously cited literature on the environmental consequences of coal mining.

Third, the discount analysis contained uncertainties. It was difficult to understand the time lag and the appropriate discount rate to apply to account for an unknown proportion of excess mortality due to delayed effects given available data.

Finally, the cost estimates may be conservative because they do not consider reduced employment productivity resulting from medical illness, increased public expenditures for programs such as food stamps and Medicaid,[32] reduced property values associated with mining activities,[55] and the costs of natural resource destruction.[56] Natural resources such as forests and streams have substantial economic value when they are left intact,[57] and mining is highly destructive of these resources. For example, Appalachian coal mining permanently buried 724 stream miles between 1985 and 2001 through mountaintop removal mining and subsequent valley fills, and will ultimately impact more than 1.4 million acres.[58] Coal generates inexpensive electricity, but not as inexpensive as the price signals indicate because those prices do not include the costs to human health and productivity, and the costs of natural resource destruction.

CONCLUSIONS

In response to this and other research showing the disadvantages of poor economic diversification,[2] it seems prudent to examine how more diverse employment opportunities for the region could be developed as a means to reduce socioeconomic and environmental disparities and thereby improve public health. Potential alternative employment opportunities include development of renewable energy from wind, solar, biofuel, geothermal, or hydropower sources; sustainable timber; small-scale agriculture; outdoor or culturally oriented tourism; technology; and ecosystem restoration.[10,59] The need to develop alternative economies becomes even more important when we realize that coal reserves throughout most of Appalachia are projected to peak and then enter permanent decline in about 20 years.[60]

Various efforts have been proposed to reduce carbon dioxide emissions to combat climate change. However, tighter pollution emission standards, carbon tax, cap-and-trade, and carbon sequestration proposals, even if effective, will only address how coal is burned. Such proposals ignore how coal is extracted, processed, and transported prior to burning. These preconsumption processes carry their own significant economic, environmental, and health costs.

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