# A Comparative Analysis of Health-Related Quality of Life for Residents of U.S. Counties with and without Coal Mining

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## **SYNOPSIS**

**Objectives.** We compared health-related quality of life (HRQOL) in mining and non-mining counties in and out of Appalachia using the 2006 Behavioral Risk Factor Surveillance System (BRFSS) survey.

**Methods.** Dependent variables included self-rated health, the number of poor physical and mental health days, the number of activity limitation days (in the last 30 days), and the Centers for Disease Control and Prevention Healthy Days Index. Independent variables included the presence of coal mining, Appalachian region residence, metropolitan status, primary care physician supply, and BRFSS behavioral (e.g., smoking, body mass index, and alcohol consumption) and demographic (e.g., age, gender, race, and income) variables. We compared dependent variables across a four-category variable: Appalachia (yes/no) and coal mining (yes/no). We used SUDAAN<sup>®</sup> Multilog and multiple linear regression models with post-hoc least-squares means to test for Appalachian coal-mining effects after adjusting for covariates.

**Results.** Residents of coal-mining counties inside and outside of Appalachia reported significantly fewer healthy days for both physical and mental health, and poorer self-rated health (p<0.0005) when compared with referent U.S. non-coal-mining counties, but disparities were greatest for people residing in Appalachian coal-mining areas. Furthermore, results remained consistent in separate analyses by gender and age.

**Conclusions.** Coal-mining areas are characterized by greater socioeconomic disadvantage, riskier health behaviors, and environmental degradation that are associated with reduced HRQOL.

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Much research has been devoted to the occupational health risks associated with coal mining.<sup>1–3</sup> Less understood are potential population-wide health risks, although recent studies have linked total mortality rates; mortality from lung cancer; and chronic heart, respiratory, and kidney disease mortality to Appalachian coal mining.<sup>4–6</sup> In addition, people in central Appalachia, where coal mining is heaviest, are at greater risk for major depression and severe psychological distress compared with other areas of Appalachia or the nation.<sup>7</sup>

Appalachian areas suffer disproportionately higher morbidity and mortality when compared with the nation.<sup>8-11</sup> More importantly, recent research has found exacerbated Appalachian health disparities as a function of coal production,<sup>4-6,12</sup> even after controlling for covariates such as smoking, education, poverty, race, health insurance, and physician supply.

The two overarching Healthy People 2010 objectives are "to increase quality and years of health life, and eliminate health disparities."<sup>13</sup> In response to tracking these overarching objectives, the Centers for Disease Control and Prevention (CDC) created four core health-related quality of life (HRQOL) questions and placed them on the Behavioral Risk Factor Surveillance System (BRFSS) survey in 1994.<sup>14,15</sup> Item 1 focuses on self-perceived health, asking: "In general, how would you rate your health?" This is a well-researched item that has been found to be predictive of mortality<sup>16-19</sup> and risk behaviors in adults.<sup>20</sup> Items 2 and 3, which relate to recent physical and mental health symptoms and are considered mutually exclusive, ask: "Now thinking about your physical (or mental) health, for how many days during the past 30 days was your physical (or mental) health not good?" Item 4 is conceptualized as a global measure of disability that explicitly incorporates both physical and mental health, asking: "During the past 30 days, on how many days did poor physical or mental health keep you from doing your usual activities . . .?" The conceptual relationships among the HRQOL scale items are detailed in the Figure.

Construct validity and test-retest reliability of the HRQOL scale have been established.<sup>14,21–23</sup> Other validity research found the scale to identify known or suspected population groups with unmet health-related needs, including those who reported chronic health conditions, disabilities, and low socioeconomic status.<sup>23–25</sup>

Most coal-mining public health research to date has relied on county-level data with limited covariates. For example, mortality was studied using CDC county-level data, and county smoking rate estimates were used in lieu of individual smoking behavior estimates. One study that used individual-level data<sup>12</sup> was limited to one state, used a nonstandard self-report instrument, and had limited covariate data, including no individuallevel smoking or obesity data. Therefore, the purpose of this study was to compare HRQOL in mining and non-mining counties in and out of Appalachia using the 2006 national BRFSS survey—an individual-level, validated instrument<sup>26</sup>—and to relate differences to socioeconomic, behavioral, and surrogate-environmental influences.

## METHODS

#### Sampling design

The study design was a retrospective analysis of 2006 BRFSS data on HRQOL in relation to individualand county-level risks, with a particular focus on the

Figure. Conceptual relationship of health-related quality-of-life scale items on the Behavioral Risk Factor Surveillance System survey

<ul> <li>✓ Question 1. Self-perceived health</li> </ul>						
>30 days ago	Past 30 days			Future		
	Days when					
	Question 2. Days when physical health was not goodQuestion 3. Days when mental health was not good					
		Question 4. Da activities were l	ı ys when usual imited			

presence of Appalachian coal mining. The BRFSS is a telephone-based, randomized, stratified survey established in 1984 to gather information on health-risk behaviors, preventive health practices, and health-care access, primarily related to chronic disease and injury-weighted to reflect the population of the United States.<sup>27</sup>

The 2006 BRFSS data were collected in all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands, with a median response rate of 51%.<sup>28</sup> Because nonresponse is an indicator of potential bias, comparison between respondents and nonrespondents on key demographics was necessary. In 2006, 60% of BRFSS respondents were female (vs. 51% nationally), 80% were non-Hispanic white (vs. 75% nationally), 6% were 18–24 years of age (vs. 14% nationally), 13% were 25-34 years of age (vs. 17% nationally), 18% were 35-44 years of age (vs. 19% nationally), 22% were 45-54 years of age (vs. 19% nationally), 18% were 55-64 years of age (vs. 14% nationally), and 21% were  $\geq$ 65 years of age (vs. 17% nationally). The combined large sample size and overall demographic differences suggest that despite the low response rate, little nonresponse bias was experienced in 2006.

#### Data

Dependent variables included the four core CDC HRQOL items: self-rated health, number of poor physical health days, number of poor mental health days, and number of activity limitation days (during the past 30 days). In addition, we calculated the CDC Healthy Days Index by adding the number of poor physical and mental health days (unhealthy days) experienced by a respondent during the past 30 days and subtracting that number from 30, with a logical maximum of 30 days. Response options to the self-rated health item included "excellent," "very good," "good," "fair," and "poor." For the "days" questions, respondents are prompted to report an exact figure (range: 0 to 30 days).

Independent variables were taken from the 2006 BRFSS survey, the county-level supplementary file provided by CDC for the 2006 survey, the Energy Information Administration (EIA),<sup>29</sup> and the Appalachian Regional Commission (http://www.arc.gov). Variables from the BRFSS include smoking, body mass index, alcohol consumption, age, gender, race/ethnicity, marital status, income, education, and metropolitan residence status.

More specifically, smoking was coded as a threelevel variable: current smoker, former smoker, or not a lifetime smoker. Body mass index was coded as a three-level variable: neither overweight nor obese, overweight, or obese. Alcohol consumption was coded as

any consumption (yes/no) in the past 30 days. Age was coded in number of years. Race/ethnicity was coded as a series of dichotomous variables specifying African American, Native American, non-white Hispanic, Asian American, or white non-Hispanic. Marital status was coded as a dummy variable specifying married or cohabiting vs. any other status. Income was coded as an eight-level variable for annual household income, ranging from <\$10,000 to  $\geq$ \$75,000. Education was coded into two dummy variables specifying high school or college graduate, with less than high school used as the referent. Metropolitan status was coded as a fivelevel variable, with higher scores indicating a more rural environment. The final variable included from the BRFSS was the county-level 2005 supply of officebased, general-practice medical doctors per 100,000 people.

The EIA was the source for identifying coal-mining counties. For the current study, we identified a coalmining county as one with any amount of coal mining during the years 1996–2005. In practice, most counties with mining during one year had mining for most or all of the years studied. Coal mining exists in Appalachia and in other areas of the nation. We used designations established by the Appalachian Regional Commission for 2006 to identify effects that may be unique to Appalachia. A four-category variable was created to classify each county in the country as Appalachian (yes/no) and coal mining (yes/no).

#### Data analysis

Analyses include descriptive summaries of the variables followed by inferential analyses to examine HRQOL in coal-mining areas. Because of the complex sampling design of the BRFSS, models were analyzed using SUDAAN<sup>®30</sup> Proc Multilog for the ordinal measure of self-rated health and Proc Regress for the continuous HRQOL "days" measures. For the Multilog models, selfrated health was dichotomized into fair/poor health and compared with the referent category of excellent/very good/good health rating. We determined odds ratios for the Multilog models and regression coefficients for the Regress models and estimated all models both before and after controlling for covariates. We examined post-hoc least-squares means in the Regress models.

Effect size (ES) was calculated from the post-hoc comparisons to determine the overall magnitude of the comparisons through the use of the f effect size index for multiple means. ES values provide an indication of the magnitude of observed differences and, in a practical sense, show the size of differences between means. ESs of 0.10, 0.25, and 0.40 indicate

small, medium, and large effects, respectively, using the f calculation.<sup>31</sup> We used counties without mining and outside Appalachia as the referent group for the categorical county grouping variable.

## RESULTS

## **Demographics**

Only people in the 50 U.S. states and the District of Columbia (n=349,287) were included in the analyses. Missing data on BRFSS items reduced the final sample size to 236,195, primarily due to missing data on the income and county identifier variables. There are 3,141 U.S. counties nationwide, of which 1,148 (37%) are represented in the study. There are 410 Appalachian counties based on the designations in place in 2006, and 150 (37%) are represented in the study. Similarly, there are 139 Appalachian counties with coal mining, and 60 (43%) are represented in this study. Table 1 provides a summary of demographic covariate study variables overall and by the four county groups.

### Multilog regression results

Both unadjusted and adjusted comparisons for the selfrated health variable suggest Appalachian coal-mining counties have significantly reduced self-rated health (Table 2). Before covariates were added to the model, residents in non-coal-mining Appalachian counties had 1.30 greater odds of reporting fair/poor self-rated health (95% confidence interval [CI] 1.24, 1.37) when compared with referent non-Appalachian non-coal-mining counties. However, residents of coal-mining Appalachian counties had 1.56 greater odds of reporting fair/poor self-rated health (95% CI 1.48, 1.63). When the covariates were added to the model, the effects persisted only in the Appalachian coal-mining counties (odds ratio [OR] = 1.11, 95% CI 1.05, 1.18).

#### Multiple regression results

Tables 3 and 4 provide unadjusted and adjusted mean comparisons for the HRQOL dependent variables. Similar to the Multilog models with self-rated health, Appalachian counties had significantly reduced health

Table 1	. Summary	y of the vari	ables of the	2006	Behavioral	<b>Risk Factor</b>	Surveillance	System
survey,	including	Appalachia	(ves/no) and	d coal	mining (yes	/no)		

Variables	Appalachia, coal mining N (percent)	Appalachia, no coal mining N (percent)	Not Appalachia, coal mining N (percent)	Not Appalachia, no coal mining N (percent)	Total
Sample size	9,339 (4.0)	9,626 (4.1)	9,092 (3.8)	208,138 (88.1)	236,195
Number of counties	60 (5 2)	90 (7.8)	42 (3 7)	956 (83 3)	1 148
Female	5.540 (4.0)	5.562 (4.1)	5.259 (3.8)	120.966 (88.1)	137.327
Smoking status			-, (,		,.
Current smoker	2,291 (5.0)	2,180 (4,4)	1,630 (3,4)	39,260 (87.2)	44,390
Former smoker	2,516 (3,7)	2,505 (3.7)	2,634 (3,9)	60,825 (88.7)	67,085
Nonsmoker	4,532 (3.8)	4,941 (4,1)	4,828 (4.0)	108,053 (90.2)	119,776
Alcohol use (in last 30 days)	3,917 (3.1)	3,737 (2.9)	4,923 (3.9)	113,229 (90.0)	125,806
High school education	5,978 (4.7)	5,607 (4.3)	5,099 (3.9)	113,451 (87.1)	130,135
College education	2,244 (2.6)	2,840 (3.3)	3,400 (3.9)	77,860 (90.2)	86,344
Married	5,218 (3.8)	5,837 (4.2)	5,437 (3.9)	122,018 (88.1)	138,510
Race/ethnicity					
African American	365 (1.9)	698 (3.6)	344 (1.8)	18,130 (92.7)	19,537
Native American	217 (1.2)	301 (1.6)	664 (3.5)	17,545 (93.7)	18,727
Asian American	116 (1.3)	179 (2.0)	623 (7.0)	7,994 (89.7)	8,912
Hispanic	108 (0.1)	194 (1.4)	477 (3.3)	13,572 (94.6)	14,351
Overweight	3,424 (4.0)	3,512 (4.1)	3,308 (3.8)	76,160 (88.1)	86,404
Obese	2,834 (4.6)	2,752 (4.5)	2,364 (3.8)	53,616 (87.1)	61,566
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Mean income category	5.0 (0.02)	5 3 (0 02)	5 8 (0 02)	57(001)	5 7 (0 01)
Mean age	52 6 (0 17)	52 0 (0 16)	51.3 (0.17)	51 5 (0.04)	51 4 (0 03)
Mean metropolitan status category	2.8 (0.01)	3 0 (0 01)	2.6 (0.01)	2 5 (0 01)	2 5 (0 01)
Mean doctors per 100,000 population	24.3 (0.03)	31.1 (0.05)	37.0 (0.05)	27.1 (0.01)	27.5 (0.01)

SE = standard error

Model	Appalachia, coal-mining counties OR (Cl)	Appalachia, non-coal-mining counties OR (Cl)	Not Appalachia, coal-mining counties OR (CI)	Not Appalachia, non-coal-mining counties OR (Cl)
Unadjusted	1.56ª	1.30ª	0.96	Ref.
	(1.48, 1.63)	(1.24, 1.37)	(0.09, 1.01)	
Adjusted	1.11ª	1.06	1.03	
	(1.05, 1.18)	(1.00, 1.12)	(0.96, 1.10)	Ref.

Table 2. Unadjusted and adjusted models with ORs and 95% Cls for fair/poor self-rated health by county group, including Appalachia (yes/no) and coal mining (yes/no): 2006 Behavioral Risk Factor Surveillance System survey

<sup>a</sup>p<0.0001

OR = odds ratio

CI = confidence interval

Ref. = referent group

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ratings on all of the variables before covariates were added to the model, but Appalachian coal-mining counties reported greater HRQOL impairment within the Appalachian region (Table 3). ESs for these differences ranged from 0.07 to 0.31, indicating small to medium effects. Specifically, the ES for poor physical health days was 0.08 (f[3, 236,192] = 70.11, p<0.0001), for poor mental health days was 0.07 (f[3, 236,192] = 47.67, p<0.0001), the ES for activity limitation days was 0.14 (f[3, 236,192] = 52.21, p<0.0001), and the ES for the Healthy Days Index was 0.31 (poor physical and mental health days combined; f[3, 236,192] = 82.39, p<0.0001).

When the covariates were added to the model, the effects of coal mining on HRQOL persisted in the Appalachian coal-mining counties (Table 4). In addition, all HRQOL impairment in Appalachian counties without coal mining disappeared, which is consistent with the body of literature documenting health disparities among the Appalachian population that result from the covariates included (e.g., income and smoking).<sup>6,12</sup> Lastly, non-Appalachian coal-mining counties began to appear more similar in HRQOL to Appalachian coal-mining counties with the covariates determining counties with the covariates added to the

model. However, the ESs for these differences were generally not as strong, ranging in strength from 0.04 to 0.09 despite retaining their statistical significance (f[3, 236, 192] = 3.35, p < 0.05 for physical health days; f[3, 236, 192] = 7.22, p < 0.0001 for mental health days; and f[3, 236, 192] = 6.32, p < 0.0005 for the Healthy Days Index).

We reanalyzed models without the income variable to test the sensitivity of the results for potential bias from missing income data. The model results were essentially unchanged, and all Appalachian coal-mining effects remained significant (data not shown).

When the models with covariates were repeated separately for men and women, we found similar results for each gender, including significant Appalachian coalmining ESs for women and men for self-rated health and the Healthy Days Index. In addition, when the models were repeated once again by age group (<50 years of age and  $\geq$ 50 years of age), the ESs remained and increased with age in the Appalachian coal-mining counties for the Healthy Days Index (Table 5). Although not shown in a table, we noted similar significant trends for greater odds of reporting fair/poor self-rated health for both women and men and among

Table 3. Unadjusted means for the continuous dependent health-related quality-of-life variables by county group, including Appalachia (yes/no) and coal mining (yes/no): 2006 Behavioral Risk Factor Surveillance System survey

Unadjusted model	Appalachia, coal-mining counties Mean (SE)	Appalachia, non- coal-mining counties Mean (SE)	Not Appalachia, coal-mining counties Mean (SE)	Not Appalachia, non- coal-mining countiesª Mean (SE)
Poor physical health (past 30 days)	5.16 (0.10) <sup>⊾</sup>	4.48 (0.09) <sup>ь</sup>	3.78 (0.09)	3.84 (0.02)
Poor mental health (past 30 days)	4.36 (0.09) <sup>b</sup>	3.78 (0.09) <sup>b</sup>	3.35 (0.08)	3.33 (0.02)
Activity limitation (past 30 days)	3.20 (0.08) <sup>b</sup>	2.78 (0.08)b	2.38 (0.07)	2.31 (0.01)
Healthy Days Index	7.98 (0.12) <sup>b</sup>	6.98 (0.11) <sup>b</sup>	6.27 (0.11)	6.23 (0.02)

<sup>a</sup>Referent group

<sup>b</sup>p<0.0001

SE = standard error

Table 4. Adjusted means for the continuous dependent health-related quality-of-life variables by county group, including Appalachia (yes/no) and coal mining (yes/no): 2006 Behavioral Risk Factor Surveillance System survey

Adjusted model	Appalachia, coal-mining counties Mean (SE)	Appalachia, non- coal-mining counties Mean (SE)	Not Appalachia, coal-mining counties Mean (SE)	Not Appalachia, non- coal-mining countiesª Mean (SE)
Poor physical health (past 30 days)	4.16 (0.09) <sup>ь</sup>	3.90 (0.09)	4.02 (0.09)	3.92 (0.02)
Poor mental health (past 30 days)	3.74 (0.09)°	3.56 (0.08) <sup>d</sup>	3.54 (0.08) <sup>d</sup>	3.37 (0.02)
Activity limitation (past 30 days)	2.47 (0.08)	2.36 (0.07)	2.51 (0.07) <sup>d</sup>	2.35 (0.01)
Healthy Days Index	6.72 (0.11) <sup>c</sup>	6.35 (0.10)	6.55 (0.10) <sup>d</sup>	6.23 (0.02)

<sup>a</sup>Referent group

<sup>b</sup>p<0.01

°p<0.001

<sup>d</sup>p<0.05

SE = standard error

those aged  $\geq 50$  years, with Appalachian coal-mining counties reporting the greatest odds (p < 0.001).

## DISCUSSION

This study expanded upon previous research on the effects of coal mining on population health outcomes

through the inclusion of individual-level health behavior data on a large, nationally representative dataset. We found that self-rated health and HRQOL were significantly reduced among residents of Appalachia when compared with residents in other county groupings in both the unadjusted and adjusted analyses. In the models adjusted for the covariates, we determined

Table 5. Adjusted means for the Healthy Days Index for men and women by county group, including Appalachia (yes/no) and coal mining (yes/no): 2006 Behavioral Risk Factor Surveillance System survey

Variable	Appalachia, coal-mining counties Mean (SE)	Appalachia, non- coal-mining counties Mean (SE)	Not Appalachia, coal-mining counties Mean (SE)	Not Appalachia, non- coal-mining countiesª Mean (SE)
Women				
Poor physical health (past 30 days)	4.37 (0.12)	4.22 (0.12)	4.39 (0.12)	4.23 (0.02)
Poor mental health (past 30 days)	4.36 (0.12) <sup>b</sup>	4.24 (0.11) <sup>c</sup>	4.13 (0.11) <sup>d</sup>	3.89 (0.02)
Activity limitation (past 30 days)	2.59 (0.10)	2.53 (0.09)	2.80 (0.09)°	2.53 (0.02)
Healthy Days Index	7.42 (0.15)°	7.28 (0.14)	7.30 (0.14) <sup>d</sup>	7.02 (0.03)
Men				
Poor physical health (past 30 days)	3.87 (0.15)°	3.44 (0.13)	3.46 (0.13)	3.45 (0.03)
Poor mental health (past 30 days)	2.82 (0.12)	2.57 (0.12)	2.67 (0.11)	2.60 (0.02)
Activity limitation (past 30 days)	2.30 (0.12)	2.11 (0.11)	2.08 (0.10)	2.10 (0.02)
Healthy Days Index	5.70 (0.17) <sup>c</sup>	5.02 (0.15)	5.43 (0.15)	5.22 (0.03)
Age $<$ 50 years				
Poor physical health (past 30 days)	3.00 (0.12)	2.78 (0.11)	2.90 (0.10)	2.82 (0.02)
Poor mental health (past 30 days)	4.19 (0.14) <sup>d</sup>	4.02 (0.12)	4.07 (0.12)	3.85 (0.02)
Activity limitation (past 30 days)	2.08 (0.10)	1.82 (0.09)	1.94 (0.08)	1.90 (0.02)
Healthy Days Index	6.21 (0.16) <sup>d</sup>	5.93 (0.14)	6.23 (0.14) <sup>d</sup>	5.88 (0.03)
Age ≥50 years				
Poor physical health (past 30 days)	5.05 (0.14)	4.78 (0.13)	4.91 (0.13)	4.83 (0.03)
Poor mental health (past 30 days)	3.16 (0.11)	2.99 (0.11)	3.05 (0.10)	2.96 (0.02)
Activity limitation (past 30 days)	2.83 (0.11)	2.76 (0.11)	2.98 (0.11) <sup>d</sup>	2.76 (0.02)
Healthy Days Index	7.02 (0.15) <sup>d</sup>	6.60 (0.15)	6.82 (0.15)	6.68 (0.03)

<sup>a</sup>Referent group

<sup>b</sup>p<0.001

<sup>c</sup>p<0.01

<sup>d</sup>p<0.05

SE = standard error

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that residents of coal-mining counties reported poorer self-rated health and HRQOL when compared with residents in counties without coal mining, inside and outside of Appalachia. The effects were consistent for both men and women and by age group, although the ESs were small.

Furthermore, we observed that once all covariates were controlled, residents of Appalachian counties without coal mining were statistically equivalent to residents of counties without coal mining outside of Appalachia in terms of their reported HRQOL. These findings add not only to the documented social disparities in Appalachia, but also to a growing environmental health-disparities literature base pertaining specifically to the coal extraction and processing industry.<sup>5,6,12</sup> Lastly, the unique contributions of coal-mining activity to health ratings become apparent when covariates are adjusted, as evidenced by the significant decreases in health ratings among residents in coal-mining counties outside of Appalachia in all adjusted models.

We observed moderate to strong effects for self-rated health in both the unadjusted and adjusted models. This empirical evidence is congruent with the theoretical underpinnings of how adults rate their health. As depicted in the Figure, self-perceived health spans past and present physical, behavioral, emotional, and cognitive aspects of health and includes cognitive aspects in the future.<sup>32</sup> Past physical aspects refer to illnesses, symptoms, pain, disabilities, and chronic conditions experienced and then treated by a physician. Present physical aspects of health refer to the condition of the respondent at the time of the self-rating. Past behavioral aspects of health may include memories of health-related behaviors or conditions. Diets; exercise regimens; sexual behavior; suicidal ideologies or attempts; exposure to poor environmental conditions; and frequency of smoking, alcohol use, or drug use would all be considered health behaviors frequently engaged in by adults. Present behavioral aspects of health refer to any current behaviors. Past emotional aspects of health refer to experienced emotional conditions (e.g., depression and anxiety), moods, one's reaction to a diagnosis of an infectious or chronic condition, and any temporary emotional problems. Present emotional aspects of health would consist of the emotional state of the respondent at the time of the self-assessment.

Self-rated health has proved to be a more powerful predictor of mortality than more detailed objective, physician-assessed health indicators.<sup>16–19,33–35</sup> Thus, the persistent effect on impaired self-rated health among residents of Appalachia, and among residents in coalmining counties outside of Appalachia, suggests a

link between this study and previous studies that have documented mortality effects. That is, even though the ORs in the current study were moderate, it may be that they capture the cumulative impacts of health problems, which, during the lifetime, increase the risk for premature mortality. For instance, present and future cognitive aspects of health "reflect the notion that individuals may project a health trajectory into the future based on the information available to them from the past and present moment."<sup>32</sup> Thus, it is likely that these projections were reflected in current selfratings of health.

The small ESs for the "days" items were also consistent with the theoretical relationship among the HRQOL items in the Figure. For these items, respondents were only asked to recall poor health in the past 30 days. However, when examining the findings from the Healthy Days Index, results reported still suggested a mean of about a half-day worse reported HRQOL among residents of Appalachian coal-mining counties when compared with the referent residents in U.S. counties, and steadily declined with age. If these results were extended across one year, this would be a mean of six additional poor health days for residents of Appalachian coal-mining counties. Across an average American lifetime of 78 years, that is approximately 462 days (15.5 months) of HRQOL impairment directly associated with residence in a coal-mining county in Appalachia, and 283 days (9.5 months) for an average resident in a coal-mining county outside Appalachia.

#### Limitations

Our study had several limitations. First, county of residence does not necessarily indicate exposure. Coalmining activity may be distributed more heavily in some parts of a county than in others, and mining effects may cross county lines to impact non-coal-mining counties. This may partially explain some of the observed small ESs. If only residents of communities where coal-mining activity directly occurred were surveyed, the ESs and reduced HRQOL could be larger than those reported in this study. Second, only 60 counties that were located within Appalachia and where coal mining was present were available for analysis. Third, multiple statistical tests raised the possibility of a Type I error, although most Appalachian mining effects were significant at p < 0.01 or better. Fourth, the study did not include direct environmental measures of air and water quality; this information, such as from the Environmental Protection Agency's (EPA's) National Ambient Air Quality Standards, exists for only a limited set of primarily urban counties. Likewise, water quality data are available nationwide only for public water systems and not for private wells, and for public systems only when they surpass an established EPA standard. Future research will need to obtain specific environmental and health measures of these communities to fully assess the impact of coal mining on human health.

## CONCLUSIONS

This was the first study to employ the national, representative, individual-level BRFSS data to explore the impacts of coal-mining activity on HRQOL. Results provide further evidence that U.S. coal-mining counties, and Appalachian coal-mining counties in particular, are characterized by greater socioeconomic disadvantage, riskier health behaviors, and environmental degradation that are associated with reduced HRQOL. Although causes for reduced HRQOL in coal-mining areas are likely multifaceted from the interactions of water and air contamination,<sup>36-38</sup> stronger effects in Appalachian coal-mining counties may be the result of resident proximity to intense mining activity.

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