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## Promotion and Protection of Rural Miner Health: Are the Resources in Place?

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### INTRODUCTION

Mining ranks among the most dangerous occupations in the U.S., with a fatality rate more than seven times the average for all private industry.<sup>1</sup> In addition, many diseases and disorders are associated with mining. These include noise-induced hearing loss, cumulative stress disorders, coal worker's pneumoconiosis (CWP, also commonly known as "Black Lung Disease"), silicosis, other respiratory diseases, physical issues related to exposure to chemical agents, and dermatitis/skin disorders.<sup>2-4</sup> Many mining occupational diseases and disorders are slow-progressing, and it may take years of exposure before symptoms appear.<sup>2</sup>

Because the majority of mining occurs in rural compared to urban areas, it is likely that rural populations are more vulnerable to health risks associated with mining. Individuals living in rural as opposed to urban areas display greater rates of unmet healthcare needs.<sup>5-6</sup> However, no study has, of yet, been conducted specifically on health care services available in rural mining communities. The current study was therefore undertaken to investigate whether mining communities face shortages in numbers of safety net providers compared to non-mining communities.

### METHODS

#### Geographic Coverage

Data on mining activity were collected for all states of the U.S. Analyses were conducted to examine mining activity and health care access by level of rurality using county-level rural-urban continuum codes, among all metropolitan (N=1,090) and non-metropolitan or rural (N=2,051) counties. Rural-urban commuting codes 1 through 3 were used to identify urban counties, and codes 4-9 were used to identify rural counties.

#### Data Sources

**Mining Community Data Sets:** Data on U.S. mining activity were drawn from a dataset provided to us from the Mining Safety and Health Administration (MSHA). This dataset included all active mines as of June 2011. For each mine there was information on the mine's location, and the type of mining commodity. Of the 14,505 active mine database entries provided by MSHA, 11,320 were converted into a spatial data format for use in the analysis (78% of the total). Three thousand one hundred eighty five (3,185) mine facilities were removed prior to creation of spatial data due to being located outside of this study's area of interest (the 50 U.S. States). All facilities were located in geographic space utilizing provided longitude/latitude

coordinate pairs. Final location information was cross-checked against other MSHA provided location information (i.e., does longitude/latitude coordinate fall within the correct county according to the database contents). All sites passed these tests.

**Safety Net Provider Data Set:** A list of Critical Access Hospitals (CAH) was downloaded from the Flex Monitoring Team site.<sup>7</sup> The Health Resources and Services Administration (HRSA) has a 'find a health center' web site containing a database with the address and ZIP code of all Federally Qualified Health Centers (FQHCs).<sup>8</sup> A list of Black Lung Clinics was obtained from the Black Lung Clinics Coordinator at HRSA's Office of Rural Health Policy. Finally, a database containing the name, address and ZIP code of Rural Health Clinics (RHCs) nationwide was downloaded from the Centers for Medicare and Medicaid Services (CMS) site.<sup>9</sup> Generation of spatial datasets was completed using Arc Map version 10.0.

**General health care provider data:** In addition to data on safety net providers, we used HRSA's 2009 Area Resource File to measure the per capita supply of practicing primary care physicians (MDs and DOs) per 10,000 persons, and to measure whether each county had at least one short term general hospital.

**County Level Dataset Development:** We conducted an analysis to join datasets for mines and health care providers together with data for U.S. counties and ZIP code areas. The end result is a spatial database of U.S. counties where each record contains counts of mines, FQHCs, Rural Health Clinics, Black Lung Clinics, and Critical Access Hospitals within that county. Mine counts were found for all mines combined and for mines by commodity type.

### **Hypotheses and Analysis**

We tested the null hypothesis that there is no association between mining activity and provider supply. In addition, we expected to see geographic variability in the extent to which safety net providers are available in mining areas across the nation.

Descriptive analyses were performed using SAS software version 9.3 to summarize the number of mining sites by several characteristics: commodity mined (i.e., stone, sand and gravel, metal, non-metal, and coal); number of safety net providers by type (i.e., Black Lung Clinics, Rural Health Clinics, Federally Qualified Health Centers, and Critical Access Hospitals), presence of short-term general hospitals, and per capita supply of primary care physicians. A P value of <.05 was used for statistical tests.

Spatial analyses were conducted using ArcGIS software to display and evaluate the geographic distribution of both mining activity and safety net providers. Bivariate spatial correlations were computed to determine whether or not there was significant spatial overlap between mining sites and safety net providers. Spatial overlap was defined as the county containing the safety net provider plus the neighboring adjacent counties; overlap existed if that space contained mining activity.

## **RESULTS**

All Tables and Figures are presented in an Appendix to this report. Table 1 presents a descriptive summary of the total and mean numbers of mines and safety net providers. The table shows, for example, that there were 2,018 active coal mines in the MSHA database, with a county-level range from 0 to 147 mines.

Table 2 shows the breakdown of mining activity by rural-urban county designation. As expected, most mining occurs in rural counties, but there is some mining that occurs in counties classified as metropolitan.

Tables 3-6 summarize the results of a set of 2x2 chi-square statistical tests to examine whether areas with mining were significantly more or less likely to have safety net providers than areas without mining. Counties were categorized into two-level groups, either the presence or absence of mining, and the presence or absence of safety net providers.

Table 3 shows results specifically for the FQHCs. Areas with any type of mining were significantly more likely to have one or more FQHCs than areas without mining.

Table 4 repeats this analysis for Rural Health Clinics, and Table 5 for Critical Access Hospitals. These analyses are limited to non-metropolitan counties because Rural Health Clinics and Critical Access Hospitals are required to be in non-metropolitan areas. Table 4 shows no significant differences between mining activity and the presence or absence of Rural Health Clinics. Table 5 shows that areas with either coal mining or stone mining were significantly less likely to have a Critical Access Hospital.

Table 6 shows the results for all safety net providers together (presence or absence of a CAH, RHC, FQHC, or Black Lung Clinic.) This table is limited to non-metropolitan counties. The bottom of this table also shows the results for all types of mining combined. As the bottom of this table shows, areas with any form of mining were significantly more likely ( $p < .05$ ) to have at least one safety net provider, although the actual percentage difference was only 88% (mining) vs. 85% (no mining) with at least one safety net provider.

### **General health care resources**

Although the intent of this study was to examine safety net providers, we also compared mining and non-mining areas on presence of short term general hospitals and per capita supply of primary care physicians. These results are found in Table 7. The supply of these types of health care providers was significantly higher in mining versus non-mining counties. This was true for all counties combined, and for rural counties.

### **Spatial Results**

The results of the spatial analyses are summarized in maps in Figures 1 through 4 (these Figures are provided in the Appendix to this report). Figure 1 shows the general distribution of mining activity in the U.S. Coal mining occurs in Appalachia, southern Illinois and Indiana, places in the Mountain States, and a few other locations. Sand/gravel and stone mining occur in many places from coast to coast, with concentrations in the Northeast, Upper Midwest, and West Coast. Other forms of mining are less common and occur in various areas around the country.

Figures 2-4 show the bivariate spatial distribution of mining and safety net providers. These maps identify mining areas with good representation of safety net providers (dark red on the maps), and mining areas with poor representation of safety net providers (light blue on the maps.) Good/Poor representation of safety net providers is a comparison against the average number of providers per county. Figure 2 specifically shows the bivariate distribution of mining and FQHCs. This map shows that there are some mining areas of the country where FQHCs are less available. The blank areas may or may not have either mining or FQHCs, but their relative distribution is average or "normal"; only clusters where mining and/or FQHCs are unusually high or low are shown. "Neighborless" in Figure 3 refers to islands; this is primarily for Hawaii but also represents a few other places where a county is one or more islands (e.g., Martha's Vineyard in Massachusetts or San Juan in Washington State).

Figure 3 repeats this analysis for Rural Health Clinics, and Figure 4 for Critical Access Hospitals.

## **DISCUSSION**

Mining areas of the US, in general, do not experience shortages of safety net providers relative to non-mining areas. In fact, in some cases, mining areas have a significantly greater supply of safety net providers compared to non-mining areas. It is also the case that mining areas, on average, have significantly more practicing primary care physicians per capita, and are more likely to have at least one short-term general hospital, than non-mining areas. This is

encouraging in the sense that mining populations, which experience high rates of illness and injury due to the demanding nature of the work, enjoy geographic proximity to providers within the same counties.

Despite this overall finding, the results of the spatial analysis indicated that there are geographic pockets where safety net providers are in short supply in areas where mining takes place. The areas of safety net provider shortages are found in regions throughout the country and for a variety of different mining commodities, but are most commonly seen in areas of the Southwest, central Appalachia, and the Northeast. The spatial pattern of shortage areas was similar, although not identical, across the three types of safety net providers.

From the results of the spatial analyses, it can be seen that the shortage areas identified in central Appalachia are coal mining areas. These areas are largely rural, and are known to experience some of the worst socioeconomic conditions and worst health statistics in the nation.<sup>10</sup> Given these disadvantages, this particular geographic region may be a priority in efforts to improve distribution and availability of safety net providers. Other priority areas include, in part, shortage areas in Pennsylvania, Wisconsin, New York and other Northeast states, and portions of Arizona, Nevada and other western locations.

Particular pockets of safety net provider shortages also vary somewhat by the specific provider type. For example, for Rural Health Clinics, there are shortage areas in places such as Arizona or western Massachusetts, whereas FQHCs in these same areas do not experience shortages. It is possible that availability of FQHCs versus Rural Health Clinics may compensate for one another, so that the availability of one or the other meets outpatient treatment needs. Particular programs that support CAHs versus FQHCs versus Rural Clinics may target different geographic areas where health care needs of mining populations may be most severe.

### **Limitations**

Potential limitations of the analysis include temporal imperfections in the data, and possible incomplete data in mapping all mining activity. Data from various sources may not necessarily cover the same time periods (e.g., a database on the location of Rural Health Clinics at a point in time may not match exactly to the time period covered by the mining database.) In addition, we were unable to assess commuting patterns, and mining populations may work and live in different locations, such that health care is not accessed in the same place as where work takes place.

## **CONCLUSIONS & POLICY IMPLICATIONS**

Our primary finding is that mining areas, compared to non-mining areas, have on average better supplies of safety net providers, hospitals, and practicing primary care physicians. The implication of this finding is that there are other, non-mining, areas that are more likely to experience provider shortages. An examination of Figures 2 through 4 in this report suggests that such areas run through the High Plains of the central US, and over parts of the Southeastern US. Future work may examine these areas more closely to determine what factors may influence these shortages.

However, the results support the need to examine and address the availability of safety net provider types in selected geographic areas where mining takes place. Improved provision of Rural Health Clinics, Critical Access Hospitals, and Federally Qualified Health Centers in targeted mining communities may be beneficial to improve care availability and delivery to mining populations. Because of the high levels of injury and illness among miners, such improved provision could have significant public health benefits.

## LITERATURE CITATIONS

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### Additional Information

*This Policy Brief represents a shorter version of the full report of this study. For the full report please visit our website: <http://publichealth.hsc.wvu.edu/wvrhrc/index.html>*

## APPENDIX

**Table 1:** Descriptive summary of mines and safety net providers (N=3,141 counties).

	Total nationwide	Mean per county	Standard Deviation	Minimum and Maximum per county
<b>Mines</b>				
<b>Coal</b>	2,018	0.64	5.28	0-147
<b>Metal</b>	203	0.06	0.45	0-9
<b>Non-metal</b>	506	0.16	0.68	0-11
<b>Sand/gravel</b>	5,082	1.62	3.22	0-49
<b>Stone</b>	3,510	1.12	2.72	0-79
<b>Safety Net Providers</b>				
<b>FQHCs</b>	9,133	2.91	10.80	0-338
<b>Rural Health Clinics</b>	3,890	1.24	2.03	0-39
<b>Critical Access Hospitals</b>	1,320	0.42	0.62	0-4
<b>Black Lung Clinics</b>	27	0.009	0.10	0-2

**Table 2:** Number of counties with mining activity summarized by urban-rural county designations.

	Number of Rural Counties with Mining	Number of Urban Counties with Mining	Total Counties with Mining
<b>Mine Type</b>			
<b>Coal</b>	152	65	217
<b>Metal</b>	65	44	109
<b>Non-metal</b>	179	120	299
<b>Sand/gravel</b>	879	523	1402
<b>Stone</b>	698	546	1244

**Table 3:** Associations between mining activity and Federally Qualified Health Centers (N=3,141 counties). Percentages sum to 100% across rows (mining type).

	FQHC present		Total
	Yes	No	
<b>Coal mining a</b>	141 (65%)	76 (35%)	217
<b>No coal mining</b>	1487 (51%)	1437 (49%)	2924
<b>Total</b>	1628 (52%)	1513 (48%)	3141
<b>Metal mining b</b>	74 (68%)	35 (32%)	109
<b>No metal mining</b>	1554 (51%)	1478 (49%)	3032
<b>Total</b>	1628 (52%)	1513 (48%)	3141
<b>Non-metal mining c</b>	174 (58%)	125 (42%)	299
<b>No non-metal mining</b>	1454 (51%)	1388 (49%)	2842
<b>Total</b>	1628 (52%)	1513 (48%)	3141
<b>Sand/gravel mining d</b>	775 (55%)	627 (45%)	1402
<b>No sand/gravel mining</b>	853 (49%)	886 (51%)	1739
<b>Total</b>	1628 (52%)	1513 (48%)	3141
<b>Stone mining e</b>	714 (57%)	530 (43%)	1244
<b>No stone mining</b>	914 (48%)	983 (52%)	1897
<b>Total</b>	1628 (52%)	1513 (48%)	3141

a.  $p < .0001$   
 b.  $p < .0006$   
 c.  $p < .03$   
 d.  $p < .0005$   
 e.  $p < .0001$

**Table 4:** Associations between mining and the presence or absence of Rural Health Clinics (N=2052 non-metropolitan counties). Percentages sum to 100% across rows (mining type).

	Rural Health Clinic Present		Total
	Yes	No	
<b>Coal mining a</b>	105 (69%)	47 (31%)	152
<b>No coal mining</b>	1164 (61%)	736 (39%)	1900
<b>Total</b>	1269 (62%)	783 (38%)	2052
<b>Metal mining b</b>	39 (60%)	26 (40%)	65
<b>No metal mining</b>	1230 (62%)	757 (38%)	1987
<b>Total</b>	1269 (62%)	783 (38%)	2052
<b>Non-metal mining c</b>	119 (66%)	60(34%)	179
<b>No non-metal mining</b>	1150 (61%)	723 (39%)	1873
<b>Total</b>	1269 (62%)	783 (38%)	2052
<b>Sand/gravel mining d</b>	523 (60%)	356 (40%)	879
<b>No sand/gravel mining</b>	746 (64%)	427 (36%)	1173
<b>Total</b>	1269 (62%)	783 (38%)	2052
<b>Stone mining e</b>	423 (62%)	265 (38%)	698
<b>No stone mining</b>	836 (62%)	518 (38%)	1354
<b>Total</b>	1269 (62%)	783 (38%)	2052

a.  $p < .06$   
 b.  $p < .76$   
 c.  $p < .18$   
 d.  $p < .06$   
 e.  $p < .90$



**Table 5:** Associations between mining and presence or absence of Critical Access Hospitals (N=2052 non-metropolitan counties). Percentages sum to 100% across rows (mining type).

	CAH Present		Total
	Yes	No	
<b>Coal mining a</b>	51 (34%)	101 (66%)	152
<b>No coal mining</b>	880 (46%)	1020(54%)	1900
<b>Total</b>	1121 (55%)	931 (45%)	2052
<b>Metal mining b</b>	36 (55%)	29 (45%)	65
<b>No metal mining</b>	895 (45%)	1092 (55%)	1987
<b>Total</b>	1121 (55%)	931 (45%)	2052
<b>Non-metal mining c</b>	108 (60%)	71 (40%)	179
<b>No non-metal mining</b>	1013 (54%)	860 (46%)	1873
<b>Total</b>	1121 (55%)	931 (45%)	2052
<b>Sand/gravel mining d</b>	417 (47%)	462 (53%)	879
<b>No sand/gravel mining</b>	704 (60%)	469 (40%)	1173
<b>Total</b>	1121 (55%)	931 (45%)	2052
<b>Stone mining e</b>	388 (56%)	310 (44%)	698
<b>No stone mining</b>	733 (54%)	621 (46%)	1354
<b>Total</b>	1121 (55%)	931 (45%)	2052

a.  $p < .003$   
 b.  $p < .10$   
 c.  $p < .11$   
 d.  $p < .0001$   
 e.  $p < .53$

**Table 6:** Associations between mining and any type of safety net provider (N=2052 non-metropolitan counties). Percentages sum to 100% across rows (mining type).

	Any Safety Net Provider Present		Total
	Yes	No	
<b>Coal mining a</b>	140 (92%)	12 (8%)	152
<b>No coal mining</b>	1639 (86%)	261 (14%)	1900
<b>Total</b>	1779 (87%)	273 (13%)	2052
<b>Metal mining b</b>	61 (94%)	4 (6%)	65
<b>No metal mining</b>	1718 (86%)	269 (14%)	1987
<b>Total</b>	1779 (87%)	273 (13%)	2052
<b>Non-metal mining c</b>	150 (84%)	29 (16%)	179
<b>No non-metal mining</b>	1629 (87%)	244 (13%)	1873
<b>Total</b>	1779 (87%)	273 (13%)	2052
<b>Sand/gravel mining d</b>	771 (88%)	108 (12%)	879
<b>No sand/gravel mining</b>	1008 (86%)	165 (14%)	1173
<b>Total</b>	1779 (87%)	273 (13%)	2052
<b>Stone mining e</b>	612 (88%)	86 (12%)	698
<b>No stone mining</b>	1167 (86%)	187 (14%)	1354
<b>Total</b>	1779 (87%)	273 (13%)	2052
<b>Any mining f</b>	1185 (88%)	165 (12%)	1350
<b>No mining</b>	594 (85%)	108 (15%)	702
<b>Total</b>	1779 (87%)	272 (13%)	2052

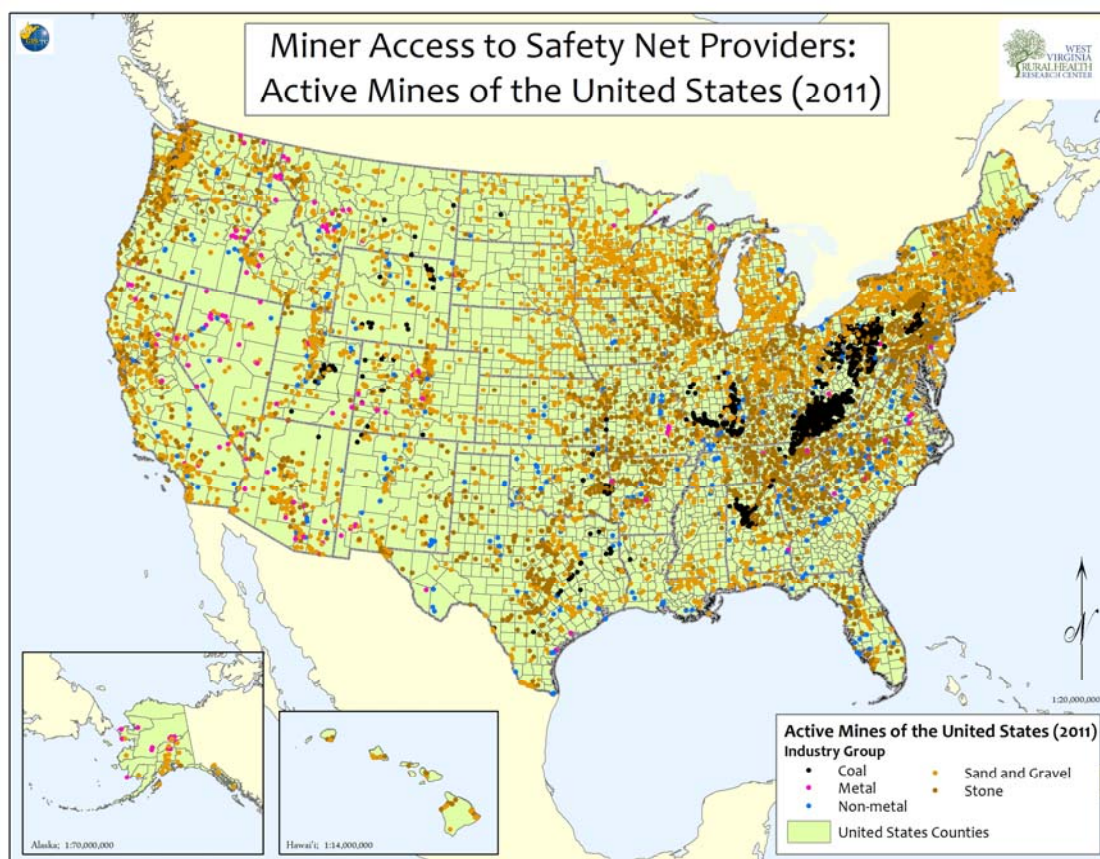
f.  $p < .05$   
 g.  $p < .09$   
 h.  $p < .24$   
 i.  $p < .24$   
 j.  $p < .35$   
 k.  $p < .05$

**Table 7:** Mean number of practicing primary care physicians, and percent of counties with at least one short-term general hospital, by mining activity in rural, urban, and combined counties.

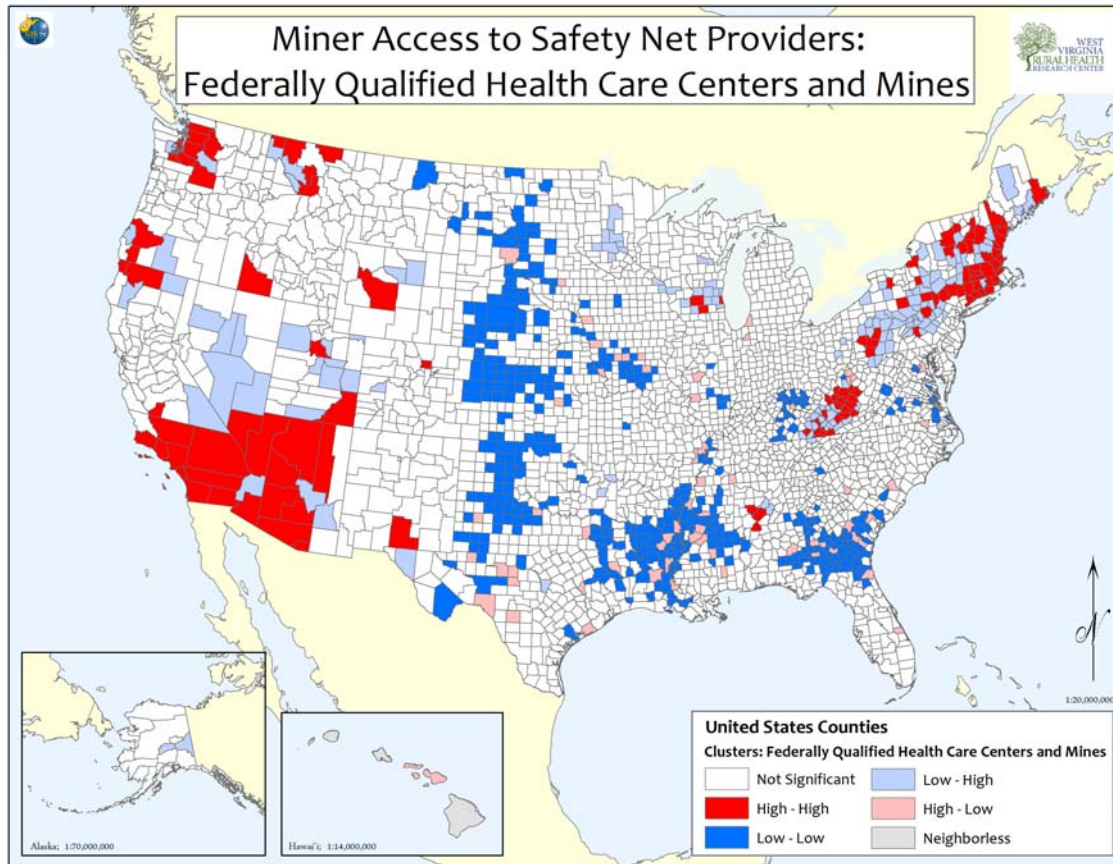
	Mining	No mining	P<*
<b>Rural counties (N=2051)</b>			
Primary care physicians per 10,000	11.2	8.4	.0001
Percent of counties with a short term general hospital	83.3%	69.7%	.0001
<b>Metropolitan counties (N=1090)</b>			
Primary care physicians per 10,000	21.5	18.4	.09
Percent of counties with a short term general hospital	85.2%	65.1%	.0001
<b>Total counties (N=3141)</b>			
Primary care physicians per 10,000	15.1	11.1	.0001
Percent of counties with a short term general hospital	84.0%	68.4%	.0001

\* For primary care physicians, P values based on two-tailed t-tests, Satterthwaite correction for unequal variances. For presence of a hospital, P values based on chi-square tests.

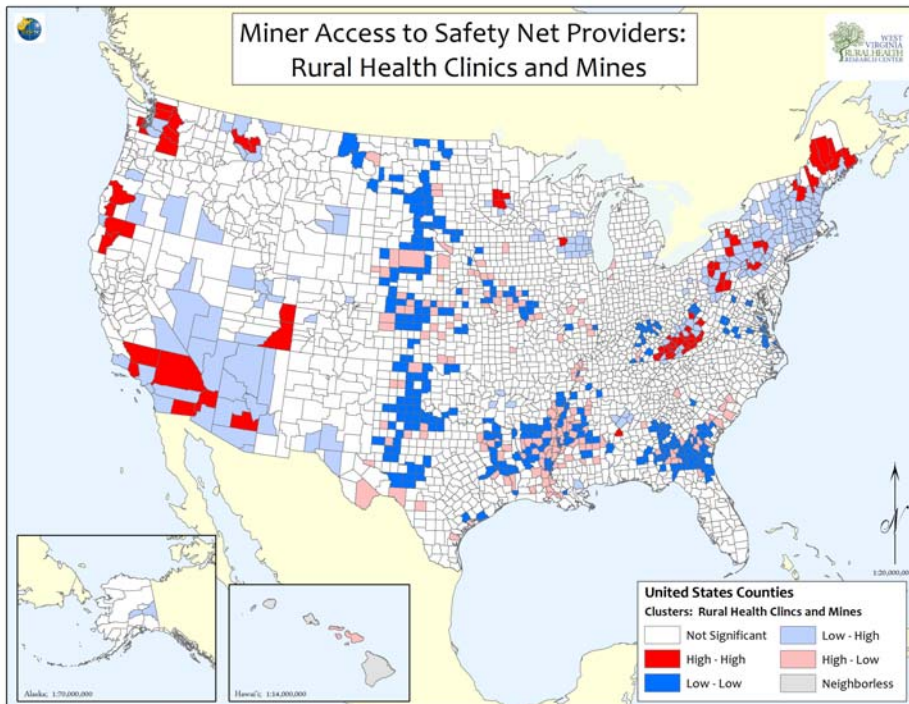
**Figure 1:** Distribution of active mine sites in the U.S., 2011.



**Figure 2:** Bivariate spatial distribution of FQHCs and active mine sites in the U.S., 2011.



**Figure 3:** Bivariate spatial distribution of Rural Health Clinics and active mine sites in the U.S., 2011.



**Figure 4:** Bivariate spatial distribution of Critical Access Hospitals and active mine sites in the U.S., 2011.

