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

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EXECUTIVE SUMMARY

Purpose of the Report: Mining communities' access to appropriate health care has not been well studied. Appropriate care includes competencies to adequately diagnose and treat mining related disease or illness. The current study has two primary objectives. First, we seek to understand whether mining communities face shortages in numbers of safety net providers compared to non-mining communities. To accomplish this, the study locates and maps mine locations in the U.S. and rural safety net providers (Rural Health Clinics, Federally Qualified Health Centers, Critical Access Hospitals and Black Lung Clinics). Second, we assess the capacity of rural safety net providers in mining areas to prevent, diagnose and treat mining related injury and illness. This was done through a survey of rural primary care providers practicing in safety net facilities co-located with mining communities.

Methods: We used databases provided by the Mining Safety and Health Administration (MSHA) to spatially map U.S. mines by latitude and longitude coordinates, nearest town, or county location. The data included active mines as of the 2011 MHSA database. We also originally intended to examine both active and inactive mining sites, but discovered that the database for inactive mines was outdated and potentially misleading, so dropped consideration of inactive mines from the study.

The databases also included information on the commodity mined (i.e., stone, sand and gravel, metal, non-metal, or coal), and the number of employees and hours worked. Mine sites were mapped in relation to four types of safety net health care providers: Critical Access Hospitals (CAHs), Federally Qualified Health Centers (FQHCs), Black Lung Clinics, and Rural Health Clinics (RHCs). Although the primary focus of the study was on safety net providers, we also examined two indicators of general health care resources not limited to safety net providers: the presence of short term general hospitals, and the per capita supply of practicing primary care physicians. Locations for providers were limited to county-level and were found in publicly accessible databases maintained by the Flex Monitoring Team, Health Resources and Services Administration, and the Centers for Medicaid and Medicare Services. Mining and health care provider sites were placed on maps using the best available location information. Following this, GIS analysis techniques were used to measure the abundance of mine sites and health care providers at the county level. Finally, we prepared and administered an online survey of a sample of the providers to determine health care competencies specific to miner health.

Results: Overall, we found that there was not a general shortage of safety net providers in areas where mining takes place. In fact, there was some evidence that mining areas, compared to non-mining areas, had on average a greater supply of safety net providers, especially in rural mining areas. More specifically, areas with mining were significantly more likely to have one or more FQHCs than areas without mining. There was one important exception: rural areas with either coal mining or stone mining were significantly less likely to have a Critical Access Hospital than areas without those forms of mining.

Among the two measures of general health care resources, we found that mining areas were significantly more likely than non-mining areas to have at least one short term general hospital, and to have a significantly greater supply of practicing primary care physicians. These results were found for all counties, and again for an analysis restricted to non-metropolitan counties.

From the spatial analyses, we also found that there exists considerable variation across the country in safety net providers. While some mining areas have a greater relative supply of safety net providers, others, especially in parts of central Appalachia, and some areas of the West, Upper Midwest, and Northeast, experience health care shortages.

Policy Implications: Results indicate that mining areas in general do not experience shortages in health care providers compared to non-mining areas, and to a degree even experience a better supply of health care resources. However, there is a need for improved health care delivery services for rural mining populations in targeted high-need geographic areas, including the need for better access to care, adequate protection for miners and their families from occupational risks, and health promotion for this population. Occupational risks involve a set of environmental dangers that increase risk of illness or injury from mining. Critical Access Hospitals appear to be underrepresented in rural areas with either coal mining or stone mining,. There may be a need to offer improved training to health care providers who will serve mining populations in proper treatment of mining conditions.

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.[1] 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 lead and welding fumes, and dermatitis/skin disorders.[2-4] Many mining occupational diseases and disorders are slow-progressing, and it may take years of exposure before symptoms appear.[2]

Cumulative trauma disorder, which refers to injury from repetitive overuse of a part of the body, is the largest category of mining-associated occupational diseases and often results in prolonged disability.[5] Noise-induced hearing loss is also a major problem among miners.[6] Miners can come in contact, in addition, with various potentially toxic or harmful materials or agents. The list includes, but is not limited to, fuels, reagents, solvents, detergents, chemicals, coal dust, silica dust, diesel particulate matter (DPM), welding fumes, poisonous plants, and metal dust. Despite increased Mining Safety and Health Administration (MSHA) regulations in recent years and increased use of safety precautions and protective equipment, coal dust remains a threat to miners, causing CWP. CWP is defined by the Federal Coal Mine Health and Safety Act of 1969 as a "chronic dust disease of the lung arising out of employment in an underground coal mine."[2] Progressive massive fibrosis (PMF), which is associated with increased mortality, characterizes advanced cases of CWP. Symptoms of PMF include breathlessness, chronic bronchitis, recurrent chest illness, and heart failure. Increased risk of tuberculosis and mycobacterial infections are other complications of CWP.[2] Studies have documented an increase in pneumoconiosis incidence and progression rates in coal miners in the United States since 2000.[7-8] Evidence suggests that this trend can be at least in part attributed to increased exposure of coal miners to respirable crystalline silica.[8] As of 2002, there were 16,000 people in the Federal Black Lung Benefits Program, which provides monthly payments and medical benefits to totally disabled coal miners with CWP.[1] This issue may disproportionately affect rural communities, in which 81% of coal mining occurs; coal mining is the most rural of the mining industries.[9]

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.[10-11] The reasons for this are complex and not completely understood, but reflect in part shortages of health care providers and possible differences in help seeking behavior in rural populations. Mining communities in general may also have less access to health care than other rural communities; a literature review of economic impact of mining on communities found that mining activity is associated with significantly higher unemployment and poverty rates[12] and poverty contributes to decreased health care access.[13] However, no study has, of yet, been conducted specifically on health care services available in rural mining communities.

In addition, health care providers in rural mining environments face challenges in service delivery due to the various presentations of acute and chronic problems related to occupational exposures of miners and their families. Rural health care providers may not be trained to assess for these unique risks, may not be equipped to diagnose and treat them, and may be challenged in engaging the community in health care solutions, although empirical data on this question is limited and forms part of the motivation for the current study.

The current study has two primary objectives. First, we seek to understand whether mining communities face shortages in numbers of safety net providers compared to non-mining communities. Second, we assess the capacity of rural safety net providers in mining areas to prevent, diagnose and treat mining related injury and illness.

METHODS

Geographic Coverage

The study is national in scope. Data on mining activity were collected for all regions and states of the U.S. Results are therefore generalizable to all areas for national decision-making. It was anticipated that most mining activity occurs in non-metropolitan areas. 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. We initially examined whether it would be possible to analyze rural-urban settings on more fine-scaled ZIP code levels using rural-urban commuting area codes, but we found that the locations of mines and safety net providers were not comprehensively available at that level, and so county-level aggregations were used for analyses. We also originally intended to examine both active and inactive mining sites, but discovered that the database for inactive mines was outdated and potentially misleading, so dropped consideration of inactive mines from the study.

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. A second MSHA dataset on employment in mines was located from a public dataset.[14] Each of the two mining datasets had a matching mine ID number that we used to merge employment data with the list of active mines. Employment data included number of full-time employee equivalents at the mine, and the number of hours worked.

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. Generation of spatial data was completed using Arc Map version 10.0.

Safety Net Provider Data Set: Data on safety net providers were drawn from several publicly available sources. A list of Critical Access Hospitals (CAH) was downloaded from the Flex Monitoring Team site.[15] 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).[16] 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.[17] 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: Utilizing Arc Map version 10.0, we conducted a basic spatial analysis to join spatial datasets for mines and health care providers together with spatial 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.

Safety Net Provider Competencies Survey: An online survey of rural safety net providers was developed to assess key environmental health competencies available to provide safe, high-quality care for miners and their families in rural areas. One of our Center's previous studies[18] on key environmental health competencies for rural primary care providers informed the selection of survey items.

An initial draft of the survey was reviewed by all Rural Health Research Center Directors and Deputy Directors,[19] and recommendations regarding survey design and content were integrated. In addition, the survey was pilot tested with 12 primary care providers (physicians, nurse practitioners and physician assistants) practicing in a rural FQHC in a mining community. In order to be sure that all questions were clear and captured all possible responses, the pilot participants were also asked to comment on the appropriateness of the survey to their practice, to point out any questions they found impossible to answer, and to suggest any additions or edits they thought would enhance the survey. Recommendations were integrated into the survey prior to Institutional Review Board approval and subsequent release.

Safety net providers in mining communities were invited to participate in this survey. From the complete list of providers, we selected 1,307 to receive an invitation to the survey. This included 187 Rural Health Centers, 1027 FQHCs, 69 Critical Access Hospitals, and 24 Black Lung Clinics. These safety net providers were all drawn from areas where mining activity was present, and included areas where safety net providers were in relatively greater supply, and in relatively less supply. We included all safety net providers within a 50 mile radius of mining activities, with one exception: because of the large number of FQHCs in some of the western counties, we limited the FQHC sample to those sites within 10 miles of mines in the western US. Initially, we had planned to contact providers by using email addresses, but found that those addresses were not available from the safety net provider databases that we received. Instead, sites selected for the survey were sent a letter in the regular mail, with a brief explanation as to the intent of the survey and a web-link to the survey location on Survey Monkey. The recipient of the letter, typically the Executive Director, CEO or President, was asked to share the survey link with primary care providers (physicians, nurse practitioners and physician assistants) in their site. While this technique was less desirable than contacting providers directly, available databases provided contact information only for site administrators, not for providers.

After approximately two weeks, non-respondents were sent a post-card follow-up with the link to the survey again. A final third post-card reminder was mailed to all non-respondents approximately two weeks later. Of the 1,197 providers contacted and not returned as undeliverable, only 26 responded to the survey (2% of the sampled population). Clearly, the low response rate prohibits us from making conclusions about treatment for mining populations among safety net providers. However, descriptive analyses of survey responses may provide insight into competency gaps for providers in mining communities.

Hypotheses, Design, and Analysis

We tested the null hypothesis that there is no association between mining activity and safety net 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. The project design is a secondary analysis of existing data from several sources merged for analysis.

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 employees; 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. This definition was designed to approximate safety net provider service areas, although the definition is not exact. Subjectively it seems that this approach works well in the eastern half of the country, but can result in large service areas in the west. Bivariate spatial correlations essentially allowed us to judge and visually display the extent to which safety net providers are co-located in areas of active mining. Spatial analyses resulted in the creation of national maps visually depicting the geographic distribution of safety net providers and mining activity across rural and urban areas.

After identifying mining sites and safety net provider locations, a sample of 1,307 safety net providers was selected for the survey portion of the study. As described above, this reflects all safety net providers within a 50 mile (or for FQHC areas in the west a 10 mile) radius of mining activity. Safety net sites were selected to represent the four provider types (i.e., Black Lung Clinics, Rural Health Clinics, Federally Qualified Health Centers, and Critical Access Hospitals), and to represent mining activity by commodity types and in various regions of the country.

RESULTS

Tabular results Nationwide

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. Of the mining commodity types, sand and gravel mines were most common, followed by stone mines and then coal mines. Regarding safety net providers, there were for example a total of 9,133 FQHCs in the database, with a county-level range from 0 to 338 FQHCs.

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

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

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. This can result from some large counties that have metropolitan areas but also large areas of less development, or from mining activity close to metropolitan centers.

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
Mine Type			
Coal	152	65	217
Metal	65	44	109
Non-metal	179	120	299
Sand/gravel	879	523	1402
Stone	698	546	1244

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. For these analyses, counties were categorized into simple two-level groups, either the presence or absence of mining, and the presence or absence of safety net providers, without regard to the numbers of mines or providers. The chi-square tests are displayed for each mining commodity type and each provider type.

Table 3 shows results for the FQHCs. Among the 217 counties with one or more coal mines, 141 (65%) had at least one FQHC. This was higher than the rate among counties without coal mining, among which 51% had at least one FQHC. Thus, areas with coal mining were actually more likely than non-coal mining areas to have at least one FQHC (p<.0001). The same pattern was found for all other mining types: areas with mining were significantly more likely to have one or more FQHCs than areas without mining.

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

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

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

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 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		
	Yes	No	Total
Coal mining a	105 (69%)	47 (31%)	152
No coal mining	1164 (61%)	736 (39%)	1900
Total	1269 (62%)	783 (38%)	2052
Metal mining b	39 (60%)	26 (40%)	65
No metal mining	1230 (62%)	757 (38%)	1987
Total	1269 (62%)	783 (38%)	2052
Non-metal mining c	119 (66%)	60(34%)	179
No non-metal mining	1150 (61%)	723 (39%)	1873
Total	1269 (62%)	783 (38%)	2052
Sand/gravel mining d	523 (60%)	356 (40%)	879
No sand/gravel mining	746 (64%)	427 (36%)	1173
Total	1269 (62%)	783 (38%)	2052
Stone mining e	423 (62%)	265 (38%)	698
No stone mining	836 (62%)	518 (38%)	1354
Total	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		
	Yes	No	Total
Coal mining a	51 (34%)	101 (66%)	152
No coal mining	880 (46%)	1020(54%)	1900
Total	1121 (55%)	931 (45%)	2052
Metal mining b	36 (55%)	29 (45%)	65
No metal mining	895 (45%)	1092 (55%)	1987
Total	1121 (55%)	931 (45%)	2052
Non-metal mining c	108 (60%)	71 (40%)	179
No non-metal mining	1013 (54%)	860 (46%)	1873
Total	1121 (55%)	931 (45%)	2052
Sand/gravel mining d	417 (47%)	462 (53%)	879
No sand/gravel mining	704 (60%)	469 (40%)	1173
Total	1121 (55%)	931 (45%)	2052
Stone mining e	388 (56%)	310 (44%)	698
No stone mining	733 (54%)	621 (46%)	1354
Total	1121 (55%)	931 (45%)	2052

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

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. Among the specific types of mining, the presence of safety net providers was significantly greater in coal mining areas (p<.05), and marginally significant (p<.09) in areas with metal mining.

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

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

a. p<.05
b. p<.09
c. p<.24
d. p<.24
e. p<.35
f. p<.05

Table 7 explores safety net provider availability by average counts of total providers, rather than presence/absence of providers. For this analysis, each county is classified as having any form of mining or not, and then the average number of safety net providers in each group is compared using two-tailed t-tests. These analyses were also done for rural and urban counties separately, defining rural counties based on non-metropolitan rural-urban continuum codes. The results indicate that rural counties with mining have significantly more safety net providers of all three types than rural counties without mining. Summed across types of providers, rural mining counties have on average about one additional safety net provider per county than rural non-mining counties. The number of safety net providers in urban counties does not differ significantly according to mining status.

Table 7: Mean number of safety net providers by presence or absence of mining activity in rural, urban, and combined counties.

	Mining (N=2181)	No mining (N=960)	
	Mean (standard deviation)	Mean (standard deviation)	P<*
Rural counties (N=2051)			
FQHCs	1.39 (2.8)	0.82 (1.4)	.0001
Rural Health Clinics	1.57 (2.0)	1.26 (1.5)	.0001
Critical Access Hospitals	0.57 (0.7)	0.47 (0.6)	.002
Black Lung Clinics	0.01 (0.11)	0.001 (0.04)	.004
Sum of all safety net providers	3.53 (3.8)	2.55 (2.2)	.0001
Metropolitan counties (N=1090)			
FQHCs	6.60 (18.3)	4.66 (14.8)	.09
Rural Health Clinics	0.85 (2.3)	0.74 (0.5)	.46
Critical Access Hospitals	0.20 (0.5)	0.22 (0.5)	.61
Black Lung Clinics	0.01 (0.12)	0 (0)	.003
Sum of all safety net providers	7.65 (18.6)	5.62 (14.7)	.07
Total counties (N=3141)			
FQHCs	3.37 (11.8)	1.85 (7.9)	.0001
Rural Health Clinics	1.29 (2.2)	1.12 (1.6)	.02
Critical Access Hospitals	0.43 (.65)	0.41 (.57)	.35
Black Lung Clinics	0.012 (0.1)	0.001 (0.03)	.0001
Sum of all safety net providers	5.10 (12.1)	3.37 (8.0)	.0001

* P values based on two-tailed t-tests, Satterthwaite correction for unequal variances.

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 may be found in Table 8. 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. For example, 83% of rural mining counties had at least one short-term general hospital, compared to about 70% of rural non-mining counties.

Table 8: Mean number of practicing primary care physicians per 10,000 people, and percent of counties with at least one short-term general hospital, by presence or absence of mining activity in rural, urban, and combined counties.

	Mining	No mining	P<*
Rural counties (N=2051)			
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
Metropolitan counties (N=1090)			
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
Total counties (N=3141)			
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.

Spatial Results

The results of the spatial analyses are summarized in maps in Figures 1 through 5. 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.

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

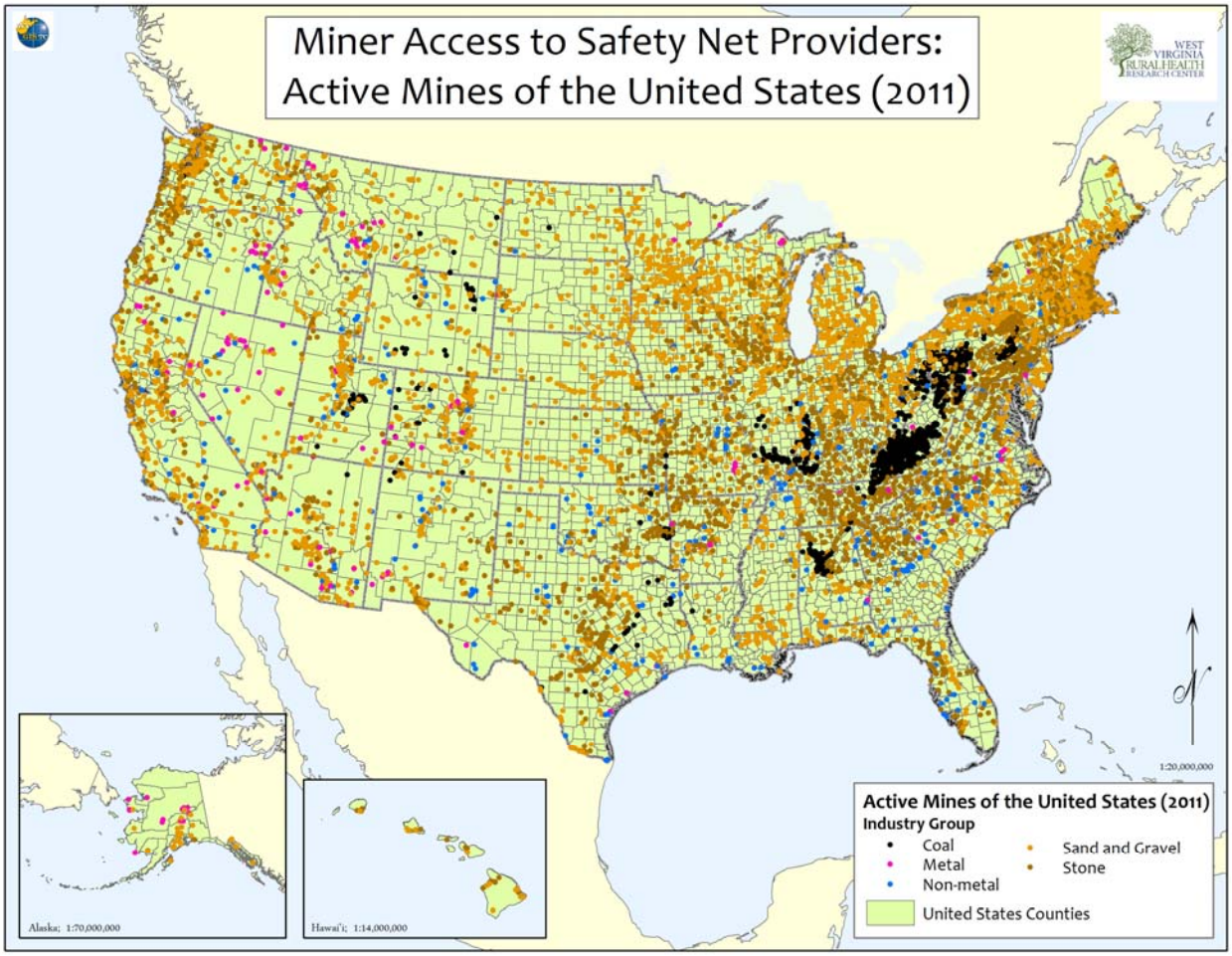
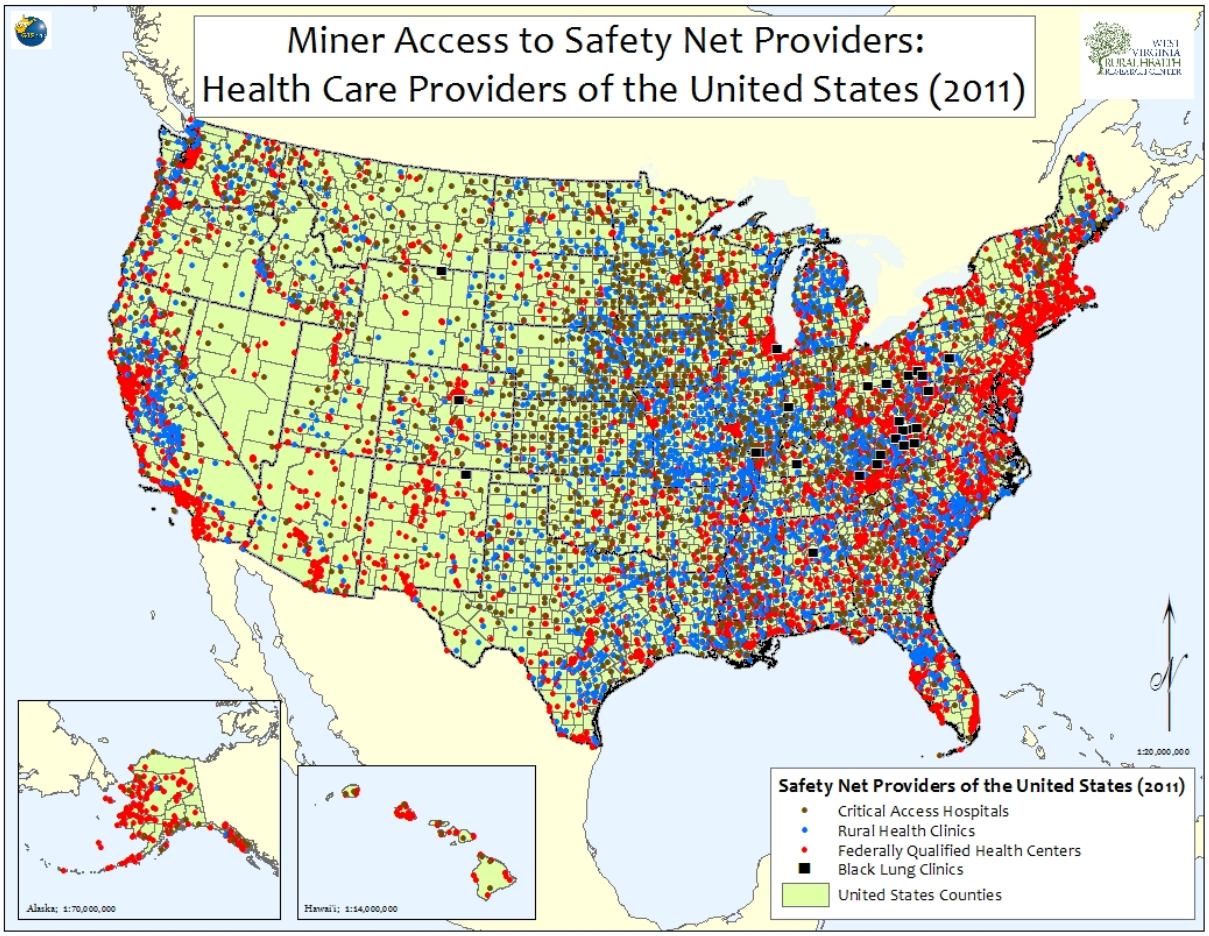


Figure 2 shows the general distribution of safety net providers. FQHCs are widely distributed including both urban and rural areas. Critical access hospitals are distributed across many rural areas, as are rural health clinics, although the rural health clinics also show some clustering in areas of the Midwest, Southeast, and California. There are a small number of Black Lung Clinics that are also included on this map although they are difficult to see in the mix of other providers; they are located in coal mining areas, mainly in Appalachia and mining areas of the West and Midwest.

Figure 2: Distribution of safety net providers in the U.S., 2011.



Figures 3-5 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. For Critical Access Hospitals, this ends up as presence/absence, as no providers is less than the average while one or more is above the average. For Rural Health Clinics, the cutoff is between 1 and 2, so zero or one is low, while two or more is high. For Federally Qualified Health Care Centers, the cutoff is between 2 and 3. (The other two colors, dark blue and pink, identify areas without mining and are less important for the current study.) Figure 3 specifically shows the bivariate distribution of mining and FQHCs. The light blue areas of this map show where mining occurs but where FQHCs are in relatively short supply; these areas include parts of the west such as areas in Nevada and Utah, some Midwest areas in Minnesota and Wisconsin, parts of central Appalachia, and parts of the Northeast from Pennsylvania to Maine, along with other scattered locations around the country. This map shows that, although mining areas as a general rule do not have shortages of FQHCs (as shown in Table 2 and 5), 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: Bivariate spatial distribution of FQHCs and active mine sites in the U.S., 2011.

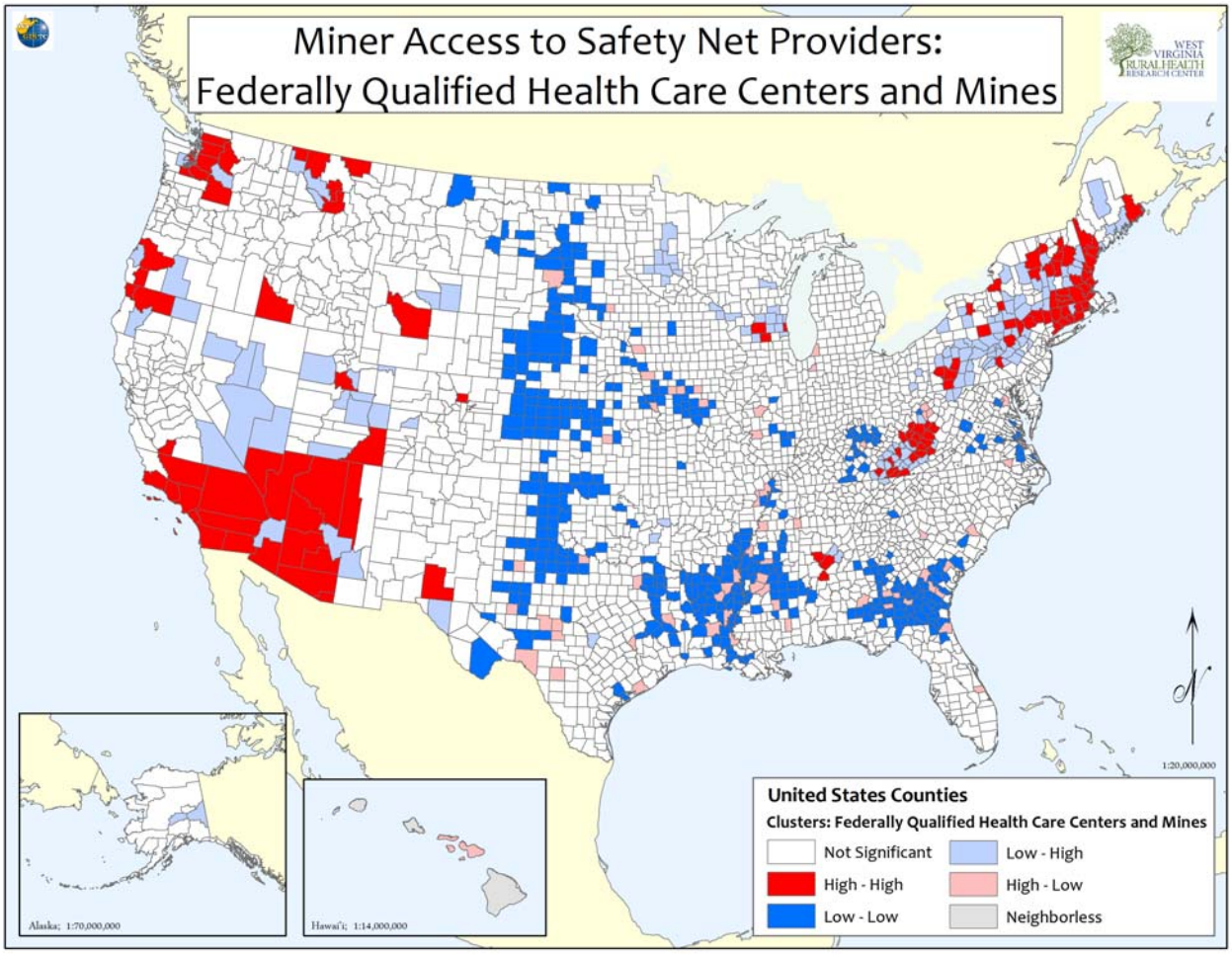


Figure 4 repeats this analysis for rural health clinics, and Figure 5 for Critical Access Hospitals. The Figure 4 distribution of rural health clinics relative to mining, similarly to Figure 3, identifies areas of the Southwest and West, Upper Midwest, Alabama, central Appalachia, and the Northeast, where mining occurs in the relative absence of rural health clinics. The map in Figure 5 shows the same general pattern, including lower availability of critical access hospitals in selected mining areas in the West, Wisconsin, Alabama, central Appalachia, and portions of the Northeast.

Figure 4: Bivariate spatial distribution of Rural Health Clinics & active mine sites in the U.S., 2011.

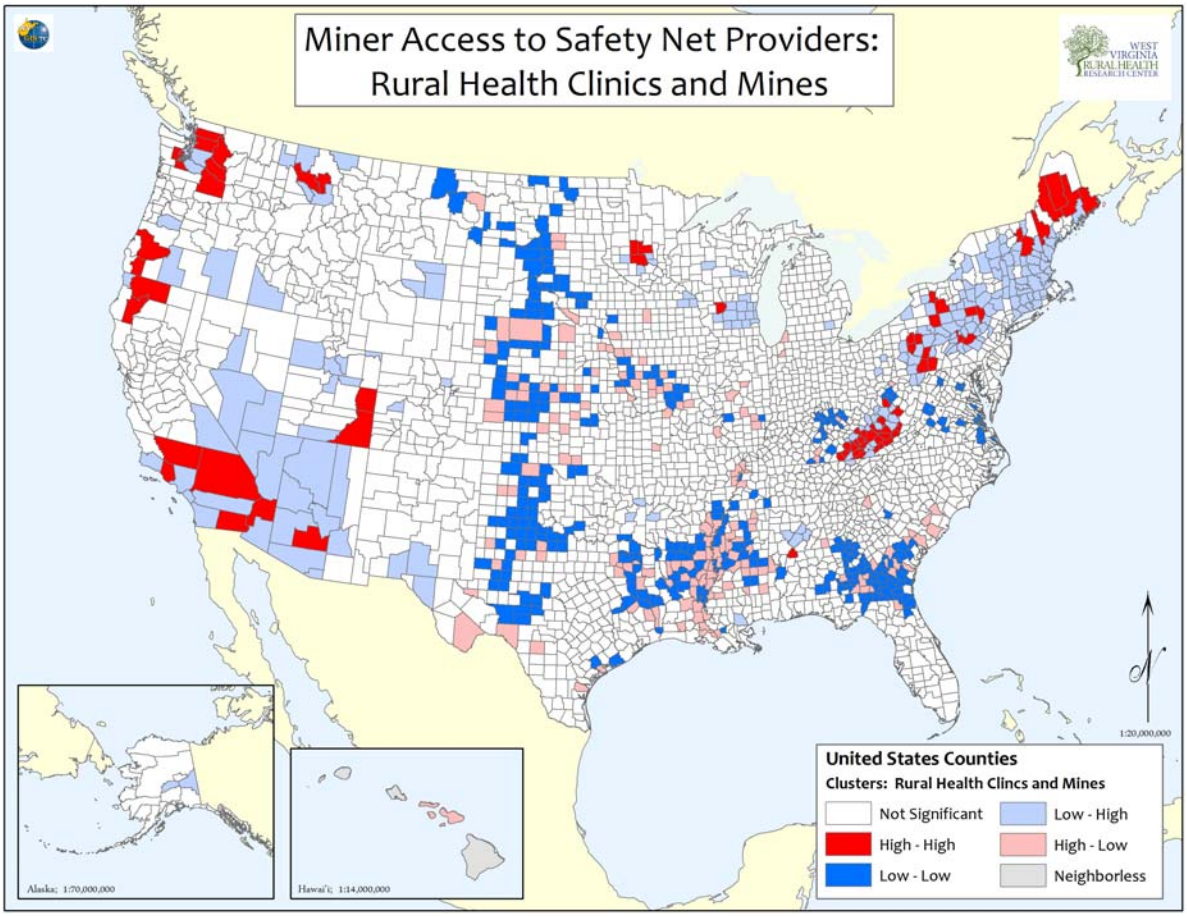


Figure 5: Bivariate spatial distribution of Critical Access Hospitals & active mine sites in the U.S., 2011.

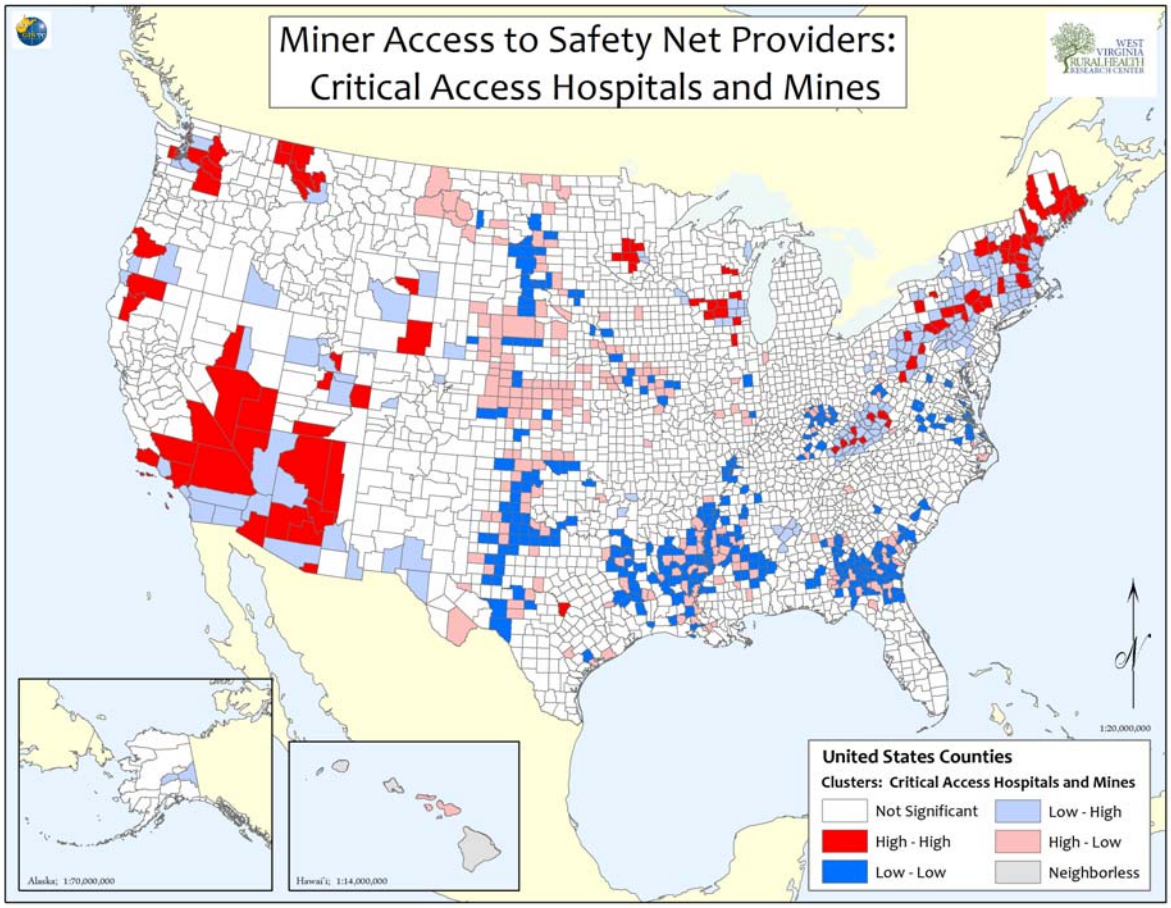


Figure 6 is provided to display the distribution of mining employment around the country. It should be noted that many of the same areas where safety net provider shortages exist are the same areas where mining activity as measured by employee hours is greatest.

Next, we counted the number of mines by commodity type that were in counties underserved by safety net providers. Underserved mining counties are defined as mining areas with shortages of safety net providers (light blue in the maps). For this definition, underserved areas were defined by combining all safety net provider types to identify counties with shortages in one or more area; a total of 132 counties were defined as shortage areas where mining occurred, including 83 counties with a shortage of one provider type, 112 with shortages of two provider types, and 73 with shortages in all three provider types. We found that coal mines were much more likely to be in underserved areas; 39% of coal mines were in underserved areas, compared to 5-9% of mines of other types. These results are summarized in Table 7.

Figure 6: Distribution of hours of mining employment in the U.S., 2011.

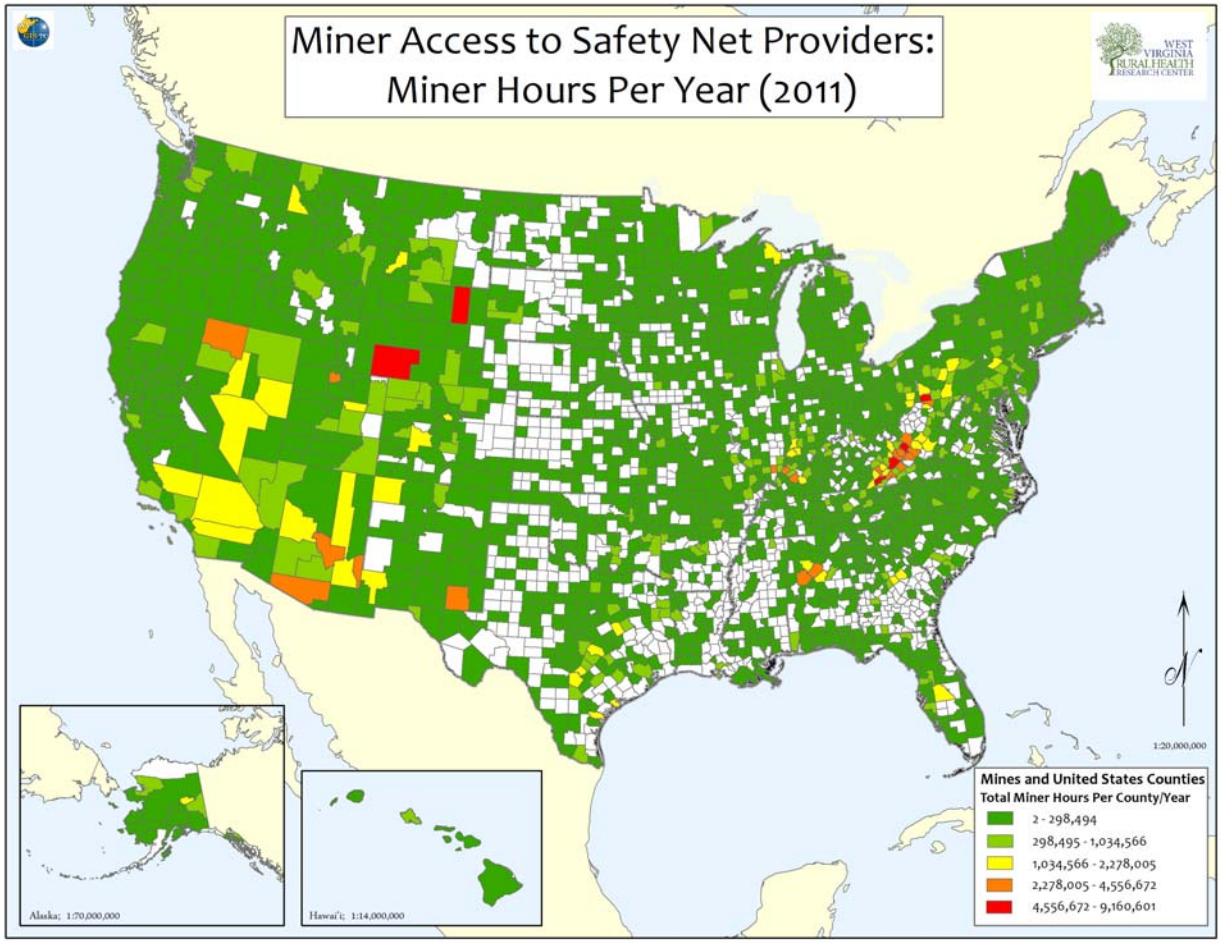


Table 7: Mines in areas underserved by safety net providers, by mining commodity type.

Mines	Total nationwide	Number and percent in underserved counties
Coal	2,018	792 (39%)
Metal	203	17 (8%)
Non-metal	506	23 (5%)
Sand/gravel	5,082	400 (8%)
Stone	3,511	311 (9%)

Survey Results

Of the 26 respondents to the survey, only 11 answered "Yes" to the question, "In the past year, have you cared for a patient in your current primary care setting whose occupation is mining (active or retired)?" Others stated that they did not provide care to mining patients in the last year, even if their practice area fell in a mining area. This could be because these providers do not deliver care to miners, or that they may deliver some care to miners without knowing that the patient is a past or current miner. Of the 11 who answered "Yes" to this question, all 11 said that the "primary type of mining that occurs in your region" is coal. Thus, we have no information on other forms of mining. Because of the very low response rate, we do not attempt to interpret the responses to these few surveys. In the future, better methods should be devised to capture these data, if not through surveys than through other data sources.

DISCUSSION

The results of the study show that 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 these safety net providers compared to 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 their work, enjoy geographic proximity to safety net providers within the same counties.

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. Why this is the case is not clear, but it may have to do with relatively greater populations in mining areas that are a function of economic activity of mining, or to a greater recognized need for, or demand for, health care services in mining areas.

Within the provision of safety net providers, an important exception to this pattern was observed for the availability of Critical Access Hospitals in rural areas. Rural counties that had either coal mining or stone mining were significantly less likely to have a Critical Access Hospital compared to rural counties without these types of mining. However, the availability of other provider types may circumvent the need for Critical Access Hospitals in these areas. .

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.

The most severe shortage areas were in coal mining locations, as opposed to other mining commodities. 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.[20] Given these disadvantages, this particular geographic region may be a foremost 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. These and other specific areas with lower availability may be found by examining the maps in this report.

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 to 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.) The mining datasets that we examined may not represent all types of mining activity and may not be complete with respect to active and inactive sites; however, based on our final inspection of these datasets, we believe we have captured extensive coverage of national active mining. We also conducted spot checks on the safety net provider datasets across a sample of states and found that errors of omission or commission represented less than 5% of the

database. We also found that 110/1307 (8%) of invitations to safety net provider sites were returned as undeliverable, suggesting that the accuracy of the provider database, although imperfect, was high.

The presence or absence of safety net providers does not necessarily indicate a corresponding level of access to health care for mining populations. It is likely that some portion of the mining population is able to access private health care resources and does not use safety net providers. Our results indicate in general that there is no overall access shortage for mining versus non-mining populations, and in fact, mining populations seem to experience better access. Active miners, as opposed to former or retired miners, may be particularly able to access non-safety net providers, as mining jobs can be relatively well-paying occupations that carry health insurance benefits that allow miners to receive care from private providers.

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.

A final limitation pertains to the poor response rate to the survey. We had originally planned to identify specific contact persons by name who could be surveyed by email, but this proved to be impractical with existing data. Instead, we resorted to a mailed survey attempt that required individuals to actively seek out an internet site to complete the survey, and despite several mailings and reminders, this ultimately was unsuccessful in generating many responses. It is very difficult to draw conclusions from such a small sample, although we did observe that only 1 of 11 respondents had received any formal training in working with mining-related health conditions during their original health care education; a number of respondents sought out and received such training on a continuing education basis. We also observed that over half (15 of 26) said that they did not provide care to miners in the last year, which may indicate issues in poor recognition of mining occupations among their patient populations. Finally, we observed some treatment areas where providers rated their level of competency in providing environmental health services as less than ideal.

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 3 through 5 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. More comprehensive 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. Black Lung Clinics are available in 25 counties around the nation; the distribution of these clinics and their relationship to rates of black lung disease is being examined in another report by our center nearing completion (as of June 2013). Because of the high levels of injury and illness among miners, such improved provision could have significant public health benefits. The results of the survey, although limited by the number of responses, indicate a need to collect more complete data on the extent to which safety net providers in rural mining communities are aware of, and able to respond appropriately to, the health care needs of miners.

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