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Center for
Water Advocacy
Water Law and Policy Services

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RE: Comments and Request for Informal Conference on Mining and Reclamation Permit Application-Kinney Mine

Dear Dana:

The Center for Water Advocacy (CWA) appreciates this opportunity to provide comments and to Request an Informal Conference on the Kinney Coal Mine Application Mining and Reclamation Permit Application-Kinney Mine (the Application) submitted by Carbon Resources LLC of Albequerue, New Mexico. CWA is a non-profit public interest entity dedicated to protecting water resources and interests of its members and the general public in Utah and the west. CWA conducts legal and scientific research, analysis, policy and litigation in its efforts to protect and restore water quantity, water quality and water rights for the health of the watershed ecosystem, preservation of cultural identity and the benefit of its members. CWA retains members who live in the town of Schofield, Utah were a portion of the main will be located. These members have an interest which is or may be adversely affected by the decision on the application. R645-300-123.100. We hope that the following comments and requests will be helpful in the Utah Department of Oil, Gas and Minings (DOGM's) decision making process regarding the Application and addressing CWA's concerns about potential impacts to water resources.

I. The Application Lacks Information as Required by the Surface Coal Mining Regulations

The Application does not comply with the Utah Coal Mining Permit Regulations (UCMPR or Rules). Specifically, R645-301-300-Biology; R645-301-600 Geology; R645-301-800-Bonding and Insurance; R645-301-200-Soils; R645-301-400- Land Use and Air Quality or R645-301-700-Hydrology because it lacks information required by these regulations.

a. General Requirements

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The UCMPR, provides that:

> Each permit application will include descriptions of: 1) Existing hydrologic resources as given under R645-301-720; 2) Proposed operations and potential impacts to the hydrologic balance as given under R645-301- 730; 3) The methods and calculations utilized to achieve compliance with hydrologic design criteria and plans given under R645-301-740; 4) Applicable hydrologic performance standards as given under R645-301-750; 5) Reclamation activities as given under R645-301-760; 6) All cross sections, maps and plans required by R645-301-722 as appropriate, and R645-301-731.700 will be prepared and certified according to R645-301-512 and Impoundments will be inspected as described under R645-301-514.300.

R645-301-711.100-500 & R645-301-712-713.

The Application, however, does not provide any of these descriptions.

b. Environmental Description.

The UCMPR, provides that "each permit application will include a description of the existing, premining hydrologic resources within the proposed permit and adjacent areas that may be affected or impacted by the proposed coal mining and reclamation operation." These descriptions include:

> cross sections and maps...; Location and extent of subsurface water, if encountered, within the proposed permit or adjacent areas. For UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES, location and extent will include, but not limited to areal and vertical distribution of aquifers, and portrayal of seasonal differences of head in different aquifers on cross-sections and contour maps; Location of surface water bodies such as streams, lakes, ponds and springs, constructed or natural drains, and irrigation ditches within the proposed permit and adjacent areas; Elevations and locations of monitoring stations used to gather baseline data on water quality and quantity in preparation of the application; Location and depth, if available, of water wells in the permit area and adjacent area; and Sufficient slope measurements or contour maps to adequately represent the existing land surface configuration of proposed disturbed areas for UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES and the proposed permit area for SURFACE COAL MINING AND RECLAMATION ACTIVITIES will be measured and recorded to take into account natural variations in slope, to provide accurate representation of the range of natural slopes and reflect geomorphic differences of the area to be disturbed.

R645-301-722.100-500. The Application, however, does not provide any of this information.

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The UCMPR, provides that all water quality analyses must meet:

> the requirements of R645- 301-723 through R645-301-724.300, R645-301-724.500, R645-301-725 through R645-301-731, and R645-301-731.210 through R645- 301-731.223 will be conducted according to the methodology in the current edition of "Standard Methods for the Examination of Water and Wastewater"1 or the methodology in 40 CFR Parts 136 and 434. Water quality sampling performed to meet the requirements of R645-301-723 through R645-301-724.300, R645-301-724.500, R645-301-725 through R645-301-731, and R645-301- 731.210 through R645-301-731.223 will be conducted according to either methodology listed above when feasible.

R645-301-723. The water quality analysis, in the Application, however, fails to meet these requirements.

c. Baseline Information

The UCMPR, provides that:

> The application will include the following baseline hydrologic, geologic and climatologic information, and any additional information required by the Division...Ground Water Information. The location and ownership for the permit and adjacent areas of existing wells, springs and other ground-water resources, seasonal quality and quantity of ground water, and usage. Water quality descriptions will include, at a minimum, total dissolved solids or specific conductance corrected to 25 degrees C, pH, total iron and total manganese. Ground-water quantity descriptions will include, at a minimum, approximate rates of discharge or usage and depth to the water in the coal seam, and each water-bearing stratum above and potentially impacted stratum below the coal seam...Surface water information. The name, location, ownership and description of all surface- water bodies such as streams, lakes and impoundments, the location of any discharge into any surface-water body in the proposed permit and adjacent areas, and information on surface-water quality and quantity sufficient to demonstrate seasonal variation and water usage. Water quality descriptions will include, at a minimum, baseline information on total suspended solids, total dissolved solids or specific conductance corrected to 25 degrees C, pH, total iron and total manganese. Baseline acidity and alkalinity information will be provided if there is a potential for acid drainage from the proposed mining operation. Water quantity descriptions will include, at a minimum, baseline information on seasonal flow

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1 "Standard Methods for the Examination of Water and Wastewater" is a joint publication of the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation and is available from the American Public Health Association, 1015 Fifteenth Street, NW, Washington, D. C. 20036.

rates…Geologic Information. Each application will include geologic information in sufficient detail, as given under R645-301-624, to assist in:…Determining the probable hydrologic consequences of the operation upon the quality and quantity of surface and ground water in the permit and adjacent areas, including the extent to which surface- and ground-water monitoring is necessary…

R645-301-724.100-310.

The only reference to such baseline information in the Application, however, provides that:

> …it is anticipated that impacts to water quality will be minor, and limited to major runoff events wherein runoff is sufficient to result in a water discharge from the sedimentation pond. Discharges during these potential extreme events are expected to be in compliance with regulations thus resulting in minimal, if any, negative water quality impact due to mining.

It is further anticipated that no impact to the local surface or ground water systems west of the mine will occur due to 1) the general lack of water encountered during drilling and 2) the fact that the local geologic dip is to the east, away from Mud Creek and Scofield Reservoir.

App. at § 3.7-7.

Simply concluding that impacts to water quality will not take place without providing any data or other justification for such conclusion, however, is not sufficient reason to fail to provide required baseline information.

Probable Hydrologic Consequences (PHC) Determination.

The UCMPR provides that the "permit application will contain a determination of the PHC of the proposed coal mining and reclamation operation upon the quality and quantity of surface and ground water under seasonal flow conditions for the proposed permit and adjacent areas." 728.100. The only information in the permit pertaining to water quality impacts of the proposed mine, however, provides:

> According to the Utah Division of Water Quality, surface water sources including Mud Creek and Scofield Reservoir have stream classifications of 1C, 2B, 3A and 4 in the areas adjacent to the proposed lease area.[2]

2 Definitions of each classification are:

1C – Protected for domestic purposes with prior treatment processes as required by the Utah Division of Drinking Water;
2B – Protected for secondary contact recreation such as boating wadding or similar uses;
3A – Protected for cold water species of game fish and other warm water aquatic life including the necessary aquatic organisms in their food chain;
4 – Protected for agricultural uses including irrigation of crops and stock watering.

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> These drainage classifications indicate that the Scofield Reservoir and associated tributaries are designated for culinary use when treated, recreation, as cold water non-game fish habitat, and irrigation and stock watering with no associated natural resource waters restrictions other than applicable effluent standards for discharges.

App. at 3.7-19.

This does not satisfy the PHC determination analysis requirement which "will be based on baseline hydrologic, geologic and other information collected for the permit application and may include data statistically representative of the site." 728.200.

Nor does the Application include a discussion of the PHC determination which will include findings on…Whether adverse impacts may occur to the hydrologic balance and…Whether acid-forming or toxic-forming materials are present that could result in the contamination of surface- or ground-water supplies. 728.300-320. Instead, the Application justifies this lack of required analysis by stating that:

> Not applicable to Kinney Mine because no waste materials – incidental roof and floor rock- will be shipped out with the coal.

App. at 4.7-34.

Yet, the Application fails to provide what will be done with waste materials. In addition, the Rules provide that the Application must describe the "impact the proposed coal mining and reclamation operation will have on:...Sediment yield from the disturbed area." 728.330-331.

> **Minor Reductions in Surface Flows and Alteration of Surface Flow Patterns Due to Operation of the Sedimentation Structure** - Although sedimentation ponds are integral to mitigating mining related impacts on the surface hydrologic system, operation of sedimentation ponds tends to reduce discharge flow volumes and extend the period of effective flow for runoff from both snowmelt and thunderstorm events. In effect, sedimentation ponds function as limited capacity flood control structures reducing the effective discharge rate for large volume flows through temporary storage and flow routing. The sedimentation pond is designed to gradually release impounded runoff following required retention for sediment control. Given provisions for retention and gradual discharge of retained storm flows, most of the runoff is returned to the surface drainage system with only a short lag time corresponding to the design retention time for the pond.

App. at 4.7-33.

Nor does the Application provide a plan for what happens to the land when mining ends. This is regardless of the fact that:

> a post-mining land use program must be established in a Mining and Reclamation Plan and approved before mining begins. When mining stops, regulations require that the mine be sealed and the surface area be returned to approximate the original land contour, or conform to the

standards set for post-mining land use. Land reclamation occurs in three phases.3

http://ogm.utah.gov/coal/water/minpost.htm

Further, the Application fails to address the question of what happens to the groundwater regime when mining stops? This is regardless of the fact that:

> groundwater and subsidence impacts can take place at depth. Therefore, impacts may not surface for a long time or may not at all. It is presumed that subsidence will continue for a period and eventually stabilize. If mines have been continuously intercepting water, it is likely that the voids of the mine will fill with water and groundwater flow direction will re-establish if mining has not re-directed the flow.
>
> …As large areas of the mine are excavated, the earth above the mine settles to fill the void. Sometimes the settling is gradual, and in other instances it is rapid.

Id.

In addition, the lack of ground water analysis when mining stops is all the more significant in this case because, among other criteria, the rate and amount of subsidence is dependent on "the amount of fracturing and faulting in an area." *Id.*

Finally, as in the case of the Kinney Mine, subsidence:

> is usually accompanied by vertical fracturing of the layers above the coal seam. These fractures can be extensive and can come in contact with water stored in the rock or perched aquifers. In some instances subsidence has extended to the surface and intercepted surface water sources, such as streams and ponds.

Id.

Acidity and Other Water Quality Impacts

The Rules provide that the Application must include a description of "[a]cidity, total suspended and dissolved solids and other important water quality parameters of local impact;…Flooding or streamflow alteration;…Ground-water and surface-water availability; and …Other characteristics as required by the Division." 728.332-335

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3 **Phase 1** requires that all designated structures are removed, the surface returned to approximate original contour, topsoil spread, proper runoff controls established and a designated vegetation mix planted. **Phase 2** requires that proper vegetation growth is established to prevent erosion and excessive sediment. **Phase 3** requires that vegetation and wildlife diversity standards are met, water quality standards satisfied, runoff controls removed and any subsidence impacts controlled and mitigated.

Further the rules require that the application include a description of whether "the proposed SURFACE COAL MINING AND RECLAMATION ACTIVITY will proximately result in contamination, diminution or interruption of an underground or surface source of water within the proposed permit or adjacent areas which is used for domestic, agricultural, industrial or other legitimate purpose" 728.340 and Whether the UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES conducted after October 24, 1992 may result in contamination, diminution or interruption of State-appropriated Water in existence within the proposed permit or adjacent areas at the time the application is submitted. 728.350.

The Application, however, dismisses these requirements by concluding that:

> As discussed in Section 3.7, Hydrology Description, under the subheading water rights and replacement, and in Section 4.7.4.2, Potential for Adverse Effects, CR's mining and related operations are not expected to adversely impact any surface or ground water rights. Consequently, there is no reason to explicitly address provisions for replacement of impacted water rights at this time.

App. at 4.7-34.

Under Section 3.7, however, the only reference to the impacts to surface water rights provides that:

> Since the mine is projected to be dry, and is not anticipated to have a mine discharge, there are no anticipated to be dry, and is not anticipated to have a mine discharge, there are no anticipated additive effects upon the local surface waters. In a similar manner, no impacts are believed possible to surface waters located within or west of Pleasant Valley and Mud Creek since surface drainages are discontinues east and west of the valley.

App. at Sect. 3.7-22.4

As a result, the Applicant fails to provide any justification such as well data, surface and ground water flow or any studies on water availability to justify this statement. As a result, the Application illegally circumvents the requirement of providing water rights and availability information by reaching an arbitrary and unfounded conclusion that such impacts will not take place.

Further the Application provides:

> In the unlikely event...that proximate contamination, diminution, or interruption does occur, CR will mitigation these impacts through the purchase and augmentation of effected water rights, monetary

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4 The Table of Context in the Application provides that there is also a discussion of ground water rights which are potentially impacted by the Mine on page 3.7-17. However, no such discussion of such water rights is found on this page or elsewhere in the Application.

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> compensation, development of alternative watering facilities such as guzzlers, or other appropriate mitigation measure.

Id.

Yet, without a proper analysis of the nature or extent of contamination, diminution, or interruption, how can the Applicant know whether it can provide such mitigation. In addition, the Application does not provide a description of any budget that it has set aside for the "purchase" of water rights or describe where it will obtain the water rights for the claimed "augmentation" measures.

The Rules provide that the:

> permit application will include a ground-water monitoring plan based upon the PHC determination required under R645-301-728 and the analysis of all baseline hydrologic, geologic and other information in the permit application. The plan will provide for the monitoring of parameters that relate to the suitability of the ground water for current and approved postmining land uses and to the objectives for protection of the hydrologic balance set forth in R645-301-731. It will identify the quantity and quality parameters to be monitored, sampling frequency and site locations. It will describe how these data may be used to determine the impacts of the operation upon the hydrologic balance. At a minimum, total dissolved solids or specific conductance corrected to 25 degrees C, pH, total iron, total manganese and water levels will be monitored.

731.211. Based on the fact, therefore, that the Application contains no information regarding PHC it fails to provide this critical ground water monitoring plan. This significance of the lack of information on water rights, instream flows and other aspects of the hydrological system are illustrated by the fact that mining can directly intercept water systems upon which people and fish and wildlife are dependent. *See* Appendix A.

Surface-Water Monitoring.

The Application entirely lacks any discussion of the following requirements:

> Surface-water monitoring will be conducted according to the plan approved under R645-301-731.220 and the following:...The permit application will include a surface-water monitoring plan based upon the PHC determination required under R645-301-728 and the analysis of all baseline hydrologic, geologic and other information in the permit application. The plan will provide for the monitoring of parameters that relate to the suitability of the surface water for current and approved postmining land uses and to the objectives for protection of the hydrologic balance as set forth in R645-301-731 as well as the effluent limitations found in R645-301-751;...The plan will identify the surface water quantity and quality parameters to be monitored, sampling frequency and site locations. It will describe how these data may be used to determine the

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impacts of the operation upon the hydrologic balance:...At all monitoring locations in streams, lakes and impoundments, that are potentially impacted or into which water will be discharged and at upstream monitoring locations, the total dissolved solids or specific conductance corrected to 25 degrees C, total suspended solids, pH, total iron, total manganese and flow will be monitored; and For point-source discharges, monitoring will be conducted in accordance with 40 CFR Parts 122 and 123, R645-301-751 and as required by the Utah Division of Environmental Health for National Pollutant Discharge Elimination System (NPDES) permits. 731.220-222.2

Further the Rules provide that:

the permit application will contain a description of measures to be taken to obtain Division approval for alteration or relocation of a natural drainageway under R645-301-358, R645-301-512.250, R645-301-527.100, R645- 301-527.230, R645-301-534.100, R645-301-534.200, R645-301-534.300, R645-301-542.600, R645-301-742.410, R645-301-742.420, R645-301-752.200, and R645-301-762. 732.410.

Rather than address drainageways, however, the Application merely provides:

The primary potential impacts on fish and aquatic species, aquatic habitat, and riparian vegetation which may result from the mining and related activities would be from drainage from the proposed sedimentation pond, or from alternative sediment controls used where drainage from small areas does not report to the sedimentation pond.

App. at 4.3-5.

Impoundments.

In apparent response to the Rules requirements regarding impoundments, the Application provides that:

The sedimentation pond described in the preceding section is the only impoundment which will be utilized for drainage and sediment control purposes in conjunction with the Kinney mining and related operations. Applicable regulatory requirements for impoundments essentially duplicated the specified requirements for sedimentation ponds addressed above. Given limited pond size and capacity, the minimum design freeboard of 1 foot is more than adequate to resist overtopping of the embankment due to wave action or suddent increases in inflow.

App. at 4.7-25.

This description, however, completely fails to comply with the rules provisions for "General Plans" which requires that:

Each permit application will contain a general plan and detailed design plans for each proposed water impoundment within the proposed permit area. Each general plan will:...Be prepared and certified as described under R645-301-512...Contain maps and cross sections...Contain a narrative that describes the structure...Contain the results of a survey as described under R645-301-531...Contain preliminary hydrologic and geologic information required to assess the hydrologic impact of the structure...Contain a certification statement which includes a schedule setting forth the dates when any detailed design plans for structures that are not submitted with the general plan will be submitted to the Division. The Division will have approved, in writing, the detailed design plan for a structure before construction of the structure begins.

733.100-160.

Further the Application completely fails to address the requirement that:

Permanent and temporary impoundments will be designed to comply with the requirements of R645-301-512.240, R645-301-514.300, R645-301-515.200, R645-301-533.100 through R645-301-533.600, R645-301-733.220 through R645-301-733.226, R645-301-743.240, and R645-301-743. Each plan for an impoundment meeting the size or other criteria of the Mine Safety and Health Administration will comply with the requirements of 30 CFR 77.216-1 and 30 CFR 77.216-2. The plan required to be submitted to the District Manager of MSHA under 30 CFR 77.216 will be submitted to the Division as part of the permit application package. For impoundments not included in R645-301-533.610 the Division may establish through the State program approval process engineering design standards that ensure stability comparable to a 1.3 minimum static safety factor in lieu of engineering tests to establish compliance with the minimum static safety factor of 1.3 specified in R645-301-533.110.

733.210.

Temporary Casing and Sealing of Wells.

The Rules provide that:

each well which has been identified in the approved permit application to be used to monitor ground water conditions will comply with R645-301-748 and be temporarily sealed before use and for the purposes of SURFACE COAL MINING AND RECLAMATION ACTIVITIES protected during use by barricades, or fences, or other protective devices approved by the Division. These devices will be periodically inspected and maintained in good operating condition by the operator conducting SURFACE COAL MINING AND RECLAMATION ACTIVITIES.

738.

Instead of compliance with R645-301-748 or the temporarily sealing standard, however, the Application merely provides that groundwater level measurements, field water quality parameters and laboratory samples were taken following well installation and development, undefined "baseline sampling" and well monitoring was conducted for several wells in the project area.

App at 4.7-14.

Design Criteria and Plans.

The Application fails to contain any of the following required information:

"Each permit application will include site-specific plans that incorporate minimum design criteria as set forth in R645-301-740 for the control of drainage from disturbed and undisturbed areas." 741.

> Impoundments meeting the criteria of the MSHA, 30 CFR 77.216(a) will comply with the requirements of 77.216 and R645-301-512.240, R645-301-514.300, R645-301-515.200, R645-301-533.100 through R645-301-533.600, R645-301-733.220 through R645-301-733.224, and R645-301-743. The plan required to be submitted to the District Manager of MSHA under 30 CFR 77.216 will also be submitted to the Division as part of the permit application.

743.110.

> Return of Coal Processing Waste to Abandoned Underground Workings. Each permit application to conduct UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES will, if appropriate, include a plan of proposed methods for returning coal processing waste to abandoned underground workings as follows:
>
> The plan will describe the source of the hydraulic transport mediums, method of dewatering the placed backfill, retainment of water underground, treatment of water if released to surface streams and the effect on the hydrologic regime;
>
> The plan will describe each permanent monitoring well to be located in the backfilled areas, the stratum underlying the mined coal and gradient from the backfilled area; and
>
> The requirements of R645-301-513.300, R645-301-528.321, R645-301-536.700, R645-301-746.410 and R645-746.420 will also apply to pneumatic backfilling operations, except where the operations are exempted by the Division from requirements specifying hydrologic monitoring.

746.400-430.

R645-301-300. Biology.

The Rules provide that "each permit application will include descriptions of the:...!) Vegetative, fish, and wildlife resources of the permit area and adjacent areas as described under R645-301-320; 2) Potential impacts to vegetative, fish and wildlife resources and methods proposed to minimize these impacts during coal mining and reclamation operations as described under R645-301-330 and R645-301-340...

746.310-330.

While the Application provides a: "comparison of the mining related surface disturbance with previous surface disturbance due to historic mining and related activities and more recent disturbances..." App. at 4.3-2.

It writes off the obligation under the Rules to list or study vegetative, fish and wildlife resources by stating:

> construction of transportation and electric transmission facilities indicates that there is little potential for any significant new fish, wildlife, habitat, or vegetation impacts. This conclusion is based on the fact that most potentially significant terrestrial biological impacts have already occurred given the extent and nature of previous development in the surface disturbance areas. In addition, while Utah AML reclamation has been successful in re-establishing vegetative cover and some habitat values, the limited age of reclaimed vegetation and proximity to human activity continue to limit wildlife use. Most of the anticipated surface disturbance for mining and related activities will involve previously disturbed areas. Mining related disturbance of previously undisturbed areas will be negligible. The potential for aquatic impacts is very limited since there are no water sources in the immediate area of the proposed mining surface facilities area. The following sections provide additional details relative to potential mining related impacts on individual biological resource values.

App. at 4.3-3.

> Development and production of the minable coal reserves by underground methods will effectively limit the area of required surface disturbance. Recognizing the environmental benefits of keeping surface disturbance to an absolute minimum, CR has designed the required surface facilities to maximize utilization of the available space and has sited the surface facilities where possible in areas which have been previously disturbed. Specific design and operational measures which will limit surface disturbance include the use of a conveyor system; and consolidation of all required new surface facilities in one area near existing transportation routes which avoids the need for both multiple surface disturbance areas and the disturbance which would be associated with required connecting roads, powerlines, and other necessary infrastructure.

App at 4.3-6.

In addition the Application entirely fails to: "Proposed reclamation designed to restore or enhance vegetative, fish, and wildlife resources to a condition suitable for the designated postmining land use as described under R645-301-340." R645-301-746.313.

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Threatened and Endangered Species

The Rules require that the applicant must provide "Listed or proposed endangered or threatened species of plants or animals or their critical habitats listed by the Secretary under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), or those species or habitats protected by similar state statutes." 322.210.

Listed Species

Threatened Species

Bald Eagle________________________________*Haliaeetus leucocephalus*
Canada lynx________________________________*Lynx Canadensis*

Endangered Species

Whooping crane (extirpated)______________*Grus Americana*
Black-footed ferret ______________________*Mustela nigripes*
(experimental, non-essential
in Duchesne & Uintah counties)

Conservation Agreement Species

Northern goshawk____________________*Accipiter gentilis*

Candidate Species

Yellow-billed cuckoo__________________*Coccyzus americanus*

Species of Concern

Western toad__________________________*Bufo boreas*
Smooth greensnake_____________________*Opheodrys vernalis*
Burrowing owl_________________________*Athene cunicularia*
Ferruginous hawk______________________*Buteo regalis*
Sage Grouse___________________________*Centrocercus urophasianus*
Black swift___________________________*Cypseloides niger*

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2/18/2008 3.3-27

The Application entirely fails to provide information regarding

> Habitats of unusually high value for fish and wildlife such as important streams, wetlands, riparian areas, cliffs supporting raptors, areas offering special shelter or protection, migration routes, or reproduction and wintering areas; or …Other species or habitats identified through agency consultation as requiring special protection under state or federal law.

322.220-230.

Operation Plan.

The Rules require each application to "contain a plan for protection of vegetation, fish, and wildlife resources throughout the life of the mine. The plan will provide:...A description of the measures taken to disturb the smallest practicable area at any one time and through prompt establishment and maintenance of vegetation for interim stabilization of disturbed areas to minimize surface erosion. This may include part or all of the plan for final revegetation as described in R645-301-341.100 and R645- 301-341.200. 746.300-331.

Based on the fact that no description is provided the Application, it fails to address critical information including the requirement that the description "will:

> Be consistent with the requirements of R645-301-358; ...Apply, at a minimum, to species and habitats identified under R645-301-322; and ...Include protective measures that will be used during the active mining phase of operation. Such measures may include the establishment of buffer zones, the selective location and special design of haul roads and powerlines, and the monitoring of surface water quality and quantity.

333.100-300.

Reclamation Plan.

The Application fails to:

> contain a reclamation plan for final revegetation of all lands disturbed by coal mining and reclamation operations, except water areas and the surface of roads approved as part of the postmining land use, as required in R645-301-353 through R645-301-357, showing how the applicant will comply with the biological protection performance standards of the State Program. The plan will include, *at a minimum*:...A detailed schedule and timetable for the completion of each major step in the revegetation plan...Descriptions of the following:...Species and amounts per acre of seeds and/or seedlings to be used. If fish and wildlife habitat will be a postmining land use, the criteria of R645-301-342.300 apply...Methods to be used in planting and seeding;...Mulching techniques, including type of mulch and rate of application;...Irrigation, if appropriate, and pest and disease control measures, if any; and...Measures proposed to be used to determine the success of revegetation as required in R645- 301-356.

341.100-250 (emphasis added).

342. Fish and Wildlife. Each application will contain a fish and wildlife plan for the reclamation and postmining phase of operation consistent with R645-301-330, the performance standards of R645-301-358 and include the following:

342.100. Enhancement measures that will be used during the reclamation and postmining phase of operation to develop aquatic and terrestrial habitat. Such measures may include restoration of streams and other wetlands, retention of ponds and impoundments, establishment of vegetation for wildlife food and cover, and the replacement of perches and nest boxes. Where the plan does not include enhancement measures, a statement will be given explaining why enhancement is not practicable.

Geology

The Rules provide that:

> Geologic information will include, at a minimum, the following:...A description of the geology of the proposed permit and adjacent areas down to and including the deeper of either the stratum immediately below the lowest coal seam to be mined or any aquifer below the lowest coal seam to be mined which may be adversely impacted by mining. This description will include the regional and structural geology of the permit and adjacent areas, and other parameters which influence the required reclamation and it will also show how the regional and structural geology may affect the occurrence, availability, movement, quantity and quality of potentially impacted surface and ground water. It will be based on:...The cross sections, maps, and plans required by R645-301-622.100 through R645-301- 622.400...The information obtained under R645-301-624.200, R645-301-624.300 and R645-301-625; and...Geologic literature and practices.

624.100-130

Faults
There are two distinct styles of faulting within the district. The oldest system is a conjugate set of strike-slip and or oblique-slip vertical faults. The dominant half of this set is oriented north ~57deg. west. The minor half of the set is oriented north ~60 east. The most prominent faults in this system form the Fish Creek Graben, the UP-South-Saddle-Fault, the UP-North-Saddle-Fault, and the G-7 Fault. These structures were first formed in the early compressive episode and then were re-activated by regional uplift Figure 3.6-4.

Two other faults, Up-North Saddle Fault, and UP-South Saddle Fault, were formed in the same structural event that formed the fish Creek Graben. These faults limit the north south length of individual mining blocks in the area. See Appendix B.

Transportation

The Application fails to provide any of the required information:

521.170. Transportation Facilities Maps. Each permit application will describe each road, conveyor, and rail system to be constructed, used, or maintained within the proposed permit area. The description will include a map, appropriate cross sections, and specifications for each road width, road gradient, road surface, road cut, fill embankment, culvert, bridge, drainage ditch, drainage structure, and each stream ford that is used as a temporary route.

527. Transportation Facilities.

527.100. The plan must classify each road.

527.110. Each road will be classified as either a primary road or an ancillary road.

527.120. A primary road is any road which is:

527.121. Used for transporting coal or spoil;

527.122. Frequently used for access or other purposes for a period in excess of six months; or

527.123. To be retained for an approved postmining land use.

527.130. An ancillary road is any road not classified as a primary road.

527.200. The plan must include a detailed description of each road, conveyor, and rail system to be constructed, used, or maintained within the proposed permit area. The description will include a map, appropriate cross sections, and the following:

527.210. Specifications for each road width, road gradient, road surface, road cut, fill embankment, culvert, bridge, drainage ditch, and drainage structure;

527.220. Measures to be taken to obtain Division approval for alteration or relocation of a natural drainageway under R645-301-358, R645-301-512.250, R645-301-527.100, R645-301-527.230, R645-301-527.240, R645-301-534.100, R645-301-534.300, R645-301-542.600, R645-301-742.410, R645-301-742.420, and R645-301-752.200;

527.230. A maintenance plan describing how roads will be maintained throughout their life to meet the design standards throughout their use.

527.240. A commitment that if a road is damaged by a catastrophic event, such as a flood or earthquake, the road will be repaired as soon as practical after the damage has occurred.

527.250. A report of appropriate geotechnical analysis, where approval of the Division is required for alternative specifications, or for steep cut slopes.

528. Handling and Disposal of Coal, Overburden, Excess Spoil, and Coal Mine Waste. The permit application will include a narrative explaining the construction, modification, use, maintenance, and removal of the following facilities (unless retention of such facility is necessary for the postmining land use as specified under R645- 301-413.100 through R645-301-413.334, R645-302-270, R645-302-271.100 through R645-302-271.400, R645-302-271.600, R645-302- 271.800, and R645-302-271.900):

528.100. Coal removal, handling, storage, cleaning, and transportation areas and structures;

524.420. All blasting will be conducted between sunrise and sunset unless nighttime blasting is approved by the Division based upon a showing by the operator that the public will be protected from adverse noise and other impacts. The Division may specify more restrictive time periods for blasting;

II. The State has not conducted investigation or requested Information as directed by the Surface Coal Mining Regulations.

The State has not conducted investigation or requested additional data as deemed necessary to ensure compliance with the requirements of the UCMPR under R645-301-300 - Biology; R645-301-600 - Geology; R645-301-800 - Bonding and Insurance; R645-301-200 - Soils; R645-301-400 - Land Use and Air Quality or R645-301-700 - Hydrology. Nor has the division required sufficient supplemental information to evaluate probable hydrologic or environmental consequences and to plan remedial and reclamation activities based on data provided by the Application that adverse impacts on or off the proposed permit area may occur to the hydrological, biological, land, soils or geological resources as required in R645-301-300-Biology; R645-301-600-Geology; R645-301-800-Bonding and Insurance; R645-301-200-Soils; R645-301-400-Land Use and Air Quality or R645-301-700-Hydrology.

The additional information lacking in the application along with the corresponding Surface Coal Mining Regulations includes:

a. Climatological Information

The UMCR provide that:

> When requested by the Division, the permit application will contain a statement of the climatological factors that are representative of the proposed permit area, including:...The average seasonal precipitation...The average direction and velocity of prevailing winds; and ...Seasonal temperature ranges...The Division may request such additional data as deemed necessary to ensure compliance with the requirements of R645-301 and R645-302.

724.400, 410-13 & 420.

724.500. Supplemental information.

If the determination of the PHC required by R645-301-728 indicates that adverse impacts on or off the proposed permit area may occur to the hydrologic balance, or that acid-forming or toxic-forming material is present that may result in the contamination of ground-water or surface-water supplies, then information supplemental to that required under R645-301-724.100 and R645-301-724.200 will be provided to evaluate such probable hydrologic consequences and to plan remedial and reclamation activities. Such supplemental information may be based upon drilling, aquifer tests, hydrogeologic analysis of the water-bearing strata, flood flows, or analysis of other water quality or quantity characteristics.

724.700. Each permit application that proposes to conduct coal mining and reclamation operations within a valley holding a stream or in a location where the permit area or adjacent area includes any stream will meet the requirements of R645-302-320.

Further, the UCMPR provides that

> ...Hydrologic and geologic information for the cumulative impact area necessary to assess the probable cumulative hydrologic impacts of the proposed coal mining and reclamation operation and all anticipated coal mining and reclamation operations on surface- and ground-water systems as required by R645-301-729 will be provided to the Division if available from appropriate federal or state agencies.

725.100.

Based on the fact that no such information has been provided by the division to the Applicant, "then the applicant may gather and submit this information to the Division as part of the permit application." 725.200. No such analysis of cumulative effects however, is provided in the Application. The significance of this information and the requirement that it be provided in the application at minium, is illustrated by the fact that the "permit *will not be approved* until the necessary hydrologic and geologic information is available to the Division." 725.300 (emphasis added).

Modeling

The UCMPR provides that the "use of modeling techniques, interpolation or statistical techniques may be included as part of the permit application, but actual surface- and ground-water information may be required by the Division for each site even when such techniques are used." 726. There, however, is no discussion in the Application or requirement from DOGM that such information be provided.

728.400. An application for a permit revision will be reviewed by the Division to determine whether a new or updated PHC determination will be required.

Environmental Description.

321. Vegetation Information. The permit application will contain descriptions as follows:

321.100. If required by the Division, plant communities within the proposed permit area and any reference area for SURFACE COAL MINING AND RECLAMATION ACTIVITIES and areas affected by surface operations incident to an underground mine for UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES. This description will include information adequate to predict the potential for reestablishing vegetation; and

321.200. The productivity of the land before mining within the proposed permit area for SURFACE COAL MINING AND RECLAMATION ACTIVITIES and areas affected by surface operations incident to an underground mine for UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES, expressed as average yield of food, fiber, forage, or wood products from such lands obtained under high levels of management. The productivity will be determined by yield data or estimates for similar sites based on current data from the U. S. Department of Agriculture, state agricultural universities, or appropriate state natural resource or agricultural agencies.

Utah Criteria for Designating Areas as Unsuitable for Coal Mining and Reclamation Operations.

Under R645-10-300 CWA would like to request that the area designated for mining by the Application be designated as unsuitable for coal mining and reclamation operations, because the operations as provided in the Application will:

a) Be incompatible with existing state or local land use plans or programs;

The mine is located up stream from a trophy fishing reservoir under the jurisdiction of Utah State Parks. In addition, once the mine becomes active there will potentially be hundreds of freightliner capacity trucks carrying produced coal down highway 96 which runs through the town of Scofield and along the Scofield Reservoir. In addition to presenting a traffic hazard, this level of truck traffic will interfere with the use and enjoyment of the Reservoir by visitors and members of the community.

b) Affect fragile or historic lands in which the activities could result in significant damage to important historic, cultural, scientific, or aesthetic values or natural systems;

The mine will be located within the city limits of the town of Scofield, UT. This town is highly dependent up the tourism economy which will be severally impacted by the noise, visual and water pollution resulting from the mine and the human health impacts of coal mining near residential and commercial buildings and activity.

c) Affect renewable resource lands in which the activities could result in a substantial loss or reduction of long-range productivity of water supply or of food or fiber products; or

The mine will be located next to Mud Creek which contains a valuable fishery and other aquatic resources. That this type of mining activity is potentially detrimental to water quality in the Creek and elsewhere is illustrated by the leak of "fine coal" into clear Creek during the summer of 2008 and which was never cleaned up but did result in a fine being levied by DOGM. See Attachments D-E.

d) Affect natural-hazard lands in which the operations could substantially endanger life and property, such lands to include areas subject to frequent flooding and areas of unstable geology.

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The mine will be located within the city limits of the town of Scofield, UT. The human health impacts of coal mining near residential and commercial buildings and activity will be high. *See* Appendix C-F.

R 645-10-322.100-400.

Conclusion and Request for Informal Conference

Based on the above comments, the State should not grant the Kinny Coal Mine Application and/or should designate the area of the Mine as unsuitable for mining activity. Please contact me if you have any questions regarding our comments or request.

Sincerely,

Harold Shepherd, Executive Directive

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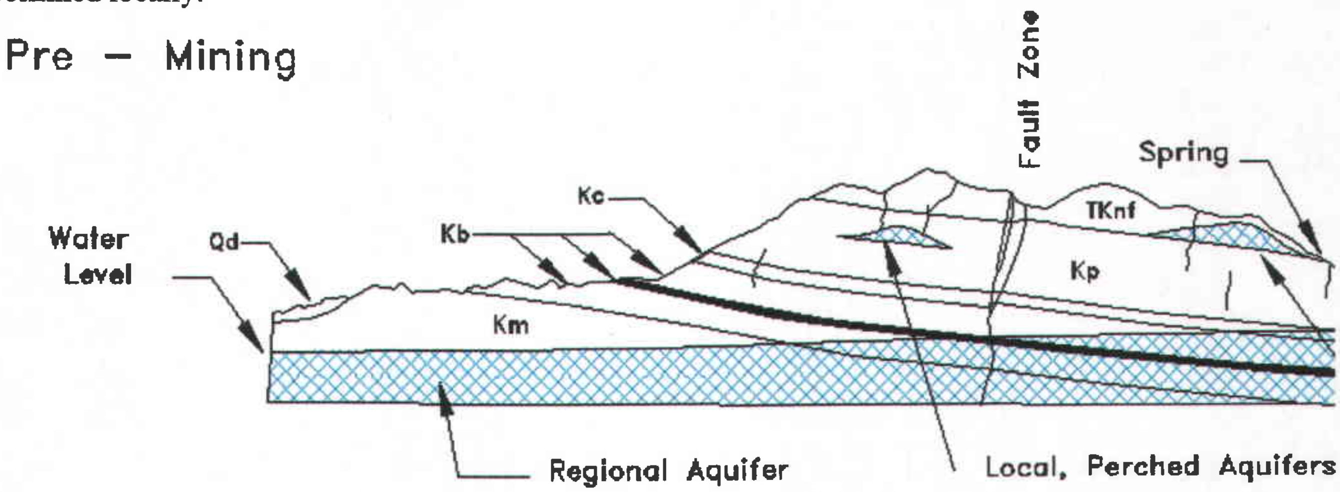
APPENDIX A

I. How Does Mining Intercept Water?

Pre-mining conditions

Below is a cross section depicting the Wasatch Plateau and Book Cliffs coal fields. Also illustrated are perched aquifer and regional aquifer systems. Unconfined ground water in perched aquifers is generally local in extent and influence. A regional water table or aquifer is generally unconfined and crosses formation boundaries, although it may be confined locally.



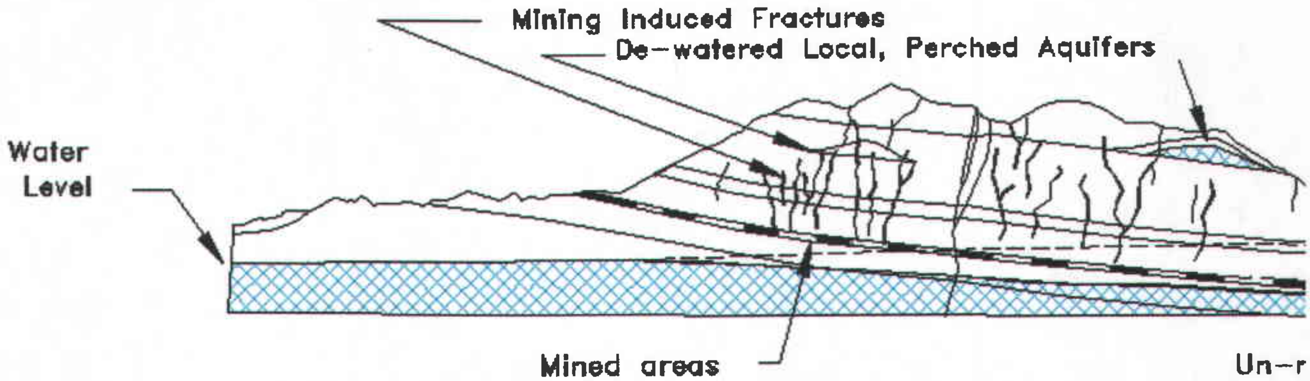
Qd = Quaternary alluvial, colluvial deposits * **TKnf** = North Horn & Flagstaff Fms * **Kp** = Price River Formation

Kc = Castle Gate Sandstone * **Kb** = Black Hawk Formation (coal bearing) * **Km** = Mancos Shale

Conditions during mining

Underground coal mining can result in subsidence of overlying rock. Cracks from subsidence extend upwards, and can reach the surface and intercept surface water. If rock thickness and strength are sufficient, the cracks will not reach the surface but may intercept ground water in perched aquifers above the mine workings and affect springs fed by these aquifers. If water in the regional aquifer is intercepted by the mine workings, the regional water table may be lowered as water is pumped from the mine to allow coal recovery.

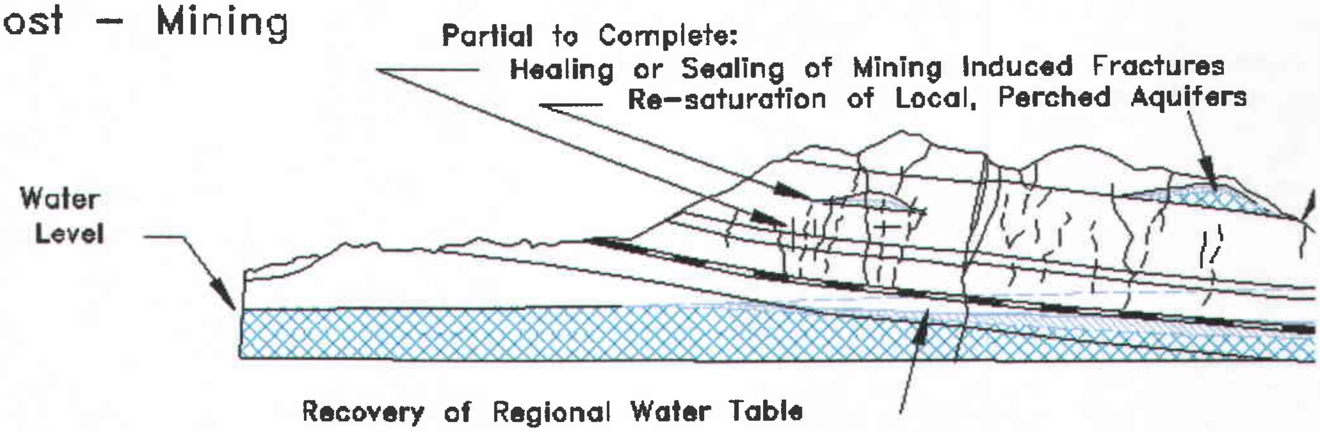
Mining



Post-mining conditions

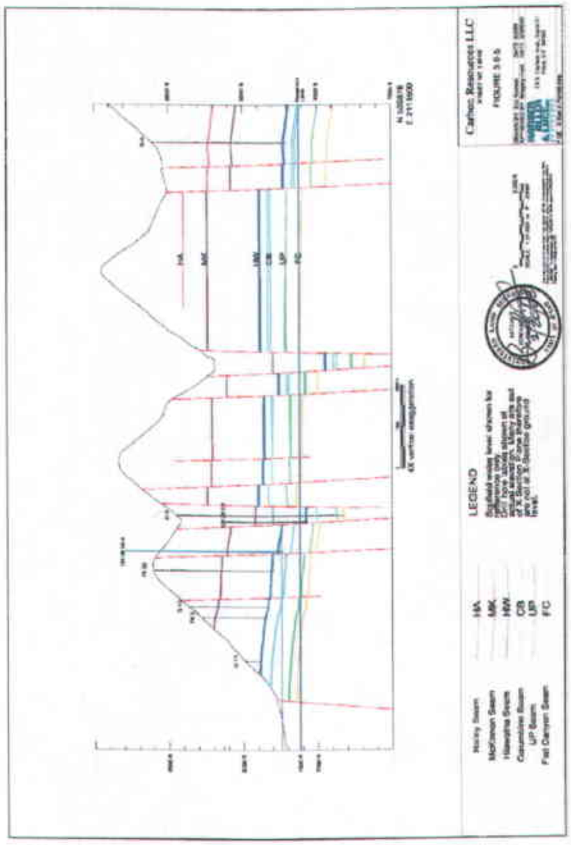
After mining ceases, the hydrologic systems may recover towards pre-mining conditions. Subsidence cracks can heal from plastic flow and swelling of clays and deposition of minerals from ground water. The regional aquifer begins to refill, often aided by the easy flow of water through abandoned mine workings. Springs from disturbed perched aquifers may also recover and refill as cracks heal and the aquifers recharge.

Post – Mining



http://ogm.utah.gov/coal/water/Minh2oin.htm

APPENDIX B



APPENDIX C

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

Michael Hendryx, PhD, and Melissa M. Ahern, PhD

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

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

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

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

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

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

METHODS

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

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

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

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

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

RESULTS

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

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

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

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

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

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

DISCUSSION

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

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

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

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

About the Authors

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Contributors

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

Human Participant Protection

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

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APPENDIX D

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ORIGINAL ARTICLE

Mortality from heart, respiratory, and kidney disease in coal mining areas of Appalachia

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Abstract
Purpose The purpose of this study was to test whether population mortality rates from heart, respiratory and kidney disease were higher as a function of levels of Appalachian coal mining after control for other disease risk factors.
Methods The study investigated county-level, age-adjusted mortality rates for the years 2000–2004 for heart, respiratory and kidney disease in relation to tons of coal mined. Four groups of counties were compared: Appalachian counties with more than 4 million tons of coal mined from 2000 to 2004; Appalachian counties with mining at less than 4 million tons, non-Appalachian counties with coal mining, and other non-coal mining counties across the nation. Forms of chronic illness were contrasted with acute illness. Poisson regression models were analyzed separately for male and female mortality rates. Covariates included percent male population, college and high school education rates, poverty rates, race/ethnicity rates, primary care physician supply, rural-urban status, smoking rates and a Southern regional variable.
Results For both males and females, mortality rates in Appalachian counties with the highest level of coal mining were significantly higher relative to non-mining areas for chronic heart, respiratory and kidney disease, but were not higher for acute forms of illness. Higher rates of acute heart and respiratory mortality were found for non-Appalachian coal mining counties.
Conclusions Higher chronic heart, respiratory and kidney disease mortality in coal mining areas may partially reflect environmental exposure to particulate matter or toxic agents present in coal and released in its mining and processing. Differences between Appalachian and non-Appalachian areas may reflect different mining practices, population demographics, or mortality coding variability.

Keywords Heart disease · Respiratory disease · Kidney disease · Mortality · Coal mining · Appalachia

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Introduction

Exposure to environmental pollutants increases risks for heart, respiratory and kidney disease. For example, low levels of environmental lead exposure accelerate progressive renal insufficiency in patients with chronic kidney disease (Lin et al. 2006), and environmental lead increases cardiovascular mortality in the general population (Menke et al. 2006). Mercury from industrial activity has been linked to kidney disease mortality (Hodgson et al. 2007). Arsenic in drinking water increases mortality from cardiovascular and kidney disease (Meliker et al. 2007). Cadmium exposure increases risk of renal dysfunction (Nishijo et al. 2006; Noonan et al. 2002). In addition to toxic agents, particulate matter (PM) from fossil fuel combustion increases risks for cardiovascular and respiratory disease morbidity and mortality (Barnett et al. 2006; Miller et al. 2007; Pope et al. 2002; Sarnat et al. 2006; Wellenius et al. 2006).

Appalachia is the mountainous, largely rural area in the eastern United States consisting of 417 counties and independent cities in 13 states. Previous research has identified that rates of cardiovascular, respiratory, and total mortality are higher in Appalachia compared to the rest of the country

(Barnett et al. 1998, 2000; Cakmak et al. 2006; Halverson et al. 2004). Furthermore, heart disease mortality in Appalachia is higher in rural areas of the region compared to metropolitan areas (Barnett et al. 1998). Comparative rates for kidney disease have not been reported. Higher mortality rates in Appalachia are believed to result from higher smoking rates, poor dietary and exercise habits, and the correlates of poor socioeconomic conditions characteristic of the region such as limited access to health care.

However, another potential impact on the health of the population may originate from the environmental impacts of Appalachian coal mining. Coal mining constitutes a major industrial activity for eight Appalachian states (Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia), where 390 million tons were mined in 2004 (Freme 2005). Residents of Appalachian coal mining communities report exposure to contaminated air and water from coal mining activities and express concerns for resulting illnesses (Goodell 2006), but empirical evidence on community health risks from coal mining activities is limited (Brabin et al. 1994; Hendryx and Ahern 2007; Hendryx et al. 2007, 2008; Higgins et al. 1969; Temple and Sykes 1992). Coal contains toxic impurities including zinc, cadmium, lead, mercury, arsenic and many others (WVGES 2007), and the mining and cleaning of coal at local processing sites creates large quantities of ambient particulate matter and contaminated water (Ghose and Banerjee 1995; Ghose and Majee 2000; Orem 2007; Stout and Papillo 2004). Not only toxic impurities, but the particulate matter from coal itself released into air or water during mining or processing may be a health hazard. Shiber (2005) reports elevated arsenic levels in drinking water sources in coal mining areas of central Appalachia, and McAuley and Kozar (2006) report that groundwater from sampled domestic wells near reclaimed surface coal mines, compared to wells in unmined areas, has higher levels of mine-drainage constituents including aluminum, iron, manganese, and others. It should be noted, however, that the chemical composition of coal slurry is largely undefined (Orem 2007) and that arsenic and other elements may result from various sources and may be present even in areas where no coal mining takes place. The objective of the current study was to determine whether heart, lung and kidney disease mortality rates in Appalachia are attributable to smoking, poverty, education, and other demographics, or whether there is an additional effect linked to residence in coal mining areas.

Methods

This study investigated mortality rates for the years 2000–2004 for heart, respiratory and kidney disease. The study is an analysis of anonymous, secondary data sources and met university Internal Review Board standards for an exemption from human subjects review.

Mortality data were obtained from the Centers for Disease Control and Prevention (CDC). These data measure county-level mortality rates per 100,000 population, age-adjusted using the 2000 US standard population (CDC 2007b). Disease categories were based on ICD-113 Groups provided by the CDC, which were cross-walked to ICD-10 Codes (The ICD-10 codes are provided in the parentheses in the Table 1 footnote). Diseases were grouped into acute or chronic conditions as shown in Table 1. Specifically excluded were codes for "pneumoconioses and chemical effects", and "pneumonitis due to solids and liquids", as these are established as occupational hazards related to coal mining, rather than potential population risks. Also excluded were several low-incidence categories for "other" or "unspecified" forms of disease or other low-incidence mortality causes. Because most coal miners are men, mortality rates were investigated separately for males and females to test the hypothesis that mining effects would be present for both sexes; support of this hypothesis suggests that results are not attributable to occupational exposure.

Coal production data were obtained from the energy information administration (Freme 2001, 2002, 2003, 2004, 2005). Production was measured as tons of coal mined in the county in both surface and underground mines. Analyses divided Appalachian coal mining into two levels: up to 4 million tons, and more than 4 million tons for the years 2000–2004. The choice of 4 million tons divided the number of coal mining counties approximately in half. Because the focus in this paper is on Appalachian coal mining, 97 non-Appalachian counties where coal mining took place were included as a separate category.

Covariates were taken from the 2005 Area Resource File (ARF 2006), CDC BRFSS smoking rate data (CDC 2007a), and the Appalachian Regional Commission (ARC 2007). Selection of covariates was based on previously identified risk factors or correlates of heart, respiratory or kidney disease (Barnett and Halverson 2001; Barnett et al. 2000; Hoffman and Paradise 2007; Iverson et al. 2005; Jones-Burton et al. 2007; Kunitz and Pesis-Katz 2005; Mannino and Buist 2007; Murray et al. 2005; Ziembroski and Brieding 2006). Covariates included percent male population, college and high school education rates, poverty rates, race/ethnicity rates, health uninsurance rates, physician supply, rural–urban continuum code, smoking rates, and Southern state (yes or no). Specific race/ethnicity groups included percent of the population who were African American, Native American, Non-white Hispanic, and Asian American (using White as the referent category in regression models). Rural–urban continuum was scored on a nine-point scale from least to most rural. Physician supply was the number of active MDs and DOs per 1,000 population. A

Table 1 Descriptive summary of study variables by county category

	County category			
	No mining	Non-Appalachian mining	Appalachian mining ≤ 4 million tons	Appalachian mining > 4 million tons
Number of counties	2,914	97	66	63
Total population	274,502,126	4,234,505	5,287,206	3,762,685
Age-adjusted annual number of deaths				
Chronic heart disease[a]	303,319	9,948	7,421	8,550
Acute heart disease[b]	302,316	11,028	8,313	8,117
Chronic respiratory disease[c]	138,777	4,921	3,601	3,871
Acute respiratory disease[d]	67,513	2,423	1,726	1,639
Chronic kidney disease[e]	44,418	1,526	1,252	1,284
Acute kidney disease[f]	171	3	5	4
Covariates				
Smoking rate	23.0	24.0	27.7	29.2
Percent male	49.9	50.0	49.5	49.1
Percent African American	9.3	4.9	2.6	3.2
Percent Native American	1.9	4.9	0.2	0.2
Percent Hispanic	6.7	6.7	0.9	0.7
Percent Asian American	1.0	0.5	0.4	0.4
Percent with high school education	77.7	77.9	71.4	70.2
Percent with college education	16.8	14.8	12.3	11.5
Physicians per 1,000	1.3	1.2	1.3	1.5
Poverty rate	13.4	14.0	16.3	18.2
Percent Southern county	25.4	1.0	45.5	31.7
Mean urban–rural code	5.1	5.1	5.2	5.3

[a] Includes hypertensive heart disease (ICD-10 code I11), atherosclerotic cardiovascular disease so described (I25), all other forms of chronic, ischemic heart disease (I25.8), and essential (primary) hypertension and hypertensive renal disease (I10, I12)

[b] Includes acute myocardial infarction (I21), other acute ischemic heart diseases (I24), acute and sub-acute endocarditis (I33), diseases of pericardium and acute myocarditis (I31, I40), and heart failure (I50)

[c] Includes chronic and unspecified bronchitis (J40-J42), emphysema (J43), asthma (J45), and other chronic lower respiratory diseases (J44)

[d] Includes pneumonia (J12–J18), acute bronchitis and bronchiolitis (J20–J21), and unspecified acute lower respiratory infection (J22)

[e] Includes chronic glomerulonephritis, nephritis and nephropathy not specified as acute or chronic, and renal sclerosis unspecified (N03–N05), and renal failure (N17–N19)

[f] Includes acute and rapidly progressive nephritic and nephrotic syndrome (N00, N01)

dichotomous Southern variable was created to capture larger regional effects that partially overlap with Appalachia; Southern states included Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia. CDC smoking rates were available for states and some county-based metropolitan areas. In an effort to improve smoking data, the state public health websites for all 50 states were reviewed and more specific county-level smoking rate data were found for 30 states, sometimes for individual counties and sometimes for groups of counties. The state average was used only when the more specific rate was not available. Appalachian counties included the 417 counties and independent cities in 13 states as defined by the Appalachian Regional Commission (ARC 2007).

Analyses were conducted using Poisson multiple regression with a log link function to test for the association between residence in coal mining areas and mortality rates with control for covariates. The primary independent variable of interest is a categorical measure of coal mining exposure with four levels: no coal mining, non-Appalachian mining, Appalachian mining up to 4 million tons, and Appalachian mining greater than 4 million tons.

Results

Table 1 contains descriptive characteristics of the counties by the four exposure groupings: no mining, non-Appalachian mining, Appalachian mining up to 4 million tons, and

Appalachian mining greater than 4 million tons. Appalachia has higher smoking rates, higher poverty rates, and lower education levels, but smaller race/ethnicity minority populations, compared to the nation. Acute kidney disease was a rare cause of mortality, and therefore this mortality category was dropped from further analysis.

Bivariate correlations among independent variables were examined for multicollinearity. Two variables, poverty rate and percent without health insurance, were correlated at $r = 0.81$, and so the insurance rate variable was dropped from regression models.

The next steps of the analysis examined age-adjusted mortality rates, and tested whether there were mortality effects linked to coal mining after accounting for covariates. Age-adjusted rates before adjusting for covariates are shown in Tables 2 and 3 for males and females, respectively. Mortality rates are higher in Appalachian mining areas compared to other areas in every instance. Mortality rates for these conditions are higher for men than for women, but this is the case for both mining and non-mining areas.

Poisson regression model results adjusting for covariates are presented in Tables 2 and 3, one table each for males and females. The rate ratios (RR) were found after exponentiating the log values back to the original scale; these figures represent the proportional increment in mortality rates per 100,000 relative to the non-mining reference category. For Appalachian mining areas, significantly higher mortality rates showed the same pattern for males and females. Among the Appalachian counties with the highest mining level, higher mortality rates were found for both males and females for total and chronic heart disease, total and chronic respiratory disease, and chronic kidney disease. Appalachian mining effects were stronger and more frequent in areas where mining was highest compared to areas of less-intense mining.

Coal mining areas outside Appalachia showed a similar but not identical pattern for males and females: for both sexes there were higher total and acute respiratory mortality, and higher acute heart disease mortality. Females, but not males, had significantly higher total heart disease mortality and chronic kidney disease mortality; males but not females had significantly higher mortality from chronic respiratory illness.

There were also instances where mortality was significantly lower than expected. For Appalachian coal mining areas, lower mortality was found for acute forms of heart and respiratory illness. In other words, higher mortality in Appalachian mining areas was specific to total and chronic forms of illness, while for non-Appalachian mining areas

Table 2 Male age-adjusted mortality rates per 100,000 population by mining category with 95% confidence interval (CI) in parentheses, followed by rate ratios (RR) and 95% CI adjusted for all covariates with non-mining as the referent

	Appalachian mining > 4 million	Appalachian mining up to 4 million	Non-Appalachian mining	Non-mining
Total heart				
Age-adjusted mortality	331 (316–346)	298 (287–309)	270 (257–283)	261 (259–263)
RR	1.07 (1.05–1.09)	1.01 (0.99–1.02)	1.01 (0.99–1.02)	–
Chronic heart				
Age-adjusted mortality	171 (160–181)	139 (129–149)	127 (119–136)	130 (128–131)
RR	1.28 (1.25–1.30)	1.06 (1.04–1.08)	0.96 (0.94–0.98)	–
Acute heart				
Age-adjusted mortality	160 (145–175)	159 (146–172)	143 (133–153)	132 (130–134)
RR	0.89 (0.87–0.91)	0.95 (0.93–0.97)	1.06 (1.04–1.08)	–
Total respiratory				
Age-adjusted mortality	113 (104–121)	105 (98–113)	96 (92–100)	90 (89–91)
RR	1.03 (1.00–1.05)	0.97 (0.95–0.99)	1.05 (1.02–1.07)	–
Chronic respiratory				
Age-adjusted mortality	81 (75–87)	74 (69–79)	67 (64–71)	63 (62–64)
RR	1.07 (1.04–1.10)	0.99 (0.97–1.03)	1.04 (1.02–1.06)	–
Acute respiratory				
Age-adjusted mortality	32 (28–36)	31 (27–35)	28 (26–31)	28 (27–28)
RR	0.94 (0.89–0.98)	0.92 (0.88–0.96)	1.05 (1.01–1.09)	–
Chronic kidney				
Age-adjusted mortality	25 (23–27)	22 (20–24)	18 (17–20)	19 (18–19)
RR	1.19 (1.13–1.25)	1.10 (1.05–1.16)	1.02 (0.98–1.06)	–

Table 3 Female age-adjusted mortality rates per 100,000 population by mining category with 95% confidence interval (CI) in parentheses, followed by rate ratios (RR) and 95% CI adjusted for all covariates with non-mining as the referent

	Appalachian mining > 4 million	Appalachian mining up to 4 million	Non-Appalachian mining	Non-mining
Total heart				
Age-adjusted mortality	213 (202–224)	192 (183–201)	174 (165–182)	165 (164–167)
RR	1.06 (1.04–1.08)	1.00 (0.98–1.02)	1.03 (1.02–1.05)	–
Chronic heart				
Age-adjusted mortality	109 (102–116)	92 (85–99)	83 (77–89)	84 (83–85)
RR	1.18 (1.15–1.21)	1.03 (1.00–1.05)	0.97 (0.95–0.99)	–
Acute heart				
Age-adjusted mortality	104 (94–114)	100 (92–108)	91 (85–96)	82 (80–83)
RR	0.95 (0.93–0.97)	0.97 (0.94–0.99)	1.10 (1.08–1.12)	–
Total respiratory				
Age-adjusted mortality	73 (68–78)	65 (61–70)	63 (59–66)	59 (58–59)
RR	1.03 (1.00–1.06)	0.94 (0.91–0.97)	1.05 (1.02–1.07)	
Chronic respiratory				
Age-adjusted mortality	61 (57–66)	55 (51–58)	51 (48–53)	48 (47–48)
RR	1.11 (1.07–1.15)	0.94 (0.90–0.98)	1.01 (0.98–1.04)	–
Acute respiratory				
Age-adjusted mortality	26 (23–29)	26 (23–29)	25 (23–27)	23 (23–24)
RR	0.89 (0.84–0.94)	0.92 (0.87–0.97)	1.13 (1.08–1.18)	–
Chronic kidney				
Age-adjusted mortality	18 (16–19)	17 (16–19)	14 (13–15)	13 (13–14)
RR	1.13 (1.06–1.21)	1.14 (1.07–1.21)	1.08 (1.02–1.14)	–

mortality was elevated for acute heart and respiratory disease, and chronic kidney disease for females.

Finally, county-level coal mining data are reported for the nation by the Energy Information Administration only back to 1999. However, disease consequences of exposure are hypothesized to be long-term phenomena. Longer historical records of county-level coal mining are available on the websites of two state Geological Surveys, those for West Virginia and Kentucky; an examination of these sources indicated that 100% of counties categorized in the highest coal-mining group for the current study had high levels of coal mining extending back at least to 1986. Appalachian areas with large coal reserves have been mining coal for decades.

Discussion

Total and chronic heart, respiratory and kidney disease mortality rates are significantly higher in coal mining areas of Appalachia compared to non-mining areas of the country. Coal mining industrial activities may expose residents to environmental contaminants, or these geographic areas may be associated with additional behavioral or demographic characteristics not captured through other covariates. The same effects are found for both males and females in Appalachia.

The different pattern of results in coal mining areas outside Appalachia was not expected. The different results may reflect differences in population demographics, migration patterns, mining practices, geographic topography, or population density [i.e., the population density of Appalachian coal mining areas (118 per square mile) is significantly higher than non-Appalachian mining areas (64 per square mile)]. Differences may also reflect variation in medical diagnostic practices that favor acute or chronic classifications; when considering total mortality rates, mining areas inside and outside Appalachia were elevated compared to non-mining areas.

Limitations of the study include the reliance on secondary county-level data. Causes of individual mortality cannot be identified, and the precise pathway between residence in coal mining areas and mortality is unknown. The phenomenon of environmental exposure occurs at an aggregate level, and as there is a risk of an ecological fallacy, so is there a risk of an atomistic fallacy by failing to account for the aggregate nature of the effect (Willis et al. 2003). More definitive research should be conducted using multi-level modeling of aggregate ecologic impacts on individual outcomes. An additional critical next research step is to collect direct air and water samples in coal mining communities to test the hypothesis that increased mortality from these chronic diseases is linked to poorer air and water quality.

Another limitation is the use of smoking rates that were imprecisely measured. Smoking effects, including exposure to second-hand smoke linked to poorer socioeconomic conditions, may be underestimated. The smoking variable, however, did predict higher mortality rates across conditions and so operated as expected.

Not all risk factors could be measured, for example, kidney disease risks associated with diabetes or hypertension were not assessed. Behaviors such as physical activity levels and alcohol consumption could not be included. Demographic or cultural variables not captured through available covariates may be contributing factors; these variables might include Appalachian cultural beliefs such as fatalism (Coyne et al. 2006) that increase risk for poor health behaviors or delay early health care intervention, or weak tobacco control policies that increase second-hand smoke exposure.

Future research should collect direct measures of smoking, occupational exposure, duration of environmental exposure, and individual-level health and disease measures to confirm the findings suggested by this research. Research to examine the different mortality patterns in Appalachian and non-Appalachian areas is indicated. Additional research is also needed to identify exposure types, levels, and mechanisms of action that can account for higher mortality in coal mining areas. For example, research can determine if pollution from mining itself is a contributing factor or whether the coal processing, cleaning and transportation activities that take place after mining are more important, and can determine through direct air and water quality monitoring if one transmission route or the other, or both, contribute to poor health outcomes. The pattern of results and prior research suggest that water quality may be a factor for kidney disease, that air quality may be a factor for respiratory disease, and that either air or water problems may be related to heart disease.

Until recently, research on the community health impacts of Appalachian coal mining had been unavailable, and only anecdotal evidence (Goodell 2006; Loeb 2007) attested to the health impacts of living in proximity to mining activities. A body of evidence is beginning to emerge, however, that confirms the beliefs of local residents at least to some extent, and suggests that coal mining-related community health problems are real (Hendryx and Ahern 2008; Hendryx et al. 2007, 2008; Orem 2007; Shiber 2005; Stout and Papillo 2004). As evidence accumulates to reveal a previously unknown contributing factor to the infamous health disparities plaguing Appalachia, it becomes critical to address issues of environmental equity and to reduce environmental and socioeconomic disparity through economic and policy interventions. These interventions may include establishing and enforcing stricter air and water quality standards in coal mining communities.

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APPENDIX E

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Hospitalization Patterns Associated with Appalachian Coal Mining

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The goal of this study was to test whether the volume of coal mining was related to population hospitalization risk for diseases postulated to be sensitive or insensitive to coal mining by-products. The study was a retrospective analysis of 2001 adult hospitalization data (*n*= 93,952) for West Virginia, Kentucky, and Pennsylvania, merged with county-level coal production figures. Hospitalization data were obtained from the Health Care Utilization Project National Inpatient Sample. Diagnoses postulated to be sensitive to coal mining by-product exposure were contrasted with diagnoses postulated to be insensitive to exposure. Data were analyzed using hierarchical nonlinear models, controlling for patient age, gender, insurance, comorbidities, hospital teaching status, county poverty, and county social capital. Controlling for covariates, the volume of coal mining was significantly related to hospitalization risk for two conditions postulated to be sensitive to exposure: hypertension and chronic obstructive pulmonary disease (COPD). The odds for a COPD hospitalization increased 1% for each 1462 tons of coal, and the odds for a hypertension hospitalization increased 1% for each 1873 tons of coal. Other conditions were not related to mining volume. Exposure to particulates or other pollutants generated by coal mining activities may be linked to increased risk of COPD and hypertension hospitalizations. Limitations in the data likely result in an underestimate of associations.

Over the past several years, coal has become more competitive as a source of power and fuel because of (1) energy security concerns, (2) an increase in the cost of oil and gas, (3) evidence for the near-term occurrence of peak global oil production, and (4) concerns about nuclear power. The United States has 27% of all known coal reserves (Folger, 2006). The U.S. Department of Energy estimates that 153 new coal-fired power plants will come on line by 2030 (Klara & Shuster, 2007). Increases in coal mining in response to these pressures pose potential adverse health risks for persons who live in the vicinity of the mining activities.

Anecdotal evidence on the negative health effects of living near coal mining sites in Appalachia is widespread. Residents reported serious health consequences they experience from living in the coalfields (Goodell, 2006). Water quality studies documented contaminated well water in West Virginia and Kentucky communities consistent with coal slurry toxins (McSpirit & Dieckmann, 2003; Stout & Papillo, 2004). However, quantitative research on the relationship between residential proximity to coal mining sites and health consequences is rare; research conducted has been limited to studies in Great Britain and to a narrow range of respiratory illnesses. These studies found elevated levels of particulate matter (PM) (Pless-Mulloli et al., 2000a) and increased symptoms of respiratory morbidity (Pless-Mulloli et al., 2000b; Brabin et al., 1994; Temple & Sykes, 1992) associated with residential proximity to coal mining sites. Contaminated dust from coal washing activities is a significant local phenomenon (Ghose & Banerjee, 1995). The harmful exposures faced by coal miners—diesel particulates, dust, chemicals, fuels, and elemental toxins (Scott et al., 2004)—may be found in less concentrated form but for larger populations of individuals living near the mining sites.

Previous research has established an association between hospitalization patterns and daily measures of air pollution in metropolitan areas (Simpson et al., 2005; Wellenius et al.,

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2006; Barnett et al., 2006; Yang et al., 2004; 2007). These hospitalizations, for cardiovascular disease, asthma, and other respiratory diseases, are thought to result from exacerbations of existing illnesses from PM. A similar phenomenon may exist for residents exposed to pollution from coal mining activities. However, previous research on residential proximity to coal mining (Pless-Mulloli et al., 2000b; Brabin et al., 1994; Temple & Sykes, 1992) has not examined hospitalization patterns. Therefore, the current study examines the relationship between hospitalization patterns and coal mining production among residents of three Appalachian states in the United States: Kentucky, Pennsylvania, and West Virginia.

METHODS

Design

The study is a retrospective analysis of 2001 person-level hospitalization data from Kentucky, Pennsylvania, and West Virginia, merged with 2001 county-level data on tons of coal mined and other county-level data.

Sample and Data Sources

Hospital data are taken from the Health Care Utilization Project (HCUP) National Inpatient Sample (NIS) of short-stay general hospitals for 2001. These data are coordinated through the Agency for Healthcare Research and Quality (AHRQ), and are available as de-identified discharge abstracts for research purposes. The NIS data represents approximately a 20% probability sample of all hospitals in participating states. For the current study, adults 19 yr and older with all diagnoses were included, except for maternal cases and transfers from other hospitals, resulting in a sample of 93,952 hospitalizations from 90 sampled hospitals. Maternal cases were excluded so as not to confound denominators in the hospitalization rates with normal labor and delivery, instead limiting the denominator to forms of illness or injury. Not every state participates in the NIS, and among those that do, only some provide the county identifier field. Among major coal-producing Appalachian states, counties were identified in the NIS data by Kentucky, Pennsylvania, and West Virginia, and thus are included in this study.

Coal production figures for 2001 were obtained from the Energy Information Administration (Annual Coal Report, 2002). The figures included the tons of coal mined in thousands from each county in both underground and surface mines. There were 73 counties represented in this database (including counties that mined no coal) with matching records in the NIS sample.

Other county indicators included percent of population in poverty from U.S. Census data, and a measure of county production of social capital, standardized to a mean of 0 across all counties in the nation (Rupasingha et al., 2006). Social capital has been shown in other research to be an important correlate of population health (Lochner et al., 2003).

Variables

NIS variables used for analysis include patient age (in years, categorized as 19–44, 45–64, 65–74, 75+), gender, payer (insured or uninsured), diagnoses, and hospital teaching status (teaching hospitals are academic health centers that conduct patient care, research, and medical education, and that tend to serve most complex cases). The Federal Information Processing Standards (FIPS) code was used to identify the county location of the hospital. The dependent variable was found from the diagnosis given in the primary diagnostic field. Diagnoses were grouped into those postulated to be "coal exposure sensitive" and "coal exposure insensitive." The list of candidates for sensitive conditions is preliminary and based on previous health risks reported in the literature for coal miners, findings established from exposure to air particulate pollution, or evidence for kidney or cardiovascular disease related to exposure to toxins found in association with coal mining (Wellenius et al., 2006; Barnett et al., 2006; Navas-Acien et al., 2004, 2005; Nishijo et al., 2006; Coggon & Taylor, 1998; Sarnat et al., 2006; Noonan et al., 2002). Where to place lung cancer is unclear; risk of lung cancer was linked to diesel particulate matter (Monforton, 2006), but other research found no elevated risk for lung cancer among miners after controlling for smoking behavior (Montes et al., 2004); for this study lung cancer was tentatively positioned in the "sensitive" column. A list of postulated coal exposure-sensitive and -insensitive conditions is provided in Table 1. The list of potential insensitive conditions is not intended to be final or exhaustive but to offer a sample of "control" conditions that are expected to be unrelated to coal mining exposure. Each diagnosis is thus a dichotomous variable, and the question becomes whether an exposure-sensitive diagnosis is significantly higher in coal mining areas as a proportion of total hospitalizations, whereas

TABLE 1

List of Potential Candidates for Coal-Sensitive and Coal-Insensitive Conditions, With Corresponding Diagnostic Codes

Coal-sensitive		Coal-insensitive	
Category	ICD-9 codes	Category	ICD-9 codes
Lung cancer	162	Diabetes	250
COPD	490–492, 494–496	Musculoskeletal and connective	710–739
Hypertension	401–405	Organic psychoses	290–294
Kidney disease	580–589		
Congestive heart failure	428		
Ischemic heart disease	410–413		
Asthma	493		

exposure-insensitive conditions should not differ as a function of coal mining intensity.

Other NIS variables are used as covariates. These include age, gender, uninsurance, hospital teaching status, and comorbidities. Comorbidities are measured in two ways: first, by the count of nonmissing secondary diagnosis fields ranging potentially from 0 to 14, and second, by a Charlson index (Charlson et al., 1987) calculated for each case based on diagnostic codes reported by Romano et al. (1993) and scored 0 to 3 to indicate increasing severity of comorbidities.

Coal production was not normally distributed across counties. Because more than half of the counties produced no coal, a square-root transformation was preferred over a log transformation. The coal production variable was transformed by taking the square root of tons of coal measured in thousands. The coal production variable was linked to the hospital records at the county level.

Analysis

After descriptive analyses, inferential analyses determined whether hospitalizations for "exposure-sensitive" and "exposure-insensitive" conditions were significantly elevated as a function of coal production, accounting for other variables likely to correlate with health indicators. The analysis was done at the person level using HLM 6.03 multilevel Bernoulli modeling for the dichotomous presence of the dependent variable diagnosis. The square root of county-level coal production was included as a level 2 predictor. Level 1 (person-level) covariates included gender, age, uninsurance status, hospital teaching status, comorbidity count, and Charlson index. Level 2 (county-level) covariates included social capital and poverty rates. The intercept effect was treated as a random variable but other predictors were treated as fixed. Results are reported for final population estimates with robust standard errors. Significant coal effects are identified based on odds ratios greater than 1 at the 95% confidence interval.

Additional analyses examined gender differences to confirm that coal effects were not limited to men, who may be current or former miners, and to examine scatterplots between observed and expected level 2 residuals to confirm adequate model fit.

RESULTS

Table 2 summarizes descriptive characteristics of study variables. The average age of the sample was about 67, and about 56% of patients were female. The most common diagnoses among those coded for analysis were congestive heart failure, ischemic heart disease, chronic obstructive pulmonary disease (COPD), and diabetes.

Table 3 summarizes hierarchical model results. Greater coal mining was positively related to more hospitalizations for two postulated coal-sensitive conditions, hypertension and COPD.

TABLE 2

Descriptive Summary of Study Variables

Variable	Mean or %	St. deviation	Minimum–maximum
Person-level (n= 93,952)			
Mean age	66.9	14.3	19–105
Mean comorbidity count	4.12	2.10	0–9
Mean Charlson index	0.41	0.65	0–3
Percent female	55.7		
Percent uninsured	1.57		
Percent teaching hospital admissions	33.2		
Percent with primary diagnosis of:			
COPD	3.33		
Asthma	0.92		
Hypertension	1.39		
Kidney disease	1.09		
Congestive heart failure	9.61		
Ischemic heart disease	4.57		
Diabetes	7.62		
Lung cancer	0.40		
Organic psychoses	0.49		
Musculoskeletal and connective disorders	3.83		
County-level (n= 73)			
Tons of coal×1000	1957.70	6643.16	0–44303
Square root (tons of coal×1000)	20.94	39.25	0–210.48
Percent population below poverty	15.22	6.69	4.8–37.7
Social capital index	-0.17	0.42	−1.14–0.50

It was not significant for other conditions, including the potential insensitive conditions. There was a significant *negative* relationship between coal production and hospitalization for lung cancer and kidney disease.

The odds ratios are expressed relative to the square root of coal in thousands of tons. Transforming the odds ratios back to the original metric results in the odds of a COPD hospitalization increasing 1% for each 1462 tons of coal, and the odds for a hypertension hospitalization increasing 1% for each 1873 tons of coal.

The possibility that the results may reflect current or former miners who live in the area, rather than a general population effect, may be dismissed through an examination of gender effects. Almost all coal miners are men. Results for the significant COPD model show no gender effect, and results for the significant hypertension model show a higher risk for women.

TABLE 3
Hierarchical Model Results, Coal Production Effects Controlling for Person and County Covariates

Independent variables	COPD Odds ratio	COPD 95% Confidence interval	LUNG CANCER Odds ratio	LUNG CANCER 95% Confidence interval
Coal production	1.003	1.001–1.006	0.997	0.993–1.000
County poverty rate	1.017	0.987–1.048	1.010	0.966–1.056
Social capital	–0.467	0.416–0.945	1.205	0.641–2.266
Age	1.154	1.098–1.213	1.216	1.076–1.374
Female	0.979	0.870–1.102	0.681	0.545–0.851
Teaching status	0.789	0.584–1.065	1.775	0.931–03.382
Comorbidity count	0.918	0.901–0.935	0.878	0.823–0.936
Charlson Index	0.664	0.600–0.735	3.602	3.220–4.029
Uninsured	0.681	0.464–0.999	0.238	0.079–0.714
	Hypertension		Diabetes	
Coal production	1.003	1.001–1.005	0.998	0.994–1.001
County poverty rate	0.992	0.957–1.027	1.045	0.980–1.113
Social capital	0.701	0.413–1.190	1.504	0.614–3.685
Age	1.086	1.033–1.141	0.605	0.582–0.629
Female	1.218	1.061–1.399	0.899	0.849–0.951
Teaching status	1.236	0.707–2.158	0.978	0.833–1.147
Comorbidity count	0.977	0.944–1.012	0.906	0.885–0.928
Charlson Index	0.913	0.847–0.985	0.983	0.936–1.033
Uninsured	1.739	0.976–3.098	1.808	1.559–2.098
	Kidney disease		Organic psychoses	
Coal production	0.997	0.994–0.999	0.998	0.994–1.001
County poverty rate	1.000	0.972–1.030	1.003	0.965–1.043
Social capital	0.639	0.408–1.000	1.812	0.833–3.941
Age	1.077	1.010–1.149	1.251	0.986–1.589
Female	1.005	0.908–1.112	0.563	0.465–0.681
Teaching status	1.269	0.975–1.635	0.509	0.151–1.717
Comorbidity count	1.441	1.352–1.536	1.025	0.918–1.145
Charlson Index	0.909	0.807–1.024	0.702	0.590–0.835
Uninsured	0.465	0.192–1.130	1.039	0.452–2.392
	Ischemic heart disease		Musculoskeletal	
Coal production	0.998	0.995–1.002	1.002	1.000–1.004
County poverty rate	1.002	0.973–1.032	0.985	0.957–1.014
Social capital	0.957	0.643–1.428	2.629	1.653–4.181
Age	1.108	1.066–1.151	0.987	0.938–1.039
Female	0.733	0.697–0.771	1.177	1.062–1.305
Teaching status	0.999	0.741–1.347	1.044	0.798–1.365
Comorbidity count	1.037	1.005–1.069	0.869	0.837–0.903
Charlson Index	0.809	0.771–0.849	0.741	0.680–0.809
Uninsured	1.494	1.077–2.073	0.463	0.294–0.729

(Continued)

TABLE 3

(Continued)

Independent variables	COPD		LUNG CANCER	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
	Asthma		Congestive heart failure	
Coal production	0.999	0.996–1.003	1.000	0.999–1.001
County poverty rate	0.981	0.941–1.022	1.009	0.986–1.033
Social capital	0.898	0.554–1.453	0.823	0.604–1.121
Age	0.598	0.549–0.651	1.324	1.280–1.368
Female	2.536	2.010–3.199	1.028	0.963–1.098
Teaching status	0.855	0.617–1.183	0.757	0.591–0.970
Comorbidity count	0.898	0.875–0.923	1.119	1.096–1.143
Charlson Index	0.448	0.388–0.517	1.049	1.004–1.095
Uninsured	0.690	0.468–1.018	0.885	0.567–1.381

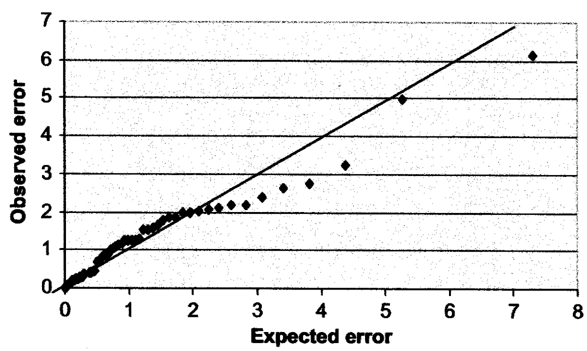

FIG. 1. Scatterplot showing observed and expected level 2 residuals for hypertension model.

The scatterplot of observed to expected model residuals was examined to determine whether the level 2 errors in the model were randomly distributed. Figure 1 shows that observed and expected errors are closely related. This figure is for the hypertension model, but the COPD model showed similar results. The correlation between observed and expected error in Figure 1 was .98.

DISCUSSION

This is the first study to show that hospitalizations for COPD and hypertension are significantly elevated as a function of Appalachian coal production at the county level. The risk increases significantly as the volume of coal mining rises. The effects might be a result of exposure to PM associated with mining activities such as coal extraction and washing (Ghose & Banerjee, 1995), exposure to diesel particulate matter from operation of engines at mining sites (Monforton, 2006), or some interactive combination thereof.

Effects were not found for other conditions that were hypothesized to be sensitive to coal exposure, including kidney disease, lung cancer, and forms of heart disease. This might be due to exposure effects that are too weak to exert negative impacts on residents, limitations in the precision of the hospitalization data (discussed in more detail later), or time lags between exposure and illness. Exposure effects were not found for any of the potential insensitive conditions. These lists of sensitive and insensitive conditions are only a starting point for refined classifications as knowledge on this topic progresses.

Limitations of this study include the ecological design, which prohibits drawing a definitive causal link between the hospitalization event and coal mining activities. Adjustments were made for a set of demographic and county indicators, but it is possible that other unmeasured variables may contribute to poorer health in a way that is confounded with coal mining. Smoking and obesity, in particular, were not measured. However, the reverse finding for lung cancer suggests that coal production and smoking patterns are not confounded. Air pollution levels from industrial sources were also not measured, although power plants tend to be located in population centers and along major rivers, whereas primary coal mining locations often occur in separate, more rural areas. The weather patterns associated with a particular season might also affect both illness and volume of mining (i.e., a cold winter increases susceptibility to illness and increases economic demand for coal); this issue may be addressed in future research by examining effects for longer time intervals. The use of the proportional hospitalization indicator, like a proportional mortality ratio, has limitations (Miettinen & Wang, 1981; Decoufle et al., 1980), such as its dependence on the relative frequency of coal-sensitive to -insensitive conditions in the population.

The data are also limited by the geographic crudeness of the county measure: Some persons may live in a coal mining county but some distance from the mining activities, while others live across county lines but closer to mining sites. Future research would be improved by obtaining a more refined geographic match between residence and coal mining activities; possibilities include secondary census tract data (e.g., Vassilev et al., 2001), or primary data collection studies with geographic information system (GIS) indicators. Unfortunately, the coal production figures for this study were not available on those smaller scales.

A significant limitation of the hospitalization data is that the county identified the location of the hospital, not necessarily the location where the patient resided. Persons who were transferred from other hospitals were excluded from analysis, but this is not a complete solution. To the extent that people move from one area to another for hospital care, this introduces error into the measurement. This error appear to be random rather than systematic, making detection of effects more difficult but not creating bias in the direction of effects. To make an argument for biased results due to patient mobility, one would have to argue that people differentially move from non-coal-mining areas to coal-mining areas for hospital care, for only COPD and hypertension and not for other conditions, and that this occurs relative to the intensity of mining. This particular pattern of movement seems unlikely. To the extent that error is random, with some patients moving into and out of coal producing areas for care, coal mining effects will be underestimated.

Another limitation of hospitalization data is that they are an indicator that is influenced by various other factors, including the quality of the ambulatory care system, and payer or geographic variation in diagnostic practices, in ways that could not be measured. COPD and hypertension in many cases are instances of ambulatory care-sensitive conditions. If the quality of outpatient care for these conditions is systematically poorer in coal mining areas, this might result in more frequent hospitalizations, but again, one would have to argue this poor quality phenomenon selectively for COPD and hypertension, when other ambulatory care-sensitive conditions, such as diabetes, showed no relationship to coal mining. Local diagnostic practice variations, such as distinctions between adult asthma and COPD, may also introduce error into estimates, as may differences due to type of payer.

The teaching status of the hospital was a variable that sometimes affected admission patterns. Teaching status likely interacts with mobility patterns, where patients with complex or serious illnesses are more likely to travel from their area of residence to a teaching hospital for specialty care. To the extent that teaching hospitals are located in urban areas where coal mining does not take place, this pattern may obscure possible coal-related effects. Lung cancer and kidney disease represent serious, complex illnesses, and hospitalization for these conditions was marginally higher as a function of teaching status ($p < .10$), which may help to account for their nonsignificant links to coal mining. Hypertension and COPD, on the other hand, were related to less severe comorbidities and unrelated to hospital teaching status, suggesting that these conditions are more likely to be treated at local hospitals near the patient's residence.

Despite the data limitations, which may be expected to dilute the magnitude of effects, effects were found for two health problems that are consistent with an exposure hypothesis. The inhalation of PM is associated with hypertension (Ibald-Mulli et al., 2001; Brook, 2005; Urch et al., 2005; Krewski et al., 2005) and COPD (Brabin et al., 1994; Coggon & Taylor, 1998) among miners and residents and in lab conditions. Individuals with hypertension show increased association between systemic inflammation and ambient PM2.5 (particulate matter with a mass mean aerodynamic diameter ≤2.5 μm) (Dubowsky et al., 2006). The current study may be detecting the acute effects from residential exposure to PM at a certain time, or a chronic exposure effect that accumulates over time into increased risk of hospitalization. Other research has found that long-term exposure to ambient air pollution is related to higher incidence and mortality rates from cardiopulmonary disease and lung cancer (Miller et al., 2007; Krewski et al., 2005). Additional research using more refined methods will be necessary to isolate the nature and magnitude of the exposure effect. Future research may employ primary data collection efforts in targeted communities distal and proximal to coal mining activities to collect data on physiological measures and disease incidence for residents in these communities. Future studies need to clearly identify specific processes and pollutants that exert pathologic effects on local populations.

CONCLUSIONS

The health consequences of exposure to mining activities reflect only a portion of the entire coal production and consumption cycle. Coal mining poses occupational hazards to miners (Scott et al., 2004), its burning contributes to air pollution and subsequent health hazards (Wellenius et al., 2006), and carbon emissions contribute to climate change with potential global health risks, including infectious epidemics, disruptions in the food chain, increased asthma prevalence, lung damage from ozone, and health consequences of floods and droughts (Patz et al., 2005; Bernard et al., 2001; Epstein, 2005). The health risks from residential proximity to mining present an additional negative consequence that results from reliance on this energy source.

If exposure effects are supported by further research, economic analyses of coal's contribution to domestic productivity may need to be revised to take into account the lost productivity and medical care costs linked to residential proximity to mining. Calculation of pollution levels in geographic areas may be developed to account for both the production and consumption of carbon-based energy. Implementation of national or state environmental and public health policies may be indicated to protect nearby citizens from mining byproduct exposure.

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