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Morbidity and Health Risk Factors Among New Mexico Miners: A Comparison Across Mining Sectors

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Abstract

Objective—This study examines differences in chronic health outcomes between coal, uranium, metal, and nonmetal miners.

Methods—In a cross-sectional study using data from a health screening program for current and former New Mexico miners, log-binomial logistic regression models were used to estimate relative risks of respiratory and heart disease, cancer, osteoarthritis, and back pain associated with mining in each sector as compared with coal, adjusting for other relevant risk factors.

Results—Differential risks in angina, pulmonary symptoms, asthma, cancer, osteoarthritis, and back pain between mining sectors were found.

Conclusions—New Mexico miners experience different chronic health challenges across sectors. These results demonstrate the importance of using comparable data to understand how health risks differ across mining sectors. Further investigation among a broader geographic population of miners will help identify the health priorities and needs in each sector.

Mining is an important industry that contributes to the economies of all US states, with over 600,000 workers currently employed nationally in the industry.[1] Mining is broadly categorized into the following sectors: coal; metal; nonmetal; and stone, sand, and gravel. Each sector varies in terms of geographical location, number of employees and contractors, proportion of mines located underground, mining equipment and methodology used, ore and mineral composition, and other characteristics. Known hazards in the mining industry include physical, chemical, and toxic exposures such as repetitive joint stress, heat, noise, dust, diesel particulate matter, and fumes.[2] Furthermore, the wide array of commodities

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mined, the varied geologic characteristics of mined regions, and the variety of tasks involved in mining contribute to varying exposures among mine workers.

Health studies among miners have frequently focused on respiratory disease. The Radiation Exposure Screening and Education Program (RESEP) and the Coal Workers' Health Surveillance Program (CWHSP) are two large federally mandated programs open to uranium and coal miners. RESEP provides medical screening for malignant and nonmalignant conditions among persons exposed to radiation, including uranium miners, but has limited information available regarding the health status of the industry as a whole. The CWHSP has been limited primarily to screening for pneumoconiosis among actively working coal miners, as well as analysis of lung autopsies among deceased coal miners. Coal mine dust exposure has been associated with excess respiratory disease including coal workers' pneumoconiosis, silicosis, dust-related diffuse fibrosis, and chronic obstructive pulmonary disease (COPD).[3] Studies have demonstrated excess lung cancer and pneumoconiosis mortality among uranium miners[4–9] and excess lung cancer mortality and pneumoconiosis risk among metal and non-metal (MNM) miners.[10–17]

Few, if any studies, have systematically estimated the prevalence of other chronic diseases, such as cardiovascular and musculoskeletal disease, that cause significant morbidity and disability among MNM miners and might have an occupational component. Anecdotal reports suggest that arthritis causes substantial impairment among current and former miners, but few studies have evaluated this disabling disease among miners. Restricted work spaces requiring coal miners to maintain awkward postures have been associated with musculoskeletal injuries.[18] Other mining sectors might also have increased risk of musculoskeletal disease. Differences in mining methods between mining sectors might contribute to differing risks of musculoskeletal disease, and a better understanding of these differences could lead to interventions to decrease risk. Cardiovascular disease causes substantial morbidity and mortality in the general population, but studies evaluating cardiovascular mortality among miners have demonstrated mixed results and could have been affected by the healthy worker bias.[19–25] Improved knowledge of cardiovascular risk among miners would aid in developing hypotheses about possible contributing factors associated with work in mining and the development of strategies to reduce risk.

The variation in exposures and job tasks among mining sectors likely leads to different health risks and outcomes. To our knowledge, no previous studies have evaluated morbidity and disability across sectors using comparable data. National surveys, such as the National Health Interview Survey (NHIS) and a subset of states participating in the Behavioral Risk Factor Surveillance System, collect information on industry and occupation and have been used to estimate the prevalence of chronic disease and risk factors for disease among miners as a whole, but cannot be used to compare differences among miners in different mining sectors.[26] In contrast to the national surveys that aggregate the sectors, the majority of published studies of miner health are relatively small and highly specific, focused narrowly on a limited number of health outcomes among workers who mine individual commodities, and with data collection methods that differ among studies. Although these studies provide valuable information on specific exposures and health effects among small subsets of miners, lack of standardization in how health outcomes are defined limits our ability to make

broad comparisons across sectors regarding the full burden of morbidity and disability among miners.

This study takes an important first step by using data from a health clinic that were obtained through identical protocols and questionnaires that assessed a broad array of health issues among coal, uranium, metal, and nonmetal miners, particularly focusing on chronic illness. These unique data allow the identification of important chronic health differences between mining sectors, thus facilitating the development of hypotheses regarding exposures specific to each sector, and providing direction for future studies to evaluate these differences.

METHODS

Data for this study came from the Miners' Outreach Program at the Miners' Colfax Medical Center, Raton, NM. The Miner's Outreach Program was started in 1987 and performs health screenings for anyone who has ever worked in the mining industry, including current and retired workers in uranium, coal, metal, and nonmetal mines, regardless of job title and duration of employment. Health screenings are offered throughout the state of New Mexico by visiting mines and mining communities with a mobile clinic. The mobile clinic is run by a nurse practitioner/physician assistant under the supervision of a medical pulmonologist, with tele-health access as needed. Current and former miners are notified about the mobile clinic health screening dates through advertising in local media and outreach through mines, particularly through mine health and safety officers, as well as through participation in mine safety conferences or local community health fairs. Additionally, the clinic performs follow-up visits to mining communities roughly every 3 years; in advance of a visit, all miners screened previously at that location receive a notification letter in the mail.

Miners who visit the mobile clinic for a screening complete an intake form and questionnaire covering demographic information, occupational and health history, hearing, sleep, respiratory illness, chronic disease, and tobacco and alcohol use. Miners are then offered, free of charge, a physical that includes the following: blood pressure, height, weight, spirometry, chest x-ray, audiometry, and exercise oximetry on a stationary bicycle. Some miners complete all parts of the questionnaire and examination; others decline to participate in some aspects of the evaluation, or are unable to participate in particular tests because of contraindications.

Data from health screenings performed on current and former miners during 2004 to 2014 were abstracted by Miner's Outreach Program staff and provided to National Institute for Occupational Safety and Health (NIOSH) researchers for analysis. Abstracted data included a health and work history questionnaire, vital statistics, height, and weight. Persons were included in the abstracted dataset if their occupational history included a total of 5 or more months working in the mining industry. For persons who had been seen on more than one occasion, data were abstracted for the most recent visit. This study was approved by the NIOSH Institutional Review Board.

The occupational history of each individual was reviewed, and miners were categorized according to the mining sector(s) in which they worked, as follows: uranium, coal, metal,

nonmetal (including stone, sand, and gravel), or a combination. Miners who had worked in a combination of mining sectors were excluded from analysis. All analyses were performed in SAS (SAS Institute Inc., Cary, NC) using a significance threshold of $P = 0.05$. Chi-squared analysis using the PROC FREQ procedure was used to test for cross-sector differences in sex, retired status, smoking status (both ever and current), and body mass index (BMI). One-way analysis of variance using the PROC GLM procedure was used to test for cross-sector differences in age and tenure in mining.

Log-binomial logistic regression models using the GENMOD procedure were used to directly estimate the relative risk of respiratory symptoms, cardiovascular disease, cancer, and musculoskeletal disorders associated with mining in the uranium, metal, or nonmetal sectors compared with coal, adjusting for other relevant risk factors. These health outcomes were chosen because they are common causes of morbidity and mortality. Miners were categorized as having angina if they answered yes to the question, “Has a doctor ever told you that you have angina or chest pain from your heart?” or “Has a doctor ever told you that you had a heart attack?” Miners were categorized as having COPD or asthma on the basis of the questions, “Have you ever had chronic bronchitis, emphysema, or COPD?” or “Have you ever had asthma?” Cancer classification was based on response to the question, “Have you ever had cancer?” with the option to write the type of cancer in a text box. Miners were reported as having other health conditions if they checked the relevant boxes for “Degenerative arthritis or osteoarthritis,” “Diabetes,” “Back pain/back injury,” “High blood pressure/hypertension,” and “Elevated cholesterol/triglycerides” that were listed under the question, “Have you ever had any of the following illnesses?” A composite variable to determine whether miners were experiencing any pulmonary symptoms included affirmative answers to questions on frequency of cough, occurrence and frequency of wheezing, and shortness of breath with walking. Additionally, two measures of breathlessness that capture level of disability were assessed individually, including whether respondents reported having to walk more slowly than most people their age on a level surface because of breathlessness, and whether persons had to stop for breath after walking approximately 100 yards on a level surface.

All analyses of health outcomes across sectors accounted for self-reported ever smoking status, age (categorized into five categories: age in years less than or equal to 34, 35 to 44, 45 to 54, 55 to 64, and more than or equal to 65), and whether the individual was retired or disabled (hereafter identified as “retired”) as opposed to reporting current status of employed or unemployed. All analyses also accounted for history of underground mine work, as this has been shown to contribute to health outcomes.[12,19] Additionally, models related to cardiovascular disease accounted for calculated BMI, based on measured height and weight, and self-reported status of having been diagnosed with diabetes, high cholesterol, and hypertension. Age and mining tenure were correlated, and could not both be included in multivariate logistic regression models. Models using tenure instead of age were constructed for all health outcomes and produced consistent results; results from models including age are presented here because the age variable had less error and generally produced models with a better fit.

RESULTS

Visits were made to the clinic during 2004 to 2014 by 2835 persons who had worked for 5 or more months in mining. Of these, 2644 (93%) persons provided occupational history information that could be used to assign mining sector(s) in which the miner worked. Of miners who provided occupational history, 2219 (84%) persons worked in only one sector during their mining careers, whereas 425 (16%) reported employment in more than one sector. Of those miners reporting work in a single sector, 722 (33%) worked in coal mining, 716 (32%) in uranium, 557 (25%) in mining of other nonmetals, and 224 (10%) in metal mining. Differences in demographic and risk factor characteristics between miners of different sectors, are shown in Table 1. Table 2 lists the commodities that metal and nonmetal miners reported mining.

Nonmetal miners in this sample tended to be younger (mean = 43.3 years of age), and uranium miners tended to be slightly older (mean = 61.9 years; Table 1). Approximately 93% of miners were men (Table 1). Average tenure in mining for the entire sample was 13.2 years, with longer median tenure among coal (median = 19.0 years) and metal miners (median = 14.0 years) than among uranium (median = 7.0 years) or nonmetal miners (median = 7.0 years; Table 1). Nearly half of miners in this sample were ever smokers, though only 19.5% were current smokers (Table 1). Metal mining had a lower proportion of current smokers (11.6%), whereas nonmetal mining had the highest proportion of current smokers (30.0%; Table 1). Forty percent of miners had a body mass index (BMI) between 25 and 29.9, considered overweight, and 42.4% had a BMI of 30 or higher, indicating obesity (Table 1).

Cancer history was reported by 159 miners, of whom 147 reported the type of cancer. Of these, 34.7% reported prostate cancer, 23.8% reported skin cancer, 7.5% reported renal cell/kidney cancer, and 6.8% reported lung cancer. Less frequently reported cancers included colorectal and other gastrointestinal, head and neck, leukemia/lymphoma, ovarian, uterine, cervical, breast, bladder, and thyroid cancers. Low numbers limited analysis, but no apparent trends in cancer by sector were noted.

Miners differed little in cardiac health by sector, with a lower risk of self-reported angina among nonmetal miners compared with coal miners, and no significant differences in risk of heart attack (Table 3). Metal miners, meanwhile, experienced a higher relative risk of cancer, though neither uranium nor nonmetal miners experienced a different cancer risk than that experienced by coal miners (Table 3).

Miners from all other sectors experienced a higher risk of reported osteoarthritis than that of coal miners (Table 3). The risk of reported back pain was significantly higher among uranium miners than among coal miners, while metal and nonmetal miners did not experience a greater relative risk of back pain (Table 3).

In general, uranium miners had a higher risk of self-reported pulmonary symptoms and conditions compared with coal miners, while both metal and nonmetal miners had lower or similar risk (Table 3). Nonmetal miners had substantially greater missing responses compared with the other mining sectors (Table 3). COPD was the only pulmonary condition

for which uranium miners and coal miners had similar risk. Metal and coal miners had similar risk of self-reported current asthma, and shortness of breath after walking 100 yards.

DISCUSSION

Our data allow the identification of important health differences between mining sectors in a sample of New Mexico miners, and our results demonstrate that these miners do not experience the same health challenges across sectors; therefore, miners should not always be grouped together during analyses. Our findings indicate that analyses of national surveys, such as NHIS that collect occupation data on all miners as a single group instead of by sector may not adequately describe disease prevalence and risk among miners because workers in each sector might experience different risks. For instance, an analysis of 1997 to 2007 NHIS data demonstrated a prevalence of 3.1% for cancer and 7.1% for heart disease among all miners.[25] However, our analyses demonstrate significant differences in prevalence of angina and cancer between sectors.

In this study, estimates from miners within the uranium, metal, and nonmetal sectors were compared with those of coal miners because much of the larger general body of knowledge on miner health is based on studies of coal miners. The greater focus on the health of coal miners over that of miners working in other sectors reflects their historical significance and numbers, and the devastating effects of coal workers' pneumoconiosis. Our results demonstrate that metal and nonmetal miners in our sample population are generally at lower risk for respiratory illness than coal miners.

It is important to consider other health concerns, and not focus simply on respiratory disease, when evaluating morbidity among miners. The risk of both cancer and osteoarthritis is significantly higher among metal miners than coal miners within this sample. Although the etiology behind these observations is unknown, this finding points to important questions concerning the possibility of specific occupational hazards that might differ in metal mining as compared with other sectors. For example, mining in general involves difficult, physical work requiring the use of heavy machinery, awkward positions, and repetitive motions that can lead to general musculoskeletal pain and arthritis, but in this sample the risk of osteoarthritis differs among sectors. Although it's possible that different mining methods and specific hazards among sectors contribute to different risks for disease, our retrospective analysis did not assess specific hazards and can not be interpreted to show a causal relationship between exposures in each sector and the health outcomes that we report. Nevertheless, a better understanding of specific hazards among sectors would facilitate interventions to mitigate risks associated with arthritis.

The general pattern of health risk for uranium miners is much more concerning, as uranium miners suffer higher risk across almost all health conditions examined here. Although our analyses controlled for age, New Mexico has a sizable population of older former uranium mine workers, due largely to the episodic history of uranium mining in the southwestern United States, and differences in age distributions could have affected results. The majority of New Mexico uranium mines closed in the 1980s, although some operations continued until 2002[27]; thus, a higher proportion of uranium miners included in our study were retired

or disabled at the time of their health evaluations. Still, this finding of poorer health among uranium miners is consistent with past findings.[4–10] Poor health among uranium miners, especially respiratory disease and lung cancer, incurs substantial direct and indirect health costs. An economic analysis of person-years of life lost and costs from lung cancer mortality among New Mexico uranium miners demonstrated over 11,000 person-years of life lost and a health cost of approximately $2.2 to 7.7 million per excess death during 1955 to 1990.[28] Current uranium mining practices are substantially different from previous mining methods, likely leading to fewer health risks, but a better understanding of all health outcomes experienced by both current and former uranium miners is necessary to mitigate the health risks in this population.

It will be useful to determine whether this pattern of health differences by mining sector, observed among a large sample of miners from New Mexico, holds true in other areas of the United States. Our results open up multiple avenues for future investigation, but emphasize the need for a better understanding of how illness and risk differ across types of mining. Furthermore, risks might also differ among commodities in the metal and nonmetal sectors, and a better understanding of that variation could also help guide us in protecting the health of miners.

Despite the evident need for more health data specific to each mining sector, there appear to be elevated risks of certain health conditions across mining in general. For instance, a high proportion of miners in each sector reported back pain, from 35% of nonmetal miners to 62% of uranium miners. Miners across all sectors had high prevalence of overweight and obesity (83%), compared with 69% among New Mexico adults in 2014.[29] Given the effect of back pain on disability, quality of life, and healthcare costs, and the association between obesity and many chronic diseases, these conditions require further evaluation regarding associated work patterns and exposures to allow for development of appropriate methods for prevention or mitigation.

It can be difficult to determine whether prevalence of risk factors and disease in our sample differs from the general population, because reference data can be difficult to find. Our sample includes both currently working and retired miners and cannot be compared with data from all workers. Nonetheless, where comparison data are available, they suggest the possibility of excess morbidity among some sectors of mining. For example, the prevalence of angina or coronary heart disease among New Mexico adults was estimated to be 3.2% (95% confidence interval [CI] 2.8 to 3.7) in 2013,[30] while the prevalence of reported heart disease among all sectors except nonmetal appears to be elevated, with approximately 11% to 22% and 10% to 14% reporting angina and heart attack, respectively. Additionally, some literature has demonstrated excess cardiovascular mortality among miners.[22–24] Our results, therefore, point to the need for further evaluation of heart disease risk among active miners, for whom appropriate comparison reference populations do exist.

The results presented in this analysis signal the need for further work, in part because of some aspects of the sample which limit its generalizability. Health effects and occupational history presented here are largely based on self-reported questionnaire data, instead of review of medical or employment records, and therefore could be subject to

misclassification. The cross-sectional design of the analysis prevents inference of causality; differences in health outcomes between sectors cannot be presumed to be attributable to differences in occupational exposures within each sector. Additional confounders might exist that were not included in the questionnaire or accounted for in this analysis, particularly race and ethnicity. Nonresponse bias could have affected some questions, especially given the substantial missing values observed among nonmetal miners. Finally, while all clinic patients seen during the time period were included in the study, clinic participation is voluntary, and therefore the study population could be thought of as a convenience sample of all NM resident miners. Results might not be generalizable to all mines of a particular type within the state or to the industry across all states, there could be some bias inherent in who reports to the clinic for a screening, and it is possible that some individuals in the sample have mined in other states or regions. In spite of these challenges, this is the first analysis of its kind, and it involves a large dataset of over 2000 miners collected during an 11-year period. Additionally, the questionnaire provided broad coverage of many important health conditions and risk factors for illness, including chronic conditions such as musculoskeletal disorders and heart disease that are generally not included in mining surveys such as the Coal Workers' Health Surveillance Program.

Analysis of this sample of miners is an important step in examining the health of workers across different sectors of the mining industry. Our analysis suggests that each mining sector might have varying health priorities and needs. Further work is needed to more systematically examine the health of miners in other geographical regions and across all sectors, and attempt to identify occupational exposures that might contribute to excess morbidity and mortality in each sector. Aligning epidemiology and industrial hygiene efforts to better characterize sector-specific worker exposures and health outcomes is necessary. Results from these studies could be used to help identify and focus future health and safety initiatives, as well as engineering controls targeted at decreasing occupational exposures, with the ultimate goal of improving the health of miners.

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TABLE 1

Demographic, Occupational, and Health Characteristics of Miners Who Visited the Miner's Colfax Medical Center Mobile Clinics, 2004–2014

Demographic Information	Overall	Coal	Uranium	Metal	Nonmetal
Number of miners	2219	722	716	224	557
Age, years, * mean (SD)	54.3 (15.5)	54.7 (16.5)	61.9 (9.1)	56.6 (16.2)	43.3 (13.9)
Age categories, *n* (%)					
17–34	310 (14.0)	112 (15.5)	0 (0)	32 (14.3)	166 (29.8)
35–44	227 (10.2)	78 (10.8)	4 (0.6)	23 (10.3)	122 (21.9)
45–54	445 (20.1)	109 (15.1)	162 (22.6)	27 (12.1)	147 (26.4)
55–64	641 (28.9)	205 (28.4)	287 (40.1)	66 (29.5)	83 (14.9)
≥65	591 (26.6)	217 (30.1)	261 (36.5)	76 (33.9)	37 (6.6)
Missing	5 (0.2)	1 (0.1)	2 (0.3)	0 (0)	2 (0.4)
Retired, * *n* (%)	763 (34.4)	291 (40.3)	352 (49.2)	88 (39.3)	32 (5.7)
Not retired	1272 (57.3)	400 (55.4)	280 (39.1)	114 (50.9)	478 (85.8)
Missing	184 (8.3)	31 (4.3)	84 (11.7)	22 (9.8)	47 (8.4)
Male sex, * *n* (%)	2071 (93.3)	689 (95.4)	640 (89.4)	212 (94.6)	530 (95.2)
Female	135 (6.1)	31 (4.3)	68 (9.5)	12 (5.4)	24 (4.3)
Missing	13 (0.6)	2 (0.3)	8 (1.1)	0 (0)	3 (0.5)
Tenure, years, * median (25th, 75th percentiles)	10.0 (4.0, 21.0)	19.0 (5.5, 29.5)	7.0 (3.0, 12.0)	14.0 (5.0, 29.0)	7.0 (3.0, 16.0)
Ever smoked, * *n* (%)					
Yes	1054 (47.5)	302 (41.8)	339 (47.3)	115 (51.3)	298 (53.5)
No	1142 (51.5)	415 (57.5)	368 (51.4)	109 (48.7)	250 (44.9)
Missing	23 (1.0)	5 (0.7)	9 (1.3)	0 (0)	9 (1.6)
Current smoker, * *n* (%)					
Yes	432 (19.5)	121 (16.8)	118 (16.5)	26 (11.6)	167 (30.0)
No	1435 (64.7)	545 (75.5)	470 (65.6)	170 (75.9)	250 (44.9)
Missing	352 (15.9)	56 (7.8)	128 (17.9)	28 (12.5)	140 (25.1)
Body mass index, *n* (%)					
<25	348 (15.7)	116 (16.1)	105 (14.7)	38 (17.0)	89 (16.0)
25–29.9	891 (40.2)	274 (38.0)	298 (41.6)	103 (46.0)	216 (38.8)

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Demographic Information	Overall	Coal	Uranium	Metal	Nonmetal
≥30	941 (42.4)	303 (42.0)	308 (43.0)	81 (36.2)	249 (44.7)
Missing	39 (1.8)	29 (4.0)	5 (0.7)	2 (0.9)	3 (0.5)
Diabetes,* *n* (%)					
Yes	500 (22.5)	159 (22.0)	236 (33.0)	43 (19.2)	62 (11.1)
No	1719 (77.5)	563 (78.0)	480 (67.0)	181 (80.8)	495 (88.9)
Missing	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
High cholesterol,* *n* (%)					
Yes	562 (25.3)	163 (22.6)	255 (35.6)	60 (26.8)	84 (15.1)
No	1657 (74.7)	559 (77.4)	461 (64.4)	164 (73.2)	473 (84.9)
Missing	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hypertension,* *n* (%)					
Yes	950 (42.8)	291 (40.3)	424 (59.2)	95 (42.4)	140 (25.1)
No	1269 (57.2)	431 (59.7)	292 (40.8)	129 (57.6)	417 (74.9)
Missing	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

*Cross-sector differences significant at $P \leq 0.05$.

TABLE 2

Nonmetal and Metal Commodities Reported in Occupational Histories of Miners Evaluated at the Miner's Colfax Medical Center Mobile Clinics, 2004–2014

Nonmetal Commodities Mined	Metal Commodities Mined
Asbestos	Copper
Clay	Gold
Gypsum	Iron
Humate	Lead
Limestone	Manganese
Mica	Molybdenum
Perlite	Platinum
Potash	Rare earth metals
Pumice	Tungsten
Salt	Vanadium
Sand and gravel	Zinc
Sandstone	
Silica	
Trona	
Turquoise	
Zeolite	

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TABLE 3

Proportion of Miners With and Relative Risk of Self-reported Health Conditions and Symptoms, by Sector

	No. (%) of Miners Reporting Condition*				Relative Risk† (95%CI)			
Health Condition or Symptom	**Coal**	**Uranium**	**Metal**	**Nonmetal**	**Coal†**	**Uranium**	**Metal**	**Nonmetal**
Angina§								
Yes	95 (13.2)	156 (21.8)	24 (10.7)	21 (3.8)	1.0	1.2 (0.99–1.5)	0.6 (0.4–1.02)	**0.6 (0.3–0.97)**
No	600 (83.1)	538 (75.1)	198 (88.4)	525 (94.3)				
Missing	27 (3.7)	22 (3.1)	2 (0.9)	11 (2.0)				
Heart attack§								
Yes	68 (9.4)	100 (14.0)	22 (9.8)	15 (2.7)	1.0	1.0 (0.8–1.4)	0.9 (0.5–1.4)	1.0 (0.5–1.7)
No	621 (86.0)	586 (81.8)	199 (88.8)	531 (95.3)				
Missing	33 (4.6)	30 (4.2)	3 (1.3)	11 (2.0)				
Cancer‡								
Yes	44 (6.1)	70 (9.8)	26 (11.6)	19 (3.4)	1.0	1.3 (0.9–1.9)	**1.8 (1.1–2.8)**	1.2 (0.7–2.3)
No	646 (89.5)	626 (87.4)	196 (87.5)	527 (94.6)				
Missing	32 (4.4)	20 (2.8)	2 (0.9)	11 (2.0)				
Arthritis?								
Yes	139 (19.3)	248 (34.6)	67 (29.9)	78 (14.0)	1.0	**1.3 (1.1–1.6)**	**1.3 (1.03–1.7)**	**1.4 (1.03–1.8)**
No	583 (80.8)	468 (65.4)	157 (70.1)	479 (86.0)				
Missing	0 (0)	0 (0)	0 (0)	0 (0)				
Back pain?								
Yes	311 (43.1)	443 (61.9)	100 (44.6)	193 (34.7)	1.0	**1.2 (1.1–1.4)**	1.0 (0.8–1.1)	0.9 (0.8–1.1)
No	411 (56.9)	273 (38.1)	124 (55.4)	364 (65.4)				
Missing	0 (0)	0 (0)	0 (0)	0 (0)				
Breathless—walks slower than people of same age‡								
Yes	221 (30.6)	381 (53.2)	52 (23.2)	37 (6.6)	1.0	**1.3 (1.2–1.5)**	**0.7 (0.6–0.95)**	**0.5 (0.4–0.8)**
No	436 (60.4)	245 (34.2)	155 (69.2)	297 (53.3)				
Missing	65 (9.0)	90 (12.6)	17 (7.6)	223 (40.0)				
Breathless—has to stop after walking 100 yards‡								

Health Condition or Symptom	No. (%) of Miners Reporting Condition*				Relative Risk† (95%CI)			
	Coal	Uranium	Metal	Nonmetal	Coal†	Uranium	Metal	Nonmetal
Yes	172 (23.8)	336 (46.9)	40 (17.9)	24 (4.3)	1.0	**1.6 (1.4–1.8)**	0.9 (0.7–1.2)	**0.5 (0.3–0.8)**
No	488 (67.6)	284 (39.7)	158 (70.5)	312 (56.0)				
Missing	62 (8.6)	96 (13.4)	17 (7.6)	221 (39.7)				
Any pulmonary symptom‡								
Yes	435 (60.3)	571 (79.8)	111 (49.6)	146 (26.2)	1.0	**1.1 (1.1–1.2)**	**0.8 (0.7–0.9)**	0.9 (0.8–1.04)
No	223 (30.9)	62 (8.9)	92 (41.1)	152 (27.3)				
Missing	64 (8.9)	83 (11.6)	21 (9.4)	259 (46.5)				
COPD‡								
Yes	62 (8.6)	88 (12.3)	14 (6.3)	12 (2.2)	1.0	1.1 (0.8–1.5)	**0.5 (0.3–0.9)**	**0.4 (0.2–0.9)**
No	626 (86.7)	595 (83.1)	207 (92.4)	529 (95.0)				
Missing	34 (4.7)	33 (4.6)	3 (1.3)	16 (2.9)				
Current asthma‡								
Yes	64 (8.9)	107 (14.9)	17 (7.6)	29 (5.4)	1.0	**1.6 (1.2–2.3)**	0.7 (0.4–1.3)	**0.6 (0.4–0.95)**
No	625 (86.6)	586 (81.8)	203 (90.6)	513 (92.1)				
Missing	33 (4.6)	23 (3.2)	4 (1.8)	15 (2.7)				

Statistically significant values in bold.

CI, confidence interval; COPD, chronic obstructive pulmonary disease.

*Numbers might not add to 100 because of rounding.

†Relative risk of all other groups compared with coal miners; coal miners are set as the referent, with RR = 1.0.

‡Adjusted for history of working underground, ever smoking, age, and retired status.

§Adjusted for history of working underground, ever smoking, age, retired status, body mass index, reported diabetes, reported high cholesterol, and reported hypertension.

?Adjusted for history of working underground, ever smoking, age, retired status, and body mass index.