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# The Mortality of Appalachian Coal Miners, 1963 to 1971

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**During 1963 to 1964, the Public Health Service conducted a prevalence study of coal workers' pneumoconiosis in Appalachia in which random samples consisting of (*a*) 2,549 employed miners and (*b*) 1,177 ex-miners were examined. A study of mortality of these miners and ex-miners through 1971 has now been carried out.**

**The effects of pneumoconiosis, years spent underground, cigarette smoking, and obstructive pulmonary disease on the length of life were examined. The mortality for actively employed miners was 7% less than the expected death rate for all men in the United States. Ex-miners, many of whom had retired because of ill health, had a death rate 24% greater than expected. While simple pneumoconiosis did not affect life expectancy, complicated pneumoconiosis was associated with premature death. Cigarette smoking and airway obstruction led to consistent excesses in mortality.**

Recent studies of the mortality of coal miners indicate that their age-standardized death rates are not excessive when compared with those of the entire male population. In these studies comparisons have been made with nonminers in the same communities and with national or state mortality data.[1-3] However, marked excesses characterized the mortality of coal miners affected by advanced complicated pneumoconiosis (stages B and C).[1] Moreover, earlier studies of mortality in the British populations indicate that, during the first six years of a 20-year period, miners and ex-miners as a whole experienced excessive mortality compared with nonminers in the same area.[4]

The present study was undertaken to answer the following questions: Do miners with coal workers' pneumoconiosis (CWP) have a decreased life expectancy as compared with (*a*) miners without CWP and (*b*) nonminers? If excess mortality exists, can it be attributed to CWP, to nonoccupational factors, or to some cumulative effect of CWP and other factors?

"Pneumoconiosis is best defined in anatomic terms as thc accumulation of dust in the lungs and the tissue reaction to its presence. Inhalation of coal mine dust is the cause of CWP. . . ."[5] It is diagnosed in life by changes in the chest radiograph. "Simple pneumoconiosis is recognized by the presence of either multiple small pinpoint or nodular densities or reticulation in the chest film."[6] The complicated form "appears on a chest film as a dense opacity or opacities that initially may be relatively small, but may grow to occupy almost the entire lung."[6]

## Subjects and Methods

In 1963 to 1965, the Bureau of Occupational Safety and Health of the Public Health Service conducted a prevalence survey of pneumoconiosis in samples of Appalachian miners and ex-miners. Both groups were randomly selected and their characteristics have been described elsewhere.[7] Each participant underwent a limited medical examination consisting of a standard chest roentgenogram and some simple tests of ventilatory function. The roentgenograms were classified for CWP according to a Public Health Service modification of the International Labour Organization's classification of pneumoconioses.[7] In addition, a questionnaire relating to chest symptoms and prior chest illnesses, total work experience, and a smoking history was administered.[7]

The samples of miners and ex-miners presented an unusual opportunity, not only to measure the effects of pneumoconiosis on mortality in the United States, but also to determine whether or not the observed effects were due to pneumoconiosis or to other factors such as cigarette smoking or airway obstructive diseases. Of the samples, 93% of the employed and 84% of the ex-miners were examined. The data were collected and classified using uniform procedures. In the subsequent mortality study, the vital status as of Jan 1, 1972 was determined for 95% of the employed miners and 99% of the ex-miners who had been examined. For all but a handful of the decedents, certificates showing dates and causes of death were obtained.

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The study was conducted in Appalachia (western Pennsylvania, West Virginia, eastern Kentucky, and a few counties in eastern Ohio, eastern Tennessee, western Virginia, and northern Alabama). The populations sampled were: (1) actively employed miners at mines with 15 or more workers and (2) ex-miners aged 35 to 65 years who at the time of the examination were members of the United Mine Workers of America. Each miner and ex-miner in the samples was selected with known probabilities; hence, a sampling error can be computed for each estimate.

Deaths were traced for both groups of miners from their dates of examination to the end of 1971. Searches for current addresses (states) and for evidence of deaths consisted of these operations:

1. Requested dates of last federal income tax return from the Internal Revenue Service. A return filed by a miner in the study group in 1972 or 1973 indicates he was living on Jan 1, 1972. The search for deaths among all other miners continued.

2. Requested updating of addresses at examination from local postmasters on all miners, with a letter citing authorization for this service and cards for return of requested data.

3. For men not established as living by (1), above, searches for death claims or certificates, as well as for current residences of men not deceased, were made in Social Security Administration files, death indexes, and files of state Vital Statistics agencies, and the United Mine Workers Welfare and Retirement Fund. Social Security central files and UMWA Welfare and Retirement Fund files were searched by means of Social Security numbers. Names and addresses were used in local Social Security and State Vital Statistics agency searches.

In this study, a man was determined to be living on the first day of 1972 if (1) he had filed a federal income tax in 1972 or 1973, or (2) a Social Security tax had been paid for him in 1972 or 1973, or (3) his death in 1972 or 1973 was established, or (4) a current address was reported for him combined with no report of his death from state death indexes or beneficiary or death claim files. A man was determined to be deceased if he was reported as deceased in state files of death certificates, through a claim for death benefits, or termination of other benefits as a result of death. Vital status was not determined (136 employed miners and 13 ex-miners) if the Social Security number or current address could not be determined and if death was not established. These men were dropped from the analysis, but only after searches of local Social Security files and state Vital Statistics files in states to which each miner would be likely to have migrated. The mortality analyses are based on 95% and 99%, respectively, of the employed and ex-miners who were examined. Age-standardized mortality ratios (SMRs) of observed to expected deaths were computed to measure relative mortality of employed and ex-miners classified by pneumoconiosis, years of mining underground, cigarette smoking, and indications of obstructive airway disease.

All men in the United States, rather than white men, were chosen as the standard population since 6.2% of the employed and 13.9% of the ex-miners were nonwhite. Adjustments for both color and age were not carried out for this analysis of deaths from all causes. Making such adjustments would have increased the SMRs for employed miners by 2% to 3%, while having the opposite effect on the SMRs of ex-miners. Also it would increase greatly the number of small unreliable subgroups for which numbers of observed and expected deaths would be computed. The male population of the United States, rather than of the Appalachian Region only, was used since data are not readily available for the states and portions of states constituting Appalachia; one could argue for restricting the standard population even more to the coal mining areas of Appalachia, but data were difficult to compile for this population. Moreover in many counties in southern West Virginia and eastern Kentucky well over 75% of the male population have worked at some time in their lives as coal miners. An SMR for these counties is, therefore, largely a reflection of the death rate for coal miners. A review of state-by-state variations in longevity indicated that all men in the United States would not differ greatly from all men in Appalachia in mortality experience, particularly in the age ranges (middle aged and older) of these miners.

The number of observed deaths was tabulated for each group or subgroup for the period up to Jan 1, 1972. The number of expected deaths is the number that the group or subgroup would have experienced during the same period had they died at the same specific annual rates in each five-year age interval as did all men in the United States. In order to compute expected deaths, miners were grouped into five-year age-at-examination intervals. Lifetable $q_x$ values (proportions dying during a year of a population alive at the beginning of a year) were computed for each five-year age group from annual average age-specific death rates reported for all men in the United States for 1968 to 1969.[8(p121)] These initial $q_x$ values for age groups 15 to 19, 20 to 24, were supplemented with interpolated values for each year of observation, ie, for ages 16 to 20, 17 to 21, and so forth up to 84 to 88, using Beers "modified" formula for interpolation between given points at intervals of 0.2.[9(p878)] For each group or subgroup of miners in this analysis, the expected number of deaths, EXP, was computed for each five-year age category with the relationship:

$$EXP_5 = \sum_{i=1}^{Y} q_{xi}\, n_i$$

where Y is the number of calender years and fractions of years from date of examination up to Jan 1, 1972; $q_{xi}$ is the proportion of persons alive at the beginning of the i'th year expected to die during that year, and $n_i$ is the number of person-years of miners in the category at risk of dying during the i'th year. The numbers of deaths expected in each five-year age category are summed to obtain the number of expected deaths over all ages, the denominator of the SMR.

In order to measure the extent to which factors other than pneumoconiosis might contribute to death rates of employed and ex-miners, the following variables were selected: (1) years spent in mining coal underground; (2) years and average amounts of cigarette smoking; (3) the presence of airway obstruction as defined by a ratio of the volume of gas exhaled in the first second of a forced exhalation to the total volume exhaled (subjects with a ratio, $FEV_1/FVC < 70\%$ were regarded as obstructed); (4) degree of dyspnea; and (5) presence or absence of persistent cough with sputum.

## Results

The 225 deaths occurring among the 2,413 actively employed bituminous coal miners were 7% less than the 242 deaths expected if their death rates equaled those reported for all men in the United States (Table 1). The 308 deaths among 1,164 ex-miners exceeded by 24% the number expected on the basis of death rates of all men. This difference is statistically significant at the .001 level, and apparently indicates higher prevalences of life-threatening disabilities in the ex-miner group. Table 2 gives specific evidence to this point.

Both the 2,134 employed men without evidence of CWP and the 179 classified as having simple CWP experienced deficits in mortality as compared with all men in the United States (Table 1). The 74 men with

complicated CWP showed an excess mortality of 32%. Deaths were 19% and 29% higher than expected for ex-miners without complicated CWP, but the presence of simple CWP as such had no significant effect on the amount of excess. Deaths were almost 60% greater than expected for the 106 men with complicated CWP.

For the miners and ex-miners without evidence of CWP, the SMRs were no higher among those who had spent 30 or more years underground than among those with less than 30 years (Table 2). However, among miners with simple CWP, the ex-miner group with 30 or more years underground showed marked elevation in mortality (SMR = 143); even the SMR of 87 for the corresponding group of employed men is higher than that of 61 for those with fewer years underground. The combination of simple pneumoconiosis and long years of underground exposure presaged higher death rates. Miners who had both complicated CWP and more than 30 years of underground work had almost the same excess in mortality whether employed or not. Employed miners with complicated CWP who had less than 30 years underground had much lower mortality than ex-miners in the same category, apparently because the most disabled men were no longer working. The data indicate differential effects of underground mining, depending on category or stage of CWP, and probably on movement of men with complicated CWP from employed to ex-miners.

Cigarette smoking had the largest impact on the death rates (Table 3). Even within the high-risk ex-miner sample, both nonsmokers' and ex-smokers' death rates were no higher than expected, except for men with complicated CWP. On the other hand, elevation of the mortality of employed miners who were smokers at the time of their examinations was statistically significant, whether or not they had simple CWP. It was more than 100% greater than expected for the subgroup with complicated CWP. The SMR was 198 for the ex-miners who were smokers at the time of their examinations. Compari-

Table 1.—Mortality of Appalachian Bituminous Coal Miners, by Radiographic Category of Coal Workers' Pneumoconiosis (CWP)*

| Radiographic Category | No. of Men† | No. of Deaths | | SMR* |
|---|---|---|---|---|
| | | Observed* | Expected* | |
| | | **Employed Miners and Ex-Miners** (Weighted Estimates of Combined Populations) | | |
| Entire group | 76,765 | 9,859 | 9,480 | 104 |
| Category 0 | 66,638 | 7,884 | 7,786 | 101 |
| Simple | 1,584 | 966 | 1,003 | 97 |
| Complicated | 3,306 | 907 | 621 | 146‡ |
| | | **Employed Miners** | | |
| Entire group | 2,413 | 225 | 241.9 | 93‡ |
| Category 0 | 2,134 | 186 | 202.5 | 92‡ |
| Simple | 179 | 20 | 25.6 | 78‡ |
| Complicated | 74 | 15 | 11.4 | 132‡ |
| | | **Ex-Miners** | | |
| Entire group | 1,164 | 308 | 248.5 | 119‡ |
| Category 0 | 937 | 235 | 196.9 | 119‡ |
| Simple | 117 | 34 | 26.3 | 129‡ |
| Complicated | 106 | 39 | 24.6 | 159‡ |

* Each figure for the combined groups was obtained by multiplying each sample figure by a weight, which was a ratio of the original population to the planned sample; then each pair of these weighted figures was summed, yielding an estimate for both populations of employed and ex-miners. Other terms are defined in the text in the "Methods" section.

† 136 employed and 13-ex-miners with vital status at end of 1971 not determined are excluded from tabulations; 26 employed and four ex-miners without x-rays are also excluded from tabulations by CWP.

‡ Level of significance (probability that SMR = 100%) ≤ .05.

Table 2.—Differences Between Employed Bituminous Coal Miners and Ex-Miners in the Appalachian Region in Specified Personal Characteristics and Respiratory Conditions: Appalachia, 1963 to 1965[7]

| Characteristic | Estimates | |
|---|---|---|
| | Employed Miners | Ex-Miners |
| Age at examination, mean | 46.5 | 57.2 |
| Race, % black | 6.2 | 13.9 |
| Years of work in coal mining industry, mean | 24.5 | 33.0 |
| Illness history (for each, entry is % reporting condition in past or present) | | |
| Asthma | 5.9 | 14.2 |
| Bronchitis | 6.9 | 14.4 |
| Tuberculosis | .7 | 2.4 |
| "Dust on the lungs" | 7.8 | 33.5 |
| "Heart trouble" | 5.6 | 24.7 |
| Persistent cough with sputum, % | 9.2 | 23.8 |
| Marked or severe dyspnea, % | 3.5 | 36.5 |
| Non-smoker, % | 19.7 | 24.7 |
| Smoker only in past, % | 19.4 | 28.1 |
| Current smoker, % | 60.9 | 47.1 |
| Complicated CWP, % | 3.0 | 9.0 |
| $FEV_1/FVC$, mean % | | |
| Age <40 yr | 76 | 74 |
| Age 40-50 yr | 74 | 69 |
| Age >50 yr | 71 | 67 |

Source: Reference 7, pp 31, 32, 35, 39, 41, 43, 49, 80.

Table 3.—Mortality of Appalachian Bituminous Coal Miners, by Radiographic Category,* Underground Mining, and Cigarette Smoking, 1963 to 1971

| Other Characteristics | Radiographic Category: Category 0 No. of Men† | Category 0 No. of Deaths* | Category 0 SMR* | Simple No. of Men† | Simple No. of Deaths* | Simple SMR* | Complicated No. of Men† | Complicated No. of Deaths* | Complicated SMR* |
|---|---|---|---|---|---|---|---|---|---|
| **Employed Miners** | | | | | | | | | |
| Years underground mining | | | | | | | | | |
| ≤29 | 1,641 | 110 | 91‡ | 81 | 5 | 61‡ | 25 | 2 | 90 |
| 30+ | 493 | 76 | 93‡ | 98 | 15 | 87‡ | 49 | 13 | 143‡ |
| **Ex-Miners** | | | | | | | | | |
| ≤29 | 419 | 86 | 120‡ | 36 | 6 | 87‡ | 30 | 14 | 221‡ |
| 30+ | 518 | 149 | 119‡ | 81 | 28 | 143‡ | 76 | 25 | 138‡ |
| **Employed Miners** | | | | | | | | | |
| Cigarette smoking | | | | | | | | | |
| Never smoked | 414 | 31 | 72‡ | 36 | 2 | 39‡ | 20 | 0 | 0 |
| Smoked only in past | 393 | 23 | 55‡ | 49 | 3 | 41‡ | 18 | 4 | 125 |
| Smoker when examined | 1,318 | 130 | 111‡ | 94 | 15 | 115‡ | 34 | 11 | 244‡ |
| **Ex-Miners** | | | | | | | | | |
| Never smoked | 224 | 37 | 73‡ | 32 | 7 | 95 | 23 | 7 | 125‡ |
| Smoked only in past | 254 | 60 | 103 | 27 | 7 | 115 | 45 | 14 | 138‡ |
| Smoker when examined | 446 | 136 | 158‡ | 57 | 19 | 148‡ | 35 | 16 | 198‡ |

* See Table 1*.
† For completeness of data on vital status and CWP, see Table 1†. Reporting was complete on years of underground mining. An additional 11 employed and 17 ex-miners are excluded from the data on smoking due to incomplete response.
‡ See Table 1‡.

Table 4.—Mortality of Appalachian Bituminous Coal Miners, by Radiographic Category,* $FEV_1/FVC$, Dyspnea, and Chronic Bronchitis

| Other Characteristics | Radiographic Category: Category 0 No. of Men† | Category 0 No. of Deaths* | Category 0 SMR* | Simple No. of Men† | Simple No. of Deaths* | Simple SMR* | Complicated No. of Men† | Complicated No. of Deaths* | Complicated SMR* |
|---|---|---|---|---|---|---|---|---|---|
| **Employed Miners** | | | | | | | | | |
| $FEV_1/FVC$ (%) | | | | | | | | | |
| ≤69.9 | 584 | 76 | 115‡ | 64 | 7 | 69‡ | 36 | 11 | 192‡ |
| ≥70.0 | 1,465 | 105 | 82‡ | 108 | 12 | 85‡ | 33 | 4 | 86 |
| **Ex-Miners** | | | | | | | | | |
| ≤69.9 | 402 | 120 | 134‡ | 53 | 17 | 140‡ | 59 | 23 | 168‡ |
| ≥70.0 | 405 | 83 | 103 | 53 | 11 | 93 | 29 | 7 | 98 |
| **Employed Miners** | | | | | | | | | |
| Dyspnea | | | | | | | | | |
| None or slight | 1,881 | 144 | 85‡ | 136 | 15 | 81‡ | 54 | 11 | 142‡ |
| Moderate, marked, severe | 244 | 41 | 130‡ | 43 | 5 | 71‡ | 20 | 4 | 113 |
| **Ex-Miners** | | | | | | | | | |
| None or slight | 427 | 82 | 91‡ | 50 | 11 | 91 | 24 | 11 | 186‡ |
| Moderate, marked, severe | 463 | 143 | 144‡ | 62 | 21 | 156‡ | 79 | 27 | 152‡ |
| **Employed Miners** | | | | | | | | | |
| Chronic bronchitis symptoms (cough with sputum) | | | | | | | | | |
| None persistent | 1,523 | 116 | 84‡ | 117 | 11 | 67‡ | 51 | 5 | 72‡ |
| One or both persistent | 611 | 74 | 115‡ | 62 | 9 | 99 | 23 | 10 | 231‡ |
| **Ex-Miners** | | | | | | | | | |
| None persistent | 457 | 100 | 102 | 51 | 15 | 126‡ | 41 | 18 | 177‡ |
| One or both persistent | 480 | 138 | 140‡ | 66 | 19 | 131‡ | 65 | 21 | 147‡ |

* See Table 1*.
† For completeness of data on vital status and CWP, see Table 1†. In addition, the following numbers of miners are excluded due to incomplete data:

| Characteristic | Employed Miners | Ex-miners |
|---|---|---|
| $FEV_1/FVC$ | 123 | 159 |
| Dyspnea | 10 | 55 |

‡ See Table 1‡.

sons of SMRs within groups of smokers by number of cigarettes per day and years of cigarette smoking yielded unreliable results owing to the small number of men in these subgroups.

The best predictor of excess mortality in both the employed and ex-miner groups was airway obstruction (Table 4). No subgroup with $FEV_1$/FVC of at least 70% regardless of employment or CWP status, showed any significant excess mortality.

The standardized mortality of miners without CWP, and of some with simple CWP, was likely to be significantly elevated with increasing severity of dyspnea. No such correlation was found for those with complicated CWP. The presence of persistent cough with sputum was associated with increases in mortality in all three CWP subgroups of employed miners and in the ex-miners without CWP. Why ex-miners with complicated CWP but without these symptoms would experience more mortality than those reporting them is not clear.

## Comment

Several questions raised by the findings of this study need to be answered. First, why are the SMRs far below those reported for all US coal miners in 1950? The standard population used at that time was all men who had ever been in the US labor force.[10] The SMR reported for all coal miners aged 20 to 64 years at death was 195. The comparable SMR for the combined population of miners and ex-miners in this study is 104. It was computed by combining estimates of deaths from the samples after weighting them according to the sizes of the Appalachian populations sampled. At the time of the study, Appalachian bituminous miners constituted about one half of all coal miners in the United States. No data concerning the prevalence of chronic respiratory diseases would support an argument that the death rates of the non-Appalachian miners would exceed those of miners in Appalachia.[11,12] The most probable sources of this difference are: (1) misclassifications of coal miners and ex-miners in the 1950 deaths and populations used in computing the rates; (2) possibly exceedingly high death rates among the 136 (6%) employed miners in this study whose vital status remains undetermined; (3) downward trends in death rates of coal miners, exceeding those for all US men, from 1950 to the period 1963 to 1971.

The 1950 SMRs were computed by: (1) tabulating observed numbers of 1950 deaths of men aged 20 to 64 years at death, after classifying them by occupation and industry reported on certificates of death; (2) computing numbers of deaths expected for men in each occupation if their age-specific death rates had equaled those of all men aged 20 to 64 years; (3) using tabulations by occupation and industry from the 1950 census of the United States to compute both rates for observed and expected deaths. Errors in these rates could take the form of (*a*) allocation to coal mining of deaths of men who were not coal miners; (*b*) allocation to other occupations of men in the census base populations who had been coal miners; (*c*) failure to include in either the coal miner deaths or the base populations many men who had low death rates and who had been coal miners.

Liddell has recently published findings from occupational data on death certificates (1961 deaths) of coal miners in Britain that indicate what he terms a "promotion" effect in reporting the occupation of coal mining on the death certificates.[2] He compared the death reports with employment rosters of the National Coal Board and coal miner pension files. He found that men reported as miners on death certificates exceeded by 19% men found on the employment rosters and pension files. SMRs based on corrected numbers of deaths of coal miners were 60, 76, and 108, respectively, for face, other underground, and surface workers. These are compared with published, uncorrected SMRs for 1949 to 1953 of 148 for face workers and approximately 100% for other underground and surface workers.[2]

If such a "promotion" effect elevated the 1950 SMRs for coal miners in the United States, it existed in both data from death certificates and census. Enterline found that 96% of the men reported as coal miners on death certificates were similarly reported on census returns.[13] A probable source of inflation in the 1950 rates depends on a supposition that most miners who leave mining at older ages or who, regardless of age, are partly or totally disabled, would report themselves to census, and be reported in the event of death, as miners; that young and middle-aged healthy men who leave coal mining for other occupations would not later report themselves as coal miners nor eventually be reported at death as such. Such a selection process would concentrate the ex-miners with the highest death rates in the populations classified as coal miners and distribute the ex-miners with lowest death rates among other occupational groups.

Failure to determine the vital status of 136 employed miners in this study could hardly account for the levels of mortality found. Of this group, 37 were under 35 years of age, only 20 were 50 years of age or older, 123 were classed category 0 on radiographic evidence of pneumoconiosis, and only 13 had worked 30 or more years underground. They were young at the time of the survey and seemingly in good health.

Differential death rate trends have been suggested for coal miners for the period from 1950 through 1963 to 1971. The death rates from accidents at work did not decline, as measured in deaths per 100,000 man-hours of work in coal mining.[14] Deaths have not been classified by cause and occupation for the United States since 1950, so one can only speculate about other deaths. The coal miners in this study died predominantly from diseases of the heart and malignant neoplasms, just as other men do. It does not seem likely that trends in coal miner death rates from these causes would decline in contrast to those for all men. Analyses prepared for this study show that death rates from these causes for employed miners did not exceed those for all US men of similar ages.

More satisfactory resolutions of problems in measuring death rates

accurately, and in controlling for variations in age, can be found by carrying out prospective studies of defined populations of coal miners over specified periods of time, and comparing findings either with matched groups of nonminers or with the mortality of the male population of which the miners are a part. Several studies, chiefly done in Great Britain, have used these methods.[1,3,4,13] The studies are in agreement with ours in that employed coal miners without pneumoconiosis, or with simple pneumoconiosis only, have no excess mortality, in contrast to miners with complicated pneumoconiosis. In this study, it has also been found that cigarette smoking presages elevation of mortality for both employed and ex-miners, regardless of category or stage of pneumoconiosis; that the same conclusion holds for airway obstruction; and that severe dyspnea is correlated with elevated mortality among employed miners without pneumoconiosis, and among ex-miners in all three subgroups of CWP. Data from both anthracite and bituminous miners in Pennsylvania who receive compensation confirm the findings of the effects of airway obstruction and pneumoconiosis on mortality.[3] Data published by Higgins for both miners and nonminers in a community in Great Britain and several communities in West Virginia are also in general agreement on the effects of airway obstruction and dyspnea on mortality, but these data were shown only for miners and nonminers combined and not classified with respect to pneumoconiosis.[15]

Another problem was raised by the comparisons of employed miners and ex-miners. It concerns the representativeness of the ex-miner sample. These men were randomly selected from all Appalachian ex-miners aged 35 to 65 years who were paying dues to the United Mine Workers of America. No larger population could be identified and sampled in the time allowed for the examinations. However, whether or not UMWA members are representative of all ex-miners is difficult to determine, since census data on ex-miners are not collected. Comparison with age distributions of 256,000 ex-miners who from 1970 to 1973 applied for benefits for pneumoconiosis under the 1969 Coal Mine Health and Safety Act indicate that the ex-miners in our sample were more concentrated in the oldest ages, 55 to 65 years. The high prevalence of complicated pneumoconiosis, airway obstruction, dyspnea, and cough with sputum (Table 2) indicates that many of these ex-miners were indeed chronically ill. Their mortality may be biased upward compared with that of all ex-miners in the United States. However, the entire US population of ex-miners would be expected to have higher mortality than employed miners due to concentrations among the former of miners too disabled to work.

Finally, the findings of this study seem to be at variance with some of the statements that have been made over the past several years. Thus, it has been claimed that of 70,000 bituminous miners and ex-miners with pneumoconiosis, no less than 13,000 are totally disabled by their occupation.[16] Were this assertion true, and there seems to be no evidence to suggest it is, then the majority can only be disabled by diseases other than CWP.

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## References

1. Cochrane AL: Relation between radiographic categories of coalworkers' pneumoconiosis and expectation of life. *Br Med J* 2:532-534, 1973.

2. Liddell FDK: Mortality of British coal miners in 1961. *Br J Ind Med* 30:15-24, 1973.

3. Ortmeyer CE, Baier EJ, Crawford GM: Life expectancy of Pennsylvania coal miners compensated for disability. *Arch Environ Health* 27:227-230, 1973.

4. Cochrane AL, et al: The mortality of miners and ex-miners in the Rhondda Fach. *Br J Ind Med* 21:38-45, 1964.

5. Penman RW: Conference on pneumoconiosis: A summary of the conclusions. *Am Rev Respir Dis* 102:243-247, 1970.

6. Morgan WKC: Coalworkers' pneumoconiosis. *Va Med Mon* 96:712-716, 1969.

7. Lainhart WS, et al. *Pneumoconiosis in Appalachian Bituminous Coal Miners.* PHS Public No. 2000. Government Printing Office, 1969.

8. Spiegelman M: *Introduction to Demography,* revised edition. Cambridge, Mass, Harvard University Press, 1968.

9. Shryock HS, et al: *The Methods and Materials of Demography.* US Bureau of the Census, Government Printing Office, 1971.

10. Enterline PE: Mortality rates among coal miners. *Am J Public Health* 54:758-768, 1964.

11. Lainhart WS, Morgan WKC: Extent and distribution of respiratory effects, in Key MM, Kerr LE, Bundy M (eds): *Pulmonary Reactions to Coal Dust.* New York, Academic Press Inc, 1971, pp 33-38.

12. Morgan WKC, et al: Ventilatory capacity and lung volumes of US coal miners. *Arch Environ Health* 28:182-189, 1974.

13. Enterline PE: A review of mortality data for American coal miners. *Ann NY Acad Sci* 200:260-272, 1972.

14. Moyer FT, McNair MB: *Injury Experience in Coal Mining, 1970.* Bureau of Mines, US Department of the Interior, Washington, DC, 1973, p 117.

15. Higgins ITT: Chronic respiratory disease in mining communities. *Ann NY Acad Sci* 200:207-208, 1972.

16. Kerr LE: Coal workers and pneumoconiosis. *Arch Environ Health* 16:582, 1968.