

Mortality from Heart Disease in Coal Miners*

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A study of 3,726 Appalachian coal miners was undertaken to determine the standard mortality ratio (SMR) for heart disease and to ascertain the effect of smoking, excess weight, and the level of physical activity on deaths due to this cause. SMR's were calculated for all forms of heart disease and also separately for ischemic heart disease. For heart disease as a whole, SMR's of 73 for working and 104 for nonworking miners were obtained. It was found in both working and nonworking miners that obese

smokers had the greatest risk of dying of heart disease (SMR's of 142 and 144, respectively). In the nonsupervisory underground work categories of face, transportation, and maintenance, an increase of SMR was observed, with face having the lowest and maintenance workers having the highest SMR. Use of all men from seven Appalachian states vs all US men as a standard population tended to slightly reduce the calculated SMR's.

It has been suggested that US coal miners have an increased death rate from heart disease over that of all US working men.¹ Such inferences have in the main been derived from the followup of miners who had bought life insurance and from similar sources of health statistics. This study is based on the followup of a randomly selected sample of coal miners.

METHODS

A cohort of 4,134 Appalachian coal miners was selected by the US Public Health Service in 1962-1963 for inclusion in a prevalence study of coal miners' pneumoconiosis.² Of the original cohort, 2,549 working miners out of a planned sample of 2,751 men, or 92.7 percent, and 1,177 ex-miners out of a planned sample of 1,397 men, or 84 percent, agreed to participate. Ex-miners are nonworking miners who have left the mines because of ill health, retirement, or for another occupation. The sampling procedure used for working miners was essentially a three-stage sample, counties, mines, and miners, with random selection at each stage. Nonworking miners were randomly selected from lists of nonworking miners supplied by the United Mine Workers Union. A detailed description of the entire sampling procedure is given in reference 2. These men have been followed to the present. Four hundred and fifty-one men of the final sample were certified as having died on or before Jan 1, 1972. At present, there are 149 men (4 percent) lost to followup.

Death certificates were obtained for each of the 451 deceased miners from the appropriate state department of vital statistics. The death certificates were then coded for underlying cause of death by a nosologist utilizing the International Classification of Diseases, adapted for use in the United States.³ All miners who were characterized as having died from diseases of the heart, international codes 390-398,

402, 404, 410-429, were separated from the rest of the certificates. In 1968, there was a major revision of the heart section of the death code. In the new classification system, coronary heart disease is now included with ischemic heart disease. This makes comparisons of studies conducted at different times difficult.

The death rate for diseases of the heart is expressed as a standardized mortality ratio (SMR), *viz*, the ratio of observed deaths to expected deaths times 100. The three standards that were used for comparison were the population of men in the United States for 1968-1969,⁴ the population of men in seven Appalachian states (Alabama, Kentucky, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia) for 1968-1969, and the cohort of 3,726 Appalachian miners. Expected deaths were calculated as follows: life table q_x values were computed for each five-year age group from annual age-specific death rates reported for all males in each of the populations. Then, for each population, these initial q_x values (proportions dying 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. These initial q_x values for age groups 15 to 20 years, 20 to 25 years, *etc*, were supplemented with interpolated values for each year of observation, using Beers' "modified" formula for interpolation between given points at intervals of 0.2.⁵ The expected number of deaths was computed by multiplying in each five-year age group the number of men at risk of dying at the outset of each year of followup by the q_x value for the age groups. The number of deaths expected in each five-year age category was summed over all ages to obtain the number of expected deaths.

Smoking history, usual occupation, height, and weight were taken from a questionnaire given to all the miners at the time of their original examination (Jan 15, 1963-Jan 14, 1965). Obesity was determined by the use of the body-mass index: $BMI = (\text{weight}/(\text{height})^2) \times 703.05$ in which weight is measured in pounds and height is measured in inches. Any miner having a BMI of ≥ 27 was considered obese.⁶ Job classification was based on usual occupation, *ie*, job with most years of experience. In general, based on declining order of dust exposure, the working force can be divided into five groups, *ie*, face (of an underground wall of coal) workers, transportation workers, maintenance workers, those who are

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Table 1—Observed and Expected Deaths and Standardized Mortality Ratios for All Heart Disease and Ischemic Heart Disease

Cause of Death	Deaths in Working Miners						
	Obs.	US Exp.	7 States Exp.	Miners Exp.	US SMR	7 States SMR	Miners SMR
All heart disease	76	104	108	120	73	70	63
Ischemic heart disease	69	95	100	111	73	69	62
All causes	200	242	249	276	83	80	72
	Deaths in Nonworking Miners						
All heart disease	122	117	122	111	104	100	110
Ischemic heart disease	114	109	112	106	105	102	108
All causes	272	249	269	256	109	101	106
	Deaths in Working and Nonworking Miners Weighted Estimates of Combined Populations						
All heart disease	2,816	3,354	3,488	3,603	84	81	78
Ischemic heart disease	2,589	3,085	3,220	3,367	84	80	77
All causes	6,902	7,526	7,875	8,295	92	88	83

employed in miscellaneous underground work, and surface workers. As far as physical activity is concerned, the most arduous jobs are those on maintenance and on the surface. In contrast, work at the face or in transportation, being mechanized, involves less physical work. A miner having equal experience in two jobs in different categories was classified in the job with most dusty exposure.

It is realized that the separation of the miners into those who were working and those who were not may introduce bias, at least as far as the overall SMR for cardiac disease is concerned. Thus, former miners would be expected to have a higher than normal SMR because many will have retired because of ill health. By the same token, those who were gainfully employed were more likely to be fit. We, therefore, derived a SMR for both groups based on the estimated population of miners and ex-miners in the survey region.

RESULTS

Table 1 gives a breakdown of standard mortality ratios (SMR's) for working and nonworking miners for all heart disease, ischemic heart disease, and for all causes of death. It can be seen that working miners have SMR's that are significantly below 100 for both heart disease categories and for all causes regardless of whether the base population is all men in the United States, all men in seven Appalachian states, or the miners themselves. Nonworking miners have SMR's which are at the average of the standard

population, *ie*, approximately 100. The combined population SMR's were between those of the working and nonworking group and were significantly below 100.

It is apparent from Table 2 that working and nonworking miners who smoked have increased SMR's over those who were either nonsmokers or exsmokers. Smokers in the nonworking miner group had a significant excess of deaths over any of the standard populations.

Using the body-mass index as an indicator of obesity, Table 3 gives the SMR's for miners of normal weight and for obese miners. In the case of working miners, SMR's are significantly below 100 in both weight categories. In the nonworking miners, both weight categories have SMR's that are at the average of the standard populations.

A combination of smoking and excess weight tends to result in excess deaths in both the working and nonworking miner groups. The SMR for obese working miners who smoke is 142 using all US men as the base population, 131 using all men, in seven states as the base, and 113 using the miners cohort as base. In the case of the obese nonworking miners who smoke, the SMR ranged from 144 to 163, de-

Table 2—Observed and Expected Deaths and Standardized Mortality Ratios for All Heart Disease by Category of Smoking

Smoking Category	Deaths in Working Miners						
	Obs.	US Exp.	7 States Exp.	Miners Exp.	US SMR	7 States SMR	Miners SMR
Smokers	52	58	60	68	90	87	76
Nonsmokers	13	23	24	26	57	54	50
Exsmokers	10	23	24	26	43	42	38
	Deaths in Nonworking Miners						
Smokers	70	50	53	49	140	132	143
Nonsmokers	24	30	32	28	80	75	86
Exsmokers	26	35	37	33	74	70	79

Table 3—Observed and Expected Deaths and Standardized Mortality Ratios for All Heart Disease By Weight Category

Wt Category	Obs.	Deaths in Working Miners			US SMR	7 States SMR	Miners SMR
		US Exp.	7 States Exp.	Miners Exp.			
Normal	49	72	76	84	68	64	58
Obese	26	31	32	36	84	81	72
Deaths in Nonworking Miners							
Normal	84	82	85	78	102	99	108
Obese	35	32	33	30	109	106	117

pending on base population. Conversely, normal weight, nonsmoking working miners have SMR's of 42 (US), 38 (seven states), and 36 (miners cohort), all of which are significantly below 100. Similarly, nonworking, nonsmoking normal-weight miners also have a SMR of 67 (US, seven states) and 75 (miners cohort). Obese exsmokers in the working miners category have an abnormally low SMR, probably owing to small numbers in this group.

Table 5 shows the effect of job classification on deaths due to all heart disease. Maintenance men in both categories of workers and nonworkers have the highest SMR's in each group, regardless of base population. These indicate a significant excess of deaths in the nonworking group. The SMR for face workers, those in the dustiest category, is significantly lower than 100 in the working group and is at 97 (US), 93 (seven states), and 101 (miners cohort) in the nonworking group. In order of increasing magnitude of SMR's, the job categories in the working miners are miscellaneous workers, surface workers, face workers, transportation workers, and maintenance workers. In the nonworking miners, the order is face workers, surface workers, transportation workers, and maintenance workers. There were no deaths in miscellaneous workers. The progression of SMR's from face worker to maintenance worker in the working miners may either indicate a move-

ment away from the face to less dusty jobs or the miner becomes older and less hardy or more likely that those who choose or are chosen to work at the coal face are fitter and more healthy.

DISCUSSION

Higgins reported a SMR of 84 in England and Wales⁷ and 144 in the United States for coal miners dying from coronary heart disease.¹ Our figure of a SMR of 73 for working miners is lower than that found in Great Britain. Higgins⁷ concluded that skinfold measurements of men with coronary disease suggest that they are slightly more obese than others. There also was a slightly higher proportion of exsmokers and a lower proportion of nonsmokers among the men with coronary disease. We found that obese miners who smoked were at the greatest risk of dying from heart disease, but that obese exsmokers in the nonworking group had a relatively normal life expectancy. The low SMR (25) in exsmoking working miners is probably due to the small number of men in this group.

Enterline¹ gave several estimates of SMR's for coronary heart disease and heart disease in three different populations of US coal miners. The first estimate utilized occupational data from the National Office of Vital Statistics of the US Public Health Service for 1950. For this population of both

Table 4—Observed and Expected Deaths and Standardized Mortality Ratios for All Heart Disease By Smoking and Weight Categories

Smoking and Wt	Obs.	Deaths in Working Miners			US SMR	7 States SMR	Miners SMR
		US Exp.	7 States Exp.	Miners Exp.			
Normal wt, smokers	35	45	47	53	78	74	66
Normal wt, nonsmokers	5	12	13	14	42	38	36
Normal wt, exsmokers	8	15	16	17	53	50	47
Obese, smokers	17	12	13	15	142	131	113
Obese, nonsmokers	7	10	11	12	70	64	58
Obese, exsmokers	2	8	8	9	25	25	22
Deaths in Nonworking Miners							
Normal wt, smokers	55	41	43	40	134	128	138
Normal wt, nonsmokers	12	18	18	16	67	67	75
Normal wt, exsmokers	16	23	24	22	70	67	73
Obese, smokers	13	9	9	8	144	144	163
Obese, nonsmokers	12	12	12	11	100	100	109
Obese, exsmokers	10	11	12	11	91	83	91

Table 5—Observed and Expected Deaths and Standardized Mortality Ratios for All Heart Disease by Job Category

Job Category	Obs.	Deaths in Working Miners			US SMR	7 States SMR	Miners SMR
		US Exp.	7 States Exp.	Miners Exp.			
Face workers	33	48	50	56	69	66	59
Transportation workers	17	20	21	23	85	81	74
Maintenance workers	14	15	15	17	93	93	82
Miscellaneous workers	3	7	7	8	43	43	38
Surface workers	9	14	15	17	64	60	53
		Deaths in Nonworking Miners					
Face workers	68	70	73	67	97	93	101
Transportation workers	26	22	23	21	118	113	124
Maintenance workers	16	13	14	12	123	114	133
Miscellaneous workers	0	0	1	1	—	—	—
Surface workers	12	12	12	11	100	100	109

working and ex-miners, Enterline¹ obtained a SMR for coronary heart disease of 144 in the 20-64 year age range and a SMR of 126 in the 20-59 year age range. The standard population used to determine expected deaths was the number of gainfully employed men listed as coal miners in the 1950 census plus a correction factor to estimate for former coal miners. The second estimate was based on 1967 data collected by the Society of Actuaries of Working Miners and showed a SMR of 109 for coronary heart disease. The standard population in this case was derived from experience of insurance companies with individual policies. The third estimate was derived from following a cohort of 553 men working in coal mines in Beckley, WV in 1937 and followed for 28.5 years. In this instance, a SMR of 124.2 was obtained for heart disease. Expected death rates were based on those of all US men from various years. In all instances, the SMR's reported have greatly exceeded the values that we have obtained for our cohort of miners. One would expect that the SMR obtained from insurance data would tend to be low; however, our value of 73 (US) for working miners with ischemic heart disease is even lower.

In 1973, Liddell⁸ published a study in which he considered the effect of job on various causes of death. Expected deaths were derived from all occupied and retired men in England and Wales for 1959-1963. He divided jobs into face, other underground, and surface. He found that in working miners, face workers, and under-officials, there was low mortality for coronary disease, while surface workers had high rates. In our study, we found low SMR's in face workers, miscellaneous (under-officials), and surface workers, and an increased SMR for maintenance workers. Maintenance workers are more active physically than miners who work at the face or on transportation. The increased SMR in maintenance workers, 93 vs a SMR of 69 (US) in face workers, while still below 100 in working miners, is at variance with the concept that increased physical

activity protects against development of coronary artery disease. Transportation workers have SMR's of 85 (US), 81 (seven states), and 74 (miners cohort), which are significantly below 100. Liddell⁸ suggested that there was a "fitness gradient" because face workers had low SMR's for many of the causes of death, while surface workers had high SMR's. Our data show a trend from face to transportation to maintenance worker. This same trend holds true for the nonworking miner. However, for this group, the SMR's, with the exception of face workers, are all significantly above 100. In a study of the effects of respiratory diseases on mortality of the same cohort of miners, Ortmeyer⁹ obtained a SMR of 84 for the working miners and 108 for nonworking miners for all causes of death. Our values of 73 (US) and 104 (US) for all heart disease are not greatly different from these values.

There is some difference of opinion as to the validity of comparing the observed death rate in our sample of coal miners to that of the total US male population. We, therefore, also included data derived from the seven Appalachian states for comparison and, as is apparent, the figures are very similar. It is neither feasible nor scientific to use death rates for individual counties because in some counties in Kentucky and West Virginia, between 50 and 80 percent of the population of working men have spent some time working underground. A SMR for these counties would, in the main, reflect the death rate for coal miners in that particular region. Moreover, most previous studies have used national rather than regional mortality data.

We have also included data derived from the miners cohort itself for comparison purposes in order to see what difference this would make in the SMR's. Again, we arrive at similar values to those of the US males as base. However, there is a general decrease in SMR's in the working miner group and a general increase in SMR's in the nonworking miner group with the miners cohort as base.

CONCLUSIONS

The following conclusions may be drawn from the analysis of these results:

1. Working coal miners have a reduced possibility of dying from either all heart disease or ischemic heart disease, while nonworking coal miners die at the average of the standard population.

2. Smoking increases the probability of dying from all heart disease in both working and nonworking coal miners. Smokers in the nonworking group have a significant excess of deaths due to heart disease.

3. Obesity alone does not cause excess deaths in either the working or nonworking coal miner groups.

4. A combination of obesity and smoking results in excess deaths due to heart disease in both groups of coal miners. This excess ranges from 13 percent in the working group to 63 percent in the nonworking group.

5. Maintenance men have an excess of deaths due to heart disease in the nonworking group. While still below a SMR of 100, this group has the largest SMR, 93, in the working miner group. Face workers, the underground category most subjected to dust, have a significant deficit of deaths in the working group of miners.

6. The effect of using all men in seven Appalachian states versus all men in the United States as a basis for determining expected deaths is to increase the

number of expected deaths and thus reduce the size of the resulting SMR. This reduction of SMR is small in most cases. The effect of using the miners cohort was to reduce SMR's in the working miner group and to increase SMR's in the nonworking group.

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The Pretty Slippers of Gloxinias

Early beginnings of this plant seem clothed in mystery. However in 1875 the discovery of gloxinia was recorded and the plant named in honor of P. B. Gloxin of Germany. Botanists discovered that gloxinia had been misnamed. Technically speaking, it was not gloxinia; it was Gesneriad and belonged to the genus Sinningia. However, it has enjoyed such popularity under its assumed name that to this day it is still commonly called gloxinia. The colors of these gorgeous flowers range from pale, frosty orchid to deepest amethyst; shell-pink to ruby-red; and there are some pure white varieties. There are variations of these colors in striped, bordered,

mottled, fully doubled, and ruffled varieties. The flowers are true slippers supposed to have been worn by elves, fairies and kings' jesters in fairy tales. The opening where the foot slips in, is surrounded by a cuff of five petals; the portion designed to hold the foot is a perfect slipper having a rounded heel and a pointed toe. The toe is the beginning of the tube or bowl, and rests in the calyx. Species plants are truly conversation pieces.

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