



THE NATIONAL COAL STUDY  
AND  
RELATED RESEARCH

Final report from round three of the study



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| 16. Abstract (Limit 200 words)<br>Results of the National Coal Study are presented. Thirty two coal mines were visited and 5275 miners were examined during a 5 year period. The incidence and progression of coalworkers' pneumoconiosis was studied. Longitudinal declines in 1 second forced expiratory volume (FEV1) in coalminers were investigated. The prevalence rate for categories 0/0, 0/1, and 1/0 of coalworkers' pneumoconiosis were 1.9, 13.6, and 18.2 percent, respectively, during which time the coal dust standard was lowered from 3 to 2 milligrams per cubic meter (mg/m3). The standard was 3mg/m3 for 3 years and 2mg/m3 for 2 years. Predicted prevalence rates for an interpolated dust standard of 2.5mg/m3 were 2, 16, and 25 percent for pneumoconiosis categories 0/0, 0/1, and 1/0, respectively. Mine Safety and Health Administration data showed that dust concentrations in the mines averaged 1 to 2mg/m3 over the study period. Decreases in FEV1 over a 9 year period were correlated with smoking and length of time working at the coal face. The author suggests that the degree and progression of pneumoconiosis has been reduced by applying the 2mg/m3 dust standard. |  |   |    |                              |
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THE NATIONAL COAL STUDY AND RELATED RESEARCH

Final report from round three of the study,  
including longitudinal analysis of radiological  
and ventilatory function data drawn from epidemiological  
and surveillance data on underground coal miners.

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PREFACE

The following is a compendium of results from the National Coal Study and related research. At the time of writing, much of the material had appeared in reports and publications, or had been submitted for publication. Many people were involved in the data gathering including the field team; data coders, keypunchers, programmers and statistical assistants. Rochelle Althouse prepared the material and wrote most of Chapter 6. Shirley Kellie undertook the analysis and wrote Chapter 7. Barbara Hall produced the profile in the Appendix. Michael Attfield was the project leader, wrote most of the rest of the material and compiled this report.

ACKNOWLEDGEMENTS

Thanks are due to the very many people who have contributed to these results, including the field team members, the data coders, data processers and programmers, X-ray readers, and those who typed and helped prepare and review this manuscript. Thanks are also due to the miners for participating, and those from industry and labor who helped in the organization of the surveys.

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CHAPTER 1  
GENERAL INFORMATION

1.1 Project description.

The National Coal Study and related research is a collection of studies mainly concerned with lung disease in coalminers. The research can be divided into three main areas:

- a. Epidemiological investigation of lung disease in a specially selected set of coalminers.
- b. Epidemiological investigation of pneumoconiosis in miners who attended the national program of surveillance for coalminers administered by the National Institute for Occupational Safety and Health.
- c. Research into environmental problems involving dust exposure amongst coalminers.

The National Coal Study (NCS) began in 1969 with medical examinations at a group of mines selected according to certain criteria. The object of the research was to estimate the prevalence of lung disease in U.S. coalminers, and through prospective follow-up, to explore the incidence and progression of disease in relation to dust exposure and other factors. The medical examinations given to the miners involved chest X-rays, the administration of a symptoms, smoking and work history questionnaire, and the performance of ventilatory function tests. A great deal of information was published concerning the health status of coal miners arising from the first round of examinations.

About three years after the first round of examinations, the same mines, if still open, were revisited and the miners re-examined. Some new mines were added to replace those that had closed. Some of the information from that study has been published, including prevalence statistics for pneumoconiosis. However, the information gathered at the second round has been overshadowed by that from the third, since data from that later round, being associated with a longer period of follow-up, affords better study of incidence and changes. Much of this report is concerned with the study of longitudinal changes in medical indices over the period between the first and third rounds, an interval of nine years on average.

Running in parallel with the NCS but applicable to all coal miners was the surveillance program. This provides for routine X-rays for all underground coal miners. Not only does this supply information on diseases such as cancer and tuberculosis, but the X-rays are read for pneumoconiosis and the results notified to the miner so that disability claims may be filed or transfer rights obtained. As with the NCS, the surveillance program has undergone three rounds. The resulting X-rays have afforded the opportunity for the examination of radiological changes in certain sub-groups in complementary analyses to those of the coal study.

Finally, special studies have been organized and undertaken to explore certain problems involving the dust exposure of coal miners. These investigations which have been carried out mostly at NCS mines have involved problems concerning particle size distribution, and the relationship between compliance and epidemiological samples.

This report is a compendium of results and findings from the National Coal Study and the related research. It has been produced in response to NIOSH requirements that a final report be produced for each project. Chapters 1 and 2 provide basic background material relevant to many of the following chapters. Chapters 3, 4 and 5 are concerned with results from longitudinal follow-up of pneumoconiosis and ventilatory function between rounds 1 and 3 of the NCS. Chapter 6 deals with findings from study of incidence and progression of pneumoconiosis in miners from the surveillance scheme. Chapter 7 is a report on a mortality follow-up of miners from the first round of the NCS. Lastly, a profile consisting of tabulated data from the third round is presented as an Appendix.

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CHAPTER 2  
METHODS AND GROUPS STUDIED

## 2.1 THE NATIONAL COAL STUDY.

The following provides general information on the populations and samples studied, and on methods employed. A short analysis of bias due to study of 'survivors' in longitudinal follow-up is also given. Specific details pertinent to each analysis are given in Chapters 3-7.

### 2.2.1 History.

The National Coal Study was begun in 1969, and during the next two years 31 mines were visited and 9078 miners examined. Mines in most coal mining states were visited, although the preponderance of the mines were located in Appalachia. Table 2.1 shows the statewide distribution at the first and later rounds. Mines were selected according to the following criteria:

- a. The mine had to employ at least 100 miners.
- b. The mine had to have an expected working life of at least 10 years.
- c. The mines had to be representative of various coal seams, mining methods, and geographic areas.
- d. The mines had to be accessible by field team mobile equipment.

Although some representativeness was ensured through the selection criteria, the group of mines included in the first round cannot be regarded as representative of all U.S. mines. In particular, miners working at small mines, of which there are many, were not included at all. As a consequence it would be invalid to extrapolate the results from coal study analyses to all underground miners. It would appear that the cohort of miners examined at the first round comprised about 10% of all underground miners employed at that time.

The second round of the NCS began in 1972, and as many as possible of the first round mines were revisited. As some mines had closed, despite the requirement laid out in criterion b., other mines were selected to replace them. Some information from the second round has been published, although the main longitudinal analysis has concentrated on changes from round 1 to 3.

The third round began in 1977 and ended in 1981. 32 mines were visited and 5275 miners examined. Participation at the third round followed the trend begun in the second, and was low at 52%.

### 2.1.2 Longitudinal cohorts.

Of the three possible longitudinal cohorts, i.e. rounds 1 to 2, rounds 2 to 3, and rounds 1 to 3, only the latter has received extensive analysis. The interval between rounds 1 and 2 was really too short for adequate study of changes, while that from rounds 2 to 3 has been overshadowed by the analysis of rounds 1 and 3. Of the 9078 miners studied in round 1, and the 5275 miners studied in the third, only 1470 were common to both rounds.

The reasons for this low number were threefold. Firstly, the workforce at the first round was relatively elderly, and many had retired prior to the third round. Secondly, many of the first round mines had closed in the interval between rounds 1 and 3. As these mines could not be visited at the third round, miners in that area were not examined. Thirdly, participation was low at the third round causing a further drop in numbers. Others who did not attend were those who had taken jobs or moved elsewhere, or those too sick. When there is the possibility of selective attendance for examination, the problem of bias exists. This is dealt with in section 2.1.4.

Many of the analyses described in this report were undertaken on the cohort of 'survivors' from the first to third rounds. Of the 1470 miners concerned, sub-groups have been formed depending on the hypotheses being investigated and the data available. For instance, not all of the 1470 had X-rays available for re-reading, and so the results on radiological changes are based on fewer than 1470 observations.

#### 2.1.3 Methods in the National Coal Study.

Methods in the National Coal Study were basically similar in all three rounds of examinations. After contact had been made with the mines involved, special site visits were made to talk with operator and labor groups to explain the purpose and details of the study. Later, mobile field teams visited the mine sites and set-up close to the bath house. Miners were scheduled to attend either before or after shift. During the examination, the miners were asked questions on their chest symptoms, smoking history, and work history; height and weight were measured; two chest X-rays were taken; and simple spirometry was performed. The whole examination typically took 20-30 minutes.

The X-rays were processed at the site in the trailers, and read for gross abnormalities on return to base. The miner, and, if he requested it, his doctor were notified if the abnormality demanded urgent attention. Later, the X-rays were sent for reading by B readers for the purpose of establishing transfer rights and satisfying other requirements of Federal law. The other data gathered was coded, keypunched and merged with the X-ray readings to form merged master data sets. The original questionnaires were then microfilmed and kept in a secure area, while the original sheets were shredded. The X-rays were also kept in a secure storage place.

For the purpose of studying longitudinal change, records for miners from each round were matched on social security number. 1470 miners who had attended rounds 1 and 3 were matched in this fashion, and special data sets for these 'survivors' were created. These datasets were used for the analysis of a number of questions involving longitudinal changes.

Two of these analyses are reported on in this publication. The first deals with radiological changes over the nine years in the 'survivors'. Full details on the methods used are given in chapter 3, but basically films for these 'survivors' were pulled from storage and randomized. These were then read, both independently, and, after re-randomization, using the side-by-side method. Changes in X-ray classification were then compared to predictions obtained from established dose-reponse curves, and tabulations were made with regard to possible causative factors.

The other main analysis dealt with changes in forced expiratory volume in one second ( $FEV_1$ ). A recent publication from the Pneumoconiosis Field Research (PFR) by Love and Miller has examined 11 year changes in relation to dust exposure and other factors. The Coal Study analysis was undertaken along similar lines so that direct comparison could be made. This analysis is given in chapter 5; full details on the methods are given there.

#### 2.1.4 Exploration of bias in the NCS follow-up groups.

Results from longitudinal studies of workers may be biased if there is a systematic exodus of workers between the surveys. This problem is further compounded if, as in this study, participation is poor. For this reason the data have been examined to see whether there is a problem of bias, and whether that problem can be alleviated or circumvented.

Data for all miners who attended the first survey were partitioned into those who attended the later survey (stayers), and those who did not (leavers). It was immediately apparent (Table 2.2) that the leavers differed systematically from the stayers. The former group were older, and displayed more indications of ill health such as greater frequency of bronchitis-related symptoms, lower ventilatory function, and more pneumoconiosis. The leavers had also greater tenure in mining and had smoked greater numbers of cigarettes.

As much of the difference between the two groups could have been age-related, the data were tabulated by age groups. This revealed that age indeed was a critical factor and by controlling it to a restricted range, the differential between the two groups could be virtually eliminated. Table 2.3 shows the summarized data for the two groups for the age range 20 to 49 years, the range employed for further analysis in this report. It is apparent that there exist only minor differences between the two groups, and thus that extrapolation to miners other than those in the stayers group in this study may be valid. This sub-group with the restricted age range is included in several of the investigations reported later.

#### 2.2 Mortality analysis of NCS data.

The cohort consisting of all miners who attended the first round was followed

up with regard to vital status until November 1979 for the purpose of studying the relationship between mortality and possible causative factors such as dust exposure. Using sources of information such as Social Security, IRS and other methods, the vital status of 8437 of these 8475 white males studied was established with certainty. Death certificates were obtained for all of the deaths. The data so obtained have been subjected to a preliminary analysis, and the results are presented in chapter 7. Further details on the methods are given there.

### 2.3 Analysis of Surveillance Program data.

#### 2.3.1 The organization of the surveillance scheme.

The 1969 U.S. Federal Coal Mine Health and Safety Act mandated a program operated by NIOSH (hereafter referred to as the Surveillance Program), which enabled all underground coal miners to receive periodic X-rays. The principle use for these X-rays is for the protection of miners' health through detection of disease, and notification of findings and of transfer rights. The results can also be used in application for benefits.

The program has been conducted since 1970 in three 'rounds'. Under the law, every working coal miner has an opportunity to have a chest X-ray taken at intervals not exceeding five years. New miners must be examined soon after employment, then within three years. X-rays are taken at no cost to the miner, at NIOSH approved facilities, based on a plan submitted to NIOSH by the operator.

#### 2.3.2 Participation.

Participation in the completed rounds has been as follows:

|         |         |                |
|---------|---------|----------------|
| Round 1 | 1970-73 | 77,758 miners  |
| Round 2 | 1973-78 | 122,625 miners |
| Round 3 | 1978-81 | 63,519 mines   |

The level of participation in the program is a key element in its use as a source for estimating prevalence and progression of pneumoconiosis in coal miners. Participation in Round 1, including the new miner pre-employment examinations, is estimated at 52%. Restriction of the group to miners having at least one year of work experience in coal mining reduces this figure to 45%. By Round 3 it is estimated that these rates had declined to 42 and 33% respectively.

#### 2.3.3 Methods and data available.

In the analysis reported in chapter 7, the cohort of 10700 round 1 to round 3 repeaters was examined for those miners who were new to mining at the first round. The X-rays for this group of 1834 miners was extracted and sent out to three B readers for reading. The statistics on radiological

change derived from this exercise were compared to predicted values from external sources, and examined against tenure and dust data. The former data were obtained from the short questionnaires given to miners in the surveillance scheme, while the dust data came from MSHA records.

#### 2.3.4 Comparison of repeaters with Round 1 attenders.

Section 2.1.4 examined the bias inherent in studying 'survivors' compared to all those who attended the initial survey in the National Coal Study longitudinal follow-up of coal miners health. This section does the same for the surveillance group, as the same question is pertinent here. Note that there is a slight difference in treatment from that in 2.1.4. Here the results for the 'survivors' are compared to all miners.

Table 2.4 gives the statewide distribution of participants in the surveillance program at the first round, and for those who were re-examined at the third round (repeaters). In general, apart from some slight differences in the percentages for Kentucky and West Virginia, the distributions are similar.

Table 2.5 shows the age distribution of all round 1 miners, and of round 1-3 repeaters. As might be expected there is a difference between them. The repeaters include more young miners and fewer older miners. To a great extent this must be due to the older miners at round 1 retiring before round 3. Restricting the age range to 20-49 years at round 1 revealed that the repeaters had a similar age distribution to that of all round 1 miners.

The tenure distributions for both groups are given in Table 2.6. Again the distributions differ somewhat, The pattern of differences mirrors that for age, and is largely due to the age disparity in the two groups.

#### 2.4 Profile of Round 3 Coal Study data.

A descriptive summary of much of the data from round 3 is included as an Appendix. This gives basic statistics and numbers. It is provided for general information and it is not intended to used for analysis of specific hypotheses. Certain numbers and values may differ from those given elsewhere due to differing defintions.

TABLE 2.1

## STATEWIDE DISTRIBUTION OF MINES

| STATE         | ROUND 1 | ROUND 2 | ROUND 3 |
|---------------|---------|---------|---------|
| PENNSYLVANIA  | 8       | 8       | 7       |
| WEST VIRGINIA | 9       | 9       | 8       |
| VIRGINIA      | 2       | 4       | 4       |
| KENTUCKY      | 3       | 6       | 5       |
| OHIO          | 1       | 1       | 1       |
| ALABAMA       | 2       | 1       | 1       |
| INDIANA       | 1       | 0       | 0       |
| ILLINOIS      | 2       | 2       | 2       |
| UTAH          | 2       | 2       | 2       |
| COLORADO      | 1       | 1       | 1       |
| TENNESSEE     | 0       | 1       | 1       |
| TOTAL MINERS  | 9078    | 9343    | 5275    |

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TABLE 2.2

COMPARISON BETWEEN SELECTED VARIABLES FOR MINERS ATTENDING BOTH SURVEYS,  
AND THOSE ATTENDING ROUND 1 ONLY<sup>+</sup>(All ages)

|                                    | Those attending<br>Round 1 Only | Those attending both<br>Round 1 and Round 3 |
|------------------------------------|---------------------------------|---|
| Number of miners                   | 7608                            | 1470  |
| Marital status (% married)         | 93                              | 93  |
| Race (% white)                     | 95                              | 94  |
| Mean age (years)                   | 45                              | 40  |
| % Smokers                          | 54                              | 53  |
| Mean pack years*                   | 23                              | 18  |
| Mean years underground             | 18                              | 14  |
| Mean FEV <sub>1</sub> (L)          | 3.5                             | 3.8   |
| Mean FVC (L)                       | 4.7                             | 5.0   |
| % reporting persistent cough       | 34                              | 24  |
| % reporting persistent phlegm      | 36                              | 28  |
| % reporting breathlessness         | 21                              | 11  |
| % ever had bronchitis              | 11                              | 7   |
| % with coalworkers' pneumoconiosis | 31                              | 24  |

+ All data are from the first round.

\* Mean for smokers and ex-smokers only.

TABLE 2.3

COMPARISON BETWEEN SELECTED VARIABLES FOR MINERS ATTENDING BOTH SURVEYS,  
AND THOSE ATTENDING ROUND 1 ONLY<sup>+</sup>  
(Ages 20-49 years)

|                                    | Those attending<br>Round 1 Only | Those attending both<br>Round 1 and Round 3 |
|------------------------------------|---------------------------------|---|
| Number of miners                   | 4139                            | 1161  |
| Marital status (% married)         | 92                              | 94  |
| Race (% white)                     | 97                              | 94  |
| Mean age (years)                   | 37                              | 38  |
| % Smokers                          | 59                              | 55  |
| Mean pack years*                   | 17                              | 17  |
| Mean years underground             | 11                              | 11  |
| Mean FEV <sub>1</sub> (L)          | 3.8                             | 3.8   |
| Mean FVC (L)                       | 5.0                             | 5.1   |
| % reporting persistent cough       | 26                              | 24  |
| % reporting persistent phlegm      | 28                              | 28  |
| % reporting breathlessness         | 14                              | 10  |
| % ever had bronchitis              | 9                               | 7   |
| % with coalworkers' pneumoconiosis | 19                              | 22  |

+ All data are from the first round.

\* Mean for smokers and ex-smokers only.

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TABLE 2.4

STATEWIDE DISTRIBUTION OF ALL MINERS AT ROUND 1  
AND OF ROUND 1-3 REPEATERS.

| STATE         | ALL ROUND 1 MINERS |      | ROUND 1-3 REPEATERS |      |
|---------------|--------------------|------|---------------------|------|
|               | NUMBER             | %    | NUMBER              | %    |
| Alabama       | 1331               | 1.8  | 229                 | 2.1  |
| Colorado      | 1028               | 1.4  | 162                 | 1.5  |
| Illinois      | 4529               | 6.2  | 861                 | 8.0  |
| Indiana       | 177                | 0.3  | 40                  | 0.4  |
| Iowa          | 68                 | 0.1  | 13                  | 0.1  |
| Kentucky      | 13430              | 18.5 | 2390                | 22.1 |
| Maryland      | 59                 | 0.1  | 1                   | 0.0  |
| Montana       | 14                 | 0.0  | 0                   | 0.0  |
| New Mexico    | 31                 | 0.0  | 3                   | 0.0  |
| Ohio          | 3105               | 4.3  | 320                 | 3.0  |
| Pennsylvania  | 15053              | 20.8 | 2237                | 20.7 |
| Tennessee     | 302                | 0.4  | 14                  | 0.1  |
| Utah          | 710                | 1.0  | 74                  | 0.7  |
| Virginia      | 5714               | 7.9  | 942                 | 8.7  |
| West Virginia | 26110              | 36.0 | 3453                | 32.0 |
| Total         | 72430              | 100  | 10787               | 100  |

TABLE 2.5

AGE DISTRIBUTION OF ALL MINERS AT ROUND 1  
AND OF ROUND 1-3 REPEATERS

| AGE GROUP<br>(years) | ALL ROUND 1 MINERS |      | ROUND 1-3 REPEATERS |      |
|----------------------|--------------------|------|---------------------|------|
|                      | NUMBER             | %    | NUMBER              | %    |
| less than 20         | 4194               | 5.8  | 769                 | 7.1  |
| 20-29                | 21448              | 29.6 | 4255                | 39.4 |
| 30-39                | 12824              | 17.7 | 2365                | 21.9 |
| 40-49                | 15339              | 21.2 | 2418                | 22.4 |
| 50-59                | 15358              | 21.2 | 967                 | 9.0  |
| 60-69                | 3195               | 4.4  | 13                  | 0.1  |
| 70 or greater        | 42                 | 0.1  | 0                   | 0.0  |
| total                | 72400              | 100  | 10787               | 100  |

TABLE 2.6

TENURE DISTRIBUTION OF ALL ROUND 1 MINERS  
AND OF ROUND 1-3 REPEATERS

| YEARS<br>UNDERGROUND | ALL ROUND 1 MINERS |      | ROUND 1-3 REPEATERS |      |
|----------------------|--------------------|------|---------------------|------|
|                      | NUMBER             | %    | NUMBER              | %    |
| 0 - 9                | 36366              | 50.2 | 6937                | 64.3 |
| 10 - 19              | 9357               | 12.9 | 1614                | 15.0 |
| 20 - 29              | 13863              | 19.1 | 1657                | 15.4 |
| 30 - 39              | 9610               | 13.3 | 561                 | 5.2  |
| 40 or greater        | 3234               | 4.5  | 18                  | 0.1  |
| total                | 72430              | 100  | 10787               | 100  |

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CHAPTER 3  
THE INCIDENCE AND PROGRESSION OF COALWORKER'S  
PNEUMOCONIOSIS IN THE NATIONAL COAL STUDY

### 3.1 SUMMARY

X-rays, taken at a nine-year interval in 1261 U.S. coal miners were read for pneumoconiosis in a series of reading trials. Incidence and progression of small rounded opacities were close to those predicted from dose-response curves used to set the current U.S. compliance level for coal dust. The results imply that the level of pneumoconiosis in U.S. miners is being reduced through application of the current  $2 \text{ mg/m}^3$  standard. The long developmental period for pneumoconiosis mandates that further study is required to verify this finding and to determine whether  $2 \text{ mg/m}^3$  is an appropriate dust level for compliance.

In a complementary analysis to that above, examination of the incidence and progression of pneumoconiosis over nine years in 1261 nationally distributed U.S. coal miners was undertaken in relationship to potential causative factors. Use has been made of a large body of data on dust levels collected by the Mine Safety and Health Administration principally for compliance purposes. No link between dust level and disease progression could be detected. Some evidence was seen that radiological change was related to dust exposures prior to the study in both coal and non-coal mines, and thus experienced before the current dust standards were mandated. Neither migration of miners nor mining method appeared to be associated with disease incidence or progression. None of these findings can be taken as final as the period of study is short and the number of cases of pneumoconiosis few.

### 3.2 INTRODUCTION

The 1969 United States Federal Coal Mine Health and Safety Act specified, among other requirements, that the average level of respirable dust in the underground coal mine atmosphere be maintained at or below  $3 \text{ mg/m}^3$ . The same Act specified that this level was to be reduced to  $2 \text{ mg/m}^3$  effective December 1972. This level, which remains in force, ranks among the lowest compliance levels worldwide.

A major source of information upon which these regulations were based was the Interim Standards Study (ISS) of the British Pneumoconiosis Field Research (PFR) (Fay and Rae, 1959). Of this material, critical guidance was received from what was later published as Figure 4 of Jacobsen et al (1971). This described how the incidence of small rounded opacities of category 2/1 or greater over 35 years varied with average dust concentration. The curve showed a rising incidence of pneumoconiosis with increasing dust level, but indicated that little or no incidence was expected at  $2 \text{ mg/m}^3$  or below. Thus it was largely on this basis that  $2 \text{ mg/m}^3$  was adopted as the compliance level for U.S. underground coal mines.

Since that time, further results on dose-response have been produced by the PFR (Hurley et al, 1981). These, in general, confirm the earlier findings, although they do indicate a small non-zero incidence at  $2 \text{ mg/m}^3$ . One important feature of these later results is the presence of 'mine effects' which suggest that a universal dose-response curve may not be applicable to all mines. The authors of this later paper caution that this evidence suggests that their results may not be valid for other situations. This statement, of course, is applicable to the U.S. coalfields and coal miners.

Since it is by no means certain that the British results apply to the U.S., their validity must be established using data on U.S. coal miners. Inquiry into this has been undertaken here using data from the National Coal Study (NCS). The average period of time between the first and third surveys was nine years, close to the 10 years of the ISS. Prevalence data from rounds one and two of the NCS have already been published (Morgan et al, 1973; Attfield and Hudak, 1980).

In our analyses of radiological changes in the NCS miners, radiographs of those who attended both the first and last of the three surveys were extracted. These were employed in three reading trials, the last of which involved some of the British readers who had participated in the ISS trial. Incidence and progression of CWP has been tabulated and compared to predictions made from dose-response curves published by the PFR. Some of this material has been presented or submitted elsewhere, or is being prepared for submission (Attfield et al, 1983; Attfield et al, 1984a-c).

Although our current results indicate that the present dust standard may be valid, and may lead to prevention of CWP, they are applicable only to the whole group of miners. It is possible that the observed incidence and progression may be distributed inequitably over the different mines and regions. If this were so, it would indicate that the present dust standard, or its application, may not be valid for certain areas. For this reason this paper explores the observed cases of progression in detail and their relationship to causative factors such as dust exposure and composition.

### 3.3 METHODS

#### 3.3.1 Groups studied.

The basic cohort of interest in these investigations was the 1470 miners who attended both rounds 1 and 3. Sub-sets of these were included in reading trials I, II, and III described below. In the biggest trial, trial III, 1261 X-ray pairs were read. Attention was also focussed on a sub-group of 1017 formed by restricting the age range to 20-49. The reason for this restriction is given in Chapter 2.

#### 3.3.2 Reading Trial I

All results reported here were derived from special reading trials in each of which the x-rays were all re-read. The first trial, undertaken in 1978 included films from six mines (two in central Pennsylvania, two from West Virginia, and two from the western coal fields). At this time, these were the only films available. The aim of the trial was to obtain a preliminary examination of the films in order to determine how future trials should be organized. The exercise thus could be considered a 'pilot trial'. X-rays for miners who had attended both the first and third surveys were extracted and batched randomly. The films were read 'independent randomized' (i.e., not side-by-side) by three certified 'B' readers using the 1971 classification of pneumoconiosis (International Labor Office, 1972).

#### 3.3.3 Reading Trial II

The results of Trial I indicated that this approach should be extended to other films which had accumulated by that later time. Accordingly, a similar trial was undertaken using identical methods and readers to the first.

#### 3.3.4 Reading Trial III

The large amount of apparent regression seen in this trial (described later) indicated that a systematic difference in film quality or appearance existed between the first and third survey films. This may have been related to the combination of technique change and the

employment of a new x-ray technician in the third round. Adjustment for quality differences in film pairs is best undertaken using the side-by-side reading method. Accordingly, all available films, including most of those read previously in Trials I and II were batched in pairs and read side-by-side. For better comparison with the ISS results, the films were sent to Great Britain and read by six Medical Officers of the National Coal Board; four of these readers had in the past participated in the ISS reading. The readers affirmed that they could read using the 1968 (International Labor Office, 1953) standards applicable to the ISS trials, and these were the ones used in this exercise.

### 3.3.5 Statistical Methods for Film Readings

This report is concerned only with small rounded opacities and large opacities. For each of these abnormalities, a summary reading was obtained for each film. In every case this was a median reading. For three readers this was the middle reading of the three. For six readers, it was the average (rounded up to nearest subcategory) of the middle two readings of the six after they had been ranked by abnormality level.

### 3.3.7 Tenure and Work History

Part of the analysis below is concerned with tenure in the various coal mining jobs between surveys. This, and information on previous history was collected from individual miners by interviewers during the surveys. For each miner, it consists of records of time spent in the various jobs in which he was employed from start of work.

### 3.3.7 Dust Levels

The NCS has never had the resources to routinely collect dust data or time records for each miner. Instead recourse has been made to data collected by the Mine Safety and Health Administration (MSHA). In the great part, these are dust samples obtained by the operators for compliance purposes. Lesser amounts of data are available from inspector sample records, and dust samples collected on non-high-risk miners as mandated by the 1969 Mine Safety and Health Act (Occupational Safety and Health Reporter, 1978). These data date back to around 1970.

The correlation between dust concentration and x-ray changes over the nine years was examined using MSHA data summarized in two closely-related ways. Firstly, mean concentrations were obtained for each miner by averaging all of the data by social security number. This led to one value per miner. The sampling procedure followed by MSHA indicates that such simple averages may tend to be biased for epidemiological usage, as sampling tends to be more frequent when faces go out of compliance. This implies that higher dust levels would get heavier weighting within the average. To control for this, at least in part, another strategy was

adopted. Firstly each person's data were averaged over each two-monthly period; final means were then derived by averaging those means. Since the compliance scheme is based generally on a bi-monthly cycle, the above procedure should have reduced or eliminated the bias.

Some data on quartz levels were also made available to us by MSHA. The data utilized here were collected in the main by inspectors. The values given refer to percentage quartz in respirable dust, and were collected between the two surveys under study here. Determination of percentage quartz was achieved through X-ray diffraction of pooled samples obtained from cyclone selected respirable dust samples.

### 3.4 RESULTS

#### 3.4.1 Overall findings.

Table 3.1 shows the distribution of miners in the first round of the National Coal Study, and the distribution in each of the three reading trials. This tabulation omits mines that closed before the third round; as a result the numbers do not add up to 9078. Overall, 1470 miners attended both the first and third surveys, but fewer film pairs could ultimately be compiled. These data are tabulated (and later analyzed by region) because earlier results on coalworkers' pneumoconiosis (Morgan et al, 1979; Attfield and Hudak, 1980) have shown a trend of decreasing level of the disease from east to west.

Some information on age, tenure and exposure is given in Table 3.2. This group of miners was aged 40 at the first survey, had spent an average of 13 years underground prior to that survey, and had worked 80% of their inter-survey time underground.

##### 3.4.1.1 Reading trial I.

Table 3.3 shows the distribution of median x-ray readings from the first trial. This trial had included films from two mines in each of the three regions: central Pennsylvania, northern West Virginia, and the West. If one ignores regression by combining such cases with the no change category, rates of progression are 8% from category 0/0 to 0/1 or greater, 19% from category 0/1 and 9% from category 1/0. To ignore regression, however, may not be a valid approach for independent reading.

If no true net change in x-ray status had occurred over the period, one would theoretically expect all the pairs of readings to lie on the no-change diagonal. This would be unlikely to occur in practice because of differences in quality and other factors affecting the radiographs. However, one might expect that under the no-change situation, roughly as much progression as regression would be seen. In other words, the table would be approximately symmetrical about the no-change diagonal. It follows that a measure of real

progression corrected for random variability would consist of the difference:

progression from 0/0 - regression to 0/0.

Of course this correction assumes that regression is due only to problems inherent in the taking and reading of x-rays, and is not a real phenomenon. If regression is real, the above formula underestimates the true progression. Using this approach indicates an absence of real progression in the 374 films studied.

#### 3.4.1.2 Reading trial II.

The second trial dealt with 593 film pairs for miners who were examined after those in the first trial. This trial was organized in an identical manner to the first and used the same three readers. The mines were drawn mostly from the southern Appalachian region. One point of difference was the use of a different x-ray technician.

The results of the second trial are shown in Table 3.4. It is immediately apparent that there is considerably more regression than progression in nearly all starting categories. This situation was not expected and seems explicable only in terms of a systematic difference in quality between the two rounds. If this is so, however, it is explicable only in terms of x-ray quality differences within the standard grading used, since most films were classified as 'good' quality in both rounds. Nevertheless, the results are clearly useless for evaluation of progression and the dust standard, and resulted in a decision to change to side-by-side reading for the final trial.

#### 3.4.1.3 Reading trial III.

The final trial contained film pairs for all miners who participated in both rounds and for whom two pairs were available at the time the batches were compiled. Six readers were involved, including four who had participated in the ISS reading exercise from which the U.S. dust standards were derived. The 1968 standards used in that exercise were also employed here. It was hoped that the side-by-side method would enable the readers to compensate for quality differences within each film pair, though it is acknowledged that there is the potential for bias in the side-by-side method.

Table 3.5 gives the results derived from median readings of the six readers. Even using the side-by-side method some regression was reported. If regression is combined with the no-change category prevalence rates from 0/0, 0/1, and 1/0 are 1.9%, 13.6% and 18.2% respectively. If, on the other hand, the regression statistics are used to 'correct' the progression indices on the assumption that the former are a measure of random variability, the figures become 0.8%, 2.4%, and 7.7% respectively.

These statistics have been compared to levels that would be expected under the dust standard during the nine years. Jacobsen (1973) presented curves linking the probability of progression from various starting categories over 10 years against dust concentration. Some of the x-ray readers used in the derivation of those curves were employed in the current exercise, and the reading standards used were the same. During the nine year period studied here, the dust levels were subject to a compliance level of  $3 \text{ mg/m}^3$  for about three years, and for two for the remainder. Thus average exposure over the period was expected to be less than  $2.5 \text{ mg/m}^3$ . Interpolating the curves shown in Table A1 of Jacobsen at  $2.5 \text{ mg/m}^3$  indicates predicted progression rates of 2%, 16%, and 25% for starting categories of 0/0, 0/1 and 1/0. Thus the observed progression rates are consistent with those predicted from the data used to set the U.S. standard. This implies that they are compatible with the expectation that  $2 \text{ mg/m}^3$  should effectively prevent miners from reaching category 2/1 or greater in 35 years.

Reader variability is considered in the next table (Table 3.6) which shows the progression rates of interest tabulated for each reader in Trial III. The results show a good degree of agreement between the readers, especially for the 'uncorrected' statistics. None of the readers was far from the median. Note that the reader reporting the highest progression rates was still obtaining levels close to those predicted from the dose-response curves.

In a letter to the authors of this paper, the chief of the British readers predicted that, had the x-rays been read independently, considerable regression would have been seen. This was a spontaneous comment since he was not aware of the earlier trials. He further noted that the films showed considerable differences in technique confirming our earlier speculations on the cause of regression. (In part, this difference in technique was due to legally mandated changes specified in the 1977 Act.) He also added that some of the readers had distinguished by a special code those x-ray pairs where they believed the regression to be purely technical in nature.

To explore this point further tabulation, of the readings was undertaken omitting the readings where a reader had commented on the technical regression. After taking medians there was a loss of five data points. The number of lost data points was small as not all readers noted technical regression. The progression indices from this dataset were 1.9%, 14.1%, and 26.3% for progression from 0/0,, 0/1 and 1/0 respectively when combining regression with no change, and 1.3%, 8.3% and 12.0% after 'correcting' for regression. Overall the effect of omitting these specially denoted readings did not lead to different conclusions.

Reference has been made earlier to the low participation in the latter survey and the associated problem of bias. It was pointed out, however, that no obvious differences existed between those who stayed on at the mine after the first examination and participated in the latter examination, and those not returning at the last examination if age was restricted to between 20 and 49 at the first round. Resulting from this potential cause of bias in the whole group, an analysis was undertaken on the subset of miners in the restricted age range.

These results are presented in Table 3.7. Progression from 0/0, 0/1 and 1/0 was 1.6%, 11.3%, and 13.3% with combination of regression with no change, and 0.5%, 0% and 0% 'correcting' for regression. This group had a mean age of 37 years and had spent an average of 10 years underground prior to the first survey, of which about 50% was face work. Thus it appears that inclusion of the older miners, who we previously noted as being in somewhat better health than their colleagues who did not attend the latter survey did not apparently bias the results. (This analysis includes those with 'technical regression'.)

Many of the older miners in the group had experienced considerable exposure to coal dust prior to the first examination. Radiological progression in these miners could have resulted more from this prior dust burden than from the exposures received over the nine years under the compliance levels. Thus the inclusion of such miners is not a fair test of the validity of the current standard.

Problems arise when attempts are made to examine progression amongst miners with little or no prior dust exposure. Firstly there are very few such miners. Secondly, unless the dust problem was severe, very little radiological progression would be expected to be seen over nine years. This was actually the case; among the 505 miners with five or fewer years underground before the first examination, no net x-ray progression was detected. Further study over a longer period and with more observations is clearly required to verify this observation. In part, this is being done in another NIOSH project dealing with coal miners and whose results given in Chapter 6.

A discussion of radiological changes in coal miners would be incomplete without mention of large opacities, since it is this severe form of pneumoconiosis that the dust standards are intended to eliminate. Five cases of large opacities were seen: one was a type A at the initial survey, which did not change categories over the study period. The remaining four, according to the definitions used here, were new cases; three of these were category B at the final survey while one was an A. Simple pneumoconiosis readings for these four were: 3/2 to 3/2, 2/2 to 2/2, 0/1 to 1/2, and 0/0 to 0/0 for

small rounded opacities. The latter miner, though apparently normal regarding small rounded opacities, was reported as changing from 0/0 to 2/2 on small combined opacity readings. One miner was 48 years of age, while the remainder were aged over 55; all miners had spent most of their working lives in mining, though one of the miners worked principally in surface jobs.

### 3.4.2 Description of findings by sub-groups.

Analysis has been undertaken in three sections: examination of dose-response in the whole group; examination of the distribution of abnormality by region and mine, and its relationship to possible causal factors; and a brief investigation of the environmental and work history data by X-ray abnormality group. The following description pertains to the results from reading trial III.

#### 3.4.2.1 Dose response in the whole cohort.

Dose-response relationships between the level of dust exposure and incidence and progression of CWP have been established in Britain and West Germany (see, for example, Jacobsen et al (1971), and Reisner (1971)). The question arises as to whether the data presented here also demonstrate such a relationship, and if so, whether it confirms the earlier European findings.

To explore this question, the mean personal exposures derived from the MSHA data base were grouped into five dust ranges of roughly equal size and interval. Incidence and progression rates were computed for each range and are shown in Table 3.8. No trend with dust level is apparent; thus the data offer no new information or confirmation of dose-response. It is clear from examination of the Table that the paucity of CWP cases coupled with the narrow range of dust levels make detection of dose-response extremely unlikely here.

#### 3.4.2.2 Study of regional distribution in CWP.

Analysis of data from the first two rounds of the National Coal Study (NCS) has shown a trend in prevalence of CWP from East to West of the United States (Morgan et al, 1973; Attfield and Hudak, 1980). The anthracite region in eastern Pennsylvania showed a distinctly higher prevalence of CWP than all of the bituminous areas. Within the bituminous area, central Pennsylvania had the greatest prevalence, followed by the Appalachian region (western Pennsylvania to Alabama), and the midwestern mines in Illinois and western Kentucky. The western mines in Colorado and Utah had the lowest prevalences.

This geographical trend in prevalence, which matches a parallel trend in the age of the coal and thus its rank, might also be expected to

be seen in the X-ray progression statistics. Table 3.9 shows the progression and regression statistics, summarized as medians, tabulated by mine within region. (None of the anthracite mines initially studied were still working at the third round.) As can be observed, these are generally consistent with past regional prevalence data. There is one exception: the west, where progression appeared to be similar to that in Appalachia. Overall there is a suggestion that the dust standard may not be equally effective in all regions.

Before the latter inference can be accepted there are a number of other relevant factors that should be considered. These include age and mining tenure, dust concentration data, information on past conditions, movement of miners from region to region, mining methods and dust composition. These are dealt with in the following sections; in some cases information on these topics is scanty.

#### 3.4.2.3 Age and Tenure Between Surveys

Table 3.10 shows the mean age at the first round, and the work experience between rounds, subdivided by region. There are no clear indications in these data as to why the regional variations occurred. Mine A12, which showed the highest progression rates in the Appalachian group was not distinctive either in its age or tenure structure.

#### 3.4.2.4 Coal Dust Exposures Between Surveys

Average dust concentrations, summarized from Mine Safety and Health Administration data were obtained for each person. These were then averaged for each mine and region. Values for Appalachia, central Pennsylvania and the west were the same at  $1.1 \text{ mg/m}^3$ , while the midwest value was 1.4. This pattern of differences clearly does not explain the variation in progression observed. No link was determinable between mine dust means and progression from category 0/0.

#### 3.4.2.5 Quartz Exposures Between Surveys

Apart from some sparse data on quartz levels made available to us by MSHA, little data on dust composition exists for the NCS mines. Furthermore, the interpretation of that which does exist is made difficult as the data were collected at different times and at varying locations. For this reason discussion on this topic has been limited. Overall, the percentage quartz level in the respirable dust between surveys was 3%. No link could be discerned between quartz level and incidence or progression.

#### 3.2.4.6 Coal Dust Exposures Prior to the First Examination

It seems reasonable to postulate that a miner's risk of progression is not solely a function of the dust exposure experienced between two points in time, but also depends on the degree of exposure prior to the period of observation. Evidence in support of this is seen in Jacobsen et al (1971) where miners with existing CWP showed higher risk of progression than did miners without the disease.

Unfortunately little data exists on exposures prior to 1969. One surrogate measure is time spent at the face or underground. Data pertinent to this is shown in Table 3.11. This shows that the central Pennsylvania miners had the greatest tenure underground, and clearly had spent the greatest time at the face. Among the remaining three regions little difference exists in the tenure data though the pattern of values echoes that of the progression data. Overall there appears to be an indication that at least part of the regional distribution in progression may be due to differences in prior exposure. In support of this it is interesting to note that at mine C1 in the central Pennsylvania region, the average prior time at the face was only 4 years which may account for its difference from its neighbors in that region.

#### 3.4.2.7 Other dust exposures prior to the first examination.

Information on exposures other than to coal is collected routinely and systematically during interview of the miners. There were 163 reports of other exposures (probably from fewer miners due to multiple reports). Forty of these were for work in foundries, 52 for work in other types of mine, and 71 for other dusty work (includes asbestos, 2; pottery, 2; cotton, 2; quarry, 5; and miscellaneous, 60). Of the 52 records of work in other types of mine, 45 were from the western mines and referred to metal mines such as uranium mines. It is possible that some of the radiological change seen in the western mines may have been due, at least in part to exposures to silica dust during that time.

#### 3.4.2.8 Mining Method

Longwall mining methods are a relatively new phenomenon in U.S. coal mines. In certain situations they are more efficient than the older established methods. Unfortunately this increased productivity is sometimes gained at the price of increased dust levels. In other respects, such as dust composition and particle size distribution, the dust generated can be dissimilar to that from other methods. The possible effect of exposure to dust from longwall faces has been explored here.

The MSHA dust data sets contain codes indicating whether samples were derived from longwall or other types of mining methods. Examination of these codes for the studied mines indicated that seven had used longwalls extensively (A3, A7, A9, A10, A12, A15, and W1). The progression statistics shown in Table 3.9 were broken down into those mines with longwalls, and those without (Table 3.12). This suggests, for at least in Appalachia, that longwalls may be a factor concerned with x-ray progression, though clearly the effect is not great.

As these results stand, it is difficult to assign the excess in progression in the longwall mines wholly to that cause. None of these mines used longwalls exclusively; in fact the majority of the faces at each of the mines in this group were not longwall faces. Thus it is possible that those people showing progression could have come from these other faces. This possibility is explored later.

#### 3.4.2.9 Inter-Regional Movement of Miners

Movement of miners from east to west has been taking place for many years. This has involved the migration of miners from the anthracite area as mines closed, and the movement of miners from the eastern coalfields to those of Utah, Colorado and Wyoming as those mines were opened. The history records of miners in this study have been examined to determine how many had moved from region to region, and thus to establish whether or not migration was a factor of importance in this study.

The examination of history records was a manual task, and perusal of all records was beyond the resources available. For this reason random sampling was done for the west and Appalachian regions ( the latter including the mid-west for this analysis). A 50% sample was taken for the west, and a 20% for Appalachia, while all central Pennsylvania records were examined.

The results showed very little migration between regions in the group studied. Two of the miners working at central Pennsylvanian mines at the first survey had previously worked in the Appalachian region. One miner at one of the western mines had also previously worked in the Appalachian region. It is clear from this analysis that the effects of migration were probably of little importance.

#### 3.4.2.10 Environmental and tenure data by X-ray progression group

The preceding exposition has concentrated on mine and regional differences and their associations with progression. In doing this, some subtlety in the results may have been lost as the actual number of miners showing X-ray changes was few, and their particular characteristics may have been overwhelmed by the mass of miners who

did not demonstrate change. For this reason analysis has been concentrated on certain groups of miners defined by their median x-ray results.

Six groups of miners were chosen on the basis of the following combinations of initial and final median X-ray determination: 0/0 and 0/0; 0/0 and 0/1 or greater; 0/1 or greater and 0/0; 0/1 or greater no change; 0/1 or greater with progression; and 0/1 or greater with regression. In all cases no change, progression and regression are defined in terms of the twelve point scale. Information on tenure prior to the first survey, inter-survey tenure and inter-survey dust concentration was averaged for each group.

The results of this tabulation are shown in Table 3.13. They confirm the earlier observations. Miners who progressed tended to have spent longer time in the mines prior to the first survey than their colleagues who experienced no change. This was true for miners whose initial categories of CWP were 0/0 and greater than 0/0. In contrast to this, no evidence can be seen to indicate that those progressing had experienced higher dust exposures or tenure at the face than their non-progressing colleagues. Thus these results confirm the earlier observation that miners currently progressing in CWP are probably doing so through exposures received prior to the application of strict dust control measures.

Previous analysis had suggested that greater X-ray progression was occurring in mines with longwall faces than in other mines. This suggestion has been investigated by examining the work experience of those who demonstrated radiological changes over the study period. Scanning of both the MSHA records and the industrial histories revealed that only one of the 42 miners exhibiting radiological progression had worked at a longwall face during the study period. This miner's classification had apparently changed from a category 0/0 to 0/1. Thus the initial impression that longwall faces were more hazardous than other types of mining is not borne out in this analysis. (It should be pointed out that there is clear evidence (Parobeck and Jankowski, 1979; Attfield et al, 1984b) that many longwall faces have had difficulty keeping dust levels to the mandated level. Continued overexposure would be expected to be eventually manifested as X-ray abnormalities. Further follow-up is clearly necessary here.)

Examination of the industrial histories revealed other findings pertinent to this inquiry. Three of the seven miners who progressed in the western mines had previously worked in metal mines compared to 45 of 279 (16%) in the whole group of western miners. This indicates that some of the radiological changes in this region may not be due solely to coal dust.

### 3.5 DISCUSSION

Recent evidence from the PFR indicates that the interim dose-response curve used to set the British and U.S. dust standards was valid. The data presented here provide additional evidence on the validity of the British epidemiological results. They also indicate that progression of pneumoconiosis is being controlled by the mandated regulatory level. No severe progression (i.e., from category 0 to 2) was noted, and levels of progression were in the region expected under the mandated dust levels during the study period. Despite this, it would be unwise to accept these findings as the last word on the validity of the  $2 \text{ mg/m}^3$  standard. The period of study was only nine years; the question will be answered conclusively only by observation of the consequences of a lifetime's exposure to  $2 \text{ mg/m}^3$ .

There is some uncertainty over the validity of extrapolating these data to all U.S. underground miners. Although, at the first round, the NCS accounted for about 10% of all U.S. underground miners, the NCS miners were drawn from mines larger than average. In addition, although the NCS is spread geographically, it is not a random sample. Lastly, there was a considerable loss of miners from the study between the two examinations for various reasons. If loss was associated with ill health, the results reported here may be biased. Analysis of a subgroup of data, which is similar in many respects to the corresponding group not examined at the later round, suggests that the problem of bias may not be severe. Plans for future follow-up are being organized to cope with these problems of loss of workers to the study, and of regression of pneumoconiosis.

Note that, despite some impressions to the contrary, the  $2 \text{ mg/m}^3$  standard should not be expected to eliminate all pneumoconiosis. Some incidence is predicted under the standard, although cases should be few and not severe in nature. Note also that miners who develop CWP are not necessarily protected against further progression under the current standard. There is some evidence of this in the results of the present analysis. Minimization of the numbers of miners who suffer further progression can only be achieved through 'successful monitoring of workers' health by schemes such as the coalminers surveillance program administered by NIOSH, and through the miners taking advantage of the knowledge gained through participation in such schemes by transferring to less dusty jobs if CWP is detected.

The question of dose-response has not been dealt with here. To what extent one can realistically expect to identify a relationship between dust exposure and radiographic changes today with these data is questionable. Not only is the dust level in a very restricted range due to dust regulation (see, for example Attfield et al, 1983c or chapter 4), but the available dust data is not as comprehensive as would be desired. This applies particularly to examination of dust composition and particle size distribution. In addition, X-ray readings have a high degree of variability, and this coupled with the rather low numbers indicates that a dose-response relationship may not be

detectable.

The findings of Shennan et al (1981) are of relevance here. They tabulated the attack rate of Progressive Massive Fibrosis (PMF) according to category of simple CWP. Although the attack rate of PMF was very low in category 0, about one-half of all their cases were derived from this background. This gives rise to some concern as it tends to partially nullify the basis of the current dust standards. It should be remembered that the basic aim of the dust standards is to prevent miners reaching advanced categories of simple CWP. If this can be achieved, the argument goes, movement to PMF be prevented as miners in those categories are at most risk of PMF. Clearly, if miners in category 0 are also susceptible to PMF the logical basis of the dust standards no longer holds. In mitigation of this argument it should be noted that the Shennan et al data were derived from miners who had experienced considerably greater dust exposures than those likely to be experienced in the U.S. today. It is expected that these lower dust levels will not only reduce or eliminate the prevalence of severe CWP, but also eliminate the risk of contracting PMF, from any category.

3.6 REFERENCES

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TABLE 3.1

## DISTRIBUTION OF MINERS BY REGION, EXAMINATION AND READING TRIAL

| REGION   | FIRST<br>EXAMINATION | PARTICIPANTS<br>IN BOTH<br>ROUNDS | FIRST<br>IR TRIAL | SECOND<br>IR TRIAL | SIDE-BY-SIDE<br>TRIAL |
|--|----------------------|-----------------------------------|-------------------|--------------------|-----------------------|
| Central Pennsylvania   | 455                  | 146                               | 97                | 16                 | 98                    |
| Western Pennsylvania,<br>Northern West Virginia,<br>and Ohio         | 2184                 | 463                               | 117               | 295                | 387                   |
| Southern West Virginia,<br>Virginia, Eastern<br>Kentucky and Alabama | 3123                 | 449                               | 0                 | 290                | 402                   |
| Western Kentucky,<br>Illinois, and Indiana                           | 1237                 | 104                               | 0                 | 0                  | 93                    |
| Colorado and Utah  | 983                  | 308                               | 174               | 0                  | 281                   |
| Total  | 7982                 | 1470                              | 388               | 601                | 1261                  |

TABLE 3.2  
INFORMATION ON MINERS IN X-RAY READING TRIAL III

| VARIABLE                               | # OBSERVED* | MEAN | S.D. |
|--|-------------|------|------|
| Age                                    | 1260        | 40   | 10   |
| Years underground prior to first round | 1261        | 13   | 11   |
| Years at face prior to first round     | 1261        | 7    | 9    |
| % of time underground between surveys  | 1261        | 80   | 36   |
| % of time at face between surveys      | 1261        | 28   | 39   |
| Estimated dust concentration           | 1094        | 1.2  | 0.8  |

\*Missing information causes numbers to differ.

TABLE 3.3

DISTRIBUTION OF MEDIAN DETERMINATIONS OF READINGS OF SMALL ROUNDED  
OPACITIES FROM THE FIRST INDEPENDENT RANDOMIZED TRIAL

|     |       | LAST ROUND OF EXAMINATIONS |     |     |     |     |     |     |       |
|-----|-------|----------------------------|-----|-----|-----|-----|-----|-----|-------|
|     |       | 0/0                        | 0/1 | 1/0 | 1/1 | 1/2 | 2/1 | 2/2 | TOTAL |
| 1st |       |                            |     |     |     |     |     |     |       |
| R   | 0/0   | 290                        | 15  | 7   | 2   | 1   |     |     | 315   |
| O   |       |                            |     |     |     |     |     |     |       |
| U   | 0/1   | 17                         | 4   | 4   | 1   |     |     |     | 26    |
| N   |       |                            |     |     |     |     |     |     |       |
| D   | 1/0   | 7                          | 7   | 5   | 1   |     | 1   |     | 21    |
| O   |       |                            |     |     |     |     |     |     |       |
| F   | 1/1   | 1                          |     | 1   | 3   | 3   | 1   | 1   | 10    |
| E   |       |                            |     |     |     |     |     |     |       |
| X   | 1/2   |                            |     |     |     | 1   |     |     | 1     |
| A   |       |                            |     |     |     |     |     |     |       |
| M   | 2/1   |                            |     |     |     |     | 1   |     | 1     |
| S   | TOTAL | 315                        | 26  | 17  | 7   | 5   | 3   | 1   | 374*  |

\*14 missing readings, mostly due to films reported as unreadable.

TABLE 3.4

DISTRIBUTION OF MEDIAN DETERMINATIONS OF READINGS OF SMALL ROUNDED  
OPACITIES FROM THE SECOND INDEPENDENT RANDOMIZED TRIAL

|       |     | LAST ROUND OF EXAMINATIONS |     |     |     |     |     |     |       |
|-------|-----|----------------------------|-----|-----|-----|-----|-----|-----|-------|
|       |     | 0/0                        | 0/1 | 1/0 | 1/1 | 1/2 | 2/1 | 2/2 | TOTAL |
| 1st   |     |                            |     |     |     |     |     |     |       |
| R     | 0/0 | 412                        | 12  | 9   | 5   |     |     |     | 438   |
| O     |     |                            |     |     |     |     |     |     |       |
| U     | 0/1 | 64                         | 1   | 4   | 3   |     |     |     | 72    |
| N     |     |                            |     |     |     |     |     |     |       |
| D     | 1/0 | 39                         | 3   | 6   | 2   | 2   |     |     | 52    |
| O     |     |                            |     |     |     |     |     |     |       |
| F     | 1/1 | 9                          | 1   | 3   | 6   |     |     |     | 19    |
| E     |     |                            |     |     |     |     |     |     |       |
| X     | 1/2 |                            |     |     |     | 1   |     |     | 1     |
| A     |     |                            |     |     |     |     |     |     |       |
| M     | 2/1 | 1                          |     |     | 1   |     | 1   | 2   | 5     |
| S     |     |                            |     |     |     |     |     |     |       |
|       | 2/2 |                            |     |     | 2   | 2   |     | 1   | 5     |
|       |     |                            |     |     |     |     |     |     |       |
|       | 2/3 |                            |     |     |     |     | 1   | 1   | 2     |
| TOTAL |     | 525                        | 17  | 22  | 19  | 5   | 1   | 4   | 593*  |

\*8 missing readings, mostly due to films reported as unreadable.



TABLE 3.6

## PROGRESSION STATISTICS BY READER AND METHOD

| READER | TREATING REGRESSION AS<br>'NO CHANGE' |      |      | 'CORRECTING' FOR VARIABILITY<br>USING REGRESSION |      |      |
|--------|---------------------------------------|------|------|--|------|------|
|        | 0/0                                   | 0/1  | 1/0  | 0/0  | 0/1  | 1/0  |
| 1      | 3.2                                   | 16.4 | 31.4 | 1.0  | 0*   | 24.8 |
| 2      | 1.1                                   | 12.8 | 17.6 | 0.6  | 11.5 | 1.0  |
| 3      | 1.0                                   | 14.8 | 21.4 | 0*   | 5.5  | 21.4 |
| 4      | 3.3                                   | 15.4 | 21.9 | 1.3  | 12.3 | 19.1 |
| 5      | 2.4                                   | 21.3 | 13.0 | 1.7  | 12.4 | 9.6  |
| 6      | 1.6                                   | 20.5 | 25.9 | 1.3  | 18.2 | 25.9 |
| MEDIAN | 1.9                                   | 13.7 | 18.2 | 0.8  | 2.4  | 7.7  |

TABLE 3.7

DISTRIBUTION OF MEDIAN DETERMINATIONS OF READINGS OF SMALL ROUNDED OPACITIES  
FROM THE SIDE-BY-SIDE TRIAL. AGE RESTRICTED TO 20-49 YEARS

|  |     | LAST ROUND OF EXAMINATIONS |     |     |     |     |     |     |     |     |     |       |   |
|--|-----|----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|---|
|  |     | 0/0                        | 0/1 | 1/0 | 1/1 | 1/2 | 2/1 | 2/2 | 2/3 | 3/2 | 3/3 | TOTAL |   |
| R<br>O<br>U<br>N<br>D<br><br>O<br>F<br><br>E<br>X<br>A<br>M<br>I<br>N<br>S | 1st | 0/0                        | 911 | 13  | 1   | 1   |     |     |     |     |     | 926   |   |
|  |     | 0/1                        | 8   | 39  | 2   | 1   | 2   | 1   |     |     |     | 53    |   |
|  |     | 1/0                        | 2   | 6   | 5   | 1   | 1   |     |     |     |     | 15    |   |
|  |     | 1/1                        |     |     | 2   | 5   |     | 1   | 1   |     | 1   | 10    |   |
|  |     | 1/2                        |     |     |     |     | 1   |     |     |     |     | 1     |   |
|  |     | 2/1                        |     | 1   |     |     |     | 1   | 2   |     |     | 4     |   |
|  |     | 2/2                        |     |     |     |     |     |     | 5   | 1   |     | 6     |   |
|  |     | 2/3                        |     |     |     |     |     |     |     |     |     | 0     |   |
|  |     | 3/2                        |     |     |     |     |     |     |     |     |     | 1     | 1 |
|  |     | 3/3                        |     |     |     |     |     |     |     |     |     | 1     | 1 |
| TOTAL  |     | 921                        | 59  | 10  | 8   | 4   | 3   | 8   | 1   | 2   | 1   | 1017  |   |

9 missing readings; mostly due to unreadable films.

(47)

TABLE 3.8

INCIDENCE AND PROGRESSION OF CWP BY DUST LEVEL

| DUST LEVEL<br>(mg <sup>3</sup> ) | % PROGRESSION |           |          |
|----------------------------------|---------------|-----------|----------|
|                                  | FROM 0/0      | FROM 0/1  | from 1/0 |
| less than 0.5                    | 2.1 (194)*    | 28.6 (7)  | 16.7 (6) |
| 0.5 to less than 0.8             | 1.5 (201)     | 7.7 (13)  | 25.0 (4) |
| 0.8 to less than 1.2             | 3.4 (205)     | 20.0 (15) | 0.0 (3)  |
| 1.2 to less than 1.7             | 1.5 (194)     | 13.3 (15) | 50.0 (2) |
| 1.7 or greater                   | 2.7 (186)     | 12.5 (8)  | 0.0 (3)  |

\* Percentage (number in starting category)

TABLE 3.9

PROGRESSION AND REGRESSION STATISTICS SUMMARIZED BY MINE AND REGION.  
DATA DERIVED FROM MEDIAN READINGS

| REGION/MINE       | FILM PAIRS | % PROGRESSION |           | % REGRESSION |         |
|-------------------|------------|---------------|-----------|--------------|---------|
|                   |            | FROM 0/0      | FROM 0/1+ | TO 0/0       | TO 0/1+ |
| <u>Central PA</u> |            |               |           |              |         |
| C1                | 12         | 0             | 0         | 0            | 33.3    |
| C2                | 51         | 6.5           | 60.0      | 0            | 0       |
| C3                | 35         | 11.5          | 55.6      | 0            | 8.3     |
| All mines         | 98         | 7.4           | 47.1      | 0            | 8.7     |
| <u>Appalachia</u> |            |               |           |              |         |
| A1                | 98         | 2.1           | 0         | 0            |         |
| A2                | 108        | 0             | 7.1       | 0            | 14.3    |
| A3                | 76         | 1.4           | 66.7      | 1.4          | 0       |
| A4                | 19         | 0             | 0         | 0            | 0       |
| A5                | 21         | 0             | 0         | 5.0          | 0       |
| A6                | 18         | 0             | 0         | 0            | 0       |
| A7                | 58         | 1.9           | 0         | 1.9          | 33.3    |
| A8                | 18         | 0             | 50.0      | 0            | 0       |
| A9                | 73         | 3.5           | 26.7      | 0            | 5.9     |
| A10               | 49         | 2.3           | 0         | 2.3          | 16.7    |
| A11               | 14         | 0             | 0         | 22.2         | 0       |
| A12               | 26         | 4.4           | 33.3      | 0            | 0       |
| A13               | 2          | 0             | 0         | 0            | 0       |
| A14               | 36         | 0             | 8.3       | 4.0          | 9.1     |
| A15               | 71         | 1.6           | 12.5      | 1.6          | 12.5    |
| A16               | 36         | 0             | 33.3      | 2.9          | 0       |
| A17               | 59         | 1.8           | 0         | 0            | 0       |
| All Mines         | 782        | 1.4           | 12.5      | 1.3          | 7.9     |
| <u>Midwest</u>    |            |               |           |              |         |
| M1                | 2          | 0             | 0         | 0            | 0       |
| M2                | 36         | 0             | 0         | 0            | 0       |
| M3                | 10         | 0             | 0         | 33.3         | 100.0   |
| M4                | 45         | 0             | 25.0      | 2.4          | 0       |
| All mines         | 93         | 0             | 9.1       | 4.7          | 14.3    |
| <u>West</u>       |            |               |           |              |         |
| W1                | 114        | 2.6           | 0         | 0            | 0       |
| W2                | 73         | 1.4           | 50.0      | 0            | 0       |
| W3                | 92         | 2.2           | 0         | 0            | 0       |
| All mines         | 279        | 2.2           | 50.0      | 0            | 0       |

TABLE 3.10

## AGE AND TENURE BETWEEN SURVEYS BY REGION

| REGION     | MEAN AGE<br>AT FIRST ROUND<br>(years) | MEAN TIME AT FACE<br>BETWEEN SURVEYS<br>(years) | MEAN TIME UNDERGROUND<br>BETWEEN SURVEYS<br>(years) |
|------------|---------------------------------------|---|---|
| Central PA | 41                                    | 2.3   | 7.3   |
| Appalachia | 39                                    | 2.6   | 7.5   |
| Midwest    | 40                                    | 1.6   | 7.5   |
| West       | 41                                    | 2.6   | 6.2   |

TABLE 3.11

TENURE IN UNDERGROUND AND FACE WORK  
PRIOR TO THE FIRST SURVEY

| REGION     | MEAN YEARS UNDERGROUND | MEAN YEARS IN FACE WORK |
|------------|------------------------|-------------------------|
| Central PA | 16                     | 12                      |
| Appalachia | 13                     | 6                       |
| Midwest    | 12                     | 5                       |
| West       | 12                     | 6                       |

50a

THE NATIONAL COAL STUDY  
AND  
RELATED RESEARCH

Final report from round three of the study



TABLE 3.12

## PROGRESSION AND REGRESSION RATES BY LONGWALL AND OTHER MINING METHODS

| REGION/<br>METHOD | NUMBER OF<br>FILM PAIRS | X-RAY RESULTS |           |              |           |
|-------------------|-------------------------|---------------|-----------|--------------|-----------|
|                   |                         | % PROGRESSION |           | % REGRESSION |           |
|                   |                         | FROM 0/0      | FROM 0/1+ | FROM 0/0     | FROM 0/1+ |
| Appalachia        |                         |               |           |              |           |
| Longwall          | 353                     | 2.2           | 17.9      | 1.3          | 9.5       |
| Other             | 429                     | 0.8           | 8.2       | 1.3          | 6.4       |
| West              |                         |               |           |              |           |
| Longwall          | 114                     | 2.6           | 0         | 0            | 0         |
| Other             | 165                     | 1.8           | 50.0      | 0            | 0         |

TABLE 3.13

## ENVIRONMENTAL AND TENURE DATA CLASSIFIED BY MEDIAN X-RAY READINGS

| STARTING<br>CATEGORY | X-RAY<br>CHANGE         | NUMBER<br>OBSERVED | YEARS SPENT PRIOR<br>TO FIRST SURVEY |             | DUST<br>CONCENTRATION<br>mg/m <sup>3</sup> | INTERSURVEY:         |                      | AGE<br>(yrs) |
|----------------------|-------------------------|--------------------|--------------------------------------|-------------|--|----------------------|----------------------|--------------|
|                      |                         |                    | UNDERGROUND                          | AT THE FACE |  | YEARS<br>UNDERGROUND | YEARS<br>AT THE FACE |              |
| 0/0                  | No change               | 1111               | 12                                   | 6           | 1.1 <sup>2</sup>                           | 7.1                  | 2.4                  | 39           |
| 0/0                  | Progression             | 22                 | 21                                   | 11          | 1.2  | 8.5                  | 3.0                  | 45           |
| 0/1+                 | Regression <sup>1</sup> | 13                 | 19                                   | 14          | 1.1  | 8.7                  | 2.9                  | 42           |
| 0/1+                 | No change               | 74                 | 20                                   | 13          | 1.2  | 7.5                  | 3.3                  | 44           |
| 0/1+                 | Progression             | 21                 | 23                                   | 17          | 1.1  | 8.4                  | 3.9                  | 46           |
| 0/1+                 | Regression              | 9                  | 24                                   | 14          | 1.1  | 6.8                  | 2.5                  | 47           |

<sup>1</sup> to category 0/0

<sup>2</sup> based on fewer observations than indicated in the table.

CHAPTER 4  
A DESCRIPTION OF THE ENVIRONMENTAL DATA  
USED IN THE COAL STUDY ANALYSIS

#### 4.1 SUMMARY

This chapter contains a description of dust data collected by the Mine Safety and Health Administration and used to study the relationship between dust exposure and incidence and progression of pneumoconiosis over nine years in a group of U.S. coal miners as described in Chapter 3. During this time the mandated maximum dust level was  $3 \text{ mg/m}^3$  for about three years, and  $2 \text{ mg/m}^3$  for the remainder. Dust levels in the group of mines studied averaged between one and two  $\text{mg/m}^3$  over the period studied. Face jobs, as expected, had higher concentrations. Little regional variation was noted. Dust levels in the mines studied were very similar to national statistics and followed the same temporal trend of reduction over time. There was an indication that inspector collected samples showed higher concentrations than those collected by operators though the difference was small. There was also evidence that longwall mining gives rise to greater airborne dust concentrations than other mining methods.

## 4.2 INTRODUCTION

A partial evaluation of the validity of the current compliance level has recently been undertaken together with an analysis of X-ray changes in relation to information on dust levels and dust composition and other data (Chapter 3). The dust exposure data used in those analyses were drawn from data collected by operators and inspectors as part of the Mine Safety and Health Administration (MSHA) compliance scheme. The purpose of the present paper is to describe the dust data as they relate to the NCS mines.

## 4.3 METHODS

### 4.3.1 Information on Tenure

Information on each job performed in mining and the duration of that job was obtained through interview of each miner using a standardized approach. The data presented here were obtained from interviews at the latter of the two surveys considered.

### 4.3.2 Dust Concentrations from MSHA

The NCS has never had the huge resources needed to obtain comprehensive dust exposure information on all miners in the study. In part, the responsibility for this was assigned to the mine operator through the sampling program overseen by MSHA. However, much of the MSHA data is naturally concerned with compliance to the regulations, and as such concentrates heavily on the high risk worker. This duality of purpose detracts from the usefulness of the data for epidemiological applications.

NIOSH obtained MSHA computer tapes on which were recorded dust sample information for coal mines between the dates 1970-79. Later data was not available at the time the request was made. Information on the tapes consists of a number of different types. Three main divisions concern us here: sample type, mining method, and sampler type. Sample type breaks down into five main categories: high risk - personal samples taken at the face on specified high risk workers, and which form the major focus of dust control; intake air - area samples for the testing of intake air quality; face non-high risk and non-face - personal samples taken on all non-high risk workers at specified intervals mainly for epidemiological analysis; and 203(B)(1) samples - those taken on miners with pneumoconiosis who have elected to transfer to less dusty areas as a preventive measure. Mining method breaks down into five categories also: continuous, conventional (drill and shoot), longwall, other and surface. Sampler type refers to operator or inspector taken samples.

MSHA supplied NIOSH with nine computer tapes which contained data on over four million samples collected between 1970 and June 1979. In part, these

included a proportion of samples voided for various reasons including oversized particles, missing data, nonapproved equipment, or contamination. To simplify analysis, these data were purged of the void samples and reorganized according to state. Data for the NCS mines was then extracted and summarized.

This paper is a description of the MSHA data, in part by region, job and year. This cannot be obtained using the personal values described in chapter 3 and used to correlate with radiological changes. Accordingly, the data were summarized differently. Mean values were obtained for each combination of mine, face, year, job and bi-monthly period. These means were then themselves averaged to give mine, year and job means. In some cases these were then grouped by region.

Statistics on variability refer to the first stage averages, i.e.; variation over time and between faces for the bi-monthly means, and not to variability between individual samples. Throughout this text the bi-monthly means are referred to as 'observations' in order to distinguish them from the individual measured samples.

#### 4.3.2 Geographical Subdivision

Four geographical areas have been used in the analysis: Central Pennsylvania, Appalachia (west Pennsylvania, West Virginia, east Kentucky, Virginia, Ohio, Alabama), Midwest (Illinois, west Kentucky), and West (Utah, Colorado). Prior experience has indicated a trend in prevalence with geographical area, from east to west.

### 4.4 RESULTS

#### 4.4.1 Occupational History Data

The occupational history data is given here for completeness, since the main concentration of this paper is on the dust data. Table 4.1 shows some details concerning the time spent in various jobs by region and over all regions. Most of the miners in the study had remained in the mining industry during the whole time between surveys; nearly all had remained at the same mine. About 80% of the time spent in mining was spent underground, although only 28% was spent on average in face work.

#### 4.4.2 Dust Concentrations from MSHA

##### 4.4.2.1 Data by Job and Region

Table 4.2 gives a tabulation of the NCS dust data by job and region. Very little difference between regions can be seen. The overall dust level was  $1.2 \text{ mg/m}^3$  in the time period covered (1970-1979). As expected, face jobs such as continuous miner operator, cutting machine operator, roofbolter and loading machine had higher dust levels than non-face jobs such as mechanic, motorman,

and beltman.

The variability between bi-monthly observations is shown for the four jobs which had over 4000 observations (continuous miner helper, roofbolter, shuttle car operator, and section foreman) in Figures 1a - 1d for the period 1974-79 when the levels had stabilized (see next section). For the occupation with the highest average concentration of the four, the roofbolters, 80% of the observations lay between 0.2 and 3.2 mg/m<sup>3</sup>, while 90% lay between 0.1 and 4.0. This includes both temporal and inter-face variation. Similar but smaller ranges were evident in the other groups.

#### 4.4.2.2 Trend in Dust Levels between 1970-1979

Figure 4.2 shows the trend in dust level between 1970 and 1979 for the four jobs having the most observations, and for all jobs. The general trend is the same in all cases. In the earlier years, when the compliance level was 3 mg/m<sup>3</sup> the dust levels were naturally higher. From this time until 1973, there was a drop in level; between 1974 and 1979 the levels were fairly stable and displayed mainly random variation.

#### 4.4.2.3 Comparison between the NCS and All Mines

Parobeck and co-authors (1979) have published information on dust concentrations collected by operators and others and processed by MSHA. Table 1 of their report gives yearly means by selected occupation. Data from this table has been abstracted here and compared with the observations for the NCS mines for the four largest groups (Table 4.3 of this report). The data for the NCS mines were very similar to that for all mines and showed an identical temporal trend.

A rank correlation performed between the results of Table 1 of Parobeck and co-workers, and the NCS results for all mines yielded a value greater than 0.7. This indicates that though dust levels appeared to have fallen since 1968-69, they have dropped proportionately, those having the higher levels earlier still tending to have relatively high levels.

#### 4.4.2.4 Operator and Inspector Data

Comparison between sample data collected by operators with that obtained by MSHA inspectors is shown in Table 4.4. Only one job, the continuous miner helper, had a sufficient number of observations to enable a reliable comparison to be made. Examination of the data by year and by region revealed that inspector-obtained samples tended to greater dust levels, but values were still below the compliance level.

#### 4.4.2.5 Longwall Information

Parobeck and colleagues noted in 1979 that longwall face jobs were associated with higher dust levels than other occupations. Table 4.5 shows the data on longwall jobs for the NCS. Detailed breakdown was not possible due to low numbers. The results agree with those of Parobeck and co-workers. Mean dust levels for the shearer and tailgate operators were higher than for any of those in Table 4.1. This finding is even more apparent in the West. These levels of 3 mg/m<sup>3</sup> were observed over the 10 year period. Inspector-derived data agreed well with the operator data.

4.5 REFERENCES

Parobeck PS and Jankowski RA. Assessment of the respirable dust levels in the nation's underground and surface coal mining operations. Am ind Hyg Ass J 40:910-915.

TABLE 4.1

## DISTRIBUTION OF TIME WORKED BY REGION

| REGION      | NUMBER<br>OBSERVED | MEAN<br>AGE | INTER-SURVEY TENURE (years) |                          |                          |
|-------------|--------------------|-------------|-----------------------------|--------------------------|--------------------------|
|             |                    |             | MEAN TIME<br>IN MINING      | MEAN TIME<br>UNDERGROUND | MEAN TIME<br>AT THE FACE |
| Central PA  | 98                 | 41          | 9.0                         | 7.3                      | 2.3                      |
| Appalachia  | 787                | 39          | 8.9                         | 7.5                      | 2.6                      |
| Midwest     | 93                 | 40          | 8.9                         | 7.5                      | 1.6                      |
| West        | 281                | 41          | 8.9                         | 6.2                      | 2.6                      |
| All regions | 1259               | 40          | 8.9                         | 7.2                      | 2.5                      |

TABLE 4.2

DUST LEVELS BY OCCUPATION AND REGION.  
NATIONAL COAL STUDY MINES 1970-1979

| JOB                       | ALL AREAS |       | CENTRAL PA | APPALACHIA | MIDWEST | WEST    |
|---------------------------|-----------|-------|------------|------------|---------|---------|
|                           | MEAN      | # OBS | MEAN       | MEAN       | MEAN    | MEAN    |
| <u>Face Jobs</u>          |           |       |            |            |         |         |
| Cutting Machine Operator  | 2.0       | 332   | --         | 2.1        | 2.0     | --      |
| Laborer                   | 1.9       | 738   | 1.7        | 2.0        | 1.0     | 1.1     |
| Loading Machine Operator  | 1.8       | 1304  | 1.6        | 1.9        | 1.4     | 1.2     |
| Roofbolter Helper         | 1.8       | 1049  | 1.3        | 1.9        | 1.5     | 0.4     |
| Timberman                 | 1.7       | 696   | --         | 1.7        | 2.2     | 1.6     |
| Blaster                   | 1.6       | 671   | --         | 1.6        | 1.6     | --      |
| Continuous Miner Operator | 1.6       | 2431  | 1.5        | 1.7        | 2.0     | 1.5     |
| Roofbolter Operator       | 1.6       | 5297  | 1.6        | 1.7        | 1.7     | 1.3     |
| Utility Man               | 1.6       | 1385  | 1.7        | 1.6        | 1.8     | 1.1     |
| Continuous Miner Helper   | 1.5       | 6668  | 1.3        | 1.4        | 1.8     | 1.8     |
| Cutting Machine Helper    | 1.5       | 1255  | --         | 1.5        | 1.5     | --      |
| Coal Drill Operator       | 1.3       | 527   | --         | 1.3        | 1.3     | --      |
| Scoop Car                 | 1.3       | 667   | 0.9        | 1.5        | 1.2     | 1.4     |
| Shuttle Car Operator      | 1.2       | 5888  | 1.1        | 1.2        | 1.4     | 1.0     |
| Section Foreman           | 1.0       | 4548  | 0.9        | 1.0        | 1.1     | 0.9     |
| Mechanic                  | 0.9       | 3326  | 1.1        | 0.9        | 1.1     | 0.9     |
| <u>Non-Face</u>           |           |       |            |            |         |         |
| Beltman                   | 1.3       | 760   | 1.3        | 1.1        | 1.9     | 1.5     |
| Laborer                   | 1.2       | 1647  | 1.2        | 1.2        | 1.6     | 1.2     |
| Stopping Builder          | 1.2       | 748   | 0.9        | 1.2        | 2.1     | 1.2     |
| Supplyman                 | 0.9       | 582   | 0.9        | 0.8        | 1.6     | 0.9     |
| Mechanic                  | 0.7       | 1126  | 0.9        | 0.6        | 1.2     | 0.6     |
| <u>Transportation</u>     |           |       |            |            |         |         |
| Trackman                  | 0.9       | 713   | 0.6        | 0.9        | 1.6     | 0.8     |
| Motorman                  | 0.8       | 1053  | 0.8        | 0.7        | 1.4     | 0.5     |
| <u>All Jobs</u>           |           |       |            |            |         |         |
|                           | 1.2       | 64699 | 1.1        | 1.2        | 1.3     | 1.1     |
|                           |           |       | (5498)*    | (45455)*   | (6813)* | (6933)* |

\*Number of observations. Numbers for jobs within region are generally in proportion to the marginal totals.

TABLE 4.3

YEARLY COMPARISON OF MSHA DATA FOR SELECTED OCCUPATIONS  
IN NCS MINES WITH ALL MINES

| JOB                        | MINE<br>GROUP | 70  | 71  | 72  | 73  | 74  | 75  | 76  | 77  | AVG # NCS<br>OBSERVATIONS/YR |
|----------------------------|---------------|-----|-----|-----|-----|-----|-----|-----|-----|------------------------------|
| Continuous Miner<br>Helper | NCS           |     | 2.0 | 1.8 | 1.5 | 1.4 | 1.4 | 1.5 | 1.2 | 670                          |
|                            | All           |     | 2.2 | 1.9 | 1.4 | 1.4 | 1.5 | 1.6 | 1.3 |                              |
| Shuttle Car<br>Operator    | NCS           | 1.5 | 1.5 | 1.4 | 1.1 | 1.1 | 1.1 | 1.2 | 1.0 | 590                          |
|                            | All           | 1.6 | 1.5 | 1.3 | 1.0 | 1.1 | 1.1 | 1.2 | 1.0 |                              |
| Section Foreman            | NCS           | 1.7 | 1.4 | 1.0 | 0.8 | 0.9 | 0.8 | 1.0 | 0.6 | 450                          |
|                            | All           | 1.6 | 1.2 | 1.1 | 0.8 | 0.7 | 0.7 | 0.8 | 0.5 |                              |
| Roof Bolter                | NCS           | 2.4 | 2.2 | 1.9 | 1.6 | 1.5 | 1.6 | 1.7 | 1.3 | 530                          |
|                            | All           | 2.6 | 2.3 | 2.0 | 1.5 | 1.5 | 1.5 | 1.6 | 1.3 |                              |

TABLE 4.4

MSHA OPERATOR AND INSPECTOR DATA FOR CONTINUOUS MINER HELPERS  
BY YEAR AND REGION FOR NCS MINES

| SAMPLER   | YEAR         |              |              |              |              |              |              |              |              |
|-----------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|           | 71           | 72           | 73           | 74           | 75           | 76           | 77           | 78           | 79           |
| Inspector | 2.0<br>(94)  | 2.0<br>(210) | 1.4<br>(58)  | 2.0<br>(84)  | 1.3<br>(103) | 1.4<br>(78)  | 1.4<br>(64)  | 1.7<br>(49)  | 1.3<br>(49)  |
| Operator  | 2.0<br>(618) | 1.8<br>(749) | 1.5<br>(784) | 1.4<br>(813) | 1.4<br>(893) | 1.5<br>(924) | 1.2<br>(774) | 1.2<br>(691) | 1.3<br>(421) |

| SAMPLER   | REGION       |               |              |              |
|-----------|--------------|---------------|--------------|--------------|
|           | CENTRAL PA   | APPALACHIA    | MIDWEST      | WEST         |
| Inspector | 1.7<br>(70)  | 1.7<br>(533)  | 1.9<br>(62)  | 1.9<br>(124) |
| Operator  | 1.3<br>(640) | 1.4<br>(4806) | 1.8<br>(445) | 1.8<br>(777) |

TABLE 4.5

## MSHA INFORMATION ON LONGWALL JOBS IN THE NCS

| JOB         | OPERATOR SAMPLES                                   |   | INSPECTOR SAMPLES                                  |
|-------------|--|---|--|
|             | DUST CONC (mg/m <sup>3</sup> )<br>ALL OBSERVATIONS | DUST CONC (mg/m <sup>3</sup> )<br>WESTERN MINES | DUST CONC (mg/m <sup>3</sup> )<br>ALL OBSERVATIONS |
| Jack setter | 1.6 (373)  | 1.7 (93)  | 1.8 (10)   |
| Shearer     | 2.0 (260)  | 2.6 (75)  | 2.2 (23)   |
| Tailgate    | 2.3 (279)  | 3.1 (132)                                       | 2.6 (18)   |
| Headgate    | 1.2 (263)  | 1.0 (57)  | -- (1)   |

Figure 4.1 Variability between bi-monthly means  
1974-79 for four occupations.

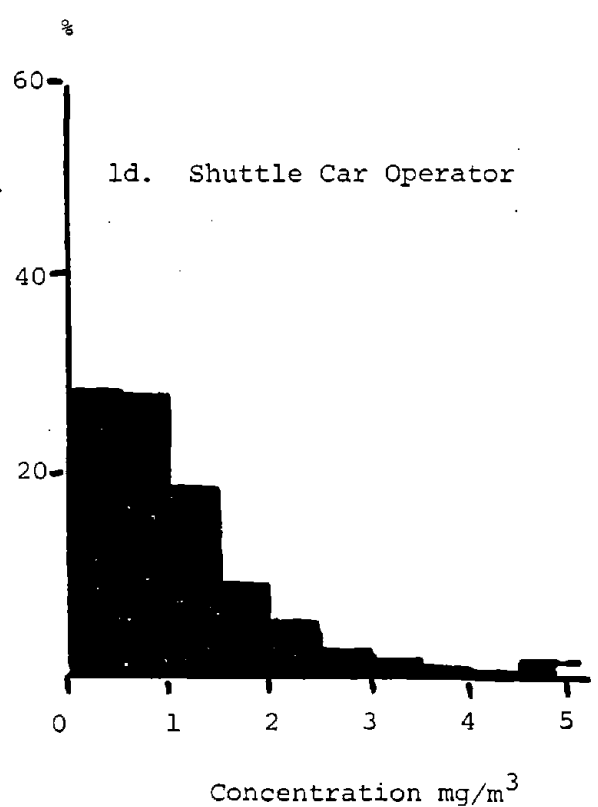
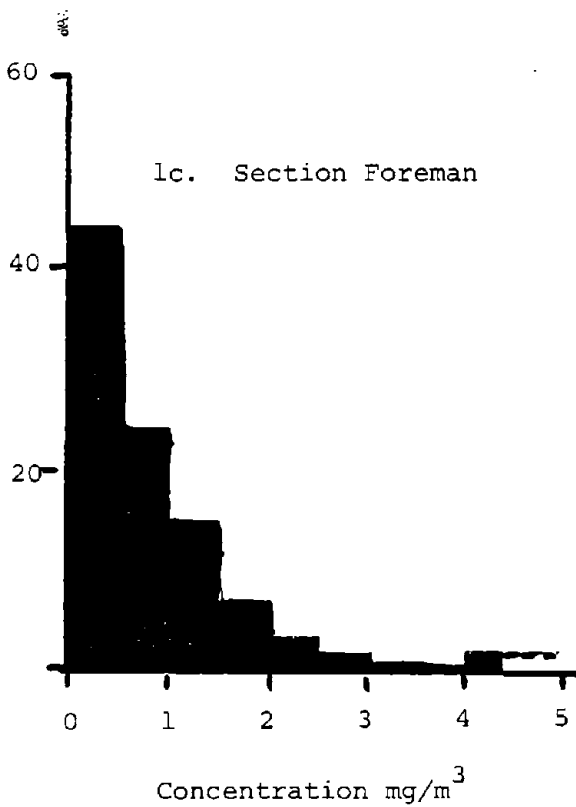
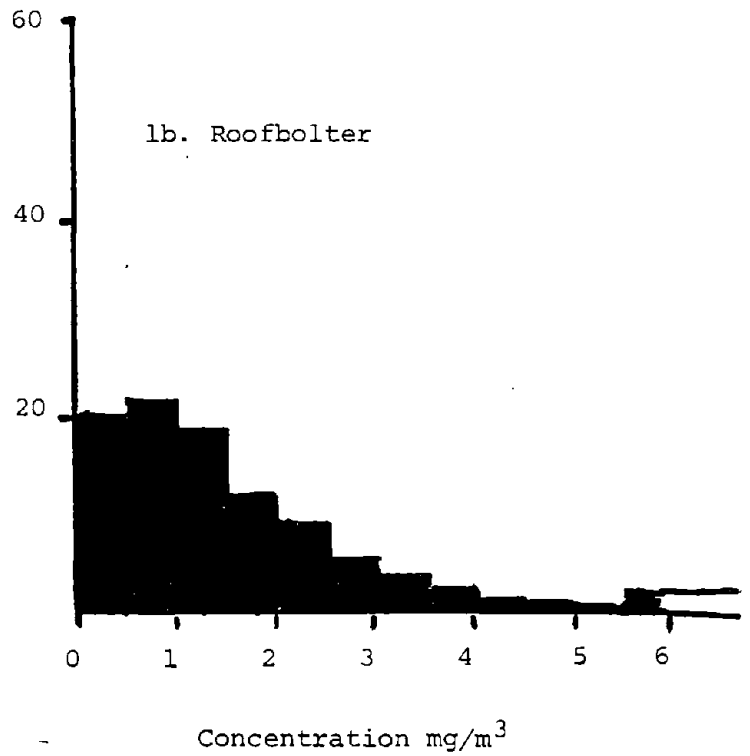
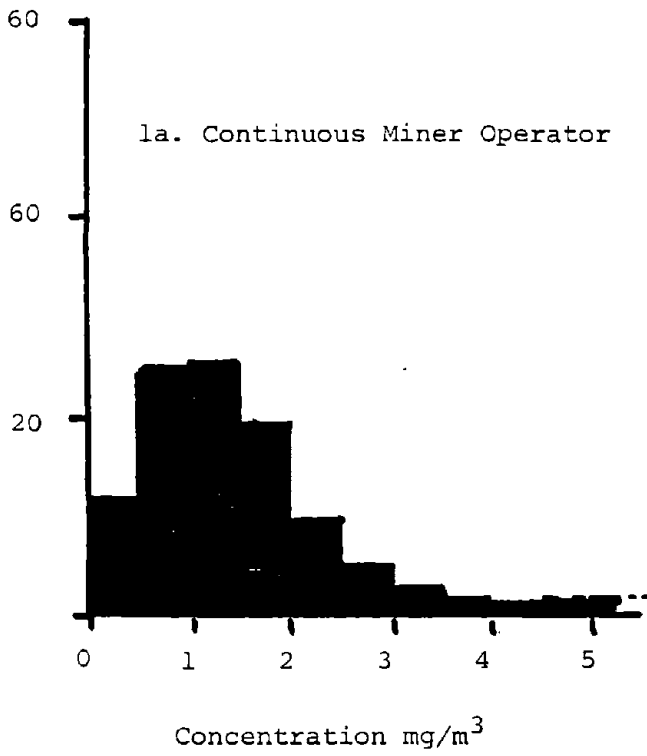
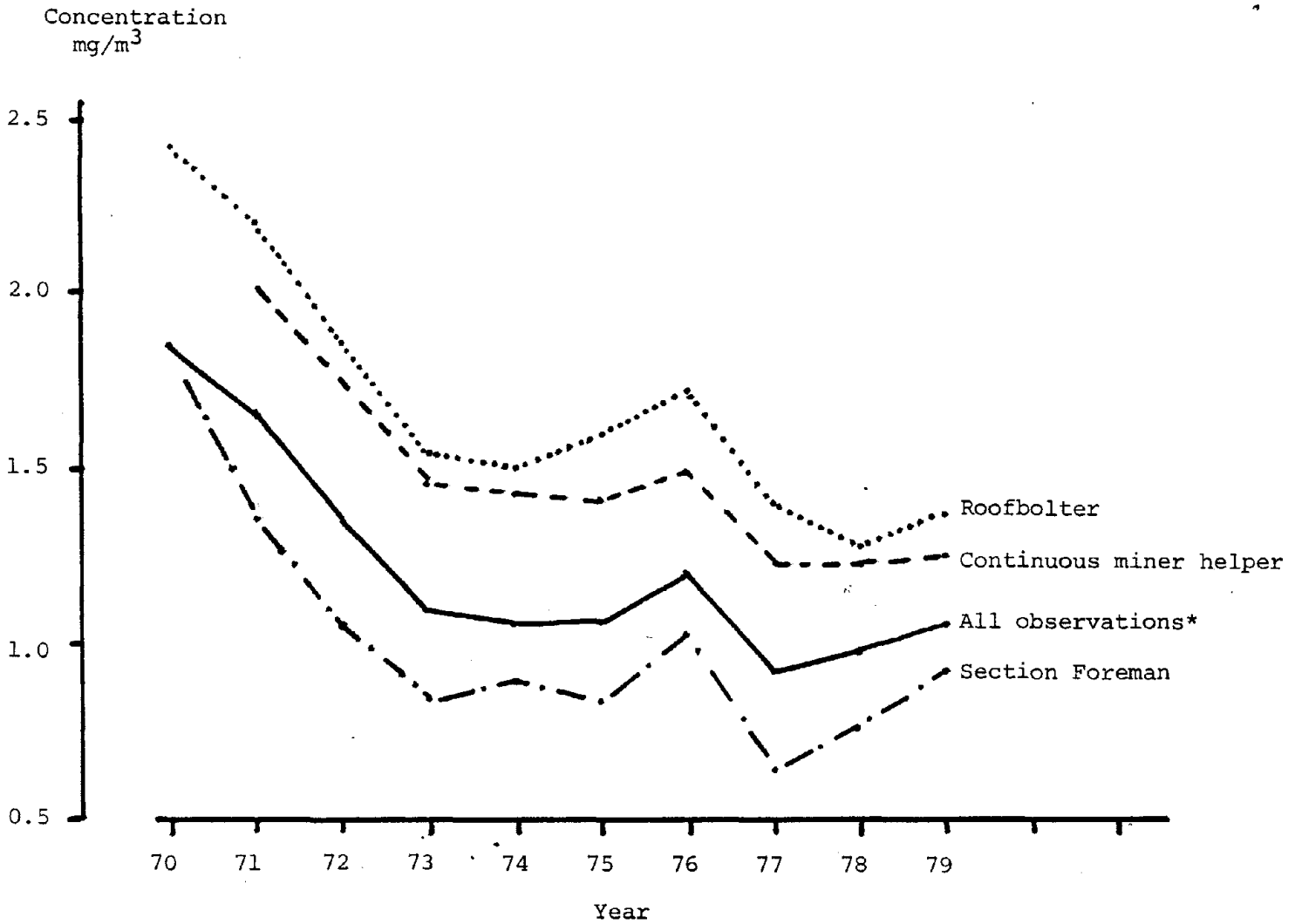


Figure 4.2 Temporal trend in dust levels for all jobs, and for four selected occupations.



\*Values for shuttle car operator are very close to those for all observations.

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CHAPTER 5  
LONGITUDINAL DECLINE IN FEV<sub>1</sub>  
IN U.S. COAL MINERS

5.1 SUMMARY

Ventilatory function measurements of U.S. miners working at 24 nationally distributed mines who had participated at two surveys held nine years apart were analyzed in relation to smoking, dust exposure, and other factors. The results showed trends very similar to those reported among British miners (Love and Miller, Thorax 1982). Loss in FEV<sub>1</sub> over time was found to be related to smoking and to the amount of time spent working at the coal face between the surveys. Similar indications were also seen for other coal dust indices including dust level and work underground undertaken prior to the initial survey. The results confirm the relationship between work in coal mines and loss in ventilatory function reported in Britain, and also seen cross-sectionally.

## 5.2 INTRODUCTION

The National Coal Study (NCS) is a longitudinal investigation of lung disease in U.S. underground coal miners in association with dust exposure. Begun in 1969 with surveys at 31 nationally distributed mines, the NCS has now completed two further surveys and has studied over 1,000 miners over a period of about nine years. At each of these surveys information on ventilatory function, chest symptoms, and working and smoking history was elicited. In addition, dust exposure data for these miners were obtained from the Mine Safety and Health Administration (MSHA). These data have been used to examine the longitudinal change in FEV<sub>1</sub> over the nine year period, and its relationship to job and dust exposure. This is believed to be the first report on long term change in ventilatory function in U.S. miners.

The form of the NCS parallels that of another large study of coal miners - the Pneumoconiosis Field Research of the National Coal Board in Britain. Like the NCS, this has involved the repeated examination of miners over the long term using somewhat similar methods and techniques.

Results on longitudinal ventilatory function change in the PFR have recently been published by Love and Miller (1982). These involved changes in FEV<sub>1</sub> over a ca. 11 year period. The results showed correlations between decrements in FEV<sub>1</sub> and dust exposure after allowance for age, height, smoking, and average mine effects. It is of direct interest to determine whether these results on British miners apply to U.S. miners. Accordingly, the format of the present analysis has been organized along similar lines to that of Love and Miller to facilitate comparison.

## 5.3 METHODS.

The data considered here were drawn from medical surveys taken initially at 31 nationally distributed mines between 1969 and 1971, and again between 1977 and 1981. During the inter-survey period, certain of the mines closed while for certain others too few miners attended both surveys to warrant the inclusion of those mines in the analysis. As a result, data from 24 mines was eventually available for analysis.

Participation in the first round was good at ca. 95%, while that for the later set of examinations was poor at around 60%. This caused difficulties in analysis which are dealt with later. Of the 9,078 miners in the first round, 1,470 were common to both surveys. Rejection of observations for reasons explained later reduced this number.

### 5.3.1 Measurements of spirometry

In the first round of surveys final FEV<sub>1</sub> determinations were obtained as the largest value of up to five exhalations (including at least two practice blows. In the latter round, up to 10 blows were permitted, but for this analysis, only the first five blows were considered so as to be consistent with the first round.

### 5.3.2 Dust Measurements

Dust data were available for the years 1970 to 1979. Each record on the dust tapes supplied by MSHA contained information on mine, job, miner's social security number, date and concentration, among other data. Records on these tapes were linked to the medical information by means of the social security number, and then averaged by a two-stage process. The data for each miner was first averaged according to bi-monthly period, these means were then themselves averaged by person. The second approach was pursued since it was thought that the increased frequency of sampling which takes place when a coal face (section) is out of compliance could have biased the simple averages upwards. Chapter 4 gives further information on the dust levels.

### 5.3.3 Methods of Analysis

In order to insure comparability with the methods of Love and Miller the following procedure was followed. Simple decrements in  $FEV_1$  were obtained by subtraction of the  $FEV_1$  obtained at the latter survey from the first round value. These were then standardized to an eleven year loss in  $FEV_1$  by application of the formula

$$(\text{First } FEV_1 - \text{Last } FEV_1) / (\text{Years between surveys}) \times 11$$

A miner whose smoking classification was the same at both surveys was defined as a 'nonsmoker', 'ex-smoker', or 'current smoker'. Those giving inconsistent replies, and those taking up or dropping smoking in the interim were classified as 'intermittent smokers'.

Change in  $FEV_1$  standardized to 11 years was related to age, height, smoking, job and dust exposure using least squares estimation of linear models. Mine differences considered as a factorial term were also included in some models.

### 5.3.4 Groups Studied

1,470 miners attended both of the surveys considered here. As explained later, analysis was restricted to those between 20 and 49 years; there were 1,161 miners in this group. Deletion of three mines at which the numbers of 'survivors' were each less than 10, and deletion of observations with missing ventilatory function data further reduced this number to 1,072. This group is used in the initial analysis. Dust data for 957 of the 1,072 was available; this subset was used in analysis of the association between ventilatory function decrements and dust concentration.

## 5.4 RESULTS

### 5.4.1 Analysis of Longitudinal Changes

Some statistics derived from the 1,072 miners are shown in Table 5.1. The mean age at the latter survey was 37 years, and the group had spent about 11 years of their working life underground prior to the first survey. Close to 80% of the time between surveys on average was spent underground, with a mean of 30% at the face. The mean dust concentration for the 957 as obtained from MSHA was  $1.2 \text{ mg/m}^3$ . Forty percent of the group admitted to being current smokers at both examinations.

The 11 year adjusted decrements in  $\text{FEV}_1$  are shown in Table 5.2 for the 1,072 miners. Decline in  $\text{FEV}_1$  clearly increased with age, and by smoking habit. The decrements are greater both in absolute and in relative terms in the older compared to younger age groups. Among the smoking groups, current smokers showed the greatest decline and nonsmokers and ex-smokers the least. The data also indicate that  $\text{FEV}_1$  decline is greater where the  $\text{FEV}_1$  level is lower, a finding noticed elsewhere (Love and Miller, 1982; Fletcher et al, 1976).

The relationship between adjusted eleven year decline in  $\text{FEV}_1$  and potential causative and confounding variables was explored through multiple regression analysis. Using adjusted eleven year decline as a response variable, models were fitted which included combinations of age, height, smoking indicators, mine effects and indices of dust exposure as predictor variables. Both smoking status and pack years were used to measure smoking, while exposure indices included years underground prior to the initial survey, years worked at the face prior to the first survey, years worked at the face and underground between the two surveys, and average dust concentration between the surveys derived as described earlier.

Four models were considered of particular interest. These all included age, height, smoking status and mine effects. Each model included one only of the following four exposure indices: years at the face between surveys, years underground between surveys, average dust concentration, and work underground prior to the initial survey. Table 5.3 shows the coefficients obtained for each of the models. In all cases age, height, smoking status and mine effects showed statistically significant associations with  $\text{FEV}_1$  decline ( $p < .01$ ). Increased age and height were associated with greater decline while current smokers showed greater declines than nonsmokers. Intermittent smokers appeared to have declined at a rate between that of current smokers and nonsmokers, although, surprisingly, ex-smokers showed the lowest declines. Findings were mixed for the exposure variables. Intersurvey years in face work was statistically significantly associated with greater reductions in  $\text{FEV}_1$  ( $p < .05$ ); and this trend was reflected in each of the other exposure coefficients though none achieved conventional levels of statistical significance.

Models additional to those shown in Table 5.3 were also fitted. In these various approaches were tried including omission of mine effects, substitution of pack years for smoking status, and use of total tenure underground or at the face in place of intersurvey exposure. In general, the results were little changed, particularly when smoking status was replaced by pack years. Use of total years underground or at the face resulted in somewhat better correlations with FEV<sub>1</sub> change than use of concurrent exposure alone. Removal of mine effects from the model reduced the absolute magnitude of the coefficients of concurrent tenure but did not alter the basic conclusions.

The equations shown in Table 5.3 have been used to obtain predicted declines for various levels of exposure to dust and smoking. For the two equations using intersurvey tenure the levels of interest were both set at 0 and 11 years of work underground and at the face respectively. For the dust concentration model, values were set at 0 and 2 mg/m<sup>3</sup> (the current U.S. dust standard), while zero and 35 years underground were used for model IV (for comparison with Love and Miller). Comparison was made to the difference between the effects observed for smokers and never smokers.

The results are shown in Table 5.4. All four models indicated that smoking was associated with an average reduction in FEV<sub>1</sub> over 11 years of close to one-tenth of a liter. In contrast the effect of work in coalmining or dust exposure was variously estimated at levels between 0.04 and 0.08 liters. Computation of the ratios of the predicted effects of smoking to dust exposure resulted in ratios varying between 1.1 and 2.6 with an average close to 1.5. Use of pack years instead of smoking status in models I and II (detailed results not given here) led to smoking/exposure index ratios of 2.2 and 1.2 respectively. Hence these results offer a confirmation of the earlier findings.

## 5.5 DISCUSSION

Comparison of the results reported here has been made with those from the British work described recently by Love and Miller. Both of these investigations involved the longitudinal study of working coal miners over roughly the same period, and used similar techniques and methods. Major differences lay in the availability and type of dust exposure data employed, and in the average age of the groups.

In general the U.S. miners were younger and taller than their British colleagues. Although the predominant group among both cohorts was the smokers, the general distribution of smoking status was different, with the U.S. miners demonstrating a more even spread over the four smoking groups considered. Mean FEV<sub>1</sub> levels were similar, particularly among the two smoking groups, but U.S. miners in the non and ex-smoking groups exhibited greater FEV<sub>1</sub> values. Comparison of dust data is difficult because of the different indices employed, but it is reasonable to assume that levels in U.S. mines are currently lower since the compliance level is lower in the United States.

There is good agreement between the two studies in terms of general decline in FEV<sub>1</sub> standardized to 11 years. Comparison of age-specific FEV<sub>1</sub> changes (Table 2 of Love and Miller, and Table 3 of this paper) reveals mean declines of 0.45 for the <39 year group (actually 30-39 years) among the British miners, and the same for U.S. miners. Values for the 40-49 year group were 0.51 and 0.53 respectively for the British and U.S. miners. Results by smoking group were also similar, particularly for smokers and nonsmokers, though the U.S. ex-smokers and intermittent smokers demonstrated lower declines than their British colleagues.

As in the Love and Miller study, age, height, smoking status and mine effects all showed statistically significant associations with FEV<sub>1</sub> change. Decline with age was three times greater than in the British study, and exhibited greater statistical significance, though the relationship of FEV<sub>1</sub> decline to height was similar in both studies.

The models in the present investigation accounted for 12% of the total variability, somewhat greater than the R<sup>2</sup> of 6% of Love and Miller. The reason for this superiority probably lies with the mine effect term, which, due to the inclusion of more mines in the U.S. study, had more levels. Dropping the mine effect term in the present analysis reduced R<sup>2</sup> to 6%. Love and Miller have discussed reasons for these low R<sup>2</sup> values and noted that they are typical in longitudinal studies of lung function.

Though both the British and the current study detected relationships between dust exposure indices and FEV<sub>1</sub> changes, it is difficult to compare the coefficients as these indices were dissimilar in nature. The PFR investigation had at hand comprehensive dust exposures derived both from measurement prior to, and during the inter-survey period. In contrast the only data available to this study were inter-survey concentrations which were not collected, in the main, for epidemiological investigation. In addition, extrapolation of these data to times prior to the first survey was not felt to be justified as there is evidence of a substantial change in general dust conditions around 1969 when the Mine Safety and Health Act came into force.

Despite these differences, the basic similarity between the two studies calls for comparison of the estimated effects of dust exposure. Love and Miller state that 245 ghrs/m<sup>3</sup>, which corresponds to a lifetime's exposure to coal dust at current British regulatory levels, is associated with a subsequent 11 year average excess decline of 0.087 liters. This exposure of 245 ghrs/m<sup>3</sup> corresponds to 35 years work at a mean concentration close to 4 mg/m<sup>3</sup> (Love, 1983). In the present study 35 years of underground work was found to be associated with 0.084 liters of excess decline (Model IV, Table 5). This agrees well with the British results. However, without information on the general dust level prior to the initial NCS survey we cannot establish complete correspondence. Fortunately, some data on dust levels in U.S. mines prior to 1969 does exist and can be employed to assist in the comparison. This data (Jacobson, 1971) indicates a general dust level of around 4 mg/m<sup>3</sup>, and leads therefore to the inference that both studies appear to be in good agreement over the effects of dust.

Comparison of the relative effects of dust exposure and smoking can be made from the results of both studies, although care should be exercised as the magnitude of smoking/dust exposure ratios depends very much on the levels of dust and smoking. Love and Miller state that 'the magnitude of the predicted effect of the average exposure to dust on rate of loss of FEV<sub>1</sub> appeared to be about one-third of the average loss due to smoking'. The results presented here are generally consistent with their finding. Changes in dust levels and smoking habits initiated since the initial survey may result in these estimates being different in the future.

5.6 REFERENCES

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TABLE 5.1

## CHARACTERISTICS OF THE STUDY POPULATION OF 1072

| VARIABLE                           | MEAN    | S.D. |
|------------------------------------|---------|------|
| Age at first survey (years)        | 37      | 9    |
| Height at first survey (cm)        | 176     | 7    |
| FEV <sub>1</sub> * (L)             | 3.7     | 0.7  |
| Smoking Status:                    |         |      |
| Nonsmokers                         | n = 211 |      |
| Ex-smokers                         | n = 199 |      |
| Intermittent                       | n = 228 |      |
| Current smokers                    | n = 431 |      |
| Unknown                            | n = 3   |      |
| Tenure:                            |         |      |
| Years UG prior to first study      | 11      | 9    |
| Years UG between surveys**         | 9       | 4    |
| Years at face between surveys**    | 3       | 4    |
| Dust concentration between surveys | 1.2     | 0.8  |

\* Mid-point of adjusted 11 year period

\*\* Adjusted to 11 year period.

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TABLE 5.2

AGE AND SMOKING SPECIFIC ADJUSTED FEV<sub>1</sub> CHANGES

|                      | Age Group (years) |       |       |          |
|----------------------|-------------------|-------|-------|----------|
|                      | 20-29             | 30-39 | 40-49 | All Ages |
| Nonsmokers           | 0.38*             | 0.42  | 0.48  | 0.44     |
|                      | 4.34              | 3.84  | 3.51  | 3.81     |
|                      | 0                 | 0     | 0     | 0        |
|                      | (57)              | (48)  | (106) | (211)    |
| Ex-smokers           | 0.36              | 0.34  | 0.47  | 0.44     |
|                      | 4.02              | 3.84  | 3.42  | 3.56     |
|                      | 0                 | 0     | 0     | 0        |
|                      | (20)              | (37)  | (142) | (199)    |
| Intermittent Smokers | 0.34              | 0.40  | 0.54  | 0.46     |
|                      | 4.19              | 3.80  | 3.24  | 3.62     |
|                      | 3.9               | 4.9   | 3.2   | 3.8      |
|                      | (63)              | (49)  | (116) | (228)    |
| Current Smokers      | 0.42              | 0.50  | 0.60  | 0.52     |
|                      | 4.09              | 3.65  | 3.13  | 3.54     |
|                      | 7.6               | 8.1   | 7.8   | 7.9      |
|                      | (97)              | (159) | (175) | (431)    |
| All Miners           | 0.38              | 0.45  | 0.53  | 0.48     |
|                      | 4.17              | 3.73  | 3.31  | 3.61     |
|                      | 4.1               | 5.2   | 3.2   | 4.0      |
|                      | (237)             | (294) | (541) | (1072)   |

\* Key: 11-year adjusted change in FEV<sub>1</sub>

Mean FEV<sub>1</sub>

Mean Pack years

(Number of miners)

TABLE 5.3

REGRESSION COEFFICIENTS ESTIMATED USING FOUR DIFFERENT MODELS  
ON ELEVEN YEAR ADJUSTED FEV<sub>1</sub> DECLINE

Model I -- Using inter-survey work underground  
 Model II -- Using inter-survey work at face  
 Model III -- Using inter-survey dust concentration  
 Model IV -- Using prior tenure underground

|  | MODEL    |          |          |          |
|--|----------|----------|----------|----------|
|  | I        | II       | III      | IV       |
| Intercept  | -1.16    | -1.21    | -1.25    | -1.08    |
| Age (years)  | 0.011*** | 0.011*** | 0.011*** | .009***  |
| Height (cm)  | 0.007*** | 0.007*** | 0.007*** | .007***  |
| Smoking Status<br>(Relative to Nonsmokers)         |          |          |          |          |
| Nonsmokers   | 0 **     | 0 **     | 0 **     | 0 ***    |
| Ex-smokers   | -.027 ** | -.027 ** | -.045 ** | -.028*** |
| Intermittent smokers                               | .013 **  | .013 **  | .019 **  | .012***  |
| Current smokers                                    | .095 **  | .096 **  | .093 **  | .096***  |
| Mine Effects (see note below)                      | ***      | ***      | ***      | ***      |
| Inter-survey UG work (yrs)                         | .0033    | ---      | ---      | ---      |
| Inter-survey at face (yrs)                         | ---      | .0073*   | ---      | ---      |
| Inter-survey<br>concentration (mg/m <sup>3</sup> ) | ---      | ---      | 0.028    | ---      |
| UG work prior to<br>initial survey (years)         | ---      | ---      | ---      | .0024    |

Note on mine effects: Results from 24 mines were included in this analysis. The large number of coefficients precludes their inclusion here. Over 0.5 liters difference was seen between the mine with the greatest decline and that with the least.

Key: \*p<.05, \*\*p<.01, \*\*\*p<.001.

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TABLE 5.4

PREDICTED AVERAGE EFFECTS OF DUST EXPOSURE AND SMOKING  
ON 11 YEAR ADJUSTED FEV<sub>1</sub> DECLINES  
(Results from Table 4, expressed in liters decline)

MODEL I

|   |      |
|---|------|
| Decline associated with 11 years work underground | .036 |
| Decline associated with smoking*                  | .095 |
| Ratio   | 2.6  |

MODEL II

|   |      |
|---|------|
| Decline associated with 11 years work at the face | .080 |
| Decline associated with smoking*                  | .096 |
| Ratio   | 1.2  |

MODEL III

|   |      |
|---|------|
| Decline associated with exposure to 2 mg/m <sup>3</sup> coal dust | .056 |
| Decline associated with smoking*                                  | .093 |
| Ratio   | 1.7  |

MODEL IV

|  |      |
|--|------|
| Decline associated with 35 yrs work UG prior to 11 yrs | .084 |
| Decline associated with smoking*                       | .096 |
| Ratio  | 1.1  |

\*Comparison between current and nonsmoker.

(80)

CHAPTER 6  
ANALYSIS OF READINGS FROM THE  
SURVEILLANCE PROGRAM

### 6.1 SUMMARY

The prevalence, incidence and progression of coal workers' pneumonconiosis has been studied through the examination of X-ray readings of miners who participated in the X-ray Surveillance Program for underground coal miners. Three rounds of this program have been held to date over a 10 year period; this interval corresponds closely to the time in which Federal dust control standards have mandated that the level of dust should be restricted to 3 mg/m<sup>3</sup> or less (currently 2 mg/m<sup>3</sup>). The analyses undertaken here, being based on a much larger base of miners than were those of the National Coal Study are therefore complementary to those of Chapter 3.

In the first analysis, readings from the third round of the program were tabulated for a group of miners with less than 10 years experience in coal mining. The prevalence of category 1 or greater among those with 1-9 years of mining experience was 1.1%, compared to 0.7% among those with zero years of coal mining work. After eliminating those cases with prior dust exposure (non-coal-mining) these percentages were 1.1% and 0.6%. Conversion of the readings to an average determination using similar methods to those often used in epidemiological investigation, compared to using the surveillance final determinations which are more sensitive to the detection of abnormality, gave prevalences of 0.8 and 0.4% respectively for the two groups. These figures should be compared to a prevalence of 0.4% seen in a non-exposed blue collar group of workers studied elsewhere.

The second study included in this chapter consisted of the re-reading of X-ray films from the first and third rounds, of miners who were new to coal mining at the first round. Films for 1834 such miners were read independently randomized by three qualified B readers. About as much regression as incidence and progression was seen in these X-rays. The incidence rate of pneumoconiosis from category 0/0 over the 10 years was 4.6% if regression was disregarded. If, however, the incidence rate was adjusted for regression, assuming that regression can be regarded as an indicator of 'noise', the adjusted rate fell to 1.2%, a value below that expected from established dose-response curves. Overall, the results from this study, and that on prevalence at the third round do not indicate that excessive rates of incidence and progression are occurring generally in U.S. coalminers when compared to rates expected under the current dust standard. Further study is necessary to validate these findings.

## 6.2 INTRODUCTION

The United States Mine Safety and Health Act of 1969 mandated a program to control respirable dust levels in underground mining environments. The initial level was set at  $3 \text{ mg/m}^3$ , to be reduced to  $2 \text{ mg/m}^3$  beginning December 1972. The level now remains at  $2 \text{ mg/m}^3$ , which makes it one of the lowest worldwide.

The same Act mandated a health surveillance program available to all working coal miners. This program, referred to here as the 'X-ray surveillance program' is operated by the National Institute for Occupational Safety and Health (NIOSH). The first round of the program began in 1970. Since then two additional rounds have been completed, providing a base of over 200,000 chest radiographs.

The following is a report on two studies undertaken using the X-rays and readings from the Surveillance Program. The first uses existing X-ray readings from the third round of the program to investigate the prevalence of pneumoconiosis in certain groups of miners. In this, the readings have been summarized over readers using the methods employed in the Surveillance Program itself, and also as if they had been gathered for epidemiological purposes. This distinction is clarified later.

The second is an investigation into radiological changes (incidence and progression) in miners new to mining at the first round. It involved the extraction and re-reading of X-rays of miners who attended both the first and third rounds of the program. These analyses are complementary to those described in Chapter 3, both of which are concerned with the question of whether the current U.S. dust standard is sufficient to protect the health of coal miners. Some of this material has been presented elsewhere (Attfield et al, 1983)

## 6.3 METHODS

Section 203 of the Mine Health and Safety Act mandated that every coal miner working as of December 1969 be eligible for a chest radiograph at least once every five years at the operator's expense. In addition, every new miner must be given a chest radiograph within six months of employment, followed by a second x-ray three years later. If the second x-ray shows signs of coal workers' pneumoconiosis, then a third must be taken two years later. The examination itself consists of a single postero-anterior chest radiograph. Additional data recorded at the time of examination includes age, job classification, region of mining, years of mining tenure, and previous employment information.

Since 1970, the X-ray Surveillance Program has been administered in three "rounds". Each round has included both an open period for working miners plus

an interim period for new miners. Round one extended from January 1970 to July 1973, Round two from August 1973 to July 1978, and Round three from August 1978 to December 1980. Totals for each round were 77,750; 122,625; and 63,519 respectively.

The following paragraphs describe the methods used in each analysis separately; section 6.3.1 is concerned with the prevalence data, while 6.3.2 deals with the incidence study.

### 6.3.1 Prevalence of CWP at the third round.

#### 6.3.1.1 Population studied.

The population studied here consisted of all miners who attended the third round of the Surveillance Program and who had worked less than 10 years in coal mining at the time of examination. The information on tenure was obtained from a brief questionnaire the miner had completed at the time of attendance.

#### 6.3.1.2 X-ray readings

The surveillance study data analysed here comprise the film readings undertaken during the third round of the program. Readings are available for 'new miners' (those starting work in the mines for the first time), and working miners (who are entitled to an x-ray approximately every five years). During this latest round NIOSH received the x-rays from the various facilities certified to take them, together with an x-ray reading by an 'A' or 'B' reader from that facility. NIOSH then dispatched the x-rays to a second reader who was a 'B' reader. If the two readings agreed to a predetermined degree the x-ray was assigned a certain category of CWP according to the level of abnormality found. If the two readings did not agree to the required extent, a further 'B' reading was obtained, and if this still did not yield agreement, a final determination was made by a panel of readers. In all cases the criterion for simple CWP was based on small opacities.

#### 6.3.1.3 Summarization of X-ray readings.

The variability inherent in X-ray reading mandates that several X-ray readers be involved, and that their readings be summarized so as to reflect a consensus of opinion. There are various ways the readings can be summarized to give final determinations; choice of method depends upon the use to which the result is to be applied. In the Surveillance Program the aim is to protect the health of the coal miner. As a result the summarization procedure is formulated to err on the side of detection of disease. In contrast, in summarization of readings for epidemiological purposes a common aim is to get a best estimate of the true level of abnormality by taking average or median readings.

The method of summarization of the X-rays used to obtain final determinations under the Surveillance Program is given in Appendix 6.1. For the purpose of comparing these X-ray readings with other data available from epidemiological studies, the readings have also been summarized along lines similar to those that might be used in epidemiological studies. The technique for doing this is described in Appendix 6.2.

### 6.3.2 Incidence and progression study

#### 6.3.2.1 Selection

Of the total participants, 10,700 miners participated in both rounds one and three. A subgroup of 1,834 was selected from these repeaters who had a maximum of 2 years tenure prior to round one. This group, referred to here as the 'new miner' group had experienced a maximum of 12 years work in coal mining by the time of the third survey.

#### 6.3.2.2 X-ray reading techniques

1,834 pairs of chest x-rays were selected and randomized according to a computer generated randomization scheme. Films were batched into groups of 100 and read "independently" by each of three "B" readers, under the 1971 ILO/UC Classification of the radiographic appearances of pneumoconiosis (ILO, 1971). A median or middle value of the three readings was determined for the profusion of small rounded opacities.

#### 6.3.2.3 MSHA dust data.

Environmental data for the 1,834 miners studies was extracted from Mine Safety and Health Administration (MSHA) tapes of dust concentration for 1970 through 1979. Mean concentrations were computed for the individual miners in the study group. 1,794 of the 1,834 miners were linked to individual dust readings. Since the MSHA data is collected mainly for compliance purposes, and as sampling is increased when working areas appear to be out of compliance, there is a possibility of bias toward higher mean values. However, chapter 5 compared means computed on bi-monthly averages over the nine years to simple overall means and found little difference in the results.

#### 6.3.2.4 Statistical methods

In independent film reading, quality and technique differences in X-rays contribute to the occurrence of variability (see chapter 3). One would expect to see this random variability reflected by equal amounts of regression and progression, assuming no net progression exists. In our findings, we use as a best estimate for progression a new value computed by subtracting the proportion of cases regressing to any one starting category from the proportion progressing from the same category. Any excess indicates net progression.

A case-control analysis was done to compare dust concentrations across selected matched groups. A group showing two or more minor units of progression was matched on age (+ 1 year) at first round and region of mining (Midwest, Appalachian, West) to a group showing two minor units of regression and to a group with no change in x-ray reading. Since all miners had roughly the same mining tenure (10 year average) mean concentration rather than time weighted-averages were compared. The selected groups were also compared for differences in job site in the mine. Jobs were classified as face/non-face to coincide with expected exposures related to mine jobs.

#### 6.4 RESULTS

The first part of this results section (6.4.1) is concerned with the prevalence at the third round in miners with less than 10 years of coal mining exposure. The reason for this restriction on work exposure is to determine what level of pneumoconiosis existed in these miners after 10 years or less work in dust levels controlled to 3 and later 2 mg/m<sup>3</sup> over that time. In essence, this is equivalent to examining incidence over nine or fewer years, as these miners would be expected to be category 0/0 at the start of exposure. However, for the purpose of distinguishing between this and the other study reported in this chapter, this analysis is defined as a study of prevalence. Section 6.4.2 is concerned with the results of the examination of incidence of CWP in new miners using re-reading of first and third round X-rays.

##### 6.4.1 Prevalence at the third round.

Only readings for those miners having between 0-9 years of mining experience are considered here, as this is the period during which strict dust standards have been in force. The data from the readings of the 48,744 miners in this group are shown in Table 6.1. Those having zero years of experience as recorded are taken to be 'new starts'; i.e., miners with no previous coal mining experience, and their determinations have been divided from the 1-9 years of work group. The prevalence of CWP (major category 1 or greater) in the latter group was 1.13% while that for the 'new starts' was 0.65%.

Since this overall group contains miners with previous work in dusty non-coal mining jobs, it was thought prudent to exclude such people from analysis as any abnormalities may have arisen from their work prior to coal mining. The results of this are shown in Table 6.2. which indicates that there were over 7,000 people with such prior exposure. The prevalences are now 1.09% for the 1-9 year group, and 0.59% for the remainder.

In order that the level of abnormality can be compared to other groups, an attempt was made to derive 'epidemiological' determinations from the existing individual readings. Results after conversion are shown in Table 6.3. The prevalences of pneumoconiosis reduce now to 0.44% for the zero years group, and to 0.79% for the 1-9 years group.

These results have been compared to those for a group of nonexposed 'blue collar' workers. Of the 2,337 workers studied, 10 cases of small rounded opacities were detected giving a prevalence of 0.43%, close to the 0.44% seen above.

#### 6.4.2 Incidence and progression.

##### 6.4.2.1 Dust levels.

Mean dust concentration by occupation for new miners are presented in Table 6.4 along with comparable data from mines in the National Coal Study (NCS) (see chapter 3). The National Coal Study is used because no other recently published comparable dust data exists. The concentrations for the new miners appear to vary less across jobs than for the NCS miners. Values for jobs with highest concentrations in NCS, i.e. cutting machine operator and laborer are lower in the new miner group, while the jobs with the lowest concentration in NCS, mechanics and motormen have higher levels in the new miner group. The smaller numbers of observations may have some effect on the mean values. These mean concentrations are not in themselves the basis for analysis. However, they do indicate that "new miners" did not have reported dust exposures greatly divergent from those of other miners.

##### 6.4.2 Data description

Descriptive data on age, region and job for the new miner group follows. The average age at first survey was twenty-eight years. At the third survey, the mean job tenure was 10 years. Twelve states were represented by the new miner group; 88% of the miners were from Appalachia, 11% from the Midwest, and 1% from West. None were from the Anthracite region of Pennsylvania. Of the Appalachian miners 20% were from Pennsylvania, 47% were from West Virginia, and 32% were from Kentucky.

Job status at round three for the new miner group represents a shift from general laboring jobs to jobs in the mine which require more training and skill. At round three the four largest groups were mechanics (19%), foreman (17%), roof bolters (14%), and continuous mining machine operators (10%). Round one job distributions for these miners reflect a higher proportion of unskilled labor jobs likely to be assigned to new workers. Highest proportions of miners were pipemen and pumpmen (24%), miscellaneous workers (9%), shaft attendants (8%) and rope riders (6%). These shifts seem consistent with the need for training for most jobs involved with operating machinery in the mine.

### 6.4.3 Radiological findings

Results of the x-ray reading trial are presented in Table 6.5. Progression from categories 0/0, 0/1, and 1/0 were 4.6%, 11.4% and 2.7%, if regressors were included in the no change category. If progression is calculated using the adjustment discussed earlier, the rates were 1.2%, 4.2%, and 0%.

Jacobsen et al (1971) has presented curves for prediction of probabilities of progression for CWP over ten years from specific starting categories in various dust exposures. The formulae for these curves are given in Jacobsen (1973). Figure 6.1 presents these curves. Assuming that the average dust exposure for the 10 year period in the "new miner" group was  $2.5 \text{ mg/m}^3$ , expected progression from category 0/0 was 1.9%, from cat 0/1, 16.2%, and from cat 1/0, 25.4%.

Results of the case control analysis are presented in Table 6.6. No significant differences in dust concentrations were found for progressors vs. regressors or progressors vs. no change group.

For comparison of job status between these groups, results are presented in Table 6.7. No significant differences were seen between groups in regard to face vs. non-face workers. It is worth noting that for this comparison foremen were classified as non-face workers. Based on information from experienced miners (Shapiro, 1984) it is felt that a foreman spends a smaller part of his work time in high dust situations than other face workers. This is supported by the fact that foreman both in the "new miner" and NCS group have the lowest mean dust concentrations of all face workers. No cases of PMF were reported.

## 6.5 DISCUSSION

This study was undertaken, in part, as a complementary analysis to those of Chapter 3. Those investigations were concerned with a group of U.S. miners restricted to a small number of specially selected mines. In addition, most of the miners studied in those reports had worked many years in mining. As a consequence, the results of those investigations do not provide the most valid information on radiological changes in miners with little exposure (new miners). In contrast the present study deals with miners from many different mines who had experienced little exposure to coal mine dust prior to the start of the study. It therefore should provide better information on the ability of the present procedures for dust control to control the incidence and progression of pneumoconiosis in newly employed miners.

Participation in the x-ray surveillance program has been approximately 40 to 45 percent of the underground mining labor force. Since participation in the X-ray program is mandatory for new miners, we believe that the information on

new miners at the first round is reasonably representative. However, participation is not mandatory for miners after start of employment, and our information indicates that few miners choose to attend for examination after their initial X-ray. This self-selection of experienced miners at the third round may have led to the introduction of bias. It is difficult to imagine that the bias is severe in the incidence and progression study as the general degree of abnormality in young miners is typically very low and rarely associated with detectable signs or symptoms. Compared to the state wide distribution of the underground mining labor force in 1980 the new miner group is quite similar. In this respect, the group studied may be considered representative of all new miners in the U.S.

Since these were new miners and dust levels were generally low compared to those existing in the past, one would not expect severe disease. This study was set up in order to determine if this was, in fact, the case. Over the average study period for the follow-up of 10 years a net incidence of 1.2% of CWP from category 0/0 was observed, with virtually no progression from higher starting categories. No cases of PMF were seen. This suggests that the procedures for dust control are not grossly inadequate. However, as CWP is a usually a slowly developing disease, with manifestation generally occurring in the fourth decade or later, the short period of observation in the present study mandates a need for continuing research. The upcoming fourth round of the surveillance program will provide this opportunity.

Comparison of the incidence and progression statistics with those of Chapter 3 reveals that a good degree of consistency. The results of Chapter 3 indicated that levels of incidence ranged from net regression to 1.9% from category 0/0. Estimates of progression varied from net regression to 18% for those miners with pneumoconiosis at the initial survey. The results from this study indicated an incidence from 0/0 of 1.2% , and progression of at most 4.2%, after both statistics had been corrected for regression. Hence, whether or not the miners had experienced previous exposure to coal dust, the incidence and progression were similar, and existed at levels to be expected under the current standards.

The case control analyses indicate that no significant disparities in mean dust exposure existed between progressors, regressors and non-changers. There is no evidence that those who progressed were exposed to consistently higher levels of dust over the 10 year period than those who did not progress. It appears overall that mean dust concentrations for individuals are below compliance levels. However, it is possible that at any given time an individual miner may be exposed to higher concentrations. Our findings are consistent with the expectations proposed by the British findings.

From Table 6.5 it is apparent that some miners, although new to mining at the time showed signs of x-ray abnormality at their first x-ray. There are several reasons why this occurred. Firstly, it appears that a small proportion of non-dust exposed workers' films will be read as abnormal. The

reasons for this are not clear, but could be due to poor films, unusually pronounced markings, or other diseases. A study of non-exposed blue collar workers showed .14% of participants with category 1 based on small rounded opacities (Petersen, 1981). Although the 2% observed in the new miner groups is higher, it is difficult to assess the contribution of x-ray reading variability to this. Another reason pertinent to this study could be that the work history was inadequate or in error, leading the miners to be classified as a new miner when in fact he had received substantial prior exposure.

Of special interest are miners whose x-ray readings were consistently abnormal. Six of the new miners fell into this classification. Five cases were reported as category 1 on both films while one was reported as category 2 on the later x-ray. To investigate whether film quality was responsible for this occurrence, the films for these six miners were re-examined. No reader gave an evaluation of poor or unreadable to any films read. In addition, two of the five miners were 26 years or less at initial x-ray, two were between 27 and 35 years, and one was 43 years. One miner, age 26 at first x-ray, progressed to category 2.

6.6 REFERENCES

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TABLE 6.1

SURVEILLANCE DETERMINATIONS FOR ALL PARTICIPATING MINERS  
AT THE THIRD ROUND WITH LESS THAN 10 YEARS OF WORK IN COAL MINING

|                          | PNEUMOCONIOSIS CATEGORY |      |      |      |      |      |      |     |     |     |     | TOTAL |       |
|--------------------------|-------------------------|------|------|------|------|------|------|-----|-----|-----|-----|-------|-------|
|                          | 0/0*                    | 0/1  | 1/0  | 1/1  | 1/2  | 2/1  | 2/2  | 2/3 | 3/2 | 3/3 | 3/4 |       | PMF   |
| zero<br>years<br>mining  | 14810                   | 529  | 59   | 28   | 6    | 4    | 1    |     |     | 1   |     | 1     | 15439 |
|                          | 95.93                   | 3.43 | 0.38 | 0.18 | 0.04 | 0.03 | 0.01 |     |     | .01 |     | .01   | 100.0 |
| 1 - 9<br>years<br>mining | 31295                   | 1636 | 212  | 114  | 37   | 5    | 5    |     |     |     |     | 1     | 33305 |
|                          | 93.97                   | 4.91 | 0.64 | 0.34 | 0.11 | 0.02 | 0.02 |     |     |     |     | 0.00  | 100.0 |

\* includes three cases diagnosed as 0/-.

TABLE 6.2

SURVEILLANCE DETERMINATIONS FOR ALL PARTICIPATING MINERS  
AT THE THIRD ROUND WITH LESS THAN 10 YEARS OF WORK IN COAL MINING  
AND NO PRIOR DUSTY WORK

|                          | PNEUMOCONIOSIS CATEGORY |      |      |      |      |      |      |     |     |     |     | TOTAL |       |
|--------------------------|-------------------------|------|------|------|------|------|------|-----|-----|-----|-----|-------|-------|
|                          | 0/0*                    | 0/1  | 1/0  | 1/1  | 1/2  | 2/1  | 2/2  | 2/3 | 3/2 | 3/3 | 3/4 |       | PMF   |
| zero<br>years<br>mining  | 12869                   | 418  | 50   | 22   | 3    | 4    | 1    |     |     | 1   |     |       | 13369 |
|                          | 96.27                   | 3.13 | 0.37 | 0.16 | 0.02 | 0.03 | 0.01 |     |     | .01 |     |       | 100.0 |
| 1 - 9<br>years<br>mining | 26420                   | 1356 | 173  | 93   | 33   | 3    | 3    |     |     |     |     | 1     | 28082 |
|                          | 94.08                   | 4.83 | 0.62 | 0.33 | 0.12 | 0.01 | 0.01 |     |     |     |     | 0.00  | 100.0 |

\* includes three cases diagnosed as 0/-.

(93)

TABLE 6.3

SURVEILLANCE READINGS CONVERTED TO EPIDEMIOLOGICAL DETERMINATIONS

MINERS WITH LESS THAN 10 YEARS COAL MINING EXPERIENCE  
AND NO PRIOR DUST EXPOSURE

|                          | PNEUMOCONIOSIS CATEGORY |      |      |      |
|--------------------------|-------------------------|------|------|------|
|                          | 0                       | 1    | 2    | 3    |
| zero<br>years<br>mining  | 99.56                   | 0.41 | 0.03 | 0.00 |
| 1 - 9<br>years<br>mining | 99.21                   | 0.77 | 0.02 | 0.00 |

N.B. One case diagnosed PMF in the 1-9 year group.

(94)

TABLE 6.4

MEAN DUST CONCENTRATIONS BY OCCUPATION  
FOR NEW MINERS AND NATIONAL  
COAL STUDY MINERS:

| JOB                       | MEAN DUST CONCENTRATION<br>NATIONAL COAL |      | STUDY | NEW MINERS |   |
|---------------------------|--|------|-------|------------|---|
|                           | mean                                     | n    |       | mean       | n |
| <u>FACE</u>               |  |      |       |            |   |
| Cutting machine           | 2.0                                      | 332  | 1.5   | 52         |   |
| Laborer                   | 1.9                                      | 738  | 1.3   | 90         |   |
| Loading machine           | 1.8                                      | 1304 | 1.6   | 72         |   |
| Roof bolter               | 1.8                                      | 1049 | 1.6   | 234        |   |
| Timberman                 | 1.7                                      | 696  | 1.3   | 7          |   |
| Continuous Miner Operator | 1.6                                      | 2431 | 1.6   | 173        |   |
| Driller                   | 1.3                                      | 529  | 1.4   | 29         |   |
| Shuttle Car               | 1.2                                      | 5888 | 1.3   | 45         |   |
| Foreman                   | 1.0                                      | 4548 | 1.2   | 281        |   |
| <u>Non Face</u>           |  |      |       |            |   |
| Beltman                   | 1.3                                      | 760  | 1.6   | 45         |   |
| Mechanic                  | .7                                       | 1126 | 1.0   | 317        |   |
| Motorman                  | .8                                       | 1053 | 1.3   | 47         |   |

TABLE 6.5

X-RAY, CATEGORIES FOR  
SMALL ROUNDED OPACITIES AT ROUND 1 AND ROUND 3  
FOR NEW MINERS

|                           |     | Category at Round 3 |     |     |     |     |      |
|---------------------------|-----|---------------------|-----|-----|-----|-----|------|
|                           |     | 0/0                 | 0/1 | 1/0 | 1/1 | 2/3 | ALL  |
| Category<br>at<br>Round 1 | 0/0 | 1662                | 39  | 36  | 6   | 0   | 1743 |
|                           | 0/1 | 35                  | 4   | 5   | 0   | 0   | 44   |
|                           | 1/0 | 23                  | 8   | 5   | 0   | 1   | 37   |
|                           | 1/1 | 1                   | 0   | 0   | 0   | 0   | 1    |
|                           |     |                     |     |     |     |     |      |

1. Total N = 1825

2. From 1834 pairs, 1 was deleted due to previous dusty work exposure.

Remaining missing pairs were due to poor quality of one film as evaluated by "B" reader.

TABLE 6.6

RESULTS OF MATCHED CASES FOR  
MCNEMAR'S TEST

|                         | Regressors<br>Face | Regressors<br>Non-Face |
|-------------------------|--------------------|------------------------|
| Progressors<br>Face     | 8                  | 16                     |
| Progressors<br>Non-Face | 6                  | 11                     |

n = 41  
McNemar's  $\chi^2 = 3.68$   
n.s.

|                         | No Change<br>Face | No Change<br>Non-Face |
|-------------------------|-------------------|-----------------------|
| Progressors<br>Face     | 6                 | 8                     |
| Progressors<br>Non-Face | 2                 | 5                     |

n = 21  
McNemar's  $\chi^2 = 2.5$   
n.s.

(97)

TABLE 6.7  
DISTRIBUTION BY STATE  
NEW MINERS AND U.S. COAL MINERS (1980)

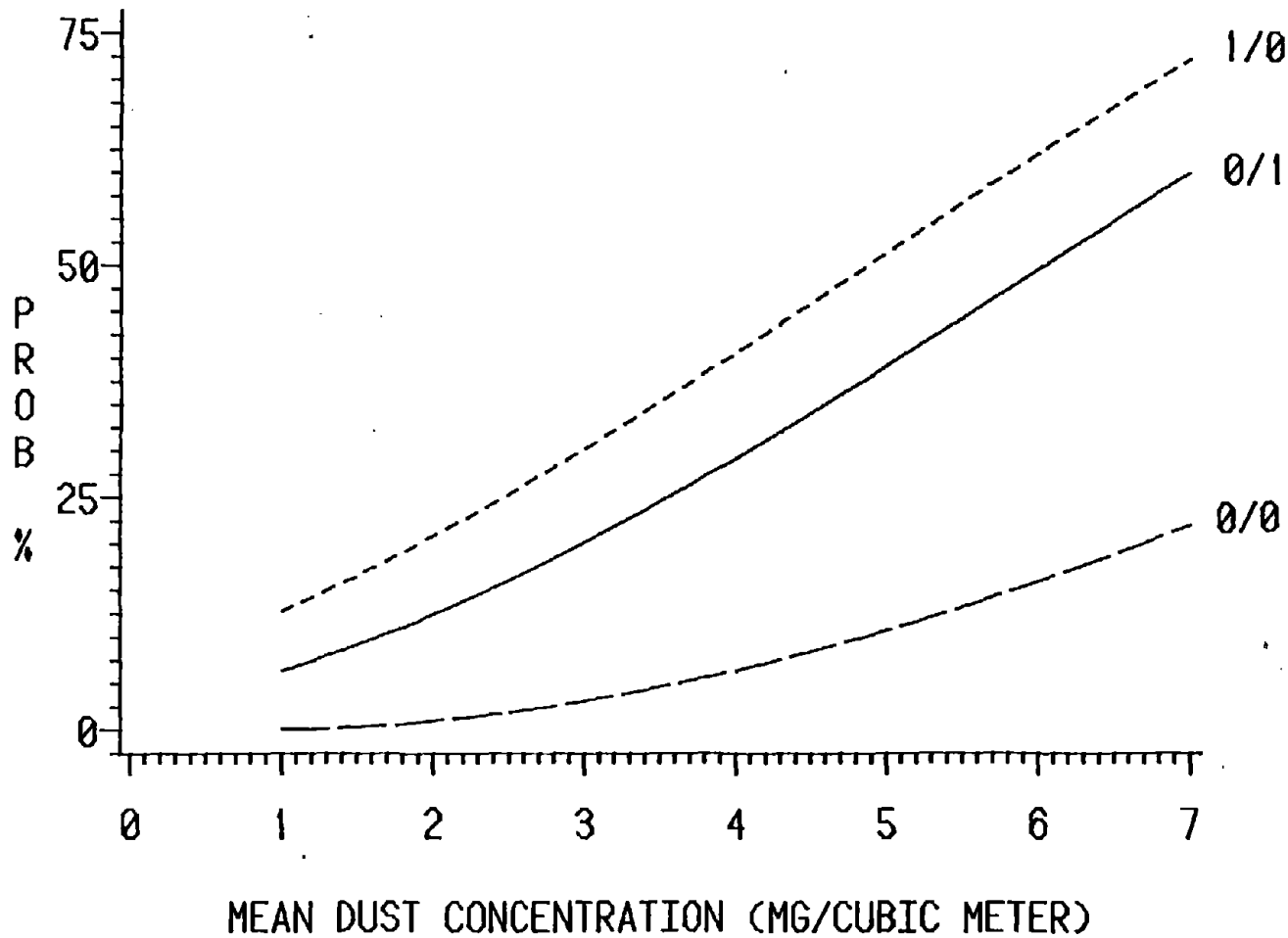
| STATE         | U.S. MINERS* (%) | NEW MINERS (%) |
|---------------|------------------|----------------|
| Alabama       | 4.8              | 1.6            |
| Colorado      | 1.6              | 1.6            |
| Illinois      | 8.4              | 8.6            |
| Indiana       | .1               | .3             |
| Kentucky      | 20.3             | 25.3           |
| Ohio          | 5.2              | 3.2            |
| Oklahoma      | -                | .1             |
| Pennsylvania  | 15.4             | 15.8           |
| Tennessee     | 1.4              | .2             |
| Utah          | 2.3              | .4             |
| Virginia      | 9.0              | 9.1            |
| West Virginia | 30.5             | 35.9           |

\*From Coal Data 1979/1980  
By The National Coal Association

Figure 6.1 Probability of progressing in 10 years  
from various starting categories

From Jacobsen et al., Inhaled Particles III, 1971

### 10 YEAR PREDICTED INCIDENCE AND PROGRESSION OF CWP



APPENDIX 6.1

METHOD OF DERIVING A FINAL READING  
IN THE SURVEILLANCE PROGRAM

Each miner in the program has a "final determination" made on his/her x-ray. The rules for arriving at this determination are the following:

1. At least two readers initially evaluate each x-ray. If these two readings are in agreement within one minor category, then the final determination is the greater of the two.

\*EXAMPLE: RD1 0/1 RD2 1/0 FNDD 1/0

If the major categories of the readings are in agreement, the final determination is taken as the greater of the two readings.

EXAMPLE: RD1 1/0 RD2 1/2 FNDD 1/2

If neither of the above situations occur, then a third reading is required.

Based on three readings the rule is as

follows:

If agreement occurs within one minor category on two pairs of the three readings, then the greatest of the readings is used.

EXAMPLE: R1 0/0 R2 1/0 R3 0/1

FNDD 1/0

If there is not agreement in this fashion, but major categories agree on two of the three readings, then the greatest of these two agreements is taken.

EXAMPLE: R1 0/0 R2 1/2 R3 1/0

FNDD 1/2

If two of the three readings do not agree on major category, but agree within one minor category, then the larger of those two agreements is taken as the final determination.

EXAMPLE: R1 0/1 R2 2/1 R3 1/2

FNDD 2/1

If none of these agreements occurs, a fourth reading is required. The fourth reading is then used as the final determination.

EXAMPLE: R1 0/0 R2 3/3 R3 2/1

R4 1/1 FNDD 1/1

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\* RD1 = reading 1, RD2 = reading 2, FNDD = final determination

## APPENDIX 6.2

METHOD FOR COMPUTING EPIDEMIOLOGICAL  
READINGS FOR THE SURVEILLANCE DATAMedian readings

Median determinations are often used to summarize film readings. They reflect the average level of abnormality seen in any one film by a group of film readers. When the number of readers is odd, the median determination is the middle reading after the readings have been ranked by abnormality. When the number of readings is even and the two central readings agree, that reading is taken; otherwise, the average of the two central readings is taken, averaging up a half category as necessary. All summarization here has been undertaken on X-rays classified on the 12-point scale.

Median determinations for the surveillance data.

As the surveillance readings sometimes consisted of three readings, and sometimes two, the summarization process to get median readings was modified as follows.

- (1) If three readings existed, the median reading was taken directly.
- (2) If two readings existed, and a median reading could not be clearly determined on the four point scale (e.g., 0/1, 1/0), the case was defined as one-half of a person in each major category.

Examples of median determinations

| READING |     |     |     | EPIDEMIOLOGICAL DETERMINATION |
|---------|-----|-----|-----|-------------------------------|
|         | 1   | 2   | 3   |                               |
|         | 0/0 | 1/1 | 2/2 | 1/1                           |
|         | 0/0 | 0/0 | 1/0 | 0/0                           |
|         | 0/1 | 1/0 | 0/0 | 0/1                           |
|         | 0/0 | 0/0 | 3/3 | 0/0                           |
|         | 3/2 | 2/3 | 1/0 | 2/3                           |

Differences between 'surveillance' readings and 'epidemiological' readings.

As can be seen from Appendix 6.1, the method of deriving 'surveillance' scores is designed to protect the health of the miner as it tends to lean towards the higher of the two or three readings. In contrast, the epidemiological determinations aim for an 'average' assessment. For example, the surveillance system would classify a film having three readings of 0/0, 1/0, and 0/1 as a 1/0 implying a major category of 1, while the epidemiological scheme would take the middle of the three, 0/1, as the final determination. This, of course, is a major category 0 score. In general, epidemiological scores are lower than the associated surveillance scores.

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Another difference between the two systems which is relevant only to this report is that the blue collar epidemiological scores are derived from small rounded opacity readings while those for the surveillance study are computed from either combined opacity readings, or the maximum of the rounded and irregular readings if the entry for the combined opacities was left blank. For a valid comparison to be made it will be necessary to recompute the scores using the same readings in each case. The effect on the present analysis is probably to underestimate the prevalence for the blue collar group.

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CHAPTER 7

THE MORTALITY ANALYSIS OF DATA FROM THE  
FIRST ROUND OF THE NATIONAL COAL STUDY

### 7.1 SUMMARY

To determine the mortality experience of the 8475 white male underground coal miners participating in Round 1 of the National Coal Study the data from the nine year follow-up period was analysed. 762 or 9% of the miners were dead at the end of the follow-up period. The overall Standardized Mortality Ratio (SMR) for all causes of death was 85.7; the SMR for all causes among the PMF subgroup of miners was 83.0 which is lower than that found in other studies but is likely explained by the relatively brief follow-up period and the survivor population reflected in this cohort of miners. The stomach cancer SMR was 100.1; comparison of Comparative Mortality Figures (CMF's)) in subgroups among those who died from stomach cancer appears to support the Meyer Hypothesis. The lung cancer SMR of 80.9 is consistent with those seen in other studies and supports the belief that neither coal mine dust exposure, nor radiographic category of PMF predict death from lung cancer. Non-malignant respiratory disease, and accidents both contribute each about 11% to the total deaths, and both have elevated SMR's of 165.0 and 156.9 respectively; the latter findings indicates the need for increased attention for accident prevention among coal miners, particularly the younger miners. The arteriosclerotic heart disease SMR of 84.00 reflects the healthy worker effect operating in the cohort. While there were only five leukemia deaths in the cohort, with an associated SMR of 73.2; these leukemia deaths need further examination to look for any occupationally related risk factors.

## 7.2 INTRODUCTION

A nine-year follow-up mortality study was done to determine the mortality experience of 8475 white male coal miners participating in Round 1 of the National Coal Study, as compared with that of the United States white male population, as well as to compare mortality between subgroups of miners in the cohort with different characteristics (or risk factors). This report presents the initial descriptive findings of the analysis of the data for this follow-up period.

The findings of past mortality studies of coal miners are very well summarized in an earlier report by Amandus (1980). In general, the standardized mortality ratio, using the United States population as a standard, for all causes of death among coal miners has been less than 100 (Amandus, 1980; Enterline, 1972; Ortmeyer, 1974; and Rockette, 1977); this finding is probably due to the healthy worker effect (Gaffey, 1976; McMichael, 1976).

## 7.3 METHODS

Between 1969 and 1971, during the first round of the National Coal Study, field teams from the Appalachian Laboratory for Occupational Safety and Health (ALOSH) visited 31 coal mines located throughout the United States. The mines were selected to be representative of all United States coal mines, and according to the following criteria: "... 1) The mine employed at least 100 miners; 2) The mine had an expected working life of at least 10 years; 3) The mines represented various coal seams, mining methods, and geographic areas; and 4) The mine was accessible by field team mobile equipment ...".

The information collected on the 9078 miners who participated in Round 1 of the NCS included: respiratory symptom questionnaire data, chest x-ray, spirometry, and smoking and work history. The miners were followed prospectively for deaths (see Figure 1 for details). The following analysis concentrates on the 8475 white males in the study.

The follow-up procedures for determination of miners' vital status included the following: current miner addresses were checked with local Postmasters; the Internal Revenue Service files were checked for date of last income tax return filed; Social Security Administration, United Mine Workers Welfare and Retirement Fund and State Vital Statistic files were searched by Social Security Number. In addition, if vital status was unknown, miners were followed-up on an individual basis to ascertain vital status. In general, a miner was defined as dead at the end of the follow-up period if the Social Security Administration indicated this, or if two or more of the above noted sources indicated that the miner was dead. A miner was defined as alive if the first line of the address was current as indicated by the Postmaster and the individual miner follow-up found the same; or if the address was current and as of the follow-up cut-off date, the miner was paying into a retirement fund.

A computerized software package, The Occupational Cohort Mortality Analysis Program (OCMAP), was used to calculate standardized mortality ratios (Marsh and Preniger, 1980 and 1981). Module 1, Standardized Mortality Ratio Analysis uses the person-days at risk in the cohort, and the 1925 - 1975 United States five-year time periods for age, race and sex-specific rates for 61 causes of death, to calculate the "expected" deaths. The United States mortality rates are those developed by Monson (1974). The mortality rates for United States white males were selected as a basis of comparison in this study.

To compare the mortality experience of subgroups of miners within the study cohort, cause-specific, directly age-adjusted death rates were calculated; the Comparative Mortality Figure (CMF) was then calculated by dividing the direct age-adjusted rates by the cause-specific mortality rate in the study cohort (Miettinen, 1972; Fleiss, 1973).

#### 7.4 RESULTS

The results of the follow-up in 1979 for the 8475 coal miners were 7677 (90.6%) still alive, 762 (9.0%) deceased and 38 (0.4%) of unknown status.

A description of the study cohort is noted in Table 7.1, which shows the age-distribution of the cohort of coal miners at the time of their entry to the study and at the time of their deaths, as well as by person-years contributed to the study. The mean age of miners at entry to the study in the 1969 - 1971 period was 44.7 years; the mean age at death was 58.3 years; and the miners in the 55 - 59 year age interval contributed most person-years to the study.

Table 7.2 shows the numbers and percent distribution of deaths by cause as well as the S.M.R. for the 762 deaths among the cohort of 8475 miners. All diseases of the circulatory system (46.3%), all cancers (20.7%), non-malignant respiratory disease (11.0%), and accidents (10.6%), contributed approximately 90% of the observed 762 deaths. Of the 353 deaths due to circulatory diseases, 284 (80.4%) were due to arteriosclerotic heart disease which includes coronary heart disease. There were 158 deaths from cancer, 64 (40.5%) were due to cancers of the respiratory tract, 40 (25.3%) were due to digestive cancers, and 5 (3%) were leukemia deaths. Furthermore, 62 of the 64 respiratory tract cancer deaths were lung cancer deaths; and 8 of the 40 digestive cancer deaths were due to stomach cancer.

#### 7.4.1 External Comparisons

Table 7.3 lists the age-specific death rates and Standardized Mortality Ratios (SMRs) for all causes of death as well as for six additional specific causes of death. The all causes of death SMR is 85.7\*\*, indicating a lower mortality rate in the coal miner cohort than in the United States white male, standard population. The arteriosclerotic heart disease SMR is 84.00; given that 37.3% of all the deaths in the cohort were due to this cause, the all causes of death SMR is heavily weighted by, and reflects, the arteriosclerotic heart disease SMR. (This is also apparent in the similarity of the 60 - 64 and 65 - 69 age-specific SMRs for all causes of death and arteriosclerotic heart disease deaths.) The non-malignant respiratory tract SMR of 165.0 (p .01), and the accident SMR of 165.9 (p .01) both indicate the higher mortality rates from these two causes of death in this coal miner cohort, as compared to the United States white male age-adjusted standard population. The 5 deaths from leukemia had an associated SMR of 73.2. There were 8 deaths from stomach cancer with an associated SMR of 100.1, while the 62 observed deaths from lung cancer were associated with an SMR of 80.9.

#### 7.4.2 Internal Subgroup Comparisons

##### 7.4.2.1 All Causes of Death

Table 7.4 is a comparison of the SMRs, age-adjusted death rates and comparative mortality figures (CMFs) for subgroups of the cohort. The subgroups are defined according to miner status on six variables; CWP radiographic category, years of underground mining tenure, FEV<sub>1</sub>/FVC status, phlegm status, cough status, and dyspnea status. (These variables were measured at the beginning of the 9-year follow-up period.) The actual numbers of miners at risk, as well as person-years at risk and crude death rates are also included in this Table. In addition, the age-specific crude death rates, SMRs, age-adjusted death rates, and comparative mortality figures for the six subgroups as well as for the smoking status subgroups are noted in the next seven Tables (Tables 7.5 to 7.11); these age-specific death rate Tables are included primarily for descriptive purposes.

Going back to Table 7.4, it is noted that the two underground tenure groups have similar CMFs indicating similar death rates from all causes after age-adjustment in these two groups of miners. The obstructed group of miners (FEV<sub>1</sub>/FVC < 70%) has a higher all causes of death CMF than does the non-obstructed group (FEV<sub>1</sub>/FVC ≥ 70%). In regard to symptoms, miners in this study with history of no phlegm have lower age-adjusted death rates from all causes of

death, than do those miners reporting mild/moderate or severe phlegm. The same is true for cough; miners reporting no cough have a lower CMF than do those miners with mild, moderate, or severe cough. In regard to dyspnea, the miner group reporting severe dyspnea had a higher CMF than did that group reporting no, mild, or moderate dyspnea.

In Table 7.11 the age-specific death rates for all causes of death by smoking category are noted. Both the CMFs and the age-adjusted death rates reflect the anticipated higher mortality from all causes of death associated with the current smoking (or smoking at beginning of follow-up period) group of miners.

In Table 7.12, the all causes of death numbers at risk, numbers of deaths, and SMRs for six subgroups by CWP radiographic category are compared. While comparisons of subgroup SMRs must be done with caution, as the standard population of all United States white males is not truly a comparable group, it will be noted from the earlier Tables that comparison of subgroup SMRs, closely approximates, or roughly estimates, comparison of subgroup age-specific death rates or SMRs. However, the findings presented in this Table are best reviewed with this precaution in mind.

#### 7.4.2.2 Stomach Cancer

Table 7.13 for stomach cancer is comparable to Table 7.4 for all causes of death; and for descriptive purposes this Table is followed by Tables 7.14 to 7.19 noting the age-specific crude death rates, SMRs, age-adjusted death rates and CMFs for the five subgroups, as well as for smoking status subgroups. While the stomach cancer CMFs for CWP and simple CWP were similar, the PMF CMF is higher, indicating the higher death rates after age-adjustment from stomach cancer, in the PMF group. This higher stomach cancer CMF holds for the 30 years of underground mining group as compared with the mining group with 30 or less years underground.

The obstructed miner group had a lower stomach cancer CMF than did the non-obstructed group. The CMF associated with severe phlegm was about twice that of the no phlegm CMF. The CMF for the miner group reporting no cough was higher than that for the miner group reporting severe cough. In Table 7.19 the age-specific stomach cancer death rates are noted for current and ex-smokers; there were no stomach cancer deaths in the group of miners who had never smoked. The age-adjusted stomach cancer death rates and CMFs are noted to be higher for ex-smokers than they are for current smokers.

In Table 7.20 SMRs for the subgroups by CWP radiographic category are compared; the precautions regarding comparison of subgroup SMRs which were noted in the "All Causes of Death" results section hold for this Table as well. Taking this precaution, one notes that while the stomach cancer death SMRs for the current smoking category decrease with increasing radiographic category of CWP, the SMRs for the ex-smoking group increase with increasing radiographic category of CWP.

#### 7.4.2.3 Lung Cancer

In Table 7.21 it is noted that while the lung cancer CMFs for the CWP and simple CWP radiographic category groups were similar, there were no lung cancer deaths in the PMF group. The CMFs associated with the two underground mining groups were similar. The obstructed miner group lung cancer CMF was over three times that for the non-obstructed group of miners. The miner group reporting no phlegm or mild or moderate phlegm had similar CMFs (0.74 and 0.71 respectively) while the mining group reporting severe phlegm had a higher CMF. The miner groups with mild or moderate or severe cough had higher lung cancer CMFs (1.18 and 1.20 respectively) than did the group reporting no cough (0.77). Lung cancer CMFs were similar for the two dyspnea groups.

A review of Table 7.28 shows the expected higher lung cancer CMF (1.67) for the current smoking group as compared to the CMFs for the ex-smoking and never smoking groups (0.51 and 0.09 respectively). Taking into consideration the limitations of comparing subgroup SMRs, in a review of Table 7.29 it is noted that the smoking status trend in lung cancer mortality holds up in both the CWP and simple CWP radiographic category groups.

#### 7.4.2.4 Non-Malignant Respiratory Disease (NMRD)

In Table 7.30 the NMRD CMFs associated with the CWP radiographic categories are shown to increase with increasing categories of CWP; from 0.64 to 1.20 to 3.08 for CWP categories 0 CWP, simple CWP and PMF respectively. The CMFs for the two mining groups are 0.80 for the less than 30 years of underground mining group and 1.09 for the greater than 30 years of underground mining group. As is expected the NMRD CMF for the obstructed group of miners is between two to three times that for the non-obstructed group. In regard to symptoms, the patterns in NMRD CMFs for phlegm and cough were similar with increasing CMFs with increasing severity of these two symptoms. The NMRD CMF for the no, mild, or moderate dyspnea group of miners was 0.85, while that for the severe dyspnea group was 2.20.

In Table 7.37 the NMRD CMFs for current smokers, ex-smokers, and the never smoked groups are noted to be 1.29, 0.91, and 0.59 respectively. Again recalling the constraints on comparison of subgroup SMRs, in Table 7.38 it is noted that the NMRD SMRs increase with increasing category of CWP in all three of the smoking status categories.

#### 7.4.2.5 Arteriosclerotic Heart Disease (ASHD)

In Table 7.39 the ASHD CMFs for the CWP and simple CWP groups are similar while the CMF for the PMF group is only about one-quarter of that of the other two groups. The two underground mining groups as well as the obstructed and non-obstructed groups have similar ASHD CMFs.

#### 7.4.2.6 Accidents

In Table 7.44 the accident CMF for simple CWP (1.60) is higher than the CMFs for either CWP (0.94) or for PMF (0.63). The accident CMF for the miner group with less than 30 years underground mining is 1.00, while that for the greater than 30 years of underground mining is 0.51.

#### 7.4.2.7 Leukemia

In Table 7.47 the leukemia CMF for CWP is noted to be 1.35 while that for simple CWP is 0.47 and there were no leukemia deaths in the PMF group of miners. As all 5 of the leukemia deaths occurred in miners with less than 30 years underground mining, the CMF for 30 years is 0.00, and for 30 years is 1.80. After correcting for age in the two years underground mining groups, the death rate is still lower in the 30 years underground groups (35.64) as compared to the rate of 109.87 for the = 30 years underground group.

### 7.5 DISCUSSION

The cohort S.M.R. of 85.7 for all causes of death is similar to but slightly lower than the S.M.R.'s found by Amandus (1980) and Ortmeyer (1974). Possible explanations for this finding include the following: (1) This cohort is a working, survivor population, representing underground miners from large US mines; and (2), the 9-year period of follow-up in this study is relatively brief. The same two factors may well help to explain the lower SMR for the causes of death in the PMF subgroup in this cohort. Further follow-up is needed to assess the significance of the all causes of death SMR found in the PMF subgroup of the cohort of miners.

The presence of pulmonary airway obstruction, or a history of severe dyspnea or current smoking at the beginning of the study period were associated

with increased age-adjusted death rates from all causes of death. These findings are consistent with those found by Amandus (1980) and Ortmeier (1974).

The overall stomach cancer SMR of 100.1 for the eight observed stomach cancer deaths is lower than that found in other studies. While a higher SMR for stomach cancer was found by Rockette (1977), most of the excess deaths in the group were in miners over 70 years of age. Once again the relatively brief 9-year follow-up period in this study, may have contributed to the lower stomach cancer SMR. In tenure subgroup comparisons, miners with PMF or 30 or more years of underground mining tenure had higher age-adjusted stomach cancer death rates than did miners with 0 or simple CWP, or miners with less than 30 years of tenure. This findings suggests a relationship between coal mine dust exposure and death from stomach cancer. In addition, miners with severe phlegm or no cough had higher age-adjusted stomach cancer death rates, supporting the idea of the role of pulmonary clearance of inhaled carcinogens as a mechanism in the etiology of stomach cancer as proposed by Meyer (Meyer et al, 1980; Gamble and Ames, 1983). There were no stomach cancer deaths among non-smokers, while ex-smokers had higher age-adjusted death ratios than did the current smoking group. To verify the appearance of support of the Meyer Hypothesis, one needs to compare the age-adjusted death rates by exposure categories, smoking and pulmonary obstruction status. Given that there were only eight stomach cancer deaths in the cohort, the required partitioning for such a comparison is not possible.

The cohort SMR for lung cancer is 80.9 which is consistent with that found by Amandus (1980) and by Costello (Costello et al, 1974). In addition, there were no lung cancer deaths in the PMF subgroup of miners; this finding is consistent with the findings of Ames that neither coal workers pneumoconiosis, nor coal mine dust exposure predict death from lung cancer (Ames, 1983; Ames et al, 1983). The most important contributing factor in age-adjusted death rates from lung cancer was the expected risk factor of smoking status. Pulmonary obstruction, severe phlegm and cough were also associated with higher lung cancer age-specific death rates.

While the cohort SMR of 165.0 for non malignant respiratory disease is slightly higher than that found by Amandus (1980), the trends in cohort subgroups are the same. The age-adjusted NMRD death rates increased with increasing radiographic category of CWP. Likewise the role of smoking in death from NMRD is reflected in the age-adjusted death rates by smoking status; in addition the SMR's increase with increasing CWP category in all three smoking groups. Severe dyspnea, cough or phlegm or pulmonary airways obstruction were associated with increased age-adjusted NMRD death rates; those findings are consistent with those found by Amandus (1980).

The cohort SMR of 84.00 for arteriosclerotic heart disease, which includes coronary heart disease, is a reflection of the healthy worker effect and is

consistent with the SMR of 83.6 found by Amandus (1980) in his working group of miners. This cause of death contributed 37.3% of the total deaths in the cohort, and heavily contributes to the all causes SMR. The low ASHD SMR in the PMF group indicates that this is a survivor group of miners, who also have a low all causes SMR, but a relatively high NMRD SMR

Perhaps one of the most important findings, which is consistent with the findings of Amandus (1980) and Rockette (1977), is the importance of accidents as a contributor to deaths among coal miners; the SMR is 156.9. While most attention has been focused on NMRD morbidity and mortality among coal miners, it is interesting to note that deaths from accidents and NMRD contributed nearly equal numbers of deaths in the cohort (81 and 84 deaths respectively). As these deaths occurred predominantly in younger miners, this cause of death was also associated with the greatest loss in expectation of life.

The cohort SMR of 73.2 for leukemia was not statistically significant. There were five leukemia deaths in the cohort. Mortality from leukemia, after age-adjustment, decreases with increasing category of CWP, as well as with greater than 30 years of underground mining exposure. These leukemia deaths need further examination to look for any occupationally related risk factors.

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Figure 7.1

Follow-up of the cohort of 8475 white male underground coal miners enrolled from 1969-1971 in the First Round of the National Coal Study.

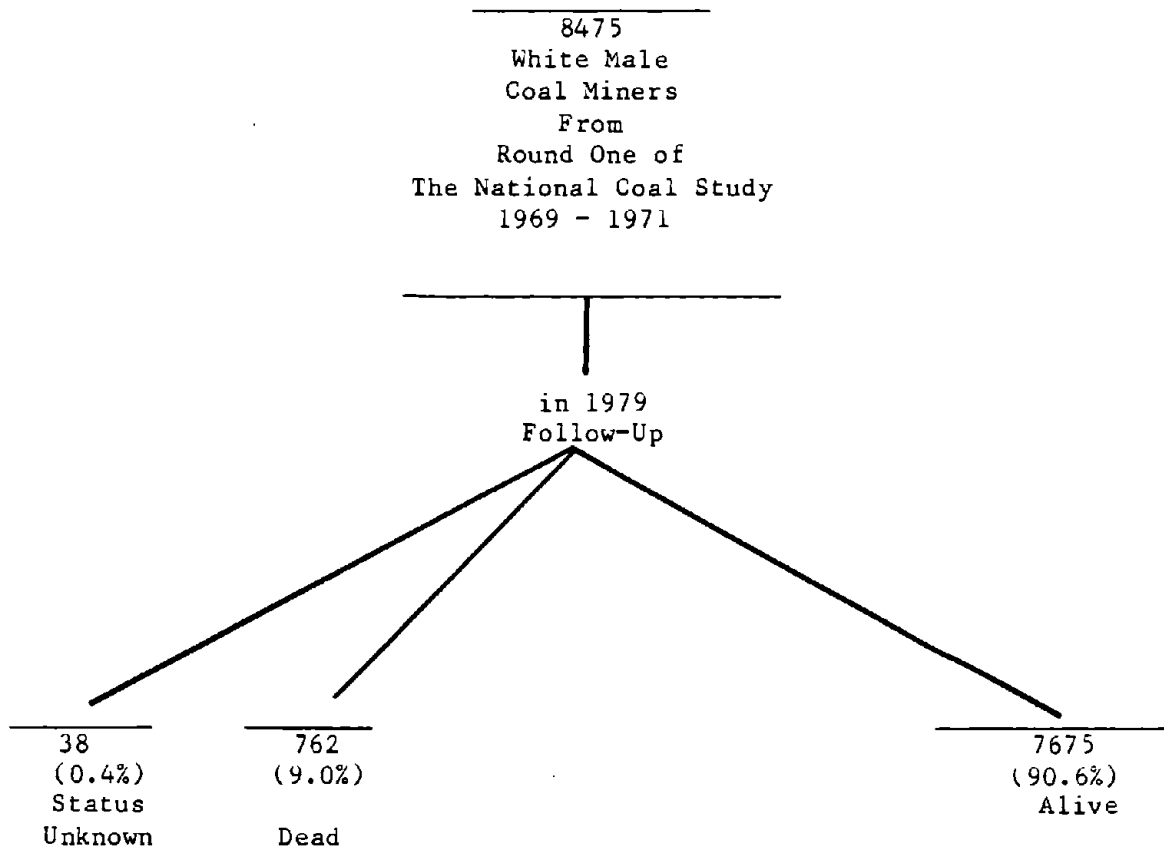


Table 7.1

Mortality Study Cohort Age-Distribution by Age at Entry to Follow-Up  
By Age at Death and By Person Years Contributed to Study

| AGE GROUP         | AGE AT ENTRY<br>INTO FOLLOW-UP |       | AGE AT DEATH |       | PERSON YEARS |       |
|-------------------|--------------------------------|-------|--------------|-------|--------------|-------|
|                   | NO.                            | %     | NO.          | %     | NO.          | %     |
| < 20              | 85                             | 1.0   | 0            | 0.0   | 59.4         | 0.1   |
| 20-24             | 600                            | 7.1   | 4            | 0.5   | 1621.1       | 2.2   |
| 25-29             | 754                            | 8.9   | 12           | 1.6   | 4993.6       | 6.8   |
| 30-34             | 677                            | 8.0   | 17           | 2.2   | 6433.1       | 8.7   |
| 35-39             | 658                            | 7.8   | 16           | 2.1   | 5963.5       | 8.1   |
| 40-44             | 1017                           | 12.0  | 19           | 2.5   | 6485.0       | 8.8   |
| 45-49             | 1329                           | 15.7  | 63           | 8.3   | 9080.0       | 12.3  |
| 50-54             | 1490                           | 17.6  | 97           | 12.7  | 11663.3      | 15.9  |
| 55-59             | 1248                           | 14.7  | 190          | 24.9  | 12411.5      | 16.9  |
| 60-64             | 560                            | 6.6   | 198          | 26.0  | 9817.7       | 13.3  |
| 65-69             | 48                             | 0.6   | 105          | 13.8  | 4300.3       | 5.8   |
| 70-74             | 1                              | 0.0   | 34           | 4.5   | 722.8        | 1.0   |
| 75-79             | 0                              | 0.0   | 2            | 0.3   | 24.8         | 0.0   |
| 80-84             | 0                              | 0.0   | 0            | 0.0   | 0.0          | 0.0   |
| 85 +              | 8                              | 0.1   | 5            | 0.7   | 53.4         | 0.1   |
| Total             | 8475                           | 100.0 | 762          | 100.0 | 73560.3      | 100.0 |
| Average Age (Yrs) | 44.7                           |       | 58.3         |       |              |       |

Table 7.2

Numbers, Percent Distribution and Standardized  
Mortality Ratios for Deaths by Cause for Mortality Follow-up Cohort

| Causes<br>Of Death                        | Nos.<br>of Deaths | % of<br>Total Deaths | S.M.R. <sup>1</sup> |
|---|-------------------|----------------------|---------------------|
| All Causes                                | 762               | 100.0                | 85.7**              |
| All Diseases of the<br>Circulatory System | 353               | 46.3                 | 80.0**              |
| Arterioscleriotic<br>Heart Disease        | 284               | 37.3                 | 84.00**             |
| All Cancer                                | 158               | 20.7                 | 78.1 **             |
| All Cancer of the<br>Respiratory Tract    | 64                | 8.4                  | 79.5                |
| Cancer of the Lung                        | 62                | 8.1                  | 80.9                |
| All Digestive Cancer                      | 40                | 5.2                  | 79.3                |
| Cancer of the Stomach                     | 8                 | 1.0                  | 100.1               |
| Leukemia                                  | 5                 | 0.6                  | 73.2                |
| Non-Malignant Respiratory<br>Disease      | 84                | 11.0                 | 165.00**            |
| Accidents                                 | 81                | 10.6                 | 156.9**             |
| Other                                     | 86                | 11.3                 | --                  |

1. \* Statistical significance at .05 level; \*\* indicates statistical significant at .01 level

Table 7.3

Age-Specific Death Rates and Standardized Mortality Ratios for  
All Causes and six specific causes of Death  
Causes of Death

| Groups | All Causes                 |        | CA of Stomach              |        | CA of Lung                 |        | Non Malignant<br>Respiratory<br>Diseases |          | Arterio-<br>Sclerotic<br>Heart Disease |        | Leukemia                   |        | All Accidents              |         |
|--------|----------------------------|--------|----------------------------|--------|----------------------------|--------|--|----------|--|--------|----------------------------|--------|----------------------------|---------|
|        | Death<br>Rate <sup>2</sup> | S.M.R. | Death<br>Rate <sup>2</sup> | S.M.R. | Death<br>Rate <sup>2</sup> | S.M.R. | Death<br>Rate <sup>2</sup>               | S.M.R.   | Death<br>Rate <sup>2</sup>             | S.M.R. | Death<br>Rate <sup>2</sup> | S.M.R. | Death<br>Rate <sup>2</sup> | S.M.R.  |
| 20     | 0.00                       | --     | 0.00                       | --     | 0.00                       | --     | 0.00                                     | --       | 0.00                                   | --     | 0.00                       | --     | 0.00                       | --      |
| 20-24  | 246.75                     | 126.9  | 0.00                       | --     | 0.00                       | --     | 0.00                                     | --       | 0.00                                   | --     | 0.00                       | --     | 246.75                     | 216.2   |
| 25-29  | 240.31                     | 142.0  | 0.00                       | --     | 0.00                       | --     | 0.00                                     | --       | 0.00                                   | --     | 0.00                       | --     | 180.23                     | 225.7*  |
| 30-34  | 264.26                     | 152.4  | 0.00                       | --     | 15.54                      | 781.6  | 0.00                                     | --       | 0.00                                   | --     | 15.54                      | 666.2  | 155.45                     | 251.0*  |
| 35-39  | 268.30                     | 112.6  | 0.00                       | --     | 16.77                      | 253.8  | 0.00                                     | --       | 50.31                                  | 130.1  | 0.00                       | --     | 117.38                     | 192.2   |
| 40-44  | 292.99                     | 77.0   | 0.00                       | --     | 15.42                      | 77.0   | 0.00                                     | --       | 46.26                                  | 44.2   | 0.00                       | --     | 154.20                     | 258.4*  |
| 45-49  | 693.84                     | 110.0  | 0.00                       | --     | 66.08                      | 141.4  | 22.03                                    | 99.4     | 231.28                                 | 106.4  | 0.00                       | --     | 99.12                      | 160.3   |
| 50-54  | 831.67                     | 82.4   | 8.57                       | 96.3   | 42.87                      | 48.3   | 42.87                                    | 101.3    | 360.10                                 | 92.6   | 0.00                       | --     | 60.02                      | 92.2    |
| 55-59  | 1530.83                    | 95.6   | 16.11                      | 109.7  | 120.86                     | 80.0   | 201.43                                   | 241.3*   | 676.79                                 | 105.5  | 8.06                       | 66.0   | 120.86                     | 174.6   |
| 60-64  | 2016.76                    | 80.7** | 50.98                      | 204.5  | 193.53                     | 79.5   | 285.20                                   | 177.8**  | 794.48                                 | 78.6*  | 30.56                      | 167.2  | 81.49                      | 103.8   |
| 65-69  | 2441.67                    | 67.1** | 0.00                       | --     | 255.79                     | 77.2   | 348.81                                   | 127.4    | 953.41                                 | 64.8** | 0.00                       | --     | 23.25                      | 27.1    |
| 70-74  | 4703.93                    | 85.9   | 0.00                       | --     | 415.05                     | 99.2   | 1106.81                                  | 238.7*   | 1245.16                                | 56.9   | 0.00                       | --     | 138.35                     | 131.7   |
| 75-79  | 8080.58                    | 97.9   | 0.00                       | --     | 0.00                       | --     | 0.00                                     | --       | 4040.29                                | 121.6  | 0.00                       | --     | 0.00                       | --      |
| 80-84  | 0.00                       | --     | 0.00                       | --     | 0.00                       | --     | 0.00                                     | --       | 0.00                                   | --     | 0.00                       | --     | 0.00                       | --      |
| 85+    | 9360.89                    | 50.8   | 0.00                       | --     | 0.00                       | --     | 1872.18                                  | 121.9    | 3744.36                                | 46.9   | 0.00                       | --     | 0.00                       | --      |
| TOTAL  | 1034.91                    | 85.7** | 10.87                      | 100.1  | 84.21                      | 80.9   | 114.08                                   | 165.00** | 385.72                                 | 84.00  | 6.79                       | 73.2   | 110.01                     | 156.9** |

1. Arteriosclerotic Heart Diseases Includes Coronary Heart Disease

2. Observed Death Rate (No. of Observed Deaths Per 100,000 Person Years)

\* S.M.R. is significant at the .05 level

\*\* S.M.R. is significant at the .01 level

TABLE 7.4

Comparison of All Causes of Death Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                                    | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Pyrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | C.M.F. <sup>3</sup> |
|------------------------------------|----------------|---------------------|-------------|---------------|------------|---------------------------|---------------------|
| CWP Category                       |                |                     |             |               |            |                           |                     |
| 0                                  | 420 (521.38)   | 80.6**              | 5931        | 51557.7       | 814.62     | 950.64                    | 0.92                |
| Simple                             | 307 (325.32)   | 94.4                | 2331        | 20198.9       | 1519.89    | 1215.42                   | 1.17                |
| PMF                                | 35 (42.18)     | 83.0                | 213         | 1872.6        | 1869.02    | 804.51                    | 0.83                |
| Years Underground                  |                |                     |             |               |            |                           |                     |
| <=30                               | 461 (551.80)   | 83.5**              | 6862        | 59956.5       | 768.89     | 933.91                    | 0.90                |
| > 30                               | 301 (337.07)   | 89.3*               | 1613        | 13672.7       | 2201.47    | 1021.03                   | 1.07                |
| FEV <sub>1</sub> /FVC <sup>4</sup> |                |                     |             |               |            |                           |                     |
| <=70                               | 317 (296.75)   | 106.8               | 2196        | 18607.7       | 1703.60    | 1296.77                   | 1.25                |
| > 70                               | 342 (482.88)   | 70.8**              | 5522        | 48330.5       | 707.63     | 806.62                    | 0.78                |
| Phlegm                             |                |                     |             |               |            |                           |                     |
| None                               | 337 (452.59)   | 74.5**              | 4975        | 43387.4       | 766.72     | 873.15                    | 0.84                |
| Mild/Mod                           | 70 (70.95)     | 98.7                | 596         | 5256.0        | 1331.81    | 1187.95                   | 1.15                |
| Severe                             | 355 (365.33)   | 97.2                | 2904        | 24985.9       | 1420.80    | 1194.69                   | 1.15                |
| Cough                              |                |                     |             |               |            |                           |                     |
| None                               | 353 (490.76)   | 71.9**              | 5284        | 46285.0       | 762.66     | 852.63                    | 0.82                |
| Mild/Mod                           | 59 (56.74)     | 104.0               | 491         | 4270.6        | 1381.55    | 1248.50                   | 1.21                |
| Severe                             | 350 (341.38)   | 102.5               | 2700        | 23073.7       | 1516.88    | 1277.10                   | 1.23                |
| Dyspnea                            |                |                     |             |               |            |                           |                     |
| None/Mild                          | 639 (793.4)    | 80.5**              | 7836        | 68282.1       | 935.08     | 968.74                    | 0.94                |
| Severe                             | 123 (95.48)    | 128.8**             | 639         | 5293.0        | 2323.84    | 2073.86                   | 2.00                |
| Total                              | 762 (888.87)   | 85.7**              | 8475        | 73629.1       | 1034.91    | --                        | --                  |

- \* Indicates significance at .05 level; \*\* indicates significance at .01 level.
2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.
3. Comparative Mortality Figure; see text for further description.
4. Of the total 762 deaths, 103 did not have pulmonary function studies done.

TABLE 7.5

All Causes Age-Specific Death Rates and Standardized  
Mortality Ratios by CWP Radiographic Category

Age-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |        | 0 CWP    |        | 1-3 CWP |        | PMF     |        |
|--|---------|--------|----------|--------|---------|--------|---------|--------|
|  | D.R.    | S.M.R. | D.R.     | S.M.R. | D.R.    | S.M.R. | D.R.    | S.M.R. |
| <20  | 0.00    | --     | 0.00     | --     | 0.00    | --     | --      | --     |
| 20-24                                      | 246.75  | 126.9  | 254.03   | 130.7  | 0.00    | --     | --      | --     |
| 25-29                                      | 240.31  | 142.0  | 209.68   | 123.9  | 891.18  | 526.5  | --      | --     |
| 30-34                                      | 264.26  | 152.4  | 270.08   | 155.9  | 196.49  | 112.6  | --      | --     |
| 35-39                                      | 268.30  | 112.6  | 192.81   | 81.0   | 772.12  | 321.3* | --      | --     |
| 40-44                                      | 292.99  | 77.0   | 310.57   | 81.8   | 226.14  | 58.9   | 0.00    | --     |
| 45-49                                      | 693.84  | 110.0  | 687.45   | 109.2  | 731.87  | 115.6  | 0.00    | --     |
| 50-54                                      | 831.67  | 82.4   | 712.93   | 70.8*  | 1091.52 | 108.2  | 386.69  | 37.7   |
| 55-59                                      | 1530.84 | 95.6   | 1556.48  | 97.6   | 1543.47 | 96.0   | 1092.23 | 67.4   |
| 60-64                                      | 2016.76 | 80.7** | 1874.17  | 75.0** | 2177.29 | 87.1   | 2113.00 | 84.3   |
| 65-69                                      | 2441.67 | 67.1** | 1855.93  | 51.0** | 3063.08 | 84.1   | 3256.98 | 89.2   |
| 70-74                                      | 4703.93 | 85.9   | 3417.18  | 62.4   | 5612.36 | 102.6  | 8728.30 | 159.3  |
| 75-79                                      | 8080.58 | 97.9   | 13670.41 | 165.6  | 0.00    | --     | 0.00    | --     |
| 80-84                                      | --      | --     | --       | --     | --      | --     | --      | --     |
| 85 +                                       | 9360.89 | 50.8   | 9435.18  | 51.2   | 9075.09 | 49.2   | 0.00    | --     |
| TOTAL                                      | 1034.91 | 85.7** | 814.62   | 80.6** | 1519.89 | 94.4   | 1869.02 | 83.0   |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 950.64   |        | 1215.42 |        | 804.51  |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.92     |        | 1.17    |        | 0.83    |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.6

## All Causes of Death Age-Specific Death Rates and Standardized Mortality Ratios By Years Underground Mining (ZYRUG)

Age-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |        | ZYRUG < = 30 |        | ZYRUG > 30 |        |
|--|---------|--------|--------------|--------|------------|--------|
|  | D.R.    | S.M.R. | D.R.         | S.M.R. | D.R.       | S.M.R. |
| <20  | 0.00    | ---    | 0.00         | --     | --         | --     |
| 20-24                                      | 246.75  | 126.9  | 246.75       | 126.9  | --         | --     |
| 25-29                                      | 240.31  | 142.0  | 240.31       | 142.0  | --         | --     |
| 30-34                                      | 264.26  | 152.4  | 264.26       | 152.4  | --         | --     |
| 35-39                                      | 268.30  | 112.6  | 268.31       | 112.6  | 0.00       | --     |
| 40-44                                      | 292.99  | 77.0   | 293.21       | 77.1   | 0.00       | --     |
| 45-49                                      | 693.84  | 110.0  | 699.01       | 110.9  | 0.00       | --     |
| 50-54                                      | 831.67  | 82.4   | 766.94       | 76.2*  | 1452.12    | 139.7  |
| 55-59                                      | 1530.84 | 95.6   | 1520.45      | 95.9   | 1552.21    | 95.1   |
| 60-64                                      | 2016.76 | 80.7** | 1676.16      | 67.4** | 2309.05    | 92.0   |
| 65-69                                      | 2441.67 | 67.1** | 4274.37      | 78.1   | 2798.56    | 76.8*  |
| 70-74                                      | 4703.93 | 85.9   | 0.00         | --     | 4976.73    | 90.9   |
| 75-79                                      | 8080.58 | 97.9   | 0.00         | --     | 11806.56   | 143.0  |
| 80-84                                      | --      | --     | --           | --     | --         | --     |
| 85 +                                       | 9360.89 | 50.8   | 10989.01     | 59.6   | 5877.61    | 31.9   |
| TOTAL                                      | 1034.91 | 85.7** | 768.89       | 83.5** | 2201.47    | 89.3*  |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 933.91       |        | 1021.03    |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.90         |        | 1.07       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.7

All Causes of Death Age-Specific Death Rates and Standardized Mortality Ratios by FEV<sub>1</sub>/FVC StatusAge-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |        | FEV <sub>1</sub> /FVC ≤ 70 |        | FEV <sub>1</sub> /FVC > 70 |        |
|--|---------|--------|----------------------------|--------|----------------------------|--------|
|  | D.R.    | S.M.R. | D.R.                       | S.M.R. | D.R.                       | S.M.R. |
| <20  | 0.00    | ---    | 0.00                       | --     | 0.00                       | --     |
| 20-24                                      | 246.75  | 126.9  | 0.00                       | --     | 271.37                     | 139.6  |
| 25-29                                      | 240.31  | 142.0  | 0.00                       | --     | 249.19                     | 147.3  |
| 30-34                                      | 264.26  | 152.4  | 155.26                     | 89.9   | 239.87                     | 138.5  |
| 35-39                                      | 268.30  | 112.6  | 662.10                     | 276.8* | 210.40                     | 88.4   |
| 40-44                                      | 292.99  | 77.0   | 317.17                     | 83.0   | 290.95                     | 76.6   |
| 45-49                                      | 693.84  | 110.0  | 819.81                     | 129.7  | 628.64                     | 99.8   |
| 50-54                                      | 831.67  | 82.4   | 1002.62                    | 99.0   | 762.18                     | 75.7*  |
| 55-59                                      | 1530.84 | 95.6   | 1747.75                    | 108.8  | 1333.17                    | 83.6   |
| 60-64                                      | 2016.76 | 80.7** | 2845.41                    | 113.7  | 1268.76                    | 50.8** |
| 65-69                                      | 2441.67 | 67.1** | 3122.99                    | 85.8   | 1732.19                    | 47.6** |
| 70-74                                      | 4703.93 | 85.9   | 7392.18                    | 135.0  | 2643.51                    | 48.3*  |
| 75-79                                      | 8080.58 | 97.9   | 10446.48                   | 126.6  | 0.00                       | --     |
| 80-84                                      | --      | --     | --                         | --     | --                         | --     |
| 85 +                                       | 9360.89 | 50.8   | 11155.25                   | 60.5   | 8345.71                    | 45.3   |
| TOTAL                                      | 1034.91 | 85.7** | 1703.60                    | 106.8  | 707.63                     | 70.8** |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 1296.77                    |        | 806.62                     |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 1.25                       |        | 0.78                       |        |

1. Death rates of observed death in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.8

All Causes of Death Age-Specific Death Rates and Standardized  
Mortality Ratios by Phlegm StatusAge-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |        | No Phlegm |        | Severe Phlegm |         |
|--|---------|--------|-----------|--------|---------------|---------|
|  | D.R.    | S.M.R. | D.R.      | S.M.R. | D.R.          | S.M.R.  |
| <20  | 0.00    | ---    | 0.00      | --     | 0.00          | --      |
| 20-24                                      | 246.75  | 126.9  | 298.06    | 153.4  | 0.00          | --      |
| 25-29                                      | 240.31  | 142.0  | 204.71    | 121.0  | 456.07        | 269.5   |
| 30-34                                      | 264.26  | 152.4  | 315.76    | 182.2* | 143.22        | 82.5    |
| 35-39                                      | 268.30  | 112.6  | 287.84    | 120.9  | 202.76        | 84.9    |
| 40-44                                      | 292.99  | 77.0   | 335.34    | 88.3   | 260.92        | 68.3    |
| 45-49                                      | 693.84  | 110.0  | 554.76    | 88.1   | 1058.63       | 167.5** |
| 50-54                                      | 831.67  | 82.4   | 736.11    | 73.0*  | 979.21        | 96.9    |
| 55-59                                      | 1530.84 | 95.6   | 1343.89   | 84.3   | 1670.96       | 104.0   |
| 60-64                                      | 2016.76 | 80.7** | 1508.33   | 60.4** | 2436.87       | 97.4    |
| 65-69                                      | 2441.67 | 67.1** | 1956.71   | 53.7** | 2793.30       | 76.7*   |
| 70-74                                      | 4703.93 | 85.9   | 3509.59   | 64.1   | 4987.86       | 91.1    |
| 75-79                                      | 8080.58 | 97.9   | 11321.34  | 137.2  | 6282.27       | 76.1    |
| 80-84                                      | --      | --     | --        | --     | --            | --      |
| 85 +                                       | 9360.89 | 50.8   | 8716.07   | 47.3   | 5877.61       | 31.9    |
| TOTAL                                      | 1034.91 | 85.7** | 776.72    | 74.5** | 1420.80       | 97.2    |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 873.15    |        | 1194.69       |         |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.84      |        | 1.15          |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.9

## All Causes of Death Age-Specific Death Rates and Standardized Mortality Ratios by Cough Status

Age-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |        | No Cough |        | Severe Cough |         |
|--|---------|--------|----------|--------|--------------|---------|
|  | D.R.    | S.M.R. | D.R.     | S.M.R. | D.R.         | S.M.R.  |
| <20  | 0.00    | ---    | 0.00     | --     | 0.00         | --      |
| 20-24                                      | 246.75  | 126.9  | 292.70   | 150.6  | 0.00         | --      |
| 25-29                                      | 240.31  | 142.0  | 173.08   | 102.3  | 543.91       | 321.4   |
| 30-34                                      | 264.26  | 152.4  | 259.43   | 149.7  | 263.57       | 151.7   |
| 35-39                                      | 268.30  | 112.6  | 229.87   | 96.7   | 374.41       | 156.4   |
| 40-44                                      | 292.99  | 77.0   | 280.44   | 73.8   | 324.35       | 85.0    |
| 45-49                                      | 693.84  | 110.0  | 520.20   | 82.5   | 1077.03      | 170.7** |
| 50-54                                      | 831.67  | 82.4   | 634.18   | 62.9** | 1102.02      | 108.9   |
| 55-59                                      | 1530.84 | 95.6   | 1442.77  | 90.4   | 1610.86      | 100.3   |
| 60-64                                      | 2016.76 | 80.7** | 1447.07  | 57.9*  | 2595.66      | 103.8   |
| 65-69                                      | 2441.67 | 67.1** | 1913.08  | 52.6** | 2983.30      | 81.9    |
| 70-74                                      | 4703.93 | 85.9   | 4409.14  | 80.5   | 5251.75      | 95.9    |
| 75-79                                      | 8080.58 | 97.9   | 11627.91 | 140.9  | 6191.69      | 75.0    |
| 80-84                                      | --      | --     | --       | --     | --           | --      |
| 85 +                                       | 9360.89 | 50.8   | 10989.01 | 59.6   | 5877.61      | 31.9    |
| TOTAL                                      | 1034.91 | 85.7** | 762.66   | 71.9** | 1516.88      | 102.5   |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 852.63   |        | 1277.10      |         |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.82     |        | 1.23         |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.10

## All Causes of Death Age-Specific Death Rates and Standardized Mortality Ratios by Dyspnea Status

Age-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                            | Cohort  |        | No Dyspnea |        | Severe Dyspnea |         |
|---------------------------------------|---------|--------|------------|--------|----------------|---------|
|                                       | D.R.    | S.M.R. | D.R.       | S.M.R. | D.R.           | S.M.R.  |
| <20                                   | 0.00    | ---    | 0.00       | --     | --             | --      |
| 20-24                                 | 246.75  | 126.9  | 247.22     | 127.2  | 0.00           | --      |
| 25-29                                 | 240.31  | 142.0  | 222.23     | 131.4  | 2279.82        | 1346.2  |
| 30-34                                 | 264.26  | 152.4  | 267.33     | 154.2  | 0.00           | --      |
| 35-39                                 | 268.30  | 112.6  | 239.89     | 100.7  | 1567.87        | 645.0   |
| 40-44                                 | 292.99  | 77.0   | 242.35     | 63.7   | 1353.17        | 352.7   |
| 45-49                                 | 693.84  | 110.0  | 631.22     | 100.1  | 1714.03        | 271.0*  |
| 50-54                                 | 831.67  | 82.4   | 755.41     | 74.9** | 1700.81        | 167.4   |
| 55-59                                 | 1530.84 | 95.6   | 1475.13    | 92.2   | 2009.55        | 125.0   |
| 60-64                                 | 2016.76 | 80.7** | 1846.29    | 73.9** | 3174.55        | 126.5   |
| 65-69                                 | 2441.67 | 67.1** | 2373.64    | 65.2** | 2834.28        | 77.9    |
| 70-74                                 | 4703.93 | 85.9   | 4415.77    | 80.7   | 6763.64        | 123.5   |
| 75-79                                 | 8080.58 | 97.9   | 9974.04    | 120.8  | 0.00           | --      |
| 80-84                                 | --      | --     | --         | --     | --             | --      |
| 85 +                                  | 9360.89 | 50.8   | 7610.25    | 41.3   | --             | 586.7   |
| TOTAL                                 | 1034.91 | 85.7** | 935.08     | 80.5** | 2323.84        | 128.6** |
| Age-Adjusted Death Rates <sup>3</sup> |         |        | 978.74     | 0.94   | 2073.86        | 2.00    |

Comparative Mortality Figures<sup>4</sup>

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.11

## All Causes of Death Age-Specific Death Rates and Standardized Mortality Ratios by Smoking Status

Age-Specific All Causes Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |        | Current Smoker |        | Ex-Smoker |        | Never Smoked |        |
|--|---------|--------|----------------|--------|-----------|--------|--------------|--------|
|  | D.R.    | S.M.R. | D.R.           | S.M.R. | D.R.      | S.M.R. | D.R.         | S.M.R. |
| <20  | 0.00    | --     | 0.00           | --     | 0.00      | --     | 0.00         | --     |
| 20-24                                      | 246.75  | 126.9  | 100.06         | 51.5   | 795.19    | 408.7  | 403.34       | 207.6  |
| 25-29                                      | 240.31  | 142.0  | 283.65         | 167.7  | 0.00      | --     | 230.46       | 136.2  |
| 30-34                                      | 264.26  | 152.4  | 266.87         | 154.0  | 215.49    | 123.8  | 289.21       | 167.2  |
| 35-39                                      | 268.30  | 112.6  | 320.46         | 134.6  | 185.18    | 77.6   | 175.62       | 73.8   |
| 40-44                                      | 292.99  | 77.0   | 259.78         | 68.4   | 412.87    | 108.0  | 253.75       | 66.8   |
| 45-49                                      | 693.84  | 110.0  | 917.40         | 145.7* | 395.86    | 62.6   | 485.24       | 76.9   |
| 50-54                                      | 831.67  | 82.4   | 1127.91        | 111.2  | 501.99    | 49.7** | 561.42       | 55.7*  |
| 55-59                                      | 1530.84 | 95.6   | 1804.79        | 112.9  | 1213.21   | 75.7   | 1340.49      | 83.5   |
| 60-64                                      | 2016.76 | 80.7** | 2654.17        | 106.4  | 1652.12   | 66.0** | 1288.57      | 51.5** |
| 65-69                                      | 2441.67 | 67.1** | 3276.02        | 90.    | 1912.25   | 52.5** | 2019.97      | 55.3** |
| 70-74                                      | 4703.93 | 85.9   | 10988.86       | 201.1  | 3010.83   | 54.9   | 1341.22      | 24.5** |
| 75-79                                      | 8080.58 | 97.9   | 0.00           | --     | 5819.51   | 70.5   | 14370.08     | 174.1  |
| 80-84                                      | --      | --     | --             | --     | --        | --     | 0.00         | --     |
| 85 +                                       | 9360.89 | 50.8   | 10046.79       | 54.5   | 3858.79   | 20.9   | 17098.69     | 92.6   |
| TOTAL                                      | 1034.91 | 85.7** | 1167.83        | 112.4  | 948.67    | 63.0** | 802.31       | 63.8** |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 1174.49        |        | 787.54    |        | 781.92       |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 1.13           |        | 0.76      |        | 0.75         |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

Table 7.12

All Causes of Death Standardized Mortality Ratios, Number of Men at Risk,  
and Number of Deaths by CWP Radiographic Category for Study Cohort Subgroups

|                                    | No CWP    |              |                     | Simple    |              |                     | PMF       |              |                     |
|------------------------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|
|                                    | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> |
| Cigarette Smoking                  |           |              |                     |           |              |                     |           |              |                     |
| Smoker when examined               | 3179      | 250          | 108.6               | 1272      | 192          | 120.6*              | 87        | 14           | 89.0                |
| Smoked only in past                | 1476      | 92           | 53.0**              | 644       | 79           | 76.4*               | 81        | 14           | 85.5                |
| Never smoked                       | 1276      | 78           | 66.8**              | 395       | 36           | 57.4**              | 45        | 7            | 69.6                |
| Years Under Ground Mining          |           |              |                     |           |              |                     |           |              |                     |
| <= 30                              | 5231      | 304          | 80.5**              | 1551      | 150          | 92.3                | 79        | 7            | 96.8                |
| > 30                               | 700       | 116          | 80.6*               | 780       | 157          | 96.4                | 133       | 28           | 53.3                |
| FEV <sub>1</sub> /FVC <sup>2</sup> |           |              |                     |           |              |                     |           |              |                     |
| <= 70                              | 1417      | 172          | 100.6               | 668       | 127          | 123.3*              | 111       | 18           | 79.0                |
| > 70                               | 4089      | 702          | 68.1**              | 1361      | 133          | 76.9**              | 71        | 7            | 53.3                |
| Phlegm                             |           |              |                     |           |              |                     |           |              |                     |
| None                               | 3749      | 212          | 73.5**              | 1131      | 111          | 76.2**              | 95        | 14           | 75.9                |
| Mild/Mod                           | 344       | 28           | 85.3                | 226       | 38           | 115.7               | 26        | 4            | 75.7                |
| Severe                             | 1838      | 180          | 90.0                | 874       | 158          | 107.6               | 91        | 17           | 92.7                |
| Cough                              |           |              |                     |           |              |                     |           |              |                     |
| None                               | 3961      | 215          | 69.1**              | 1220      | 123          | 77.1**              | 103       | 15           | 74.5                |
| Mild/Mod                           | 302       | 30           | 102.9               | 174       | 27           | 109.6               | 14        | 2            | 70.6                |
| Severe                             | 1668      | 175          | 96.6                | 937       | 157          | 111.2               | 95        | 18           |                     |
| Dyspnea                            |           |              |                     |           |              |                     |           |              |                     |
| None                               | 2905      | 109          | 58.1**              | 644       | 51           | 69.1**              | 25        | 4            | 78.6                |
| Severe                             | 331       | 54           | 133.8*              | 262       | 52           | 123.7               | 46        | 12           | 128.8               |
| TOTALS                             | 5931      | 420          | 80.6**              | 2331      | 307          | 94.4                | 212       | 35           | 83.0                |

(125)

1. For a discussion of the limitations of comparison of study subgroup S.M.R.s, see the Text.
2. Of the total 762 deaths, 103 did not have pulmonary function studies done.

TABLE 7.13

Comparison of Stomach Cancer Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                       | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Pyrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF <sup>3</sup> |
|-----------------------|----------------|---------------------|-------------|---------------|------------|---------------------------|------------------|
| CWP Category          |                |                     |             |               |            |                           |                  |
| 0                     | 4 (4.54)       | 88.1                | 5931        | 51557.7       | 7.76       | 9.54                      | 0.88             |
| Simple                | 3 (3.04)       | 98.6                | 2331        | 20198.9       | 14.85      | 9.68                      | 0.89             |
| PMF                   | 1 (.41)        | 244.6               | 213         | 1872.6        | 53.40      | 27.41                     | 2.52             |
| Years Underground     |                |                     |             |               |            |                           |                  |
| <=30                  | 3 (4.71)       | 63.7                | 6862        | 59956.5       | 5.00       | 7.90                      | 0.86             |
| > 30                  | 5 (3.28)       | 152.3               | 1613        | 13672.7       | 36.57      | 26.11                     | 2.40             |
| FEV <sub>1</sub> /FVC |                |                     |             |               |            |                           |                  |
| <=70                  | 2 (2.77)       | 72.3                | 2196        | 18607.7       | 10.75      | 7.23                      | 0.67             |
| > 70                  | 4 (4.21)       | 95.1                | 5522        | 48330.5       | 8.28       | 9.71                      | 0.89             |
| Phlegm                |                |                     |             |               |            |                           |                  |
| None                  | 3 (3.97)       | 75.6                | 4975        | 43387.4       | 6.91       | 8.12                      | 0.75             |
| Mild/Mod              | 0 (0.65)       | --                  | 596         | 5256.0        | --         | --                        | --               |
| Severe                | 5 (3.38)       | 148.1               | 2904        | 24985.9       | 20.01      | 15.36                     | 1.41             |
| Cough                 |                |                     |             |               |            |                           |                  |
| None                  | 5 (4.32)       | 115.9               | 5284        | 46285.0       | 10.80      | 13.00                     | 1.20             |
| Mild/Mod              | 0 (0.52)       | --                  | 491         | 4270.6        | 0.00       | 0.00                      | --               |
| Severe                | 3 (3.16)       | 95.0                | 2700        | 23073.7       | 13.00      | 10.54                     | 0.97             |
| Total                 | 8 (7.99)       | 100.1               | 8475        | 73629.1       | 10.87      | --                        | --               |

1. \* Indicates significance at .05 level; \*\* indicates significance at .01 level.

2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.

3. Compariative mortality figure; see text for further description.

TABLE 7.14

Stomach Cancer Age-Specific Death Rates and Standardized  
Mortality Ratios by CWP Radiographic Category

Age-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | 0 CWP |        | 1-3 CWP |        | PMF    |        |
|--|--------|--------|-------|--------|---------|--------|--------|--------|
|  | D.R.   | S.M.R. | D.R.  | S.M.R. | D.R.    | S.M.R. | D.R.   | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00  | --     | 0.00    | --     | --     | --     |
| 20-24                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --     | --     |
| 25-29                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --     | --     |
| 30-34                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --     | --     |
| 35-39                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --     | --     |
| 40-44                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| 45-49                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| 50-54                                      | 8.57   | 96.3   | 13.20 | 148.6  | 0.00    | --     | 0.00   | --     |
| 55-59                                      | 16.11  | 109.7  | 28.56 | 195.8  | 0.00    | --     | 162.54 | 650.1  |
| 60-64                                      | 50.93  | 204.5  | 19.73 | 79.2   | 72.58   | 291.5  | 0.00   | --     |
| 65-69                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| 70-74                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| 75-79                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| 80-84                                      | --     | --     | --    | --     | --      | --     | --     | --     |
| 85 +                                       | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00   | --     |
| TOTAL                                      | 10.87  | 100.1  | 7.76  | 88.1   | 14.85   | 98.6   | 53.40  | 244.6  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 9.54  |        | 9.68    |        | 27.41  |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.88  |        | 0.98    |        | 2.52   |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.15

## Stomach Cancer Age-Specific Death Rates and Standardized Mortality Ratios by Years of Underground Mining (ZYRUG)

Age-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | ZYRUG < = 30 |        | ZYRUG > 30 |        |
|--|--------|--------|--------------|--------|------------|--------|
|  | D.R.   | S.M.R. | D.R.         | S.M.R. | D.R.       | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00         | --     | --         | --     |
| 20-24                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 25-29                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 30-34                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 35-39                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 40-44                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 45-49                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 50-54                                      | 8.57   | 96.3   | 11.97        | 82.7   | 90.76      | 996.4  |
| 55-59                                      | 16.11  | 109.7  | 44.11        | 178.0  | 24.62      | 163.0  |
| 60-64                                      | 50.93  | 204.5  | 0.00         | --     | 56.78      | 227.0  |
| 65-69                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 70-74                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 75-79                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 80-84                                      | --     | --     | --           | --     | --         | --     |
| 85 +                                       | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| TOTAL                                      | 10.87  | 100.1  | 5.00         | 63.7   | 36.57      | 152.3  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 9.32         |        | 26.11      |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.86         |        | 2.40       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.16

Stomach Cancer Age-Specific Death Rates and Standardized  
Mortality Ratios by FEV<sub>1</sub>/FVC Status

Age-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | FEV <sub>1</sub> /FVC ≤ 70 |        | FEV <sub>1</sub> /FVC > 70 |        |
|--|--------|--------|----------------------------|--------|----------------------------|--------|
|  | D.R.   | S.M.R. | D.R.                       | S.M.R. | D.R.                       | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 20-24                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 25-29                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 30-34                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 35-39                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 40-44                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 45-49                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 50-54                                      | 8.57   | 96.3   | 0.00                       | --     | 13.61                      | 153.2  |
| 55-59                                      | 16.11  | 109.7  | 0.00                       | --     | 29.63                      | 202.9  |
| 60-64                                      | 50.93  | 204.5  | 34.20                      | 217.4  | 20.80                      | 83.6   |
| 65-69                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 70-74                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 75-79                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 80-84                                      | --     | --     | --                         | --     | --                         | --     |
| 85 +                                       | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| TOTAL                                      | 10.87  | 100.1  | 10.75                      | 72.3   | 8.28                       | 95.1   |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 7.23                       |        | 9.71                       |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.67                       |        | 0.89                       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.17

Stomach Cancer Age-Specific Death Rates and Standardized  
Mortality Ratios by Phlegm Status

Age-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | No Phlegm |        | Severe Phlegm |        |
|--|--------|--------|-----------|--------|---------------|--------|
|  | D.R.   | S.M.R. | D.R.      | S.M.R. | D.R.          | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 20-24                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 25-29                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 30-34                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 35-39                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 40-44                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 45-49                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 50-54                                      | 8.57   | 96.3   | 15.34     | 172.5  | 0.00          | --     |
| 55-59                                      | 16.11  | 109.7  | 16.19     | 110.9  | 19.66         | 133.1  |
| 60-64                                      | 50.93  | 204.5  | 22.18     | 89.1   | 90.25         | 362.0  |
| 65-69                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 70-74                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 75-79                                      | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| 80-84                                      | --     | --     | --        | --     | --            | --     |
| 85 +                                       | 0.00   | --     | 0.00      | --     | 0.00          | --     |
| TOTAL                                      | 10.87  | 100.1  | 6.91      | 75.6   | 20.01         | 148.1  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 8.12      |        | 15.36         |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.75      |        | 1.41          |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.18

Stomach Cancer Age-Specific Death Rates and Standardized  
Mortality Ratios by Cough StatusAge-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | No Cough |        | Severe Cough |        |
|--|--------|--------|----------|--------|--------------|--------|
|  | D.R.   | S.M.R. | D.R.     | S.M.R. | D.R.         | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 20-24                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 25-29                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 30-34                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 35-39                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 40-44                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 45-49                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 50-54                                      | 8.57   | 96.3   | 0.00     | --     | 25.63        | 287.5  |
| 55-59                                      | 16.11  | 109.7  | 29.44    | 201.4  | 0.00         | --     |
| 60-64                                      | 50.93  | 204.5  | 60.29    | 242.2  | 48.52        | 194.6  |
| 65-69                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 70-74                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 75-79                                      | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| 80-84                                      | --     | --     | --       | --     | --           | --     |
| 85 +                                       | 0.00   | --     | 0.00     | --     | 0.00         | --     |
| TOTAL                                      | 10.87  | 100.1  | 10.80    | 115.9  | 13.00        | 95.0   |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 13.00    |        | 10.54        |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.20     |        | 0.97         |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.19

Stomach Cancer Age-Specific Death Rates and Standardized  
Mortality Ratios by Smoking StatusAge-Specific Stomach Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                         | Cohort |        | Current Smoker |        | Ex-Smoker |        |
|---------------------------------------|--------|--------|----------------|--------|-----------|--------|
|                                       | D.R.   | S.M.R. | D.R.           | S.M.R. | D.R.      | S.M.R. |
| < 20                                  | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 20-24                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 25-29                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 30-34                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 35-39                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 40-44                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 45-49                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 50-54                                 | 8.57   | 96.3   | 16.83          | 189.1  | 0.00      | --     |
| 55-59                                 | 16.11  | 109.7  | 16.26          | 111.0  | 25.81     | 175.5  |
| 60-64                                 | 50.93  | 204.5  | 46.16          | 185.7  | 88.51     | 354.5  |
| 65-69                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 70-74                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 75-79                                 | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| 80-84                                 | --     | --     | --             | --     | --        | --     |
| 85 +                                  | 0.00   | --     | 0.00           | --     | 0.00      | --     |
| TOTAL                                 | 10.87  | 100.1  | 10.24          | 112.1  | 20.51     | 147.5  |
| Age-Adjusted Death Rates <sup>3</sup> |        |        | 11.56          |        | 16.16     |        |

Comparative Mortality Figures<sup>4</sup>

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

Table 7.20

Cancer of Stomach Standardized Mortality Ratios, Number of Men at Risk,  
and Number of Deaths by CWP Radiographic Category for Study Cohort Subgroups

|                           | Category of CWP |              |                     |           |              |                     |           |              |                     |
|---------------------------|-----------------|--------------|---------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|
|                           | 0               |              |                     | Simple    |              |                     | PMF       |              |                     |
|                           | No of Men       | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> |
| Cigarette Smoking         |                 |              |                     |           |              |                     |           |              |                     |
| Smoker when examined      | 3179            | 3            | 154.0               | 1272      | 31           | 68.1                | 87        | 0            | --                  |
| Smoked only in past       | 1476            | 1            | 63.6                | 644       | 2            | 204.0               | 81        | 1            | 629.5               |
| Never smoked              | 1276            | 0            | --                  | 395       | 0            | --                  | 45        | 0            | --                  |
| Years Under Ground Mining |                 |              |                     |           |              |                     |           |              |                     |
| <=30                      | 5231            | 2            | 63.6                | 1551      | 1            | 68.7                | 79        | 0            | --                  |
| > 30                      | 700             | 2            | 143.0               | 780       | 2            | 126.1               | 133       | 1            | 335.1               |
| FEV <sub>1</sub> /FVC     |                 |              |                     |           |              |                     |           |              |                     |
| <=70                      | 1417            | 0            | 48.5                | 668       | 2            | 205.4               | 111       | 0            | --                  |
| > 70                      | 4089            | 4            | 41.9**              | 1361      | 1            | 62.5                | 71        | 0            | --                  |
| Phlegm                    |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 3749            | 2            | 82.0                | 1131      | 1            | 74.1                | 95        | 0            | --                  |
| Mild/Mod                  | 344             | 0            | --                  | 226       | 0            | --                  | 26        | 0            | --                  |
| Severe                    | 1838            | 2            | 110.3               | 974       | 2            | 144.5               | 91        | 1            | 560.6               |
| Cough                     |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 3961            | 2            | 75.7                | 1220      | 2            | 135.2               | 103       | 1            | 513.1               |
| Mild/Mod                  | 302             | 0            | --                  | 174       | 0            | --                  | 14        | 0            | --                  |
| Severe                    | 1668            | 2            | 121.9               | 937       | 1            | 75.1                | 95        | 0            | --                  |
| Dyspnea                   |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 2905            | 2            | 132.2               | 644       | 0            | --                  | 25        | 0            | --                  |
| Severe                    | 331             | 0            | --                  | 262       | 0            | --                  | 46        | 1            | 1103.3              |
| TOTALS                    | 5931            | 4            | 80.6                | 2331      | 3            | 94.4                | 212       | 1            | 83.0                |

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1. For a discussion of the limitations of comparison of study subgroup S.M.R.s, see the Text.

TABLE 7.21

Comparison of Cancer of Lung Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                       | OBS (Exposure) | S.M.R. | No. at Risk | Pyrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF  |
|-----------------------|----------------|--------|-------------|---------------|------------|---------------------------|------|
| CWP Category          |                |        |             |               |            |                           |      |
| 0                     | 37 (43.50)     | 85.1   | 5931        | 51557.7       | 71.76      | 87.07                     | 1.03 |
| Simple                | 25 (29.24)     | 85.5   | 2331        | 20198.9       | 123.77     | 93.26                     | 1.11 |
| PMF                   | 0 ( 3.86)      | --*    | 213         | 1872.6        | 0          | 0                         | 0.00 |
| Years Underground     |                |        |             |               |            |                           |      |
| <=30                  | 33 (45.84)     | 72.0   | 6862        | 59956.5       | 55.04      | 68.38                     | 0.81 |
| > 30                  | 29 (30.76)     | 94.3   | 1613        | 13672.7       | 212.10     | 77.70                     | 0.92 |
| FEV <sub>1</sub> /FVC |                |        |             |               |            |                           |      |
| <=70                  | 39 (26.45)     | 147.4* | 2196        | 18607.7       | 209.59     | 153.42                    | 1.82 |
| > 70                  | 17 (40.62)     | 41.9** | 5522        | 48330.5       | 35.17      | 39.50                     | 0.47 |
| Phlegm                |                |        |             |               |            |                           |      |
| None                  | 24 (38.04)     | 63.1*  | 4975        | 43387.4       | 55.32      | 62.72                     | 0.74 |
| Mild/Mod              | 4 (6.30)       | 63.5   | 596         | 5256.0        | 76.10      | 59.80                     | 0.71 |
| Severe                | 34 (32.28)     | 105.3  | 2904        | 24985.9       | 136.08     | 108.40                    | 1.29 |
| Cough                 |                |        |             |               |            |                           |      |
| None                  | 27 (41.40)     | 65.2*  | 5284        | 46285         | 58.33      | 65.22                     | 0.77 |
| Mild/Mod              | 5 (5.03)       | 99.4   | 491         | 4270.6        | 117.08     | 99.52                     | 1.18 |
| Severe                | 30 (30.17)     | 99.4   | 2700        | 23073.7       | 130.02     | 101.16                    | 1.20 |
| Dyspnea               |                |        |             |               |            |                           |      |
| None/Mild             | 54 (67.95)     | 79.5   | 7836        | 68282.1       | 79.02      | 84.42                     | 0.98 |
| Severe                | 8 (8.65)       | 92.5   | 639         | 5293.0        | 151.14     | 88.16                     | 1.05 |
| Total                 | 62 (76.60)     | 80.9   | 8475        | 73629.1       | 84.21      | --                        | --   |

- \* Indicates significance at .05 level; \*\* indicates significance at .01 level.
2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.
3. Comparative mortality figure; see text for further description.

TABLE 7.22

## Lung Cancer Age-Specific Death Rates and Standardized Mortality Ratios by CWP Radiographic Category

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | 0 CWP  |        | 1-3 CWP |        | PMF  |        |
|--|--------|--------|--------|--------|---------|--------|------|--------|
|  | D.R.   | S.M.R. | D.R.   | S.M.R. | D.R.    | S.M.R. | D.R. | S.M.R. |
| <20  | 0.00   | --     | 0.00   | --     | 0.00    | --     | --   | --     |
| 20-24                                      | 0.00   | --     | 0.00   | --     | 0.00    | --     | --   | --     |
| 25-29                                      | 0.00   | --     | 0.00   | --     | 0.00    | --     | --   | --     |
| 30-34                                      | 15.54  | 781.6  | 16.88  | 848.9  | 0.00    | --     | --   | --     |
| 35-39                                      | 16.77  | 253.8  | 0.00   | --     | 128.69  | 1927.3 | --   | --     |
| 40-44                                      | 15.52  | 77.0   | 19.41  | 97.0   | 0.00    | --     | 0.00 | --     |
| 45-49                                      | 66.08  | 141.4  | 76.38  | 163.2  | 40.66   | 87.3   | 0.00 | --     |
| 50-54                                      | 42.87  | 48.3   | 57.81  | 59.4   | 26.11   | 29.5   | 0.00 | --     |
| 55-59                                      | 120.86 | 80.0   | 128.51 | 85.1   | 123.48  | 81.8   | 0.00 | --     |
| 60-64                                      | 193.53 | 79.5   | 197.28 | 81.0   | 217.73  | 89.4   | 0.00 | --     |
| 65-69                                      | 255.79 | 77.2   | 265.13 | 80.0   | 288.94  | 87.3   | 0.00 | --     |
| 70-74                                      | 415.05 | 99.2   | 262.86 | 62.9   | 701.55  | 167.4  | 0.00 | --     |
| 75-79                                      | 0.00   | --     | 0.00   | --     | 0.0     | --     | 0.00 | --     |
| 80-84                                      | --     | --     | --     | --     | --      | --     | --   | --     |
| 85 +                                       | 0.00   | --     | 0.00   | --     | 0.00    | --     | 0.00 | --     |
| TOTAL                                      | 84.21  | 80.9   | 71.76  | 85.1   | 123.77  | 85.5   | 0.00 | --     |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 87.07  |        | 93.26   |        | --   |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.03   |        | 1.11    |        | --   |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.23

## Lung Cancer Age-Specific Death Rates and Standardized Mortality Ratios by Years of Underground Mining (ZYRUG)

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | ZYRUG < = 30 |        | ZYRUG > 30 |        |
|--|--------|--------|--------------|--------|------------|--------|
|  | D.R.   | S.M.R. | D.R.         | S.M.R. | D.R.       | S.M.R. |
| <20  | 0.00   | --     | 0.00         | --     | --         | --     |
| 20-24                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 25-29                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 30-34                                      | 15.54  | 781.6  | 15.54        | 781.6  | --         | --     |
| 35-39                                      | 16.77  | 253.8  | 16.77        | 253.8  | 0.00       | --     |
| 40-44                                      | 15.52  | 77.0   | 15.43        | 77.1   | 0.00       | --     |
| 45-49                                      | 66.08  | 141.4  | 66.57        | 142.4  | 0.00       | --     |
| 50-54                                      | 42.87  | 48.3   | 47.34        | 53.2   | 0.00       | --     |
| 55-59                                      | 120.86 | 80.0   | 119.72       | 79.2   | 123.19     | 81.8   |
| 60-64                                      | 193.53 | 79.5   | 132.33       | 54.1   | 246.05     | 101.5  |
| 65-69                                      | 255.79 | 77.2   | 123.43       | 37.3   | 335.83     | 101.4  |
| 70-74                                      | 415.05 | 99.2   | 356.20       | 85.1   | 452.43     | 108.1  |
| 75-79                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 80-84                                      | --     | --     | --           | --     | --         | --     |
| 85 +                                       | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| TOTAL                                      | 84.21  | 80.9   | 55.04        | 72.0   | 212.10     | 94.3   |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 68.38        |        | 77.70      |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.81         |        | 0.93       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.24

Lung Cancer of Death Age-Specific Death Rates and Standardized Mortality Ratios by FEV<sub>1</sub>/FVC StatusAge-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | FEV <sub>1</sub> /FVC ≤ 70 |        | FEV <sub>1</sub> /FVC > 70 |        |
|--|--------|--------|----------------------------|--------|----------------------------|--------|
|  | D.R.   | S.M.R. | D.R.                       | S.M.R. | D.R.                       | S.M.R. |
| <20  | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 20-24                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 25-29                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 30-34                                      | 15.54  | 781.6  | 0.00                       | --     | 18.45                      | 928.0  |
| 35-39                                      | 16.77  | 253.8  | 0.00                       | --     | 21.04                      | 318.7  |
| 40-44                                      | 15.52  | 77.0   | 0.00                       | --     | 20.78                      | 103.9  |
| 45-49                                      | 66.08  | 141.4  | 136.64                     | 292.8  | 48.36                      | 103.4  |
| 50-54                                      | 42.87  | 48.3   | 91.15                      | 102.9  | 27.22                      | 30.6   |
| 55-59                                      | 120.86 | 80.0   | 256.34                     | 169.8  | 59.25                      | 39.2   |
| 60-64                                      | 193.53 | 79.5   | 379.39                     | 156.0  | 83.20                      | 34.1*  |
| 65-69                                      | 255.79 | 77.2   | 420.40                     | 126.9  | 50.95                      | 15.4*  |
| 70-74                                      | 415.05 | 99.2   | 369.61                     | 88.4   | 0.00                       | --     |
| 75-79                                      | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| 80-84                                      | --     | --     | --                         | --     | --                         | --     |
| 85 +                                       | 0.00   | --     | 0.00                       | --     | 0.00                       | --     |
| TOTAL                                      | 84.21  | 80.9   | 209.59                     | 174.4* | 35.17                      | 41.9** |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 153.42                     |        | 39.50                      |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.82                       |        | 0.47                       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.25

## Lung Cancer Age-Specific Death Rates and Standardized Mortality Ratios by Phlegm Status

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | No Phlegm |        | Mild/Mod Phlegm |        | Severe Phlegm |        |
|--|--------|--------|-----------|--------|-----------------|--------|---------------|--------|
|  | D.R.   | S.M.R. | D.R.      | S.M.R. | D.R.            | S.M.R. | D.R.          | S.M.R. |
| <20  | 0.00   | --     | 0.00      | --     | 0.00            | --     | 0.00          | --     |
| 20-24                                      | 0.00   | --     | 0.00      | --     | 0.00            | --     | 0.00          | --     |
| 25-29                                      | 0.00   | --     | 0.00      | --     | 0.00            | --     | 0.00          | --     |
| 30-34                                      | 15.54  | 781.6  | 21.05     | 1058.7 | 0.00            | --     | 0.00          | --     |
| 35-39                                      | 16.77  | 253.8  | 23.99     | 363.5  | 0.00            | --     | 0.00          | --     |
| 40-44                                      | 15.52  | 77.0   | 0.00      | --     | 0.00            | --     | 52.18         | 260.1  |
| 45-49                                      | 66.08  | 141.4  | 73.97     | 158.1  | 0.00            | --     | 66.16         | 141.8  |
| 50-54                                      | 42.87  | 48.3   | 61.34     | 69.0   | 0.00            | --     | 23.88         | 26.9   |
| 55-59                                      | 120.86 | 80.0   | 80.96     | 53.6   | 174.14          | 115.4  | 157.27        | 104.2  |
| 60-64                                      | 193.53 | 79.5   | 88.73     | 36.4*  | 227.91          | 93.4   | 293.33        | 120.6  |
| 65-69                                      | 255.79 | 77.2   | 200.69    | 60.6   | 0.00            | --     | 349.16        | 105.5  |
| 70-74                                      | 415.05 | 99.2   | 292.47    | 69.9*  | 0.00            | 00     | 586.81        | 140.2  |
| 75-79                                      | 0.00   | --     | 0.00      | --     | 0.00            | --     | 0.00          | --     |
| 80-84                                      | --     | --     | --        | --     | --              | --     | --            | --     |
| 85 +                                       | 0.00   | --     | 0.00      | --     | 0.00            | --     | 0.00          | --     |
| TOTAL                                      | 84.21  | 80.9   | 55.32     | 63.1*  | 76.10           | 63.5   | 136.08        | 105.3  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 62.72     |        | 59.80           |        | 108.40        |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.74      |        | 0.71            |        | 1.29          |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.26

## Lung Cancer Age-Specific Death Rates and Standardized Mortality Ratios by Cough Status

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | No Cough |        | Mild/Mod Cough |        | Severe Cough |        |
|--|--------|--------|----------|--------|----------------|--------|--------------|--------|
|  | D.R.   | S.M.R. | D.R.     | S.M.R. | D.R.           | S.M.R. | D.R.         | S.M.R. |
| <20  | 0.00   | --     | 0.00     | --     | 0.00           | --     | 0.00         | --     |
| 20-24                                      | 0.00   | --     | 0.00     | --     | 0.00           | --     | 0.00         | --     |
| 25-29                                      | 0.00   | --     | 0.00     | --     | 0.00           | --     | 0.00         | --     |
| 30-34                                      | 15.54  | 781.6  | 19.96    | 1003.5 | 0.00           | --     | 0.00         | --     |
| 35-39                                      | 16.77  | 253.8  | 22.99    | 348.7  | 0.00           | --     | 0.00         | --     |
| 40-44                                      | 15.52  | 77.0   | 0.00     | --     | 0.00           | --     | 54.06        | 269.5  |
| 45-49                                      | 66.08  | 141.4  | 86.70    | 185.5  | 0.00           | --     | 35.90        | 76.8   |
| 50-54                                      | 42.87  | 48.3   | 42.28    | 47.6   | 150.24         | 169.5  | 25.63        | 28.9   |
| 55-59                                      | 120.86 | 80.0   | 117.78   | 78.0   | 119.20         | 79.0   | 125.52       | 83.2   |
| 60-64                                      | 193.53 | 79.5   | 80.39    | 33.0*  | 416.72         | 171.2  | 291.10       | 119.7  |
| 65-69                                      | 255.79 | 77.2   | 186.64   | 56.4   | 0.00           | --     | 372.91       | 112.7  |
| 70-74                                      | 415.05 | 99.2   | 275.57   | 65.9   | 0.00           | --     | 617.85       | 147.7  |
| 75-79                                      | 0.00   | --     | 0.00     | --     | 0.00           | --     | 0.00         | --     |
| 80-84                                      | --     | --     | --       | --     | --             | --     | --           | --     |
| 85 +                                       | 0.00   | --     | 0.00     | --     | 0.00           | --     | 0.00         | --     |
| TOTAL                                      | 84.21  | 80.9   | 58.33    | 65.2*  | 117.08         | 99.4   | 130.02       | 99.4   |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 65.22    |        | 99.52          |        | 101.16       |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.77     |        | 1.18           |        | 1.20         |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.27

## Lung Cancer Death Age-Specific Death Rates and Standardized Mortality Ratios by Dyspnea Status

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | No Dyspnea |        | Severe Dyspnea |        |
|--|--------|--------|------------|--------|----------------|--------|
|  | D.R.   | S.M.R. | D.R.       | S.M.R. | D.R.           | S.M.R. |
| <20  | 0.00   | --     | 0.00       | --     | 0.00           | --     |
| 20-24                                      | 0.00   | --     | 0.00       | --     | 0.00           | --     |
| 25-29                                      | 0.00   | --     | 0.00       | --     | 0.00           | --     |
| 30-34                                      | 15.54  | 781.6  | 15.73      | 790.6  | 0.00           | --     |
| 35-39                                      | 16.77  | 253.8  | 17.14      | 259.5  | 0.00           | --     |
| 40-44                                      | 15.52  | 77.0   | 16.16      | 80.7   | 0.00           | --     |
| 45-49                                      | 66.08  | 141.4  | 70.14      | 150.0  | 0.00           | --     |
| 50-54                                      | 42.87  | 48.3   | 46.63      | 52.5   | 0.00           | --     |
| 55-59                                      | 120.86 | 80.0   | 125.93     | 83.4   | 77.29          | 51.2   |
| 60-64                                      | 193.53 | 79.5   | 163.60     | 67.2   | 396.82         | 163.6  |
| 65-69                                      | 255.79 | 77.2   | 300.12     | 90.6   | 0.00           | --     |
| 70-74                                      | 415.05 | 99.2   | 157.71     | 37.7   | 2254.55        | 539.0  |
| 75-79                                      | 0.00   | --     | 0.00       | --     | 0.00           | --     |
| 80-84                                      | --     | --     | --         | --     | --             | --     |
| 85 +                                       | 0.00   | --     | 0.00       | --     | 0.00           | --     |
| TOTAL                                      | 84.21  | 80.9   | 79.02      | 79.5   | 151.14         | 92.5   |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 82.42      |        | 88.16          |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 0.98       |        | 1.05           |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.28

## Lung Cancer Age-Specific Death Rates and Standardized Mortality Ratios by Smoking Status

Age-Specific Lung Cancer Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort |        | Current Smoker |        | Ex-Smoker |         | Never Smoked |        |
|--|--------|--------|----------------|--------|-----------|---------|--------------|--------|
|  | D.R.   | S.M.R. | D.R.           | S.M.R. | D.R.      | S.M.R.  | D.R.         | S.M.R. |
| <20  | 0.00   | --     | 0.00           | --     | 0.00      | --      | 0.00         | --     |
| 20-24                                      | 0.00   | --     | 0.00           | --     | 0.00      | --      | 0.00         | --     |
| 25-29                                      | 0.00   | --     | 0.00           | --     | 0.00      | --      | 0.00         | --     |
| 30-34                                      | 15.54  | 781.6  | 0.00           | --     | 107.74    | 5407.3* | 0.00         | --     |
| 35-39                                      | 16.77  | 253.8  | 26.70          | 404.4  | 0.00      | --      | 0.00         | --     |
| 40-44                                      | 15.52  | 77.0   | 25.98          | 129.8  | 0.00      | --      | 0.00         | --     |
| 45-49                                      | 66.08  | 141.4  | 101.93         | 217.8  | 0.00      | --      | 60.65        | 129.9  |
| 50-54                                      | 42.87  | 48.3   | 67.34          | 75.9   | 27.89     | 31.4    | 0.00         | --     |
| 55-59                                      | 120.86 | 80.0   | 17.85          | 118.4  | 103.25    | 68.4    | 0.00         | --     |
| 60-64                                      | 193.53 | 79.5   | 300.04         | 123.0  | 177.01    | 72.9    | 0.00         | --     |
| 65-69                                      | 255.79 | 77.2   | 567.00         | 171.1  | 119.52    | 36.1    | 0.00         | --     |
| 70-74                                      | 415.05 | 99.2   | 1498.48        | 356.8  | 0.00      | --      | 0.00         | --     |
| 75-79                                      | 0.00   | --     | 00.0           | --     | 0.00      | --      | 0.00         | --     |
| 80-84                                      | --     | --     | --             | --     | --        | --      | --           | --     |
| 85 +                                       | 0.00   | --     | 0.00           | --     | 0.00      | --      | 0.00         | --     |
| TOTAL                                      | 84.21  | 80.9   | 120.37         | 135.6  | 71.79     | 54.3*   | 6.63         | 6.2**  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 140.64         |        | 43.09     |         | 7.49         |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.67           |        | 0.51      |         | 0.09         |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

Table 7.29

Lung Cancer Standardized Mortality Ratios, Number of Men at Risk,  
and Number of Deaths by CWP Radiographic Category for Study Cohort Subgroups

## Category of CWP

|                           | 0         |              |                     | Simple    |              |                     | PMF       |              |                     |
|---------------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|
|                           | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> |
| Cigarette Smoking         |           |              |                     |           |              |                     |           |              |                     |
| Smoker when examined      | 3179      | 26           | 136.9               | 1272      | 21           | 147.8               | 87        | 0            | --                  |
| Smoked only in past       | 1476      | 11           | 73.8                | 664       | 3            | 32.0*               | 81        | 0            | --                  |
| Never smoked              | 1276      | 0            | --**                | 395       | 1            | 17.7*               | 45        | 0            | --                  |
| Years Under Ground Mining |           |              |                     |           |              |                     |           |              |                     |
| <=30                      | 5231      | 23           | 75.8                | 1551      | 10           | 69.5                | 79        | 0            | --                  |
| > 30                      | 700       | 14           | 106.6               | 780       | 15           | 101.0               | 133       | 0            | --                  |
| FEV <sub>1</sub> /FVC     |           |              |                     |           |              |                     |           |              |                     |
| <=70                      | 1417      | 25           | 165.9*              | 668       | 14           | 150.8               | 111       | 0            | --                  |
| > 70                      | 4089      | 10           | 41.9**              | 1361      | 7            | 45.1**              | 71        | 0            | --                  |
| Phlegm                    |           |              |                     |           |              |                     |           |              |                     |
| None                      | 3749      | 14           | 60.2                | 1131      | 10           | 76.4                | 95        | 0            | --                  |
| Mild/Mod                  | 344       | 2            | 70.5                | 226       | 2            | 67.4                | 26        | 0            | --                  |
| Severe                    | 1838      | 21           | 120.6               | 974       | 13           | 98.7                | 91        | 0            | --                  |
| Cough                     |           |              |                     |           |              |                     |           |              |                     |
| None                      | 3961      | 16           | 63.4                | 1220      | 11           | 76.9                | 103       | 0            | --                  |
| Mild/Mod                  | 302       | 1            | 39.8                | 174       | 4            | 178.3               | 14        | 0            | --                  |
| Severe                    | 1668      | 20           | 127.0               | 937       | 10           | 78.8                |           |              |                     |
| Dyspnea                   |           |              |                     |           |              |                     |           |              |                     |
| None                      | 2905      | 13           | 90.9                | 644       | 2            | 30.5                | 25        | 0            | --                  |
| Severe                    | 331       | 5            | 125.7               | 262       | 3            | 78.2                | 46        | 0            | --                  |
| TOTALS                    | 5931      | 37           | 80.6**              | 2331      | 25           | 94.4                | 212       | 0            | 83.0                |

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1. For a discussion of the limitations of comparison of study subgroup S.M.R.s, see the Text.

TABLE 7.30

Comparison of Non Malignant Respiratory Disease Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                       | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Pyrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF <sup>3</sup> |
|-----------------------|----------------|---------------------|-------------|---------------|------------|---------------------------|------------------|
| CWP Category          |                |                     |             |               |            |                           |                  |
| 0                     | 30 (28.74)     | 104.4               | 4931        | 51557.7       | 58.19      | 73.53                     | 0.64             |
| Simple                | 39 (19.43)     | 200.8**             | 2331        | 20198.9       | 193.08     | 136.41                    | 1.20             |
| PMF                   | 15 (2.73)      | 549.9**             | 213         | 1872.6        | 801.01     | 351.58                    | 3.08             |
| Years Underground     |                |                     |             |               |            |                           |                  |
| <=30                  | 39 (28.61)     | 136.3               | 6862        | 59956.5       | 65.05      | 91.50                     | 0.80             |
| > 30                  | 45 (22.29)     | 201.9**             | 1613        | 13672.7       | 329.12     | 124.41                    | 1.09             |
| FEV <sub>1</sub> /FVC |                |                     |             |               |            |                           |                  |
| <=70                  | 41 (17.84)     | 229.8**             | 2196        | 18607.0       | 220.34     | 153.87                    | 1.35             |
| > 70                  | 23 (26.29)     | 84.5                | 5522        | 48330.5       | 45.59      | 60.40                     | 0.53             |
| Phlegm                |                |                     |             |               |            |                           |                  |
| None                  | 25 (25.12)     | 99.5                | 4975        | 43387.4       | 57.62      | 70.62                     | 0.62             |
| Mild/Mod              | 9 (4.06)       | 221.9*              | 596         | 5256.0        | 171.23     | 180.88                    | 1.58             |
| Severe                | 50 (21.73)     | 230.1**             | 2904        | 24985.9       | 200.11     | 157.44                    | 1.38             |
| Cough                 |                |                     |             |               |            |                           |                  |
| None                  | 29 (27.28)     | 106.3               | 5284        | 46285.0       | 62.66      | 95.69                     | 0.84             |
| Mild/Mod              | 7 (3.28)       | 213.4               | 491         | 4270.6        | 163.91     | 119.79                    | 1.05             |
| Severe                | 48 (20.33)     | 236.1**             | 2700        | 23073.7       | 208.03     | 160.87                    | 1.41             |
| Dyspnea               |                |                     |             |               |            |                           |                  |
| None/Mild             | 63 (45.01)     | 140.0*              | 7836        | 68282.1       | 92.19      | 97.20                     | 0.85             |
| Severe                | 21 (5.89)      | 356.6**             | 639         | 5293.0        | 396.75     | 251.15                    | 2.20             |
| Total                 | 84 (50.90)     | 165.0**             | 8475        | 73629.1       | 114.08     | --                        | --               |

1. \* Indicates significance at .05 level; \*\* indicates significance at .01 level.

2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.

3. Comparative mortality figure; see text for further description.

TABLE 7.31

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios by CWP Radiographic Category

Age-Specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |         | 0 CWP  |        | 1-3 CWP |         | PMF     |          |
|--|---------|---------|--------|--------|---------|---------|---------|----------|
|  | D.R.    | S.M.R.  | D.R.   | S.M.R. | D.R.    | S.M.R.  | D.R.    | S.M.R.   |
| < 20                                       | 0.00    | --      | 0.00   | --     | 0.00    | --      | --      | --       |
| 20-24                                      | 0.00    | --      | 0.00   | --     | 0.00    | --      | --      | --       |
| 25-29                                      | 0.00    | --      | 0.00   | --     | 0.00    | --      | --      | --       |
| 30-34                                      | 0.00    | --      | 0.00   | --     | 0.00    | --      | --      | --       |
| 35-39                                      | 0.00    | --      | 0.00   | --     | 0.00    | --      | --      | --       |
| 40-44                                      | 0.00    | --      | 0.00   | 00     | 0.00    | --      | 0.00    | --       |
| 45-49                                      | 22.03   | 99.4    | 30.55  | 138.5  | 0.00    | --      | 0.00    | --       |
| 50-54                                      | 42.87   | 101.3   | 26.40  | 62.7   | 78.32   | 183.7   | 0.00    | --       |
| 55-59                                      | 201.43  | 241.3** | 171.36 | 206.4* | 164.64  | 196.0   | 910.19  | 1071.5** |
| 60-64                                      | 285.20  | 177.5** | 197.28 | 122.8  | 314.50  | 195.8   | 812.69  | 503.9**  |
| 65-69                                      | 384.81  | 127.4   | 176.76 | 64.6   | 520.15  | 189.9   | 651.40  | 237.6    |
| 70-74                                      | 1106.81 | 238.7*  | 0.00   | --     | 1753.86 | 378.3*  | 5236.98 | 1129.8** |
| 75-79                                      | 0.00    | --      | 0.00   | --     | 0.00    | --      | 0.00    | --       |
| 80-84                                      | --      | --      | --     | --     | --      | --      | --      | --       |
| 85 +                                       | 1872.18 | 121.9   | 0.00   | --     | 9075.09 | 592.5** | 0.00    | --       |
| TOTAL                                      | 114.08  | 165.0** | 58.19  | 104.4  | 193.08  | 200.8*  | 801.01  | 549.9**  |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 73.53  |        | 136.41  |         | 351.58  |          |
| Comparative Mortality Figures <sup>4</sup> |         |         | 0.64   |        | 1.20    |         | 3.08    |          |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.  
 \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.32

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios By Years Underground Mining (ZYRUG)

| Age Groups                                 | Age-Specific Non Malignant Respiratory Disease Death Rates <sup>1</sup> and S.M.R.s <sup>2</sup> |         | ZYRUG < = 30 |         | ZYRUG > 30 |         |
|--|--|---------|--------------|---------|------------|---------|
|  | Cohort D.R.  | S.M.R.  | D.R.         | S.M.R.  | D.R.       | S.M.R.  |
| <20  | 0.00   | --      | 0.00         | --      | --         | --      |
| 20-24                                      | 0.00   | --      | 0.00         | --      | --         | --      |
| 25-29                                      | 0.00   | --      | 0.00         | --      | --         | --      |
| 30-34                                      | 0.00   | --      | 0.00         | --      | --         | --      |
| 35-39                                      | 0.00   | --      | 0.00         | --      | 0.00       | --      |
| 40-44                                      | 0.00   | --      | 0.00         | --      | 0.00       | --      |
| 45-49                                      | 22.03  | 99.4    | 22.10        | 100.2   | 0.00       | --      |
| 50-54                                      | 42.89  | 101.3   | 47.34        | 112.5   | 0.00       | --      |
| 55-59                                      | 201.43   | 241.3** | 179.58       | 217.9** | 246.38     | 287.6** |
| 60-64                                      | 285.20   | 177.5** | 220.55       | 138.0   | 340.68     | 211.2** |
| 65-69                                      | 284.81   | 127.4   | 308.57       | 112.7   | 373.14     | 136.3   |
| 70-74                                      | 1106.81  | 238.7*  | 356.20       | 76.8    | 1583.50    | 341.6*  |
| 75-79                                      | 0.00   | --      | 2747.25      | 179.0   | 0.00       | --      |
| 80-84                                      | --   | --      | --           | --      | --         | --      |
| 85 +                                       | 1872.18  | 121.9   | 0.00         | --      | 0.00       | --      |
| TOTAL                                      | 114.08   | 165.0** | 65.05        | 136.3   | 329.12     | 201.9** |
| Age-Adjusted Death Rates <sup>3</sup>      |  |         | 91.50        |         | 124.41     |         |
| Comparative Mortality Figures <sup>4</sup> |  |         | 0.80         |         | 1.09       |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.33

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios by FEV<sub>1</sub>/FVC Status

Age-specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |         | FEV <sub>1</sub> /FVC ≤ 70 |         | FEV <sub>1</sub> /FVC > 70 |        |
|--|---------|---------|----------------------------|---------|----------------------------|--------|
|  | D.R.    | S.M.R.  | D.R.                       | S.M.R.  | D.R.                       | S.M.R. |
| < 20                                       | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 20-24                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 25-29                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 30-34                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 35-39                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 40-44                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 45-49                                      | 22.03   | 99.4    | 45.55                      | 204.4   | 16.21                      | 72.9   |
| 50-54                                      | 42.87   | 101.3   | 30.38                      | 71.4    | 40.83                      | 91.9   |
| 55-59                                      | 201.43  | 241.3** | 233.03                     | 277.7** | 103.69                     | 124.8  |
| 60-64                                      | 285.20  | 177.5** | 433.59                     | 269.6** | 145.60                     | 90.8   |
| 65-69                                      | 384.81  | 127.4   | 480.46                     | 175.5   | 203.79                     | 74.5   |
| 70-74                                      | 1106.81 | 238.7*  | 1848.84                    | 398.7*  | 330.44                     | 71.3   |
| 75-79                                      | 0.00    | --      | 0.00                       | --      | 0.00                       | --     |
| 80-84                                      | --      | --      | --                         | --      | --                         | --     |
| 85 +                                       | 1872.18 | 121.9   | 0.00                       | --      | 0.00                       | --     |
| TOTAL                                      | 114.08  | 165.0** | 220.34                     | 229.8** | 47.59                      | 87.5   |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 153.87                     |         | 60.40                      |        |
| Comparative Mortality Figures <sup>4</sup> |         |         | 1.35                       |         | 0.53                       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.34

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios by Phlegm Status

Age-Specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |         | None   |        | Mild/Mod |        | Severe  |         |
|--|---------|---------|--------|--------|----------|--------|---------|---------|
|  | D.R.    | S.M.R.  | D.R.   | S.M.R. | D.R.     | S.M.R. | D.R.    | S.M.R.  |
| < 20                                       | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 20-24                                      | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 25-29                                      | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 30-34                                      | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 35-39                                      | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 40-44                                      | 0.00    | --      | 0.00   | 00     | 0.00     | --     | 0.00    | --      |
| 45-49                                      | 22.03   | 99.4    | 0.00   | --     | 9.00     | --     | 66.16   | 297.1   |
| 50-54                                      | 42.87   | 101.3   | 30.67  | 72.7   | 104.65   | 245.0  | 47.77   | 112.6   |
| 55-59                                      | 201.43  | 241.3** | 145.72 | 175.4  | 87.07    | 103.8  | 294.87  | 351.4** |
| 60-64                                      | 285.20  | 177.5** | 177.45 | 110.5  | 227.91   | 142.3  | 406.14  | 252.5** |
| 65-69                                      | 384.81  | 127.4   | 200.69 | 73.3   | 992.09   | 362.6  | 399.04  | 145.7   |
| 70-74                                      | 1106.81 | 238.7*  | 584.93 | 126.2  | 2496.75  | 538.6  | 1467.02 | 316.4*  |
| 75-79                                      | 0.00    | --      | 0.00   | --     | 0.00     | --     | 0.00    | --      |
| 80-84                                      | --      | --      | --     | --     | --       | --     | --      | --      |
| 85 +                                       | 1872.18 | 121.9   | 0.00   | --     | 50484.09 | 3370.4 | 200.11  | 230.1** |
| TOTAL                                      | 114.08  | 165.0** | 57.62  | 99.5   | 171.23   | 221.9* |         |         |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 70.62  |        | 180.88   |        | 157.44  |         |
| Comparative Mortality Figures <sup>4</sup> |         |         | 0.62   |        | 1.58     |        | 1.38    |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.35

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios by Cough Status

Age-Specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |         | No Cough |        | Mild/Mod Cough |        | Severe Cough |         |
|--|---------|---------|----------|--------|----------------|--------|--------------|---------|
|  | D.R.    | S.M.R.  | D.R.     | S.M.R. | D.R.           | S.M.R. | D.R.         | S.M.R.  |
| < 20                                       | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 20-24                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 25-29                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 30-34                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 35-39                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 40-44                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 45-49                                      | 22.03   | 99.4    | 0.00     | --     | 189.57         | 854.5  | 35.90        | 161.8   |
| 50-54                                      | 42.87   | 101.3   | 28.19    | 66.8   | 0.00           | --     | 76.89        | 180.8   |
| 55-59                                      | 201.43  | 241.3** | 161.94   | 194.7  | 119.20         | 141.6  | 271.96       | 324.5** |
| 60-64                                      | 285.20  | 177.5** | 160.79   | 100.1  | 277.81         | 172.9  | 436.65       | 271.5** |
| 65-69                                      | 384.81  | 127.4   | 186.64   | 68.2   | 1071.16        | 391.8  | 426.19       | 155.6   |
| 70-74                                      | 1106.81 | 238.7*  | 826.71   | 178.3  | 0.00           | --     | 154.63       | 333.2*  |
| 75-79                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 80-84                                      | 0.00    | --      | 0.00     | --     | 0.00           | --     | 0.00         | --      |
| 85 +                                       | 1872.18 | 121.9   | 2747.25  | 179.0  | 0.00           | --     | 0.00         | --      |
| TOTAL                                      | 114.08  | 165.0** | 62.66    | 106.3  | 163.91         | 213.4  | 208.03       | 236.1** |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 95.69    |        | 119.79         |        | 160.87       |         |
| Comparative Mortality Figures <sup>4</sup> |         |         | 0.84     |        | 1.05           |        | 1.41         |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.36

Non Malignant Respiratory Disease Age-Specific Death Rates and Standardized  
Mortality Ratios by Dyspnea Status

Age-Specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |         | None/Mild/Mod |        | Severe  |         |
|--|---------|---------|---------------|--------|---------|---------|
|  | D.R.    | S.M.R.  | D.R.          | S.M.R. | D.R.    | S.M.R.  |
| < 20                                       | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 20-24                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 25-29                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 30-34                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 35-39                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 40-44                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 45-49                                      | 22.03   | 99.4    | 11.69         | 52.8   | 190.45  | 853.1   |
| 50-54                                      | 42.87   | 101.3   | 46.63         | 110.3  | 0.00    | --      |
| 55-59                                      | 201.43  | 241.3** | 161.90        | 194.1  | 541.03  | 644.3** |
| 60-64                                      | 285.20  | 177.5** | 233.71        | 145.5  | 634.91  | 393.4** |
| 65-69                                      | 384.81  | 127.4   | 354.68        | 129.5  | 314.92  | 115.1   |
| 70-74                                      | 1106.81 | 238.7*  | 788.53        | 170.1  | 3381.82 | 729.5*  |
| 75-79                                      | 0.00    | --      | 0.00          | --     | 0.00    | --      |
| 80-84                                      | --      | --      | --            | --     | --      | --      |
| 85 +                                       | 1872.18 | 121.9   | 1904.81       | 124.0  | 0.00    | --      |
| TOTAL                                      | 114.08  | 165.0** | 92.19         | 140.0* | 396.75  | 356.6*  |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 97.20         |        | 251.15  |         |
| Comparative Mortality Figures <sup>4</sup> |         |         | 0.85          |        | 2.20    |         |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.37

Non-Malignant Respiratory Disease Age-Specific Death Rates and Standardized Mortality Ratios by Smoking Status

Age-Specific Non Malignant Respiratory Disease Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age Groups                                 | Cohort  |         | Current Smoker |         | Ex-Smoker |        | Never Smoked |        |
|--|---------|---------|----------------|---------|-----------|--------|--------------|--------|
|  | D.R.    | S.M.R.  | D.R.           | S.M.R.  | D.R.      | S.M.R. | D.R.         | S.M.R. |
| < 20                                       | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 20-24                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 25-29                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 30-34                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 35-39                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 40-44                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 45-49                                      | 22.03   | 99.4    | 40.77          | 184.8   | 0.00      | --     | 0.00         | --     |
| 50-54                                      | 42.87   | 101.3   | 67.34          | 15.90   | 27.89     | 65.9   | 0.00         | --     |
| 55-59                                      | 201.43  | 241.3** | 392.36         | 234.2*  | 180.69    | 216.1  | 251.34       | 300.1* |
| 60-64                                      | 285.20  | 177.5** | 378.00         | 244.8** | 236.02    | 146.5  | 143.17       | 89.0   |
| 65-69                                      | 384.81  | 127.4   | 2497.47        | 138.2   | 478.06    | 174.6  | 96.19        | 35.1   |
| 70-74                                      | 1106.81 | 238.7*  | 0.00           | 538.6** | 1003.61   | 216.5  | 0.00         | --     |
| 75-79                                      | 0.00    | --      | 0.00           | --      | 0.00      | --     | 0.00         | --     |
| 80-84                                      | --      | --      | --             | --      | --        | --     | --           | --     |
| 85 +                                       | 1872.18 | 121.9   | 0.00           | --      | 0.00      | --     | 5699.56      | 371.9  |
| TOTAL                                      | 114.08  | 165.0** | 117.81         |         | 138.45    | 153.5* | 72.94        | 98.3   |
| Age-Adjusted Death Rates <sup>3</sup>      |         |         | 147.63         |         | 104.21    |        | 67.16        |        |
| Comparative Mortality Figures <sup>4</sup> |         |         | 1.29           |         | 0.91      |        | 0.59         |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

Table 7.38

Non Malignant Respiratory Disease Standardized Mortality Ratios, Number of Men at Risk,  
and Number of Deaths by CWP Radiographic Category for Study Cohort Subgroups

|                           | Category of CWP |              |                     |           |              |                     |           |              |                     |
|---------------------------|-----------------|--------------|---------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|
|                           | 0               |              |                     | Simple    |              |                     | PMF       |              |                     |
|                           | No of Men       | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> |
| Cigarette Smoking         |                 |              |                     |           |              |                     |           |              |                     |
| Smoker when examined      | 3179            | 20           | 167.8*              | 1272      | 20           | 216.7**             | 87        | 6            | 613.1**             |
| Smoked only in past       | 1476            | 7            | 68.7                | 644       | 13           | 205.3*              | 81        | 7            | 656.2**             |
| Never smoked              | 1276            | 3            | 45.2                | 395       | 6            | 155.3               | 45        | 2            | 293.1               |
| Years Under Ground Mining |                 |              |                     |           |              |                     |           |              |                     |
| <=30                      | 5231            | 22           | 114.2               | 1551      | 13           | 150.1               | 79        | 4            | 598.8**             |
| > 30                      | 700             | 8            | 84.5                | 780       | 26           | 241.6**             | 133       | 11           | 535.1**             |
| FEV <sub>1</sub> /FVC     |                 |              |                     |           |              |                     |           |              |                     |
| <=70                      | 1417            | 14           | 139.4               | 668       | 19           | 300.9**             | 111       | 8            | 539.8**             |
| > 70                      | 4089            | 11           | 71.3                | 1361      | 9            | 89.8                | 71        | 3            | 362.2               |
| Phlegm                    |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 3749            | 13           | 84.2                | 1131      | 7            | 82.5                | 95        | 5            | 420.9*              |
| Mild/Mod                  | 344             | 1            | 56.6                | 226       | 7            | 358.7**             | 26        | 1            | 795.3               |
| Severe                    | 1838            | 16           | 138.7               | 974       | 25           | 278.1**             | 91        | 9            | 751.8**             |
| Cough                     |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 3961            | 13           | 78.0                | 1220      | 12           | 128.8               | 103       | 4            | 309.5               |
| Mild/Mod                  | 302             | 3            | 184.1               | 174       | 4            | 272.7               | 14        | 0            | --                  |
| Severe                    | 1668            | 14           | 134.1               | 937       | 23           | 266.0**             |           |              |                     |
| Dyspnea                   |                 |              |                     |           |              |                     |           |              |                     |
| None                      | 2905            | 5            | 52.1                | 644       | 5            | 119.9               | 25        | 1            | 300.2               |
| Severe                    | 331             | 54           | 133.8*              | 262       | 9            | 343.1**             | 46        | 4            | 646.5**             |
| TOTALS                    | 5931            | 30           | 80.6                | 2331      | 39           | 94.4                | 212       | 15           | 83.0                |

1. For a discussion of the limitations of comparison of study subgroup S.M.R.s, see the Text.

TABLE 7.39

Comparison of Arteriosclerotic Heart Disease Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                       | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Yrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF <sup>3</sup> |
|-----------------------|----------------|---------------------|-------------|--------------|------------|---------------------------|------------------|
| CWP Category          |                |                     |             |              |            |                           |                  |
| 0                     | 158 (193.11)   | 81.8                | 5931        | 51557.7      | 306.45     | 374.13                    | 0.97             |
| Simple                | 121 (128.02)   | 94.5                | 2331        | 20198.9      | 599.04     | 440.17                    | 1.14             |
| PMF                   | 5 (16.91)      | 29.6**              | 212         | 1862.6       | 268.45     | 95.98                     | 0.25             |
| Years Underground     |                |                     |             |              |            |                           |                  |
| <=30                  | 169 (202.09)   | 83.6*               | 6862        | 59956.5      | 281.87     | 365.24                    | 0.94             |
| > 30                  | 115 (135.99)   | 84.6                | 1613        | 13672.7      | 841.09     | 421.63                    | 1.09             |
| FEV <sub>1</sub> /FVC |                |                     |             |              |            |                           |                  |
| <=70                  | 115 (116.56)   | 98.7                | 2196        | 18607.7      | 618.02     | 454.47                    | 1.17             |
| > 70                  | 126 (178.66)   | 70.5**              | 5522        | 48330.5      | 260.70     | 315.80                    | 0.82             |
| Total                 | 284 (338.08)   | 84.0**              | 8475        | 73629.1      | 385.72     | --                        | --               |

1. \* Indicates significance at .05 level; \*\* indicates significance at .01 level.

2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.

3. Comparative mortality figure; see text for further description.

TABLE 7.40

Arteriosclerotic Heart Disease Age-Specific Death Rates and Standardized  
Mortality Ratios by CWP Radiographic Category

Age-Specific Heart Disease Age-specific Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |        | 0 CWP   |        | 1-3 CWP |        | PMF     |        |
|--|---------|--------|---------|--------|---------|--------|---------|--------|
|  | D.R.    | S.M.R. | D.R.    | S.M.R. | D.R.    | S.M.R. | D.R.    | S.M.R. |
| < 20                                       | 0.00    | --     | 0.00    | --     | 0.00    | --     | --      | --     |
| 20-24                                      | 0.00    | --     | 0.00    | --     | 0.00    | --     | --      | --     |
| 25-29                                      | 0.00    | --     | 0.00    | --     | 0.00    | --     | --      | --     |
| 30-34                                      | 0.00    | --     | 0.00    | --     | 0.00    | --     | --      | --     |
| 35-39                                      | 50.31   | 130.1  | 38.56   | 100.0  | 128.69  | 326.5  | --      | --     |
| 40-44                                      | 46.26   | 44.2   | 38.82   | 37.2   | 75.38   | 71.3   | 0.00    | --     |
| 45-49                                      | 231.28  | 106.4  | 259.70  | 119.7  | 162.64  | 74.4   | 0.00    | --     |
| 50-54                                      | 360.10  | 92.6   | 277.75  | 71.5   | 548.26  | 140.3  | 0.00    | --     |
| 55-59                                      | 676.79  | 105.5  | 671.14  | 105.1  | 761.45  | 118.0  | 0.00    | --     |
| 60-64                                      | 794.48  | 78.6*  | 828.58  | 82.0   | 846.72  | 83.9   | 162.54  | 16.0*  |
| 65-69                                      | 953.41  | 64.8   | 883.77  | 60.2*  | 1040.29 | 70.7   | 977.09  | 66.2   |
| 70-74                                      | 1245.16 | 56.9   | 1051.44 | 48.0   | 1403.09 | 64.2   | 1745.66 | 79.6   |
| 75-79                                      | 4040.29 | 121.6  | 6835.20 | 205.7  | 0.00    | --     | 0.00    | --     |
| 80-84                                      | --      | --     | --      | --     | --      | --     | --      | --     |
| 85+  | 3744.36 | 46.9   | 4717.59 | 59.2   | 0.00    | --     | 0.00    | --     |
| TOTAL                                      | 385.72  | 84.0** | 306.45  | 81.8*  | 599.04  | 94.5   | 268.45  | 29.6** |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 374.13  |        | 440.17  |        | 95.98   |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.97    |        | 1.14    |        | 0.25    |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.41

Arteriosclerotic Heart Disease Age-Specific Death Rates and  
Standardized Mortality Ratios by Years Underground Mining (ZYRUG)

Arteriosclerotic Heart Disease Age-Specific Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |        | ZYRUG < = 30 |        | ZYRUG > 30 |        |
|--|---------|--------|--------------|--------|------------|--------|
|  | D.R.    | S.M.R. | D.R.         | S.M.R. | D.R.       | S.M.R. |
| < 20                                       | 0.00    | --     | 0.00         | --     | --         | --     |
| 20-24                                      | 0.00    | --     | 0.00         | --     | --         | --     |
| 25-29                                      | 0.00    | --     | 0.00         | --     | --         | --     |
| 30-34                                      | 0.00    | --     | 0.00         | --     | --         | --     |
| 35-39                                      | 50.31   | 130.1  | 50.31        | 130.1  | 0.00       | --     |
| 40-44                                      | 46.26   | 44.2   | 46.30        | 44.3   | 0.00       | --     |
| 45-49                                      | 231.28  | 106.4  | 233.00       | 107.2  | 0.00       | --     |
| 50-54                                      | 360.10  | 92.6   | 321.92       | 83.1   | 726.06     | 179.3  |
| 55-59                                      | 676.79  | 105.5  | 658.46       | 103.8  | 714.51     | 108.7  |
| 60-64                                      | 794.48  | 78.6*  | 705.75       | 70.3*  | 870.62     | 85.7   |
| 65-69                                      | 953.41  | 64.8** | 863.99       | 58.8   | 1007.48    | 68.5*  |
| 70-74                                      | 1245.16 | 56.9   | 1780.99      | 81.4   | 904.86     | 41.3   |
| 75-79                                      | 4040.29 | 121.6  | 0.00         | --     | 5903.28    | 177.6  |
| 80-84                                      | --      | --     | --           | --     | --         | --     |
| 85 +                                       | 3744.36 | 46.9   | 5494.50      | 68.8   | 0.00       | --     |
| TOTAL                                      | 385.72  | 84.0** | 281.87       | 83.6*  | 841.09     | 84.6   |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 365.24       |        | 421.63     |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 0.94         |        | 1.09       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.42

Arteriosclerotic Heart Disease Age-Specific Death Rates and  
Standardized Mortality Ratios by FEV<sub>1</sub>/FVC Status

Arteriosclerotic Heart Disease Age-Specific Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort  |        | FEV <sub>1</sub> /FVC ≤ 70 |        | FEV <sub>1</sub> /FVC > 70 |        |
|--|---------|--------|----------------------------|--------|----------------------------|--------|
|  | D.R.    | S.M.R. | D.R.                       | S.M.R. | D.R.                       | S.M.R. |
| < 20                                       | 0.00    | --     | 0.00                       | --     | 0.00                       | --     |
| 20-24                                      | 0.00    | --     | 0.00                       | --     | 0.00                       | --     |
| 25-29                                      | 0.00    | --     | 0.00                       | --     | 0.00                       | --     |
| 30-34                                      | 0.00    | --     | 0.00                       | --     | 0.00                       | --     |
| 35-39                                      | 50.31   | 130.1  | 0.00                       | --     | 63.12                      | 163.6  |
| 40-44                                      | 46.26   | 44.2   | 0.00                       | --     | 41.56                      | 39.8   |
| 45-49                                      | 231.28  | 106.4  | 318.82                     | 146.2  | 177.31                     | 81.6   |
| 50-54                                      | 360.10  | 92.6   | 546.88                     | 140.0  | 258.60                     | 66.7   |
| 55-59                                      | 676.79  | 105.5  | 629.19                     | 97.6   | 666.58                     | 104.3  |
| 60-64                                      | 794.48  | 78.6*  | 948.47                     | 93.8   | 582.38                     | 52.8** |
| 65-69                                      | 953.41  | 64.8** | 1141.09                    | 77.6   | 815.15                     | 55.5*  |
| 70-74                                      | 1245.16 | 56.9   | 2587.26                    | 118.0  | 330.44                     | 15.1*  |
| 75-79                                      | 4040.29 | 121.6  | 10441.48                   | 314.3  | 0.00                       | --     |
| 80-84                                      | --      | --     | --                         | --     | --                         | --     |
| 85 +                                       | 3744.36 | 46.9   | 5577.62                    | 69.9   | 4177.86                    | 52.4   |
| TOTAL                                      | 385.72  | 84.0** | 618.02                     | 98.7   | 260.70                     | 70.5** |
| Age-Adjusted Death Rates <sup>3</sup>      |         |        | 426.71                     |        | 315.80                     |        |
| Comparative Mortality Figures <sup>4</sup> |         |        | 1.11                       |        | 0.82                       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

Table 7.43

Arteriosclerotic Heart Disease Standardized Mortality Ratios, Number of Men at Risk,  
and Number of Deaths by CWP Radiographic Category for Study Cohort Subgroups

|                      | Category of CWP |              |                     |           |              |                     |           |              |                     |
|----------------------|-----------------|--------------|---------------------|-----------|--------------|---------------------|-----------|--------------|---------------------|
|                      | 0               |              |                     | Simple    |              |                     | PMF       |              |                     |
|                      | No of Men       | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> | No of Men | No of Deaths | S.M.R. <sup>1</sup> |
| Cigarette Smoking    |                 |              |                     |           |              |                     |           |              |                     |
| Smoker when examined | 3179            | 95           | 114.7*              | 1272      | 78           | 125.4**             | 87        | 4            | 63.4                |
| Smoked only in past  | 1476            | 37           | 55.2**              | 664       | 30           | 73.2                | 80        | 1            | 15.3*               |
| Never smoked         | 1276            | 26           | 60.0**              | 395       | 13           | 52.4*               | 45        | 0            | --*                 |
| TOTALS               | 5931            | 148          | 80.6                | 2331      | 111          | 94.4                | 212       | 5            | 83.0                |

1. For a discussion of the limitations of comparison of study subgroup S.M.R.s, see the Text.

TABLE 7.44

Comparison of Accidents Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                   | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Yrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF <sup>3</sup> |
|-------------------|----------------|---------------------|-------------|--------------|------------|---------------------------|------------------|
| CWP Category      |                |                     |             |              |            |                           |                  |
| 0                 | 56 (35.82)     | 156.4**             | 5931        | 51557.7      | 108.62     | 103.34                    | 0.94             |
| Simple            | 23 (14.36)     | 160.1*              | 2331        | 20198.9      | 113.87     | 175.98                    | 1.60             |
| PMF               | 2 (1.43)       | 140.0               | 212         | 1862.6       | 107.38     | 43.39                     | 0.63             |
| Years Underground |                |                     |             |              |            |                           |                  |
| <=30              | 70 (40.83)     | 171.53*             | 6862        | 59956.5      | 116.75     | 109.87                    | 1.00             |
| > 30              | 11 (10.79)     | 102.0               | 1613        | 13672.7      | 80.45      | 35.64                     | 0.51             |
| Total             | 81 (51.61)     | 156.9**             | 8475        | 73629.1      | 110.01     | --                        | --               |

1. \* Indicates significance at .05 level; \*\* indicates significance at .01 level.

2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.

3. Comparative mortality figure; see text for further description.

TABLE 7.45

Accidents Age-Specific Death Rates and Standardized  
Mortality Ratios by CWP Radiographic Category

Age-Specific Accidents Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |         | 0 CWP  |         | 1-3 CWP |         | PMF    |        |
|--|--------|---------|--------|---------|---------|---------|--------|--------|
|  | D.R.   | S.M.R.  | D.R.   | S.M.R.  | D.R.    | S.M.R.  | D.R.   | S.M.R. |
| < 20                                       | 0.00   | --      | 0.00   | --      | 0.00    | --      | --     | --     |
| 20-24                                      | 246.75 | 216.2   | 254.03 | 222.6   | 0.00    | --      | --     | --     |
| 25-29                                      | 180.23 | 225.7*  | 146.77 | 183.9   | 891.18  | 1107.1* | --     | --     |
| 30-34                                      | 155.45 | 251.0*  | 151.92 | 254.7*  | 196.49  | 312.2   | --     | --     |
| 35-39                                      | 117.38 | 192.2   | 96.41  | 158.1   | 257.37  | 416.3   | --     | --     |
| 40-44                                      | 154.20 | 258.4*  | 155.28 | 261.1*  | 150.76  | 249.3   | 0.00   | --     |
| 45-49                                      | 99.12  | 160.3   | 61.11  | 99.1    | 203.30  | 326.5*  | 0.00   | --     |
| 50-54                                      | 60.02  | 92.2    | 66.01  | 101.9   | 52.22   | 79.6    | 0.00   | --     |
| 55-59                                      | 120.86 | 174.6   | 114.24 | 166.6   | 144.06  | 206.0   | 0.00   | --     |
| 60-64                                      | 81.49  | 103.8   | 78.91  | 100.6   | 48.38   | 61.7    | 325.08 | 410.8  |
| 65-69                                      | 23.25  | 27.1    | 44.19  | 51.5    | 0.00    | --      | 0.00   | --     |
| 70-74                                      | 138.35 | 131.7   | 262.86 | 249.9   | 0.00    | --      | 0.00   | --     |
| 75-79                                      | 0.00   | --      | 0.00   | --      | 0.00    | --      | 0.00   | --     |
| 80-84                                      | --     | --      | --     | --      | --      | --      | --     | --     |
| 85 +                                       | 0.00   | --      | 0.00   | --      | 0.00    | --      | 0.00   | --     |
| TOTAL                                      | 110.01 | 156.9** | 108.62 | 156.4** | 113.87  | 160.1*  | 107.38 | 140.0  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |         | 103.34 |         | 175.98  |         | 43.39  |        |
| Comparative Mortality Figures <sup>4</sup> |        |         | 0.94   |         | 1.60    |         | 0.63   |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
  2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
  3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
  4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.
- \* Indicates S.M.R. is significant at .05 level.
- \*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.46

Accidents Age-Specific Death Rates and  
Standardized Mortality Ratios by Years Underground Mining (ZYRUG)

Age-Specific Accidents Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |         | ZYRUG < = 30 |         | ZYRUG > 30 |        |
|--|--------|---------|--------------|---------|------------|--------|
|  | D.R.   | S.M.R.  | D.R.         | S.M.R.  | D.R.       | S.M.R. |
| < 20                                       | 0.00   | --      | 0.00         | --      | --         | --     |
| 20-24                                      | 246.75 | 216.2   | 246.75       | 216.2   | --         | --     |
| 25-29                                      | 180.23 | 225.7*  | 180.23       | 225.7*  | --         | --     |
| 30-34                                      | 155.45 | 251.0   | 155.45       | 251.0*  | --         | --     |
| 35-39                                      | 117.38 | 192.2   | 117.30       | 192.2   | 0.00       | --     |
| 40-44                                      | 154.20 | 258.4*  | 154.32       | 258.6*  | 0.00       | --     |
| 45-49                                      | 99.12  | 160.3   | 99.86        | 161.5   | 0.00       | --     |
| 50-54                                      | 60.02  | 92.2    | 66.28        | 102.4   | 0.00       | --     |
| 55-59                                      | 120.86 | 174.6   | 119.72       | 176.6   | 123.19     | 170.7  |
| 60-64                                      | 81.49  | 103.8   | 66.16        | 85.3    | 94.63      | 119.4  |
| 65-69                                      | 23.25  | 27.1    | 61.71        | 71.8    | 0.00       | --     |
| 70-74                                      | 138.35 | 131.7   | 0.00         | --      | 226.21     | 215.3  |
| 75-79                                      | 0.00   | --      | 0.00         | --      | 0.00       | --     |
| 80-84                                      | --     | --      | --           | --      | --         | --     |
| 85 +                                       | 0.00   | --      | 0.00         | --      | 0.00       | --     |
| TOTAL                                      | 110.01 | 156.9** | 116.75       | 171.5** | 80.45      | 102.0  |
| Age-Adjusted Death Rates <sup>3</sup>      |        |         | 109.87       |         | 35.64      |        |
| Comparative Mortality Figures <sup>4</sup> |        |         | 1.00         |         | 0.51       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.47

Comparison of Leukemia Standardized Mortality Ratios, Age-Adjusted Death Rates and Comparative Mortality Figures for Sub-Groups of Study Cohort

|                   | OBS (Exposure) | S.M.R. <sup>1</sup> | No. at Risk | Yrs. at Risk | Crude D.R. | Age-Adj <sup>2</sup> D.R. | CMF <sup>3</sup> |
|-------------------|----------------|---------------------|-------------|--------------|------------|---------------------------|------------------|
| CWP Category      |                |                     |             |              |            |                           |                  |
| 0                 | 4 (4.08)       | 98.1                | 5931        | 51557.7      | 7.76       | 9.14                      | 1.35             |
| Simple            | 1 (2.44)       | 41.0                | 2331        | 20198.9      | 4.95       | 3.22                      | 0.47             |
| PMF               | 0 (0.31)       | --                  | 212         | 1862.6       | 0.00       | 0.00                      | 0.00             |
| Years Underground |                |                     |             |              |            |                           |                  |
| <=30              | 5 (4.34)       | 115.3               | 6862        | 59956.3      | 8.34       | 12.21                     | 1.80             |
| > 30              | 0 (2.50)       | --                  | 1613        | 13672.7      | 0.00       | 0.00                      | 0.00             |
| Total             | 5 (6.83)       | 73.2                | 8475        | 73629.1      | 6.79       | --                        | --               |

1. \* Indicates significance at .05 level; \*\* indicates significance at .01 level.
2. Direct Age-Adjustment using the cohort as standard, and subgroup age-specific death rates.
3. Comparative mortality figure; see text for further description.

TABLE 7.48

Leukemia Age-Specific Death Rates and Standardized  
Mortality Ratios by CWP Radiographic Category

Age-Specific Leukemia Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | 0 CWP |        | 1-3 CWP |        | PMF  |        |
|--|--------|--------|-------|--------|---------|--------|------|--------|
|  | D.R.   | S.M.R. | D.R.  | S.M.R. | D.R.    | S.M.R. | D.R. | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00  | --     | 0.00    | --     | --   | --     |
| 20-24                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --   | --     |
| 25-29                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --   | --     |
| 30-34                                      | 15.54  | 666.2  | 16.88 | 723.8  | 0.00    | --     | --   | --     |
| 35-39                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | --   | --     |
| 40-44                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| 45-49                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| 50-54                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| 55-59                                      | 8.06   | 66.0   | 14.28 | 117.1  | 0.00    | --     | 0.00 | --     |
| 60-64                                      | 30.56  | 167.2  | 39.46 | 215.9  | 24.10   | 132.4  | 0.00 | --     |
| 65-69                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| 70-74                                      | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| 80-84                                      | --     | --     | --    | --     | --      | --     | --   | --     |
| 85 +                                       | 0.00   | --     | 0.00  | --     | 0.00    | --     | 0.00 | --     |
| TOTAL                                      | 6.79   | 73.2   | 7.76  | 98.1   | 4.95    | 41.0   | 0.00 | --     |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 9.14  |        | 3.22    |        | 0.00 |        |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.35  |        | 0.72    |        | 0.00 |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

TABLE 7.49

Leukemia Age-Specific Death Rates and  
Standardized Mortality Ratios by Years Underground Mining (ZYRUG)

Age-Specific Leukemia Death Rates<sup>1</sup> and S.M.R.s<sup>2</sup>

| Age<br>Groups                              | Cohort |        | ZYRUG < = 30 |        | ZYRUG > 30 |        |
|--|--------|--------|--------------|--------|------------|--------|
|  | D.R.   | S.M.R. | D.R.         | S.M.R. | D.R.       | S.M.R. |
| < 20                                       | 0.00   | --     | 0.00         | --     | --         | --     |
| 20-24                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 25-29                                      | 0.00   | --     | 0.00         | --     | --         | --     |
| 30-34                                      | 15.54  | 666.2  | 15.54        | 666.2  | --         | --     |
| 35-39                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 40-44                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 45-49                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 50-54                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 55-59                                      | 8.06   | 66.0   | 11.79        | 98.2   | 0.00       | --     |
| 60-64                                      | 30.56  | 167.2  | 66.16        | 362.4  | 0.00       | --     |
| 65-69                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 70-74                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 75-79                                      | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| 80-84                                      | --     | --     | --           | --     | --         | --     |
| 85 +                                       | 0.00   | --     | 0.00         | --     | 0.00       | --     |
| TOTAL                                      | 6.79   | 73.2   | 8.34         | 115.3  | 0.00       | --     |
| Age-Adjusted Death Rates <sup>3</sup>      |        |        | 12.21        | 0.00   | 0.00       | --     |
| Comparative Mortality Figures <sup>4</sup> |        |        | 1.80         | 0.00   | 0.00       |        |

1. Death rates of observed deaths in cohort per 100,000 person years.
2. S.M.R. is standardized mortality ratio using the age specific death rates for the total US white male population as a standard.
3. The death rates were age-adjusted using the direct method with the total study cohort population as the standard population.
4. The comparative mortality figure is the directly age-adjusted death rate for the study cohort sub-group divided by the death rate in the entire study cohort.

\* Indicates S.M.R. is significant at .05 level.

\*\* Indicates S.M.R. is significant at .01 levels.

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APPENDIX

A PROFILE OF THE THIRD ROUND OF THE  
NATIONAL STUDY OF COALWORKER'S PNEUMOCONIOSIS

ABSTRACT

This report is a profile of data collected during the third round of the U.S. Public Health Service's National Study of Coalworkers' Pneumoconiosis. From 1977 through 1981 a mobile field team visited 32 coal mines and examined 5155 miners. This report describes the background, methods, and information collected. Statistical tables are presented to coincide with those presented in the profile of Rounds One and Two data. These are not designed here for statistical comparisons, but as an information base.

## INTRODUCTION

This report presents a profile of data collected during the third round of the National Study of Coalworkers' Pneumoconiosis. The survey was conducted from October 1977 through December 1981. Data was collected from 5155 United States underground coal miners. Tables showing general characteristics, respiratory symptoms, occupational and smoking history, spirometry tests of ventilatory capacity, and radiographic interpretation of coalworkers' pneumoconiosis are presented. The tables are displayed in a format similar to that of the Round One profile.

## BACKGROUND

Historical background describing the development of the National Study for Coalworkers' Pneumoconiosis is described in some detail in the profile of Round One.<sup>(1)</sup> In 1969 the first round of the survey was initiated and completed in 1971. The second round was begun in August 1972 and completed in February 1975. Of the 31 mines studied in Round One, 26 were restudied in Round Two. Four of the Round One mines had closed in the interim. A total of thirty-five mines were studied in Round Two, including one anthracite mine. Replacements for the Round One mines not participating in Round Two were selected to maintain proportional allocations of miners from geographic areas, coal seams, and mining methods.

Between the second and third round an additional three of the original 31 mines closed. None of the second round additional mines closed, and no additional mines were selected. Surveys were undertaken at 32 mines employing 10142 of which 5155 miners participated.

Selection criteria for the mines remained unchanged from Round One. These were:

- (1) the mine employed at least 100 miners;
- (2) the mine had an expected work life of at least 10 years;
- (3) the miners represented various coal seams, mining methods, and geographic areas;
- (4) the mine was accessible by field team mobile units.

The field team was composed of an x-ray technician, a pulmonary function technician, a physician, and one or two nurses. The nurses administered questionnaires in addition to weighing and measuring the participants. Voluntary participation in the Round Three survey was approximately 52%.

#### DESCRIPTION OF DATA

Each participating miner was administered a postero-anterior and lateral chest x-ray, a test of spirometry and a questionnaire. The questionnaire was a modified version of the British Medical Research Council's Questionnaire of Respiratory Symptoms, with additional smoking and occupational histories.

#### QUESTIONNAIRE

The questionnaire (see Appendix 1) consisted of:

- (1) Consent Form;
- (2) Identification of Miner;
- (3) Occupational History;
- (4) Symptomatology.

Definitions of respiratory symptoms, as in Round One, are based on the following responses:

Persistent Phlegm: Yes to C4 or C5 and Yes to C6.

Moderate Phlegm: Yes to C4 or C5 and No to C6.

Persistent chronic bronchitis was defined as persistent phlegm.

Persistent bronchitis was defined as moderate phlegm and persistent cough. An indication of either persistent chronic bronchitis or persistent bronchitis was considered as a symptom of bronchitis in the study.

Persistent Cough: Yes to C1 or C2 and Yes to C3.

Moderate Cough: Yes to C1 or C2 and No to C3.

No Cough: No to C1 and C2.

The remaining symptoms were defined as follows:

Breathlessness (Dyspnea)

Persistent: Yes to C11 and C12, Yes to C13.

Moderate: Yes to C11 and C12, No to C13.

None: No to C11 or C12.

Wheezing:

Persistent: Yes to C14 and C15.

Moderate: Yes to C14 and No to C15.

None: No to C14.

X-RAY INTERPRETATION

Each coal miner's PA and lateral chest radiograph was interpreted for coal-workers' pneumoconiosis according to UICC 1971 classification.<sup>(3)</sup> Three qualified "B" readers read all of the third round films. Consensus readings of combined opacities provided a single score on a four-point scale (0, 1, 2, 3) and a single classification for large opacities (A, B, or C). If there was not consensus of at least two readers, then a fourth reader was brought in. The differences in the readers between Round One, Two, and Three makes it essential to consider any overall comparisons of prevalence between these rounds with great caution.

SPIROMETRY

A test of spirometry was administered to each miner, using a high fidelity waterless electronic spirometer (Ohio Medical Products, Model #800).\*

At least five manoeuvres were performed. The first two were considered as practice blows, and the last three were retained for analysis. The flow and volume signals from the spirometer were recorded on FM analog tape, and later processed on a PDP-12 laboratory computer. These methods differ from the Round One spirometry testing and recording methods. In Round One, in some cases if the first two manoeuvres seemed good, only one more was taken to complete the three test readings.<sup>(5)</sup> Furthermore, a polaroid picture was taken from the flow volume curves. The flow at 50% of FVC was hand-measured from the pictures.

PROFILE

The profile of data collected is included in Tables 1-72. These tables are presented in a format consistent with Round One tables.

DIFFERENCES BETWEEN ROUNDS TWO AND THREE

The table shown below compares certain of the data from Rounds Two and Three.

|                         | ROUND 2   |    | ROUND 3   |    |
|-------------------------|-----------|----|-----------|----|
|                         | $\bar{X}$ | S  | $\bar{X}$ | S  |
| Age                     | 41        | 13 | 39        | 12 |
| Years in Mining         | 17        | 13 | 14        | 12 |
| Years Underground       | 14        | 13 | 12        | 11 |
| Years at Face           | 7         | 10 | 5         | 8  |
| Highest Grade Completed | 10        | 3  | 11        | 2  |

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\*Mention of brand name does not constitute endorsement by the U.S. Public Health Service.

Certain of the trends noted in the Profile for Round 2 are also evident here. Again the participating group is younger than in the previous survey, and has fewer years in mining, underground and at the face. Education continues to increase reflecting a mine force which is better educated, yet younger.

The x-ray results indicate a prevalence of 6% which is close to the 8% of the previous round. To some extent the lower age in this group may be responsible for this. A contributing factor may have been the participation rate, which at 52%, was poor.

#### ACKNOWLEDGEMENTS

We wish to acknowledge the assistance of all those who contributed to the completion of this study: the coal miners who participated in the study, and the Field Team of the Division of Respiratory Disease Studies for gathering the data.

\*\*Note: Missing categories are due to incomplete responses to questionnaire or to missing or unreadable x-rays.

LIST OF TABLESTABLEDESCRIPTIVE RESULTS

|    |  |
|----|--|
| 1  | Means and standard deviations.                                     |
| 2  | Age by state.  |
| 3  | Height by state.   |
| 4  | Weight by state.   |
| 5  | Race by state.   |
| 6  | Marital status by state.   |
| 7  | Highest grade completed by state.                                  |
| 8  | Current job by state.  |
| 9  | Total years employed in mining by state.                           |
| 10 | Total years worked underground by state.                           |
| 11 | Total years worked at surface by state.                            |
| 12 | Current underground face occupation by state.                      |
| 13 | Total years worked at other (non-coal mining) dusty jobs by state. |
| 14 | Current job category by years underground.                         |
| 15 | Current job category by age.                                       |
| 16 | Current underground face occupation by age.                        |

SYMPTOMS

|    |                              |
|----|------------------------------|
| 17 | Cough by state.              |
| 18 | Phlegm by state.             |
| 19 | Bronchitis by state.         |
| 20 | Breathlessness by state.     |
| 21 | Wheezing by state.           |
| 22 | Effects of weather by state. |

- 23 Nasal catarrh by state.
- 24 Chest illness by state.
- 25 Previous chest injury or operation by state.
- 26 Previous heart trouble by state.
- 27 Previous bronchitis by state.
- 28 Previous pneumonia by state.
- 29 Previous pleurisy by state.
- 30 Previous bronchial asthma by state.
- 31 Previous emphysema by state.
- 32 Previous other chest trouble by state.

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SMOKING HISTORY

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- 33 Smoking status by state.
- 34 Pack years by state.
- 35 Current job category by smoking status.

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- 36 Means and standard deviations.
  - 37 FEV<sub>1.0</sub> by state.
  - 38 FVC by state.
  - 39 Not available -- no RV measurements.
  - 40 FEF<sub>25</sub> by state.
  - 41 FEF<sub>50</sub> by state.
  - 42 FEF<sub>75</sub> by state.
  - 43 (FEV<sub>1</sub>/FVC)% by state.
  - 44 Not available -- no RV or TLC.
  - 45 Not available -- no RV or TLC.

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X-RAY INTERPRETATIONS

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- 46 X-ray category by state.  
47 X-ray category by age.  
48 X-ray category by years underground.  
49 X-ray category by years underground and smoking status.  
50 X-ray category by current job category.

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YEARS UNDERGROUND

---

- 51 Means and standard deviations by years underground.  
52 Cough by years underground.  
53 Phelgm by years underground.  
54 Bronchitis by years underground.  
55 Breathlessness by years underground.  
56 Wheezing by years underground.  
57 Effects of weather on chest by years underground.  
58 Nasal catarrh by years underground.  
59 Chest illness by years underground.  
60 Previous chest injuries or operations by years underground.  
61 Previous heart trouble by years underground.  
62 Previous bronchitis by years underground.  
63 Previous pneumonia by years underground.  
64 Previous pleurisy by years underground.  
65 Previous bronchial asthma by years underground.  
66 Previous emphysema by years underground.  
67 Previous other chest trouble by years underground.

BRONCHITIS

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- 68 Means and standard deviations by bronchitis and smoking.  
69 Bronchitis by smoking and x-ray category.  
70 Bronchitis by smoking and age.  
71 Bronchitis by smoking and years underground.  
72 Bronchitis by smoking and job category.

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APPENDIX 1

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Job Codes

Questionnaire

TABLE 1  
MEANS AND STANDARD DEVIATIONS

| VARIABLE        | NUMBER | MEANS  | STANDARD DEVIATION |
|-----------------|--------|--------|--------------------|
| Age             | 5275   | 38.68  | 12.33              |
| Height          | 5275   | 175.77 | 6.98               |
| Weight          | 5275   | 83.92  | 13.95              |
| Yrs Face        | 5275   | 5.22   | 7.75               |
| Yrs UG Trans    | 5275   | 2.44   | 5.44               |
| Yrs UG Maint    | 5275   | 2.25   | 4.88               |
| Yrs UG Misc     | 5275   | 1.69   | 4.29               |
| Yrs SUR Frans   | 5275   | 0.23   | 1.96               |
| Yrs SUR Maint   | 5275   | 0.54   | 2.91               |
| Yrs Tipple      | 5275   | 0.56   | 3.11               |
| Yrs SUR Misc    | 5275   | 0.45   | 2.56               |
| Yrs Mining      | 5275   | 13.53  | 11.94              |
| Yrs UG          | 5275   | 11.60  | 11.08              |
| Yrs SURFACE     | 5275   | 1.78   | 5.69               |
| Yrs Other Dusty | 973    | 4.34   | 5.38               |
| Pack Years      | 3855   | 19.74  | 17.60              |
| Highest Grade   | 5240   | 11.08  | 2.35               |

TABLE 2  
AGE BY STATE

| AGE YRS | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------|-----|-----|------------|------------|--------|-------|
| <20     | 2   | 7   | 3          | 1          | 9      | 22    |
| 20-29   | 396 | 380 | 384        | 221        | 171    | 1552  |
| 30-39   | 256 | 391 | 487        | 201        | 148    | 1483  |
| 40-49   | 165 | 175 | 316        | 118        | 92     | 866   |
| 50-59   | 276 | 198 | 306        | 105        | 164    | 1049  |
| ≥60     | 116 | 45  | 59         | 27         | 56     | 303   |

TABLE 3  
HEIGHT BY STATE  
(inches)

| HEIGHT | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|--------|-----|-----|------------|------------|--------|-------|
| <64    | 39  | 34  | 26         | 15         | 19     | 133   |
| 64-67  | 363 | 369 | 371        | 190        | 186    | 1479  |
| 68-71  | 650 | 611 | 851        | 360        | 323    | 2795  |
| 72-75  | 155 | 177 | 300        | 105        | 103    | 840   |
| ≥76    | 4   | 5   | 7          | 3          | 9      | 28    |

TABLE 4

WEIGHT BY STATE  
(pounds)

| WEIGHT  | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------|-----|-----|------------|------------|--------|-------|
| <130    | 18  | 24  | 22         | 6          | 13     | 83    |
| 130-144 | 81  | 80  | 72         | 23         | 49     | 305   |
| 145-159 | 164 | 157 | 210        | 77         | 110    | 718   |
| 160-174 | 236 | 229 | 269        | 135        | 146    | 1015  |
| 175-189 | 253 | 292 | 320        | 138        | 115    | 1118  |
| 190-204 | 195 | 177 | 276        | 121        | 95     | 864   |
| 205-219 | 137 | 119 | 191        | 77         | 60     | 584   |
| 220-234 | 51  | 51  | 88         | 39         | 30     | 259   |
| 235-249 | 40  | 31  | 59         | 28         | 12     | 170   |
| ≥250    | 36  | 36  | 48         | 29         | 10     | 159   |

TABLE 5

## RACE BY STATE

| RACE      | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-----------|------|------|------------|------------|--------|-------|
| Caucasian | 1173 | 1125 | 1357       | 666        | 542    | 4863  |
| Black     | 37   | 70   | 189        | 7          | 3      | 306   |
| Other     | 1    | 1    | 1          | 0          | 95     | 98    |

TABLE 6  
MARITAL STATUS BY STATE

| MARITAL STATUS | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------------|------|------|------------|------------|--------|-------|
| Married        | 1013 | 1038 | 1386       | 587        | 546    | 4570  |
| Widowed        | 11   | 11   | 11         | 5          | 2      | 40    |
| Divorced       | 47   | 53   | 77         | 34         | 29     | 240   |
| Separated      | 14   | 5    | 5          | 2          | 3      | 29    |
| Never Married  | 120  | 89   | 75         | 44         | 58     | 386   |

TABLE 7  
HIGHEST GRADE COMPLETED BY STATE

| HIGHEST GRADE | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|-----|-----|------------|------------|--------|-------|
| <8            | 53  | 81  | 207        | 10         | 21     | 372   |
| 8             | 179 | 92  | 157        | 46         | 46     | 520   |
| 9             | 75  | 81  | 83         | 33         | 34     | 306   |
| 10            | 87  | 106 | 115        | 50         | 38     | 396   |
| 11            | 74  | 76  | 83         | 30         | 59     | 322   |
| 12            | 602 | 613 | 714        | 404        | 304    | 2637  |
| 13-15         | 87  | 108 | 161        | 72         | 106    | 534   |
| ≥16           | 45  | 31  | 27         | 22         | 28     | 153   |

TABLE 8

## CURRENT JOB BY STATE

| CURRENT JOB | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-------------|-----|-----|------------|------------|--------|-------|
| SUR MAINT   | 42  | 31  | 60         | 10         | 87     | 230   |
| SUR MISC    | 44  | 46  | 65         | 36         | 34     | 225   |
| SUR TIPPLE  | 43  | 27  | 55         | 4          | 15     | 144   |
| SUR TRANS   | 12  | 25  | 23         | 6          | 17     | 83    |
| UG FACE     | 380 | 408 | 512        | 237        | 213    | 1750  |
| UG MAINT    | 275 | 238 | 329        | 135        | 114    | 1091  |
| UG MISC     | 198 | 214 | 239        | 138        | 75     | 864   |
| UG TRANS    | 215 | 204 | 269        | 105        | 81     | 874   |
| STRIP       | 1   | 1   | 1          | 2          | 1      | 6     |

TABLE 9

## TOTAL YEARS EMPLOYED IN MINING BY STATE

| YRS MINING | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| <5         | 440 | 226 | 269        | 90         | 177    | 1202  |
| 5-9        | 266 | 405 | 532        | 309        | 180    | 1692  |
| 10-14      | 76  | 239 | 267        | 118        | 47     | 747   |
| 15-19      | 42  | 70  | 96         | 43         | 20     | 271   |
| 20-24      | 24  | 38  | 90         | 23         | 37     | 212   |
| 25-29      | 72  | 42  | 76         | 18         | 40     | 248   |
| ≥30        | 291 | 176 | 225        | 72         | 139    | 903   |

TABLE 10

## TOTAL YEARS WORKED UNDERGROUND BY STATE

| YRS UG | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|--------|-----|-----|------------|------------|--------|-------|
| < 5    | 503 | 284 | 366        | 125        | 248    | 1526  |
| 5-9    | 261 | 425 | 548        | 307        | 175    | 1716  |
| 10-14  | 70  | 217 | 233        | 111        | 50     | 681   |
| 15-19  | 46  | 57  | 93         | 36         | 28     | 260   |
| 20-24  | 32  | 39  | 90         | 19         | 24     | 204   |
| 25-29  | 69  | 48  | 72         | 18         | 31     | 238   |
| ≥30    | 230 | 126 | 153        | 57         | 84     | 650   |

TABLE 11

## TOTAL YEARS WORKED AT SURFACE BY STATE

| YRS SURF | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| ≤5       | 1105 | 1088 | 1389       | 626        | 518    | 4726  |
| 5-9      | 34   | 49   | 75         | 23         | 46     | 227   |
| 10-14    | 17   | 24   | 41         | 9          | 17     | 108   |
| 15-19    | 14   | 7    | 15         | 6          | 7      | 49    |
| 20-24    | 6    | 9    | 10         | 5          | 17     | 47    |
| 25-29    | 13   | 2    | 11         | 2          | 11     | 39    |
| ≥30      | 22   | 17   | 14         | 2          | 24     | 79    |

TABLE 12

## CURRENT UNDERGROUND FACE OCCUPATION BY STATE

| FACE OCC | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|-----|-----|------------|------------|--------|-------|
| 00       | 20  | 23  | 9          | 4          | 36     | 92    |
| 01       | 1   | 0   | 2          | 0          | 0      | 3     |
| 02       | 4   | 8   | 35         | 14         | 1      | 62    |
| 03       | 148 | 148 | 100        | 43         | 59     | 498   |
| 04       | 9   | 5   | 9          | 1          | 32     | 56    |
| 05       | 12  | 2   | 6          | 7          | 6      | 33    |
| 06       | 137 | 141 | 159        | 79         | 55     | 571   |
| 07       | 4   | 42  | 89         | 32         | 10     | 177   |
| 08       | 7   | 10  | 66         | 34         | 2      | 119   |
| 09       | 38  | 29  | 37         | 23         | 12     | 139   |

See Appendix for codes

TABLE 13

## TOTAL YEARS WORKED AT OTHER DUSTY JOBS

| YRS DUSTY | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-----------|------|------|------------|------------|--------|-------|
| <5        | 1145 | 1161 | 1442       | 627        | 602    | 4977  |
| 5-9       | 36   | 23   | 62         | 29         | 32     | 182   |
| 10-14     | 14   | 5    | 32         | 5          | 4      | 60    |
| 15-19     | 9    | 5    | 7          | 7          | 1      | 29    |
| ≥20       | 7    | 2    | 12         | 5          | 1      | 27    |

TABLE 14

## CURRENT JOB CATEGORY BY YEARS UNDERGROUND

| JOB CAT    | <5  | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|-----|-----|-------|-------|-------|-------|-----|-------|
| Missing    | 8   | -   | -     | -     | -     | -     | -   | 8     |
| SUR Maint  | 93  | 37  | 24    | 18    | 24    | 16    | 18  | 230   |
| SUR Misc   | 134 | 19  | 12    | 8     | 11    | 14    | 27  | 225   |
| SLR Tipple | 63  | 25  | 14    | 11    | 13    | 10    | 8   | 144   |
| SUR Trans  | 35  | 17  | 4     | 4     | 7     | 5     | 11  | 83    |
| UG Face    | 488 | 702 | 222   | 64    | 42    | 64    | 168 | 1750  |
| UG Maint   | 288 | 396 | 164   | 55    | 33    | 34    | 121 | 1091  |
| UG Misc    | 154 | 257 | 157   | 64    | 38    | 43    | 151 | 864   |
| UG Trans   | 259 | 261 | 84    | 36    | 36    | 52    | 146 | 874   |
| Strip      | 4   | 2   | 0     | 0     | 0     | 0     | 0   | 6     |

TABLE 15

## CURRENT JOB CATEGORY BY AGE

| JOB CAT    | <20 | 20-29 | 30-39 | 40-49 | 50-59 | ≥60 | TOTAL |
|------------|-----|-------|-------|-------|-------|-----|-------|
| Missing    | 4   | 3     | 0     | 0     | 1     | 0   | 8     |
| SUR Maint  | 0   | 17    | 44    | 53    | 90    | 26  | 230   |
| SUR Misc   | 1   | 37    | 39    | 47    | 74    | 27  | 225   |
| SUR Tipple | 0   | 10    | 24    | 35    | 54    | 21  | 144   |
| SUR Trans  | 0   | 4     | 12    | 15    | 40    | 12  | 83    |
| UG Face    | 9   | 620   | 559   | 249   | 243   | 70  | 1750  |
| UG Maint   | 2   | 346   | 327   | 197   | 182   | 37  | 1091  |
| UG Misc    | 4   | 234   | 260   | 144   | 170   | 52  | 864   |
| UG Trans   | 2   | 278   | 216   | 126   | 194   | 58  | 874   |
| Strip      | 0   | 3     | 2     | 0     | 1     | 0   | 6     |

TABLE 16  
CURRENT UNDERGROUND FACE OCCUPATIONS BY AGE

| OCCUP | <20 | 20-29 | 30-39 | 40-49 | 50-59 | >60 | TOTAL |
|-------|-----|-------|-------|-------|-------|-----|-------|
| 00    | 5   | 43    | 18    | 14    | 9     | 3   | 92    |
| 01    | 0   | 1     | 0     | 1     | 1     | 0   | 3     |
| 02    | 0   | 12    | 19    | 10    | 16    | 5   | 62    |
| 03    | 1   | 176   | 170   | 75    | 58    | 18  | 498   |
| 04    | 2   | 25    | 16    | 4     | 6     | 3   | 56    |
| 05    | 0   | 13    | 10    | 5     | 3     | 2   | 33    |
| 06    | 0   | 192   | 189   | 80    | 89    | 21  | 571   |
| 07    | 1   | 59    | 51    | 27    | 28    | 11  | 177   |
| 08    | 0   | 38    | 40    | 22    | 14    | 5   | 119   |
| 09    | 0   | 61    | 46    | 11    | 19    | 2   | 139   |

TABLE 17  
COUGH BY STATE

| COUGH      | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Persistent | 367 | 368 | 478        | 195        | 150    | 1558  |
| Moderate   | 84  | 152 | 182        | 74         | 66     | 558   |
| None       | 759 | 670 | 875        | 398        | 423    | 3125  |
| Missing    | 1   | 6   | 20         | 6          | 1      | 34    |

TABLE 18  
PHLEGM BY STATE

| PHLEGM     | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Persistent | 424 | 438 | 526        | 218        | 191    | 1797  |
| Moderate   | 101 | 151 | 211        | 73         | 70     | 606   |
| None       | 682 | 600 | 797        | 374        | 377    | 2830  |
| Missing    | 4   | 7   | 21         | 8          | 2      | 42    |

TABLE 19  
BRONCHITIS BY STATE

|               | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|-----|-----|------------|------------|--------|-------|
| Bronchitis    | 444 | 461 | 565        | 235        | 197    | 1902  |
| No Bronchitis | 767 | 735 | 990        | 438        | 443    | 3373  |

TABLE 20  
BREATHLESSNESS BY STATE

| BREATHLESSNESS | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------------|-----|-----|------------|------------|--------|-------|
| Persistent     | 101 | 183 | 166        | 40         | 40     | 530   |
| Moderate       | 139 | 164 | 253        | 64         | 71     | 691   |
| None           | 970 | 846 | 1135       | 569        | 529    | 4049  |
| Missing        | 1   | 3   | 1          | 0          | 0      | 5     |

TABLE 21

## WHEEZING BY STATE

| WHEEZE     | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Persistent | 185 | 325 | 400        | 116        | 95     | 1121  |
| Moderate   | 330 | 258 | 326        | 154        | 139    | 1207  |
| None       | 696 | 612 | 828        | 403        | 406    | 2945  |
| Missing    | 0   | 1   | 1          | 0          | 0      | 2     |

TABLE 22

## EFFECTS OF WEATHER BY STATE

| WEATHER    | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Persistent | 205 | 302 | 306        | 123        | 71     | 1007  |
| Moderate   | 21  | 61  | 66         | 32         | 8      | 188   |
| None       | 983 | 832 | 1182       | 518        | 561    | 4076  |
| Missing    | 2   | 1   | 1          | 0          | 0      | 4     |

TABLE 23

## NASAL CATARRH BY STATE

| NASAL      | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Persistent | 420 | 490 | 531        | 218        | 230    | 1889  |
| Moderate   | 178 | 225 | 309        | 124        | 112    | 948   |
| None       | 611 | 470 | 702        | 325        | 298    | 2406  |
| Missing    | 2   | 11  | 13         | 6          | 0      | 32    |

TABLE 24

## CHEST ILLNESS BY STATE

| CHEST ILLNESS | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|------|------|------------|------------|--------|-------|
| Persistent    | 81   | 70   | 103        | 42         | 30     | 326   |
| Moderate      | 38   | 43   | 62         | 15         | 12     | 170   |
| None          | 1092 | 1082 | 1389       | 616        | 597    | 4776  |
| Missing       | 0    | 1    | 1          | 0          | 1      | 3     |

TABLE 25

## PREVIOUS CHEST INJURY OR OPERATION BY STATE

| NUMBER   | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| 0        | 1147 | 1140 | 1469       | 644        | 579    | 4979  |
| $\geq 1$ | 64   | 55   | 55         | 29         | 61     | 294   |
| Missing  | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 26

## PREVIOUS HEART TROUBLE BY STATE

| NUMBER   | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| 0        | 1159 | 1108 | 1462       | 646        | 607    | 4982  |
| $\geq 1$ | 52   | 87   | 92         | 27         | 33     | 291   |
| Missing  | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 30

## PREVIOUS BRONCHIAL ASTHMA BY STATE

| NUMBER   | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| 0        | 1187 | 1130 | 1497       | 641        | 618    | 5073  |
| $\geq 1$ | 24   | 65   | 57         | 32         | 22     | 200   |
| Missing  | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 31

## PREVIOUS EMPHYSEMA BY STATE

| NUMBER   | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| 0        | 1192 | 1157 | 1519       | 661        | 630    | 5159  |
| $\geq 1$ | 19   | 38   | 35         | 12         | 10     | 114   |
| Missing  | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 32

## PREVIOUS OTHER CHEST TROUBLE BY STATE

| NUMBER   | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|------|------------|------------|--------|-------|
| 0        | 1168 | 1138 | 1494       | 651        | 598    | 5049  |
| 1        | 43   | 56   | 60         | 22         | 42     | 223   |
| $\geq 2$ | 0    | 1    | 0          | 0          | 0      | 1     |
| Missing  | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 27

## PREVIOUS BRONCHITIS BY STATE

| NUMBER        | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|------|------|------------|------------|--------|-------|
| 0             | 1088 | 1075 | 1401       | 603        | 562    | 4729  |
| 1             | 82   | 81   | 87         | 49         | 43     | 342   |
| <u>&gt;</u> 2 | 41   | 39   | 66         | 21         | 35     | 202   |
| Missing       | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 28

## PREVIOUS PNEUMONIA BY STATE

| NUMBER        | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|------|------|------------|------------|--------|-------|
| 0             | 1005 | 1008 | 1257       | 541        | 534    | 4345  |
| 1             | 162  | 131  | 217        | 94         | 66     | 670   |
| <u>&gt;</u> 2 | 44   | 56   | 80         | 38         | 40     | 258   |
| Missing       | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 29

## PREVIOUS PLEURISY BY STATE

| NUMBER        | PA   | WV   | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|---------------|------|------|------------|------------|--------|-------|
| 0             | 1111 | 1117 | 1481       | 611        | 579    | 4899  |
| 1             | 72   | 57   | 54         | 47         | 27     | 257   |
| <u>&gt;</u> 2 | 13   | 21   | 19         | 15         | 34     | 102   |
| Missing       | 0    | 1    | 1          | 0          | 0      | 2     |

TABLE 33

## SMOKING STATUS BY STATE

| STATUS     | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| Smokers    | 560 | 518 | 769        | 347        | 272    | 2466  |
| Ex-Smokers | 348 | 325 | 406        | 153        | 197    | 1429  |
| Nonsmokers | 303 | 344 | 375        | 172        | 170    | 1364  |
| Missing    | 0   | 9   | 5          | 1          | 1      | 16    |

TABLE 34

## PACK YEARS BY STATE

| PACK YEARS | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------|-----|-----|------------|------------|--------|-------|
| <10        | 620 | 699 | 731        | 339        | 352    | 2741  |
| 10-19      | 220 | 225 | 340        | 132        | 119    | 1036  |
| 20-29      | 119 | 110 | 200        | 83         | 60     | 572   |
| 30-39      | 108 | 79  | 144        | 56         | 52     | 439   |
| 40-49      | 70  | 36  | 66         | 29         | 33     | 234   |
| 50-59      | 19  | 16  | 22         | 13         | 3      | 73    |
| 60-69      | 15  | 5   | 22         | 4          | 8      | 54    |
| 70-79      | 10  | 6   | 10         | 5          | 2      | 33    |
| 80-89      | 9   | 2   | 5          | 5          | 2      | 23    |
| ≥90        | 11  | 5   | 6          | 3          | 2      | 27    |

TABLE 35  
CURRENT JOB CATEGORY BY SMOKING STATUS

| JOB CATEGORY | SMOKERS | EX-SMOKERS | NONSMOKERS | MISSING | TOTAL |
|--------------|---------|------------|------------|---------|-------|
| SUR Maint    | 85      | 77         | 67         | 0       | 229   |
| SUR Misc     | 88      | 71         | 66         | 0       | 225   |
| SUR Trans    | 38      | 21         | 24         | 0       | 83    |
| SUR Tipple   | 67      | 61         | 16         | 0       | 144   |
| UG Face      | 845     | 452        | 448        | 5       | 1746  |
| UG Maint     | 488     | 310        | 291        | 2       | 1089  |
| UG Misc      | 422     | 218        | 218        | 6       | 858   |
| UG Trans     | 426     | 216        | 231        | 1       | 873   |
| Strip        | 5       | 1          | 0          | 0       | 6     |

TABLE 36  
MEANS AND STANDARD DEVIATIONS

| VARIABLE                       | NUMBER | MEANS | STANDARD DEVIATION |
|--------------------------------|--------|-------|--------------------|
| FVC. (liters)                  | 5220   | 4.86  | .90                |
| FEV <sub>1</sub> (liters)      | 5220   | 3.79  | .81                |
| FEF <sub>25</sub> (liters/sec) | 5220   | 7.63  | 2.00               |
| FEF <sub>50</sub> (liters/sec) | 5220   | 4.63  | 1.60               |
| FEF <sub>75</sub> (liters/sec) | 5220   | 1.78  | .85                |
| FEF <sub>90</sub> (liters/sec) | 5215   | .46   | .38                |
| (FEV <sub>1</sub> /FVC)%       | 5220   | 77.94 | 8.22               |

TABLE 37

FEV<sub>1.0</sub> BY STATE  
(liters)

| FEV <sub>1</sub> | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------------|-----|-----|------------|------------|--------|-------|
| <2.00            | 31  | 46  | 40         | 13         | 16     | 146   |
| 2.00-2.49        | 67  | 52  | 83         | 21         | 18     | 241   |
| 2.50-2.99        | 139 | 104 | 163        | 57         | 58     | 521   |
| 3.00-3.49        | 233 | 204 | 293        | 122        | 126    | 978   |
| 3.50-3.99        | 258 | 266 | 384        | 166        | 156    | 1230  |
| 4.00-4.49        | 271 | 284 | 328        | 155        | 144    | 1182  |
| 4.50-4.99        | 147 | 165 | 180        | 84         | 70     | 646   |
| ≥5.00            | 65  | 75  | 84         | 55         | 52     | 331   |

TABLE 38

FVC BY STATE  
(liters)

| FVC       | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-----------|-----|-----|------------|------------|--------|-------|
| <3.00     | 41  | 40  | 59         | 15         | 17     | 172   |
| 3.00-3.49 | 44  | 46  | 82         | 24         | 18     | 214   |
| 3.50-3.99 | 134 | 121 | 171        | 61         | 50     | 537   |
| 4.00-4.49 | 209 | 192 | 272        | 116        | 92     | 881   |
| 4.50-4.99 | 280 | 271 | 372        | 140        | 144    | 1207  |
| 5.00-5.49 | 238 | 235 | 296        | 148        | 118    | 1035  |
| 5.50-5.99 | 148 | 175 | 181        | 84         | 106    | 694   |
| 6.00-6.49 | 79  | 79  | 76         | 62         | 56     | 352   |
| 6.50-6.99 | 30  | 28  | 33         | 18         | 23     | 132   |
| ≥7.00     | 8   | 9   | 13         | 5          | 16     | 51    |

TABLE 40

FEF<sub>25</sub> BY STATE  
(liters/sec)

| FEF <sub>25</sub> | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-------------------|-----|-----|------------|------------|--------|-------|
| <1.00             | 10  | 22  | 13         | 3          | 9      | 57    |
| 1.00-1.99         | 6   | 9   | 5          | 2          | 2      | 24    |
| 2.00-2.99         | 18  | 23  | 22         | 5          | 8      | 76    |
| 3.00-3.99         | 44  | 27  | 40         | 13         | 15     | 139   |
| 4.00-4.99         | 74  | 58  | 93         | 19         | 25     | 269   |
| 5.00-5.99         | 140 | 111 | 144        | 59         | 57     | 511   |
| 6.00-6.99         | 223 | 157 | 211        | 87         | 109    | 787   |
| 7.00-7.99         | 290 | 264 | 288        | 124        | 119    | 1085  |
| 8.00-8.99         | 240 | 216 | 327        | 141        | 134    | 1058  |
| >9.00             | 166 | 309 | 412        | 220        | 162    | 1269  |

TABLE 41

FEF<sub>50</sub> BY STATE  
(liters/sec)

| FEF <sub>50</sub> | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-------------------|-----|-----|------------|------------|--------|-------|
| <1.00             | 20  | 33  | 19         | 4          | 12     | 88    |
| 1.00-1.99         | 57  | 44  | 70         | 21         | 34     | 226   |
| 2.00-2.99         | 168 | 100 | 150        | 55         | 87     | 560   |
| 3.00-3.99         | 295 | 187 | 279        | 131        | 148    | 1040  |
| 4.00-4.99         | 275 | 305 | 347        | 167        | 174    | 1268  |
| 5.00-5.99         | 228 | 235 | 345        | 130        | 103    | 1041  |
| 6.00-6.99         | 121 | 177 | 221        | 97         | 54     | 670   |
| 7.00-7.99         | 35  | 78  | 88         | 50         | 23     | 274   |
| 8.00-8.99         | 11  | 33  | 30         | 12         | 3      | 89    |
| >9.00             | 1   | 4   | 6          | 6          | 2      | 19    |

TABLE 42

FEF<sub>75</sub> BY STATE  
(liters/sec)

| FEF <sub>75</sub> | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|-------------------|-----|-----|------------|------------|--------|-------|
| <.50              | 66  | 54  | 59         | 12         | 35     | 226   |
| .50-.99           | 238 | 153 | 208        | 84         | 138    | 821   |
| 1.00-1.49         | 291 | 215 | 320        | 131        | 177    | 1134  |
| 1.50-1.99         | 255 | 290 | 355        | 176        | 120    | 1196  |
| 2.00-2.49         | 197 | 207 | 298        | 112        | 93     | 907   |
| 2.50-2.99         | 93  | 141 | 178        | 85         | 51     | 548   |
| 3.00-3.49         | 43  | 81  | 72         | 38         | 15     | 249   |
| 3.50-3.99         | 18  | 27  | 37         | 22         | 7      | 111   |
| ≥4.00             | 10  | 28  | 28         | 13         | 4      | 83    |

TABLE 43

FEV<sub>1</sub>/FVC% BY STATE

| FEV <sub>1</sub> /FVC% | PA  | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|------------------------|-----|-----|------------|------------|--------|-------|
| <40%                   | 9   | 25  | 14         | 3          | 10     | 61    |
| 40% <50%               | 7   | 11  | 6          | 4          | 3      | 31    |
| 50% <60%               | 33  | 30  | 38         | 10         | 19     | 130   |
| 60% <70%               | 156 | 121 | 160        | 60         | 94     | 591   |
| 70% <80%               | 509 | 454 | 557        | 280        | 305    | 2105  |
| 80% <90%               | 463 | 518 | 722        | 298        | 196    | 2197  |
| ≥90%                   | 34  | 37  | 58         | 18         | 13     | 160   |

TABLE 46  
X-RAY CATEGORY BY STATE

| CATEGORY | PA   | WV  | VA, KY, AL | OH, IN, IL | CO, UT | TOTAL |
|----------|------|-----|------------|------------|--------|-------|
| 0        | 1118 | 991 | 1474       | 636        | 610    | 4829  |
| 1        | 47   | 49  | 62         | 34         | 25     | 217   |
| 2        | 17   | 15  | 11         | 1          | 1      | 45    |
| 3        | 1    | 0   | 0          | 0          | 0      | 1     |
| PMF      | 10   | 15  | 2          | 0          | 0      | 27    |
| Missing  | 18   | 126 | 6          | 2          | 4      | 156   |

TABLE 47  
X-RAY CATEGORY BY AGE

| CATEGORY | <20 | 20-29 | 30-39 | 40-49 | 50-59 | ≥60 | TOTAL |
|----------|-----|-------|-------|-------|-------|-----|-------|
| 0        | 22  | 1485  | 1428  | 790   | 870   | 234 | 4829  |
| 1        | 0   | 4     | 14    | 45    | 112   | 42  | 217   |
| 2        | 0   | 1     | 0     | 5     | 30    | 9   | 45    |
| 3        | 0   | 0     | 0     | 0     | 1     | 0   | 1     |
| PMF      | 0   | 0     | 0     | 4     | 13    | 10  | 27    |
| Missing  | 0   | 62    | 41    | 22    | 23    | 8   | 156   |

TABLE 48

## X-RAY CATEGORY BY YEARS UNDERGROUND

| CATEGORY | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|----------|------|------|-------|-------|-------|-------|-----|-------|
| 0        | 1464 | 1648 | 635   | 237   | 178   | 191   | 476 | 4829  |
| 1        | 11   | 17   | 20    | 18    | 16    | 31    | 104 | 217   |
| 2        | 1    | 0    | 1     | 2     | 3     | 7     | 31  | 45    |
| 3        | 0    | 0    | 0     | 0     | 0     | 0     | 1   | 1     |
| PMF      | 0    | 0    | 0     | 0     | 2     | 3     | 22  | 27    |
| Missing  | 50   | 51   | 25    | 3     | 5     | 6     | 16  | 156   |

TABLE 49

X-RAY CATEGORY BY YEARS UNDERGROUND AND SMOKING STATUS

|       | SMOKERS |    |    |   |     | EX-SMOKERS |    |    |   |     | NONSMOKERS |    |   |   |     | TOTAL |
|-------|---------|----|----|---|-----|------------|----|----|---|-----|------------|----|---|---|-----|-------|
|       | 0       | 1  | 2  | 3 | PMF | 0          | 1  | 2  | 3 | PMF | 0          | 1  | 2 | 3 | PMF |       |
| <5    | 698     | 7  | 0  | 0 | 0   | 332        | 2  | 0  | 0 | 0   | 431        | 2  | 1 | 0 | 0   | 1473  |
| 5-9   | 790     | 12 | 0  | 0 | 0   | 398        | 4  | 0  | 0 | 0   | 456        | 1  | 0 | 0 | 0   | 1661  |
| 10-14 | 322     | 9  | 1  | 0 | 0   | 162        | 5  | 0  | 0 | 0   | 148        | 6  | 0 | 0 | 0   | 653   |
| 15-19 | 114     | 7  | 1  | 0 | 0   | 67         | 6  | 1  | 0 | 0   | 55         | 5  | 0 | 0 | 0   | 256   |
| 20-24 | 88      | 9  | 2  | 0 | 1   | 63         | 6  | 1  | 0 | 0   | 26         | 1  | 0 | 0 | 1   | 198   |
| 25-29 | 77      | 15 | 5  | 0 | 0   | 70         | 13 | 1  | 0 | 2   | 42         | 3  | 1 | 0 | 1   | 230   |
| >30   | 185     | 29 | 14 | 0 | 5   | 182        | 53 | 11 | 1 | 11  | 109        | 19 | 1 | 0 | 6   | 626   |

(195)

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TABLE 50

## X-RAY CATEGORY BY CURRENT JOB CATEGORY

| JOB CAT    | 0    | 1  | 2  | 3 | PMF | MISSING | TOTAL |
|------------|------|----|----|---|-----|---------|-------|
| SUR Maint  | 207  | 16 | 2  | 0 | 2   | 3       | 230   |
| SUR Misc   | 196  | 19 | 1  | 0 | 3   | 6       | 225   |
| SUR Tipple | 129  | 8  | 5  | 0 | 1   | 1       | 144   |
| SUR Trans  | 78   | 2  | 3  | 0 | 0   | 0       | 83    |
| UC Face    | 1612 | 63 | 12 | 1 | 8   | 54      | 1750  |
| UG Maint   | 1011 | 31 | 8  | 0 | 3   | 38      | 1091  |
| UG Misc    | 790  | 35 | 6  | 0 | 5   | 28      | 864   |
| UG Trans   | 794  | 41 | 9  | 0 | 5   | 25      | 874   |
| Strip      | 5    | 1  | 0  | 0 | 0   | 0       | 6     |
| Missing    | 7    | 0  | 0  | 0 | 0   | 1       | 8     |

TABLE 51

## MEANS AND STANDARD DEVIATIONS BY YEARS UNDERGROUND

| VARIABLE              | <5   |        |       | 5 - 9 |        |       | 10 - 14 |        |       | 15 - 19 |        |       | 20 - 24 |        |       | 25 - 29 |        |       | >30 |        |       |
|-----------------------|------|--------|-------|-------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|-----|--------|-------|
|                       | N    | MEAN   | S.    | N     | MEAN   | S     | N       | MEAN   | S     | N       | MEAN   | S     | N       | MEAN   | S     | N       | MEAN   | S     | N   | MEAN   | S     |
| Age                   | 1526 | 31.77  | 10.57 | 1716  | 33.13  | 7.91  | 681     | 39.59  | 8.41  | 260     | 45.65  | 8.03  | 204     | 50.05  | 7.15  | 238     | 53.25  | 5.18  | 650 | 56.91  | 4.05  |
| Height                | 1526 | 176.45 | 7.58  | 1716  | 176.48 | 6.73  | 681     | 175.82 | 6.71  | 260     | 175.33 | 6.40  | 204     | 175.39 | 6.16  | 238     | 174.59 | 6.05  | 650 | 173.10 | 6.54  |
| Weight                | 1526 | 82.27  | 13.82 | 1716  | 84.46  | 13.96 | 681     | 85.91  | 14.77 | 260     | 85.53  | 12.79 | 204     | 85.76  | 14.16 | 238     | 84.09  | 13.58 | 650 | 83.00  | 13.37 |
| HGr. Com*             | 1519 | 12.12  | 1.83  | 1703  | 11.69  | 1.82  | 676     | 10.81  | 2.07  | 259     | 9.86   | 2.50  | 201     | 9.09   | 2.70  | 238     | 9.25   | 2.59  | 644 | 9.09   | 2.39  |
| Pk Yrs                | 1062 | 14.45  | 16.40 | 1224  | 14.97  | 13.77 | 515     | 20.63  | 14.87 | 193     | 28.01  | 19.72 | 174     | 30.76  | 20.74 | 188     | 28.77  | 16.80 | 499 | 31.39  | 19.31 |
| FEV <sub>1</sub>      | 1514 | 4.05   | 0.75  | 1699  | 4.08   | 0.69  | 676     | 3.74   | 0.69  | 259     | 3.51   | 0.73  | 197     | 3.25   | 0.70  | 234     | 3.09   | 0.67  | 641 | 2.97   | 0.65  |
| FVC                   | 1514 | 5.07   | 0.86  | 1699  | 5.13   | 0.80  | 676     | 4.84   | 0.81  | 259     | 4.61   | 0.82  | 197     | 4.40   | 0.79  | 234     | 4.24   | 0.79  | 641 | 4.08   | 0.80  |
| FEF <sub>25</sub>     | 1514 | 7.97   | 1.82  | 1699  | 8.27   | 1.80  | 676     | 7.61   | 1.86  | 259     | 7.17   | 2.03  | 197     | 6.67   | 1.99  | 234     | 6.38   | 2.09  | 641 | 6.11   | 1.90  |
| FEF <sub>50</sub>     | 1514 | 4.88   | 1.50  | 1699  | 5.15   | 1.51  | 676     | 4.58   | 1.49  | 259     | 4.25   | 1.58  | 197     | 3.84   | 1.49  | 234     | 3.61   | 1.45  | 641 | 3.45   | 1.38  |
| FEF <sub>75</sub>     | 1514 | 2.00   | 0.85  | 1699  | 2.01   | 0.81  | 676     | 1.70   | 0.77  | 259     | 1.54   | 0.79  | 197     | 1.36   | 0.69  | 234     | 1.24   | 0.68  | 641 | 1.18   | 0.65  |
| FEF <sub>90</sub>     | 1514 | 0.58   | 0.46  | 1699  | 0.45   | 0.34  | 676     | 0.37   | 0.29  | 259     | 0.39   | 0.33  | 197     | 0.35   | 0.26  | 234     | 0.38   | 0.33  | 641 | 0.36   | 0.32  |
| FEV <sub>1</sub> /FVC | 1514 | 79.94  | 7.46  | 1699  | 79.78  | 6.81  | 676     | 77.15  | 7.53  | 259     | 76.13  | 8.73  | 197     | 73.74  | 9.20  | 234     | 72.93  | 9.22  | 641 | 73.02  | 9.40  |

\*Highest grade completed.

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TABLE 52

## COUGH BY YEARS UNDERGROUND

| COUGH      | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|------|------|-------|-------|-------|-------|-----|-------|
| Persistent | 273  | 388  | 223   | 104   | 101   | 115   | 354 | 1558  |
| Moderate   | 161  | 190  | 76    | 28    | 23    | 18    | 62  | 558   |
| None       | 1083 | 1129 | 377   | 127   | 79    | 103   | 227 | 3125  |
| Missing    | 9    | 9    | 5     | 1     | 1     | 2     | 7   | 34    |

TABLE 53

## PHLEGM BY YEARS UNDERGROUND

| PHLEGM     | <5  | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|-----|------|-------|-------|-------|-------|-----|-------|
| Persistent | 353 | 491  | 240   | 110   | 102   | 122   | 379 | 1797  |
| Moderate   | 185 | 195  | 93    | 26    | 24    | 19    | 64  | 606   |
| None       | 978 | 1015 | 341   | 123   | 75    | 97    | 201 | 2830  |
| Missing    | 10  | 15   | 7     | 1     | 3     | 0     | 6   | 42    |

TABLE 54

## BRONCHITIS BY YEARS UNDERGROUND

| BRONCHITIS | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|------|------|-------|-------|-------|-------|-----|-------|
| Bronchitis | 375  | 528  | 259   | 115   | 108   | 123   | 394 | 1902  |
| None       | 1151 | 1188 | 422   | 145   | 96    | 115   | 256 | 3373  |

TABLE 55  
BREATHLESSNESS BY YEARS UNDERGROUND

| BREATHLESSNESS | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|----------------|------|------|-------|-------|-------|-------|-----|-------|
| Persistent     | 38   | 76   | 67    | 44    | 49    | 58    | 198 | 530   |
| Moderate       | 86   | 178  | 106   | 59    | 40    | 63    | 159 | 691   |
| None           | 1401 | 1460 | 508   | 156   | 114   | 117   | 293 | 4049  |
| Missing        | 1    | 2    | 0     | 1     | 1     | 0     | 0   | 5     |

TABLE 56  
WHEEZING BY YEARS UNDERGROUND

| WHEEZING   | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|------|------|-------|-------|-------|-------|-----|-------|
| Persistent | 137  | 246  | 181   | 84    | 87    | 104   | 282 | 1121  |
| Moderate   | 354  | 388  | 147   | 64    | 48    | 50    | 156 | 1207  |
| None       | 1034 | 1082 | 353   | 112   | 68    | 84    | 212 | 2945  |
| Missing    | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 57  
EFFECT OF WEATHER ON CHEST BY YEARS UNDERGROUND

| EFFECT     | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|------------|------|------|-------|-------|-------|-------|-----|-------|
| Persistent | 127  | 235  | 162   | 82    | 85    | 80    | 236 | 1007  |
| Moderate   | 47   | 73   | 28    | 6     | 7     | 9     | 18  | 188   |
| None       | 1351 | 1407 | 491   | 172   | 111   | 148   | 396 | 4076  |
| Missing    | 1    | 1    | 0     | 0     | 1     | 1     | 0   | 4     |

TABLE 58

## NASAL CATARRH BY YEARS UNDERGROUND

| CATARRH    | <5  | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|------------|-----|-----|-------|-------|-------|-------|-----|-------|
| Persistent | 440 | 581 | 257   | 107   | 88    | 112   | 304 | 1889  |
| Moderate   | 283 | 320 | 135   | 43    | 42    | 34    | 91  | 948   |
| None       | 796 | 803 | 285   | 107   | 73    | 91    | 251 | 2406  |
| Missing    | 7   | 12  | 4     | 3     | 1     | 1     | 4   | 32    |

TABLE 59

## CHEST ILLNESS BY YEARS UNDERGROUND

| CHEST ILLN | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|------------|------|------|-------|-------|-------|-------|-----|-------|
| Persistent | 70   | 100  | 40    | 26    | 16    | 22    | 52  | 326   |
| Moderate   | 31   | 38   | 24    | 11    | 8     | 16    | 42  | 170   |
| None       | 1424 | 1578 | 616   | 223   | 179   | 200   | 556 | 4776  |
| Missing    | 1    | 0    | 1     | 0     | 1     | 0     | 0   | 3     |

TABLE 60

## PREVIOUS CHEST INJURIES OR OPERATIONS BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1464 | 1637 | 642   | 249   | 192   | 218   | 577 | 4979  |
| >1      | 61   | 79   | 39    | 11    | 11    | 20    | 73  | 294   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 61

## PREVIOUS HEART TROUBLE BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1475 | 1655 | 653   | 242   | 175   | 214   | 568 | 4982  |
| >1      | 50   | 61   | 28    | 18    | 28    | 24    | 82  | 291   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 62

## PREVIOUS BRONCHITIS BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1377 | 1547 | 606   | 232   | 183   | 214   | 570 | 4729  |
| 1       | 99   | 101  | 54    | 18    | 10    | 15    | 45  | 342   |
| >2      | 49   | 68   | 21    | 10    | 10    | 9     | 35  | 202   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 63

## PREVIOUS PNEUMONIA BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | >30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1294 | 1450 | 560   | 213   | 150   | 178   | 500 | 4345  |
| 1       | 181  | 196  | 78    | 28    | 43    | 41    | 103 | 670   |
| >2      | 50   | 70   | 43    | 19    | 10    | 19    | 47  | 258   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 64

## PREVIOUS PLEURISY BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1457 | 1628 | 640   | 236   | 178   | 202   | 558 | 4899  |
| 1       | 49   | 62   | 30    | 15    | 17    | 26    | 58  | 257   |
| ≥2      | 19   | 26   | 11    | 9     | 8     | 10    | 34  | 117   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 65

## PREVIOUS BRONCHIAL ASTHMA BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1467 | 1655 | 653   | 250   | 194   | 229   | 625 | 5073  |
| ≥1      | 58   | 61   | 28    | 10    | 9     | 9     | 25  | 200   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 66

## PREVIOUS EMPHYSEMA BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1511 | 1715 | 662   | 245   | 189   | 231   | 606 | 5159  |
| ≥1      | 14   | 1    | 19    | 15    | 14    | 7     | 44  | 114   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 67

## PREVIOUS OTHER CHEST TROUBLE BY YEARS UNDERGROUND

| NUMBER  | <5   | 5-9  | 10-14 | 15-19 | 20-24 | 25-29 | ≥30 | TOTAL |
|---------|------|------|-------|-------|-------|-------|-----|-------|
| 0       | 1487 | 1671 | 656   | 243   | 190   | 222   | 580 | 5049  |
| ≥1      | 38   | 45   | 25    | 17    | 13    | 16    | 70  | 224   |
| Missing | 1    | 0    | 0     | 0     | 1     | 0     | 0   | 2     |

TABLE 68

## MEANS AND STANDARD DEVIATIONS BY SMOKING AND BRONCHITIS

| VARIABLE              | SMOKERS<br>BRONCHITIS |        |       |      |        |       | EX SMOKERS<br>BRONCHITIS |        |       |     |        |       | NONSMOKERS<br>BRONCHITIS |        |       |      |        |       |
|-----------------------|-----------------------|--------|-------|------|--------|-------|--------------------------|--------|-------|-----|--------|-------|--------------------------|--------|-------|------|--------|-------|
|                       | YES                   |        |       | NO   |        |       | YES                      |        |       | NO  |        |       | YES                      |        |       | NO   |        |       |
|                       | N                     | MEAN   | S.D.  | N    | MEAN   | S.D.  | N                        | MEAN   | S.D.  | N   | MEAN   | S.D.  | N                        | MEAN   | S.D.  | N    | MEAN   | S.D.  |
| Age                   | 1007                  | 40.78  | 12.46 | 1459 | 35.56  | 10.42 | 442                      | 46.99  | 12.57 | 987 | 40.10  | 12.17 | 345                      | 41.59  | 13.34 | 1019 | 35.08  | 11.77 |
| Height                | 1007                  | 175.57 | 6.85  | 1459 | 176.01 | 7.35  | 442                      | 175.02 | 6.81  | 987 | 176.21 | 6.84  | 345                      | 175.17 | 6.29  | 1019 | 175.75 | 7.00  |
| Weight                | 1007                  | 81.98  | 14.18 | 1459 | 82.09  | 13.89 | 442                      | 85.47  | 13.19 | 987 | 85.43  | 13.33 | 345                      | 86.64  | 14.28 | 1019 | 85.40  | 14.05 |
| HGr Com <sup>a</sup>  | 1000                  | 10.62  | 2.33  | 1450 | 11.34  | 2.10  | 441                      | 10.02  | 2.56  | 982 | 10.99  | 2.34  | 340                      | 10.77  | 2.50  | 1011 | 11.81  | 2.34  |
| Pk Yrs                | 1000                  | 19.84  | 14.93 | 1450 | 14.82  | 13.10 | 439                      | 28.82  | 21.96 | 962 | 22.94  | 21.14 | 0                        | 0      | 0     | 0    | 0      | 0     |
| FEV <sub>1</sub>      | 995                   | 3.55   | 0.85  | 1445 | 3.88   | 0.78  | 435                      | 3.41   | 0.84  | 979 | 3.85   | 0.78  | 341                      | 3.70   | 0.80  | 1010 | 4.03   | 0.74  |
| FVC                   | 995                   | 4.66   | 0.90  | 1445 | 4.97   | 0.85  | 435                      | 4.50   | 0.95  | 979 | 4.93   | 0.87  | 341                      | 4.69   | 0.90  | 1010 | 5.02   | 0.88  |
| FEF <sub>25</sub>     | 995                   | 7.11   | 2.13  | 1445 | 7.77   | 1.96  | 435                      | 6.98   | 2.14  | 979 | 7.81   | 1.92  | 341                      | 7.45   | 1.88  | 1010 | 8.12   | 1.81  |
| FEF <sub>50</sub>     | 995                   | 4.22   | 1.66  | 1445 | 4.67   | 1.58  | 435                      | 4.13   | 1.58  | 979 | 4.68   | 1.59  | 341                      | 4.72   | 1.51  | 1010 | 5.08   | 1.48  |
| FEF <sub>75</sub>     | 995                   | 1.61   | 0.85  | 1445 | 1.79   | 0.86  | 435                      | 1.56   | 0.81  | 979 | 1.77   | 0.83  | 341                      | 1.86   | 0.86  | 1010 | 2.03   | 0.81  |
| FEF <sub>90</sub>     | 993                   | 0.44   | 0.35  | 1442 | 0.46   | 0.39  | 435                      | 0.45   | 0.38  | 979 | 0.44   | 0.35  | 341                      | 0.45   | 0.34  | 1010 | 0.49   | 0.41  |
| FEV <sub>1</sub> /FVC | 995                   | 75.91  | 9.55  | 1445 | 78.03  | 7.78  | 435                      | 75.62  | 9.62  | 979 | 78.03  | 7.57  | 341                      | 78.76  | 7.73  | 1010 | 80.45  | 6.60  |

<sup>a</sup>Highest grade completed.

50

50

TABLE 69

## BRONCHITIS BY SMOKING AND X-RAY

| X-RAY | SMOKERS    |      | EX-SMOKERS |     | NONSMOKERS |     | TOTAL |
|-------|------------|------|------------|-----|------------|-----|-------|
|       | BRONCHITIS |      | BRONCHITIS |     | BRONCHITIS |     |       |
|       | YES        | NO   | YES        | NO  | YES        | NO  |       |
| 0     | 973        | 1301 | 382        | 892 | 330        | 937 | 4815  |
| 1     | 48         | 40   | 49         | 42  | 21         | 16  | 216   |
| 2     | 18         | 5    | 9          | 5   | 7          | 1   | 45    |
| 3     | 0          | 0    | 1          | 0   | 0          | 0   | 1     |
| PMF   | 5          | 1    | 11         | 2   | 4          | 4   | 27    |
| TOTAL | 1044       | 1347 | 452        | 941 | 362        | 958 | 5104  |

TABLE 70

## BRONCHITIS BY SMOKING AND AGE

| AGE GROUP | SMOKERS    |      | EX-SMOKERS |     | NONSMOKERS |      | TOTAL |
|-----------|------------|------|------------|-----|------------|------|-------|
|           | BRONCHITIS |      | BRONCHITIS |     | BRONCHITIS |      |       |
|           | YES        | NO   | YES        | NO  | YES        | NO   |       |
| <20       | 1          | 9    | 0          | 1   | 0          | 11   | 22    |
| 20-29     | 239        | 490  | 59         | 245 | 90         | 423  | 1546  |
| 30-39     | 255        | 511  | 71         | 270 | 86         | 287  | 1480  |
| 40-49     | 202        | 245  | 68         | 181 | 36         | 131  | 863   |
| 50-59     | 236        | 169  | 180        | 234 | 105        | 121  | 1045  |
| ≥60       | 74         | 35   | 64         | 56  | 28         | 46   | 303   |
| TOTAL     | 1007       | 1459 | 442        | 987 | 345        | 1019 | 5259  |

TABLE 71

## BRONCHITIS BY SMOKING AND YEARS UNDERGROUND

| YEARS UG | SMOKERS    |      | EX-SMOKERS |     | NONSMOKERS |      | TOTAL |
|----------|------------|------|------------|-----|------------|------|-------|
|          | BRONCHITIS |      | BRONCHITIS |     | BRONCHITIS |      |       |
|          | YES        | NO   | YES        | NO  | YES        | NO   |       |
| <5       | 230        | 493  | 66         | 282 | 57         | 394  | 1522  |
| 5-9      | 289        | 541  | 90         | 320 | 112        | 360  | 1712  |
| 10-14    | 139        | 207  | 51         | 123 | 48         | 110  | 678   |
| 15-19    | 66         | 58   | 22         | 52  | 22         | 39   | 259   |
| 20-24    | 58         | 42   | 32         | 42  | 12         | 17   | 203   |
| 25-29    | 63         | 37   | 38         | 50  | 20         | 28   | 236   |
| ≥30      | 162        | 81   | 143        | 118 | 74         | 71   | 649   |
| TOTAL    | 1007       | 1459 | 442        | 987 | 345        | 1019 | 5259  |

TABLE 72

## BRONCHITIS BY SMOKING AND JOB CATEGORY

| JOB CAT    | SMOKERS    |      | EX-SMOKERS |     | NONSMOKERS |      | TOTAL |
|------------|------------|------|------------|-----|------------|------|-------|
|            | BRONCHITIS |      | BRONCHITIS |     | BRONCHITIS |      |       |
|            | YES        | NO   | YES        | NO  | YES        | NO   |       |
| SUR Maint  | 40         | 45   | 27         | 50  | 25         | 42   | 229   |
| SUR Misc   | 40         | 48   | 24         | 47  | 12         | 54   | 225   |
| SUR Tipple | 41         | 26   | 23         | 38  | 7          | 9    | 144   |
| SUR Trans  | 22         | 16   | 9          | 12  | 10         | 14   | 83    |
| UG Face    | 337        | 508  | 135        | 317 | 118        | 330  | 1745  |
| UG Maint   | 194        | 294  | 90         | 220 | 80         | 211  | 1089  |
| UG Misc    | 155        | 267  | 66         | 152 | 41         | 177  | 858   |
| UG Trans   | 177        | 249  | 68         | 148 | 51         | 180  | 873   |
| Strip      | 0          | 5    | 0          | 1   | 0          | 0    | 6     |
| TOTAL      | 1006       | 1458 | 442        | 985 | 344        | 1017 | 5252  |

APPENDIX 1

Job Codes

Face Occupation

- 00 - Development work in coal
- 01 - Development work in rock.
- 02 - Cutting machine operators and helpers
- 03 - Continuous mining machine operators and helpers
- 04 - Hand loaders, coal diggers, general miners
- 05 - Timberman and helpers
- 06 - Roof bolters and helpers
- 07 - Loading machine operators and helpers; duckbill operator
- 08 - Miscellaneous drillers and helpers, hand and machine conveyor men, conveyor helpers, shotfirers and blasters, slate work
- 09 - Work at face -- Specific nature not determined; nature too varied to classify; other

### HUMAN SUBJECTS REVIEW BOARD CONSENT FORM

#### I. Project Description

1. Project Title: Study of Coalworkers' Pneumoconiosis (and related)
2. Project Director: R. B. Reger, M.D.
3. Project Purpose and Benefits: This study is a continuing effort to determine the prevalence and incidence of coalworkers' pneumoconiosis and other respiratory diseases in the coal mining industry, and to relate these conditions to the underground mining environment and other factors.  
During the course of this study, our examinations may identify diseases or conditions (which may or may not be related to mining) which should have further medical attention or treatment. With your permission we will notify both you and your private physician of such finding so that it can be taken care of. This is one way in which you may personally benefit from the tests. In addition, all miners may benefit from the research into all areas of respiratory ailments afflicting the coal miner work force.

#### II. Consent

I, ..... hereby voluntarily agree to cooperate in the above named study and to undergo the tests listed in this Part II. The study has been discussed with me; I have been furnished a copy of this form, and I understand the following:

1. The procedures to be followed are as noted in Attachment A.
2. Attendant discomforts and risks are minimal, and provision has been made for any necessary medical support to cover unforeseen conditions.
3. Benefits are as indicated in the project description in Part I.
4. If alternative procedures are available, the procedure most advantageous for me will be indicated and used or an explanation given to me as to the use of any other procedure.
5. My inquiries concerning any procedure used with me will be answered by Mr. R. Reger or Dr. J. Merchant, U.S. Public Health Service, Appalachian Laboratory for Occupational Safety and Health, P. O. Box 4292, Morgantown, West Virginia 26505. Telephone number (304) 599-7476.
6. I am free to terminate my consent and to discontinue participation in the project at any time without prejudice to myself.
7. Confidentiality of information will be maintained as stated in Part III, which I have read and understand.
8. If my medical records are required, a separate written consent for release of the records will be requested.
9. My participation in this study will not affect my employment except as required by law for the protection of the health and safety of myself or others.
10. There will be questions that I will be asked to answer, and my inquiries concerning the questions will be answered by Mr. R. Reger or Dr. J. Merchant, U.S. Public Health Service, Appalachian Laboratory for Occupational Safety and Health, P.O. Box 4292, Morgantown, West Virginia 26505. Telephone number (304) 599-7476.
11. A report of any significant information from the study that specifically concerns me, including medical information, will be furnished to me or my designated physician(s) upon completion of the study or earlier if appropriate.

SIGNATURE ..... DATE .....

SIGNATURE ..... DATE .....  
(Parent or Guardian)

WITNESS ..... DATE .....

#### III. Use of Information

Your identity and your relationship to any information in our possession (1) disclosed by you in completing any project questionnaire and (2) reported by you or derived from you during your participation in the above-named project shall be kept confidential and will not be disclosed without your written consent except as required by law and except that such information will be used for statistical and research purposes in such a manner that no individual can be identified.

#### IV. Request and Authorization for Release of Information

I, ..... hereby request and authorize the Project Director to inform the following physicians whose names and addresses I have entered below of any significant findings from the above-named study concerning me. (Do not leave blank. Write "NO" in any block where you do not wish to give a name and address.)

- (1) My personal physician:
  - Doctor: .....
  - Street: .....
  - City, State, Zip Code .....

(2) Company physician:

Doctor: .....

Street: .....

City, State, Zip Code .....

SIGNATURE ..... DATE .....

V. If a project questionnaire is required, it will constitute this Part V as a separate attachment to be retained by the Project Director. A copy of the questionnaire is not retained by the participant.

**ATTACHMENT A**

A. Project title and number: Study of Coalworkers' Pneumoconiosis (3rd Round)

B. Procedures and tests which involve human subjects in conduct of this project are as follows:

(1) Questionnaire:

You will be asked a series of questions by a trained interviewer. The questions will concern your occupational history, your present and past smoking habits, and possible health problems.

(2) Chest X-rays:

Two chest X-rays will be taken: one from the back and one from the side. These are primarily to see if you have any signs of disease.

(3) Breathing tests:

You will be asked to perform a simple breathing test (spirometry). For breathing test you take a deep breath and blow into a special machine and you will do this five times. This will measure the amount and speed of air coming from your lungs.

(4) Measurement of height and weight.

(5) Although unlikely, you may be asked to donate 50 cc of blood which will be used for several laboratory tests.

(6) Although unlikely, you may be asked to cough into a cup, thereby depositing sputum (phlegm) in a cup. If you cannot do this, a salt and water compound mist will be provided to assist you.

These tests are standard hospital procedures and involve essentially no risk.

C. Right under the Privacy Act of 1974, Title 5, United States Code, Section 552(a)(e)(3).

The information required to be given to me under the Privacy Act of 1974 is as follows:

(1) The authority for collecting information is the Federal Coal Mine Health and Safety Act of 1969 (PL91-173).

(2) The principal purpose of collecting this information is to define positive factors involved in occupational respiratory diseases and to determine the prevalence of pneumoconiosis and other respiratory diseases in coal miners.

(3) Routine use of this information is for research purposes and to inform you of your test results (this was published in the *Federal Register* on September 20, 1976, page 40828, CDC/NIOSH 32.01).

(4) I do not have to furnish any information I do not wish to. Nothing happens to me as a result of my not providing information, whether all or in part of that requested, except that I may be terminated from the project.

The risks associated with all of these procedures have been described in each case and are regarded as minimal. However, should you have any reactions that you think are a result of the test procedures, contact the project director, Mr. R. Reger (304) 599-7476, or the designated physician identified in the following:

Doctor: .....

Street: .....

City, State, and Zip Code: .....

Telephone: .....

**DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE**

Public Health Service

(209)

Center for Disease Control

National Institute for Occupational Safety and Health

Morgantown, West Virginia 26505

**Study of Coalworkers' Pneumoconiosis**

This report is authorized by the Federal Coal Mine Health and Safety Act of 1969 (PL 91-173). While your response is voluntary, your cooperation is necessary for the understanding of health factors related to conditions of the underground mining environment.

---

Identification No.

Interviewer Code

---

Mine

Date of Interview

---

B      A

Q

X

P

**A. IDENTIFICATION**

|   |  |  |  |                            |  |
|---|--|--|--|----------------------------|--|
| 1. NAME (Last) (First) (Middle Initial)   |  |  | 3. PHONE NUMBER  | 4. SOCIAL SECURITY NUMBER* |  |
| 2. CURRENT ADDRESS (Number, Street, or Rural Route, City or Town, County, State, Zip Code)  |  |  | 5. BIRTHDATE (Month, Day, Year)  |                            | 6. AGE LAST BIRTHDAY   |
|   |  |  | 7. SEX<br>1 <input type="checkbox"/> MALE<br>2 <input type="checkbox"/> FEMALE |                            | 8. RACE<br>1. AM. INDIAN <input type="checkbox"/> 4. HISPANIC <input type="checkbox"/><br>2. ASIAN <input type="checkbox"/> 5. WHITE <input type="checkbox"/><br>3. BLACK <input type="checkbox"/> |
| 9. MARITAL STATUS<br>1 <input type="checkbox"/> MARRIED 3 <input type="checkbox"/> DIVORCED 5 <input type="checkbox"/> NEVER MARRIED<br>2 <input type="checkbox"/> WIDOWED 4 <input type="checkbox"/> SEPARATED |  |  | 10. STANDING HEIGHT<br>..... (cms)   |                            | 11. WEIGHT<br>.....(kgs)   |
|   |  |  | 12. WHAT WAS THE HIGHEST GRADE OF REGULAR SCHOOL YOU COMPLETED?                |                            |  |

**B. OCCUPATIONAL HISTORY**

I am now going to ask you about the jobs you have held since you started to work regularly. I would like to start with your present job and go back to the first.

For present job, indicate industry and location on first line of occupational history table.

|  |  |   |  |
|--|--|---|--|
| 1. IN WHAT YEAR DID YOU START WORKING HERE?  |  | 2. WHAT EXACTLY IS YOUR MAIN JOB?   |  |
| 3. ON THE AVERAGE, HOW MANY DAYS PER WEEK DO YOU WORK?   |  | 5. (IF UNDERGROUND) DO YOU WORK MOSTLY AT THE STOPE, IN TRANSPORTATION, IN MAINTENANCE, OR AT SOMETHING ELSE? |  |
| 4. IS YOUR MAIN JOB MOSTLY UNDERGROUND OR MOSTLY ON THE SURFACE?   |  |   |  |
| 6. FOR HOW MANY YEARS?   |  | 8. FOR HOW MANY YEARS?  |  |
| 7. (IF SURFACE) DO YOU WORK MOSTLY IN TRANSPORTATION, IN MAINTENANCE, AT THE TIPPLE, OR AT SOMETHING ELSE? |  |   |  |

For prior jobs, determine industry and location and insert on proper line of occupational history table. If industry is mining, be specific on name of company and location of mine. Change the above sequence of questions to past tense and ask for each prior job — one exception to this is that after question 1 in the above sequence, ask the following question:

“In what year did you stop working there?”

If sufficient space is not available on the occupational history table for the full history of the individual, append an extra table and label it accordingly.

\*Furnishing your Social Security Number is voluntary. Your refusal to provide your Social Security Number will not affect any right, benefit or privilege to which you should be entitled if you did provide your Social Security Number. Use of the Social Security Number will permit us to include you in future follow-up studies and will permit future determination of vital status.

IDENTIFICATION NO.

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(PAGE 5)

**B. OCCUPATIONAL HISTORY TABLE**

Complete the following table showing the entire work history of the individual from present to initial employment. Sporadic, parttime periods of employment, each of no significant duration, should be grouped if possible.

| INDUSTRY & LOCATION | TENURE OF EMPLOYMENT |              | SPECIFIC OCCUPATION | AVER. NO. OF DAYS WORKED PER WEEK | IF OCCUPATION IS MINING, INDICATE: |        |        |       |                |        |      |       | YEARS STRIP |  |
|---------------------|----------------------|--------------|---------------------|-----------------------------------|------------------------------------|--------|--------|-------|----------------|--------|------|-------|-------------|--|
|                     | From<br>19....       | To<br>19.... |                     |                                   | *YEARS UNDERGROUND                 |        |        |       | *YEARS SURFACE |        |      |       |             |  |
|                     |                      |              |                     |                                   | FACE                               | TRANS. | MAINT. | MISC. | TRANS.         | MAINT. | TIPP | MISC. |             |  |
|                     | Pr.                  |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |
|                     |                      |              |                     |                                   |                                    |        |        |       |                |        |      |       |             |  |

| SUMMARY                               |                                   |                         |                     |
|---------------------------------------|-----------------------------------|-------------------------|---------------------|
| TOTAL YEARS IN NON-MINING OCCUPATIONS | TOTAL YEARS IN MINING OCCUPATIONS | TOTAL YEARS UNDERGROUND | TOTAL YEARS SURFACE |
|                                       |                                   |                         |                     |

\*Record to nearest 1/2 year.

B. OCCUPATIONAL HISTORY (Continued)

(21.2)

IDENTIFICATION NO.

Record on lines the number of years in which subject has worked in any of the below listed industries.

Have you ever worked:

- 9. In any other type of mine? 1  Yes 2  No No. Yrs. ....
- 10. In a quarry? 1  Yes 2  No No. Yrs. ....
- 11. In a foundry? 1  Yes 2  No No. Yrs. ....
- 12. In a pottery? 1  Yes 2  No No. Yrs. ....
- 13. In a cotton, flax or hemp mill? 1  Yes 2  No No. Yrs. ....
- 14. With asbestos? 1  Yes 2  No No. Yrs. ....
- 15. In any other dusty job? 1  Yes 2  No No. Yrs. ....

(Specify) .....  
.....

TOTAL  
NUMBER OF YEARS .....

C. SYMPTOMS

I am now going to ask you some questions, mainly about your chest. I would like you to answer "YES" or "NO" whenever possible.

COUGH

- 1. Do you usually cough first thing in the morning (on getting up\*) in the winter? 1  Yes 2  No  
Count a cough with first smoke or on first going out of doors.  
Exclude clearing throat or a single cough.
- 2. Do you usually cough during the day (or at night\*) in the winter? 1  Yes 2  No  
Ignore an occasional cough.  
If "No" to both questions 1 and 2, go to question 4.  
If "Yes" to either question 1 or 2:
- 3. Do you cough like this on most days (or nights\*) for as much as three months each year? 1  Yes 2  No 9  NA

PHLEGM

- 4. Do you usually bring up any phlegm from your chest first thing in the morning (on getting up\*) in the winter? 1  Yes 2  No  
Count phlegm with first smoke or on first going out of doors.  
Exclude phlegm from the nose. Count swallowed phlegm.

\*For individuals who work at night.

5. Do you usually bring up any phlegm from your chest during the day (or at night\*) in the winter? 1  Yes 2  No

Accept twice or more.

If "No" to both questions 4 and 5, go to question 7.

If "Yes" to either question 4 or 5:

6. Do you bring up phlegm like this on most days (or nights\*) for as much as three months each year? 1  Yes 2  No 9  NA

7. In the past three years have you had a period of (increased\*\*) cough and phlegm lasting for three weeks or more? 1  Yes 2  No

If "No" to question 7, go to question 9.

If "Yes" to question 7:

8. Have you had more than one such period? 1  Yes 2  No 9  NA

9. Have you ever coughed up blood? 1  Yes 2  No

If "No" to question 9, go to question 11.

If "Yes" to question 9:

10. Was this in the past year? 1  Yes 2  No 9  NA

#### BREATHLESSNESS

11. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? 1  Yes 2  No  \*\*\* Disabled

If "No" or "Disabled" to question 11, go to question 14.

If "Yes" to question 11:

12. Do you get short of breath walking with other people of your own age on level ground? 1  Yes 2  No 9  NA

If "No" to question 12, go to question 14.

If "Yes" to question 12:

13. Do you have to stop for breath when walking at your own pace on level ground? 1  Yes 2  No 9  NA

#### WHEEZING

14. Does your chest ever sound wheezing or whistling? 1  Yes 2  No

If "No" to question 14, go to question 16.

If "Yes" to question 14:

15. Do you get this most days — or nights? 1  Yes 2  No 9  NA

\*For individuals who work at night.

\*\*For individuals who usually have phlegm.

\*\*\*Disabled from walking by any conditions other than heart or lung disease.

WHEEZING (Continued)

(214)

16. Have you ever had attacks of shortness of breath with wheezing? 1  Yes 2  No

If "No" to question 16, go to question 18.

If "Yes" to question 16:

17. Is/was your breathing absolutely normal between attacks? 1  Yes 2  No 9  NA

WEATHER

18. Does the weather affect your chest? 1  Yes 2  No

Only record "Yes" if adverse weather definitely and regularly causes chest symptoms.

If "No" to question 18, go to question 21.

If "Yes" to question 18:

19. Does the weather make you short of breath? 1  Yes 2  No 9  NA

20. What kind of weather? ..... 9  NA

NASAL DRAINAGE

21. Do you usually have a stuffy nose or drainage at the back of your nose in the winter? 1  Yes 2  No

22. Do you have this in the summer? 1  Yes 2  No

If "No" to both questions 21 and 22, go to question 24.

If "Yes" to either question 21 or 22:

23. Do you have this on most days for as much as three months each year? 1  Yes 2  No 9  NA

CHEST ILLNESSES

24. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? 1  Yes 2  No

If "No" to question 24, go to question 27.

If "Yes" to question 24; ask question 25.

25. Did you bring up more phlegm than usual in any of these illnesses? 1  Yes 2  No 9  NA

If "No" to question 25, go to question 27.

If "Yes" to question 25:

26. How many illnesses like this have you had in the past three years? \_\_\_\_\_ 9  NA

**C. SYMPTOMS (Continued)**

HAVE YOU EVER HAD (Insert proper code, questions 27 through 36)

- |  |                          |                             |                          |
|--|--------------------------|-----------------------------|--------------------------|
| 27. An injury or operation affecting your chest? | <input type="checkbox"/> | 32. Pulmonary tuberculosis? | <input type="checkbox"/> |
| 28. Heart trouble?                               | <input type="checkbox"/> | 33. Bronchial asthma?       | <input type="checkbox"/> |
| 29. Bronchitis?                                  | <input type="checkbox"/> | 34. Emphysema?              | <input type="checkbox"/> |
| 30. Pneumonia?                                   | <input type="checkbox"/> | 35. Bronchiectasis?         | <input type="checkbox"/> |
| 31. Pleurisy?                                    | <input type="checkbox"/> | 36. Other chest trouble?    | <input type="checkbox"/> |

Code: 0=No; 1=Once; 2=Twice .....9=Nine or more times. Codes only 0 or 1 for questions 27, 28, 32, 33, 34 and 35.

- |   |                                |                               |                               |
|---|--------------------------------|-------------------------------|-------------------------------|
| 37. Have you ever been exposed regularly to irritating gas or chemical fumes?                                       | 1 <input type="checkbox"/> Yes | 2 <input type="checkbox"/> No |                               |
| 38. Have you ever been exposed (within 30 feet) to the smoke of an underground cable fire?<br>If so, how many ..... | 1 <input type="checkbox"/> Yes | 2 <input type="checkbox"/> No | 9 <input type="checkbox"/> NA |

**D. TOBACCO SMOKING**

- |  |  |   |                               |
|--|--|---|-------------------------------|
| 1. Do you now smoke cigarettes?<br>If "Yes" to question 1, go to question 4.<br>If "No" to question 1:   | 1 <input type="checkbox"/> Yes   | 2 <input type="checkbox"/> No   |                               |
| 2. Have you ever smoked cigarettes?<br>If "Yes" to question 2, go to question 4.<br>If "No" to question 2:   | 1 <input type="checkbox"/> Yes   | 2 <input type="checkbox"/> No   | 9 <input type="checkbox"/> NA |
| 3. Have you smoked at least as many as five packs of cigarettes, that is, 100 cigarettes during your entire life?<br>If "Yes" to question 3, go to question 4.<br>If "No" to question 3, go to question 9. | 1 <input type="checkbox"/> Yes   | 2 <input type="checkbox"/> No   | 9 <input type="checkbox"/> NA |
| 4. How old were you when you started smoking cigarettes regularly?<br>If an ex-cigarette smoker, ask:  |  |   | .....<br>(Age in years)       |
| 5. How old were you when you last gave up smoking cigarettes?  |  |   | .....<br>(Age in years)       |
| 5a. During the years that you smoked, did you ever quit for a year or more?<br>If yes, how long? .....   | 1 <input type="checkbox"/> Yes   | 2 <input type="checkbox"/> No   |                               |
| 6. How much do/did you smoke on the average?   |  |   | .....<br>(Cigarettes a day)   |
| 7. Do/did you inhale the cigarette smoke?  | 1 <input type="checkbox"/> Yes   | 2 <input type="checkbox"/> No   |                               |
| 8. What do/did you mostly smoke?   | 1 <input type="checkbox"/> Filters<br>2 <input type="checkbox"/> Non-Filters | 1 <input type="checkbox"/> Regular<br>2 <input type="checkbox"/> King Size<br>3 <input type="checkbox"/> 100 Millimeter |                               |

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D. TOBACCO SMOKING (Continued)

9. Do you now smoke a pipe?

1  Yes      2  No

If "Yes" to question 9, go to question 11.

If "No" to question 9:

10. Have you ever smoked a pipe?

1  Yes      2  No      9  NA

11. How many bowlsful a week do/did you smoke? \_\_\_\_\_

12. Do you now smoke cigars?

1  Yes      2  No

If "Yes" to question 12, go to question 14.

If "No" to question 12:

13. Have you ever smoked cigars?

1  Yes      2  No      9  NA

If "Yes" to question 13, go to question 14.

If "No" to question 13, end interview.

14. How many cigars a week do/did you smoke? \_\_\_\_\_

Use "did" only for ex-smokers.