

## THE FOURTH ROUND OF THE NATIONAL STUDY OF COALWORKERS' PNEUMOCONIOSIS: A PRELIMINARY ANALYSIS

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### INTRODUCTION

The year 1969 was a landmark time for underground coal miners in the United States, for it was in that year that the Federal Coal Mine Health and Safety Act was passed.<sup>1</sup> This enacted three provisions of benefit to miners: a low dust exposure limit; an x-ray surveillance and job transfer program; and a requirement that research be carried out on the health of coal miners, on dust reduction techniques, and on safety in mines.

Of these three provisions, that involving research activities into the health of miners was satisfied through the creation of a research project known as 'The National Coal Study' (now known as the National Study of Coalworkers' Pneumoconiosis (NSCWP)), currently administered by the National Institute for Occupational Safety and Health.

This project was begun in August 1969 with medical surveys at 31 nationally distributed mines. The mines were chosen to represent different coal seams and mining methods. Other criteria for selection were a working force of at least 100 miners, expected continued coal production for at least another 10 years, and preferably some earlier dust measurements. Of the 31 mines, 17 had been environmentally sampled in a study by the Bureau of Mines.<sup>2,3</sup>

The medical surveys were undertaken through use of mobile examination units which went from mine to mine. At each mine the complete workforce was examined by being given a postero-anterior and lateral chest x-ray, by undertaking spirometry, and by answering questions on chest symptoms using a slightly modified version of the British Medical Research Council's symptoms questionnaire.<sup>4</sup> In addition, working and smoking histories were ascertained, and demographic information and height and weight determined. The participation rate at this initial round of surveys (Round 1) was excellent, at 91%.

Two further rounds of surveys were completed subsequent to Round 1. The second round began about three years after Round 1, the methods being virtually the same. Owing to the closure of mines in the period between these rounds, and in order to improve representation, nine additional mines were brought into the study for this round. Round 3 began in 1977, the procedures being again virtually identical to those of the previous two rounds.

Figure 1 shows some information graphically on the timing of the surveys. It also shows the permitted exposure limits in force during this time, and the general trend in dust levels based on the survey reported by Jacobson,<sup>3</sup> and from data collected by the Mine Safety and Health Administration.<sup>5</sup>

The data collected in the three completed rounds have led to the publication of many findings and results on lung disease in U.S. coal miners. It has been shown that CWP prevalence follows a trend with the rank of coal, with tenure in mining, and with job.<sup>6</sup> In addition, indices of lung function and chest symptoms have been shown to be correlated with job and with tenure underground.<sup>7,8</sup> More recently results have been published on longitudinal change in ventilatory function,<sup>9</sup> and on incidence and progression of CWP.<sup>10</sup> Many other reports have been published.

The remainder of this paper is concerned with the rationale for the fourth round, and a description of its design and methods. This is followed by a description of the status of the selected cohort and an examination of selection bias.

### NEED FOR A FOURTH ROUND

A further round of examinations in the NSCWP was deemed necessary for the following reasons:

1. The period of follow-up between rounds 1 and 3 was too short for proper evaluation of the effectiveness of the dust control limit set by the 1969 Act.
2. Participation in Rounds 2 and 3 at 75% and 52% was much lower than the 91% attained at Round 1, leading to uncertainty in the later findings.
3. Rounds 1-3 were concerned only with miners employed at time of examination. The omission of ex-miners may have led to bias in the reported results.

### STRATEGY FOR THE FOURTH ROUND

Continuation of the NSCWP along the lines of the previous three rounds was thought inadvisable for these reasons:

- a. Mine based surveys were starting to prove inadequate as a mechanism for follow-up of miners. The closure of mines and the movement of miners between mines and to other jobs meant that members of the study examined in the early rounds were no longer at the same mines, and therefore being lost to the study.

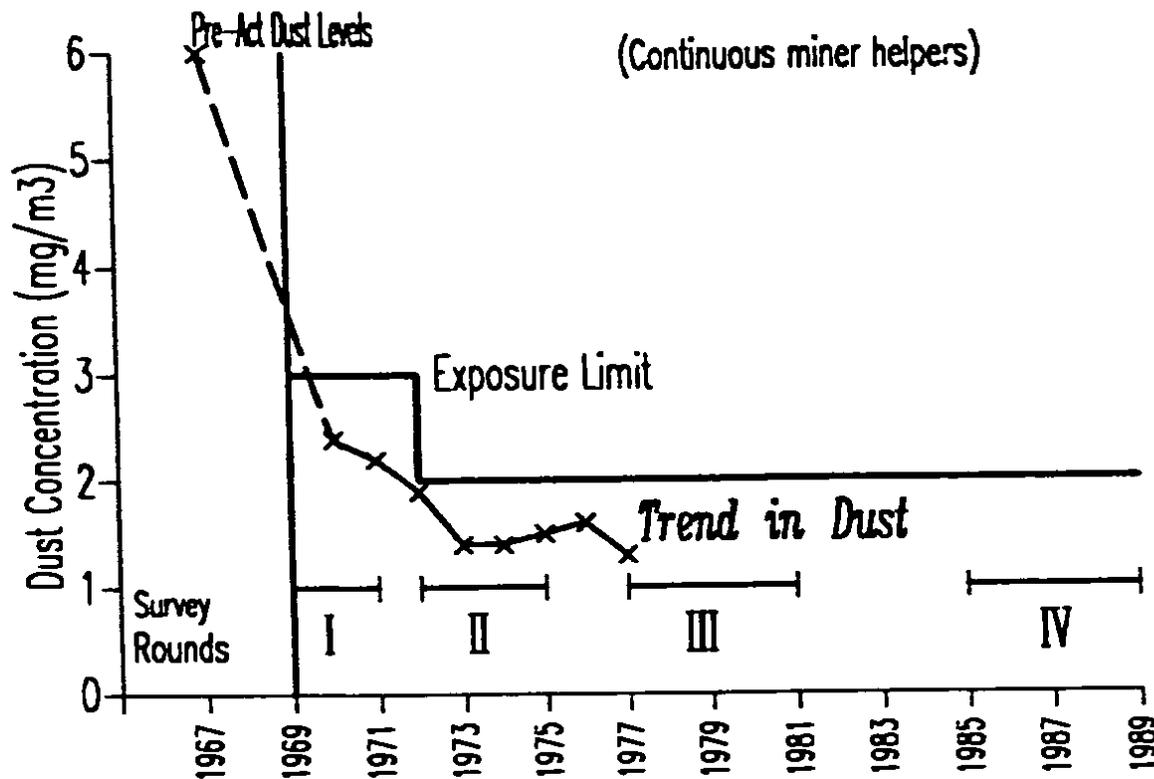


Figure 1. Dust limits, dust exposure trends, and NSCWP surveys, 1967-89.

- b. Mine based surveys were inappropriate for examination of ex-miners.
- c. Experience during the third round had shown that the lack of interest in the study by miners was exacerbated by mine based medical surveys.
- d. Most importantly, the aims of the NSCWP had evolved from research into the relationship between dust characteristics and indices of respiratory health into an evaluation of the effectiveness of the 2 mg/m<sup>3</sup> dust standard. This change in emphasis called for a change in the nature of the design of the study.

For the above reasons it was decided that the fourth round would not be based on mine visits but would rather center around the location and examination of a cohort defined by initial attendance at either Round 1 or Round 2. The intent of this exercise was to measure changes in health over the intervening period. These changes could then be compared to those expected to occur under 2 mg/m<sup>3</sup> based on current knowledge on dust exposure and disease.

#### FOURTH ROUND PLANNING

The fourth round follow-up cohort was formed from two subsets of miners who attended either Round 1 or Round 2 initially. The selection criterion that miners had to be young enough at these rounds for them to have been able to work a further 15 or so years up to the fourth Round was imposed. This led to 3719 miners remaining out of the 9081 Round 1 miners and 3677 out of the 9343 Round 2 miners, making a total of 7396 miners for follow-up.

Without the age criterion the cohort would have consisted of mainly older coal miners, most of whom would have retired before the 4th round. As this investigation was intended to be a study of those potentially able to work the inter-survey period between the first two rounds and round 4, those older than 45 at Round 1, and 48 at Round 2 were excluded from the cohort.

Figure 2 shows the geographical distribution of the cohort of interest. This, of course, follows the distribution of mines originally selected for the study, which itself reflected the general pattern of employment in the various coal fields.

Table I shows some basic statistics on the cohort by round (see Appendix for brief details of the data and methods). The miners of Round 2 were slightly younger and less experienced because many of them had just started work as a result of the hiring boom that took place in coal mining in the early 1970s. In other respects the groups were very similar.

#### DATA COLLECTION METHODS

Two methods of data collection were used. In cases where it was established that a sufficiently large cluster of the cohort miners were working at a particular mine, a survey was held at that mine. Three such mine surveys were held, the number being few because most of the study mines had been shut down or were inactive during the data collection period.

In order to improve participation NIOSH staff spent extensive amounts of time talking to the miners at those mines.



(UMWA) and usually another from the local UMWA District President. Once the letters had been sent the telephone person began calling the miners and setting up appointments.

Contact with miners was difficult in many cases owing to unlisted telephone numbers and lack of telephones. Letters were sent where telephone contact proved impossible although the reply rate was low. Whenever possible personal contact was made by visits to the house by the telephone person or by members of the examination team at the time of survey.

Out of the 7396 cohort members, 4712 were selected for examination in the three mine and twenty community surveys held to date. Additional community surveys are planned in order to complete data collection, although it is not expected that all of the cohort will be selected for examination as many are located too remotely or too sparsely to justify a survey in their area. The completed surveys have been held throughout all but one of the states in which the original mines were located, and as a result the 4712 selected miners are distributed by state in roughly the same proportion to the cohort state distribution (Figure 3).

**STATUS OF SELECTED SAMPLE**

Figure 4 shows the breakdown of the 4712 selected cohort members according to status at time of examination (final status). The groups are denoted as follows: 1. Examined; 2. No contact; 3. Moved; 4. Refused; 5. No-shows (had appointments but did not attend); 6. Deceased; 7. Valid reasons for non-attendance; and 8. Probable excuse.

The no contact group consisted of those with whom telephone contact was not made, and who did not return letters. In many cases the person could not be reached when a personal visit was made also. Such people may have left the area, become reclusive, been out of the area or worked away from home, or may have died; certainly, exact determination of the reason was impossible. The crude participation rate was 60%, while if those who had died, moved or had valid reasons for non-attendance were excluded, the rate rose to 68%. If the no contacts are also excluded the rate was 74%.

**STUDY OF PARTICIPATION BIAS USING EARLIER DATA**

Since there is the potential for bias, in that the healthy may choose to be tested while the unfit be unable to or refuse (perhaps through fear of loss of health benefits), an examination of bias was made. This was done in two ways. Firstly, bias was measured indirectly by tabulating data from the initial rounds of the study according to status at round 4 (see Appendix for brief details of the data). The second approach is described in the next section of this report.

Table II shows data from the Round 1 part of the cohort tabulated according to the first five of the final status groups described earlier (the valid reasons and excuses groups, being small, were omitted, while the deceased group is not relevant to discussions of bias). The table shows that age differed little between the five groups, while smokers were more frequent in all of the non-examined groups. The refusal group was noteworthy for having the most reports and findings of ill health as well as having the longest tenure. The movers

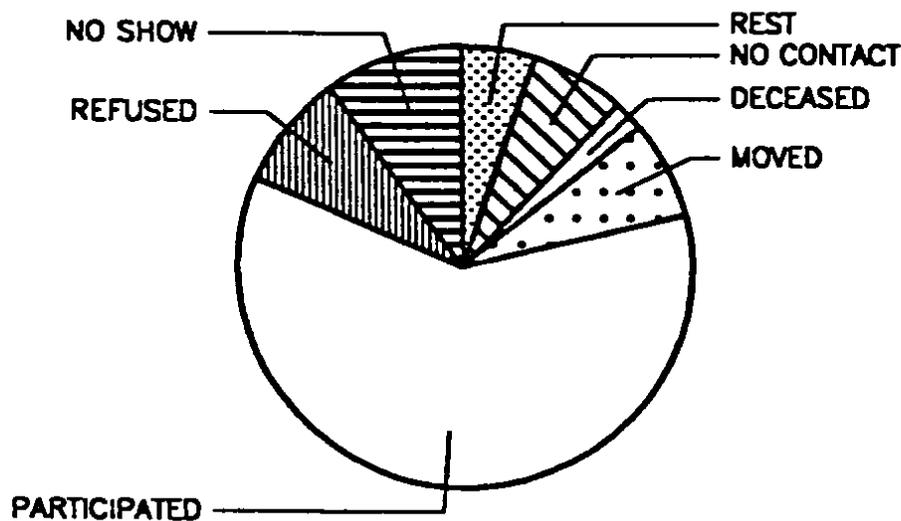


Figure 3. Distribution of complete cohort, and of those selected for examination to date, by state.

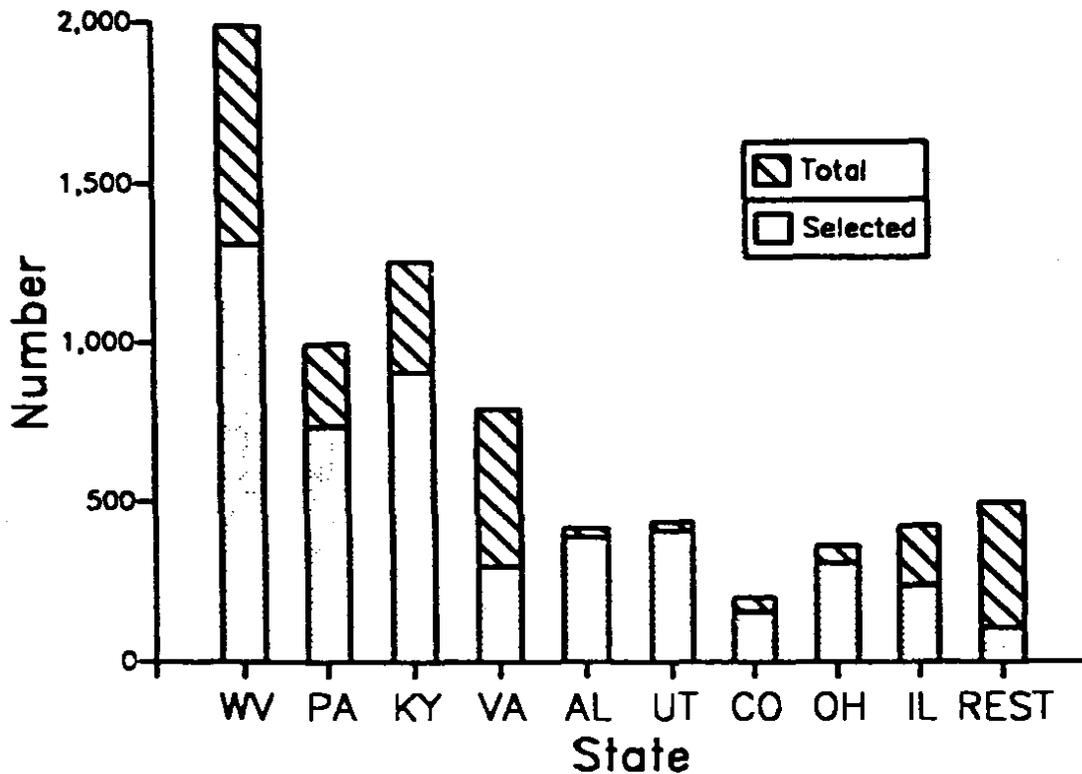


Figure 4. Distribution of final status of selected group.

Table II  
Medical Information at Round 1 by Final Status at Round 4

	Exam- ined	No contact	Moved	Re- fused	No show
Number	1549	125	166	206	186
Age (yr)	33	32	30	33	31
Tenure UG (yr)	7	8	5	9	7
% Smokers	58	62	71	66	67
% Obstructed	20	17	18	24	20
% CWP Cat 1+	5	3	2	8	6
% CWP Cat 2+	1	1	1	1	1
% Cough	20	23	20	26	21
% Dyspnea	7	10	8	9	9

Note: all percentages rounded for simplicity of presentation. Zero percentages may actually be less than 0.5%. Deceased, unknown status, and two other small non-participating groups omitted (n=173).

group had the most smokers but generally had the fewest signs of health problems.

Table III shows the data for the Round 2 part of the cohort. In general the results parallel those seen in Table II. Again the age range between the groups is small, and the exam-

ined group had the fewest smokers. The refusal group had the longest tenure, greatest percentage obstructed, most CWP and high levels of symptoms, as they did in Table II. Similarly, movers were younger, had large numbers of smokers, yet tended to have fewest signs of lung disease. There was

more evidence of lung problems in the no contacts in this Round 2 part of the cohort.

Overall, the results from both portions of the cohort indicate the following. The refusals appeared to have had more exposure to coal dust, smoked more, and had more disease. This excess of disease is balanced in part by the deficit seen in the movers. No-shows in general had about as much ab-

normality as those examined, while the findings were mixed for the no contacts.

In general, there is evidence of bias, but it does not appear severe. This observation is confirmed by the results of Table IV, which shows the data by round for the examined group compared to that for those not examined, and for all of the cohort excepting deceased miners. It shows that only minor

Table III  
Medical Information at Round 2 by Final Status at Round 4

	Exam- ined	No contact	Moved	Re- fused	No show
Number	1357	197	170	203	288
Age (yr)	30	31	28	33	29
Tenure UG (yr)	5	7	4	8	5
% Smokers	56	69	69	60	59
% Obstructed	18	21	18	23	15
% CWP Cat 1+	2	5	2	5	2
% CWP Cat 2+	0	0	0	1	0
% Cough	16	25	16	23	21
% Dyspnea	11	19	13	16	13

Note: all percentages rounded for simplicity of presentation. Zero percentages may actually be less than 0.5%. Deceased, unknown status, and two other small non-participating groups omitted (n=185)

Table IV  
Examination of Bias for Round 1 and Round 2 Cohorts

	Round 1 cohort			Round 2 cohort		
	Examined Yes	No	All	Examined Yes	No	All
Number	1549	801	2350	1357	990	2347
Age (yr)	33	32	33	30	30	30
Tenure UG (yr)	7	7	7	5	6	5
% Smokers	58	66	61	56	63	59
% Obstructed	20	20	20	18	18	18
% CWP Cat 1+	5	5	5	2	1	2
% CWP Cat 2+	1	1	1	0	0	0
% Cough	20	23	21	16	21	18
% Dyspnea	7	9	8	11	15	12

Notes: all percentages rounded for simplicity of presentation. Zero percentages may actually be less than 0.5%. The not examined and total groups exclude deceased miners.

differences existed between those tested and those not tested, the biggest discrepancies occurring for smoking (7–8% difference) and for cough (3–5% difference) and dyspnea (2–4% difference). When the data for the examined group are compared to those for all living miners the differences are trivial, indicating that the examined group may be reasonably representative of the whole.

#### ANALYSIS OF BIAS USING COMPENSATION DATA

The above approach is not particularly satisfactory, since there was a 10–15 year inter-round period during which lung disease could develop. The second approach used more current data from the U.S. Department of Labor (DOL) on Black Lung compensation. To do this, a file of information on name, Social Security number and final status was sent to the DOL. This was matched with the DOL records and a table created showing the percentage in each final status category that had been granted benefits. (While a more powerful analysis would have used DOL medical data in an approach similar to that used in Tables II and III, no formal agreement existed at the time this was written that would have permitted the necessary exchange of data.)

The history of DOL compensation is complicated and much too lengthy for description here in detail. However, two broad periods of time between 1970 and 1988 can be identified during which the regulations were less and more restrictive respectively, viz. pre- and post-1980. Award of compensation was contingent on either ventilation tests or x-ray results during each period, but the criteria were made much more strict after 1980. In addition the rebuttable presumption that lung disease was the result of coal mining was repealed at that time. The result of this tightening was to reduce the approval rate from a high of 46% to 5% (section

435 claims under the 1977 amendments compared to section 718 claims, post 1981 amendment—figures from DOL staff). Since the criteria for these two time periods are so distinctly different the results have been subdivided accordingly.

Table V shows the percentages of miners in each of the final status groups (both rounds combined) who were awarded benefits based on the less and more restrictive criteria respectively, and overall. They show that those examined had the lowest percentage in receipt of benefits, while refusals had the most, followed by the no-contacts, movers and no-shows. This pattern is evident both in those awarded benefits under the less and under the more restrictive criteria, although the differences under the latter criteria are much less pronounced. The overall percentage of miners awarded benefits was 4.9% (excluding deceased miners), compared to the 2.9% seen in those examined, indicating the possibility of bias. Based on the more restrictive criteria, these percentages are 0.9% overall, and 0.8% in the examined group, suggesting the absence of severe bias.

#### CONCLUSIONS

Data collection is continuing in order to fill some of the major gaps in miner selection noted earlier and to increase the number of examined cases in the round 4 cohort. At this point in time about 65% of the combined round 1 and 2 cohorts have been selected for examination. Of those 4805 miners, 60% have been examined. On the basis of earlier data, the examined group appears to be in slightly better health than those alive at time of survey who did not attend. Certain subgroups of the nonparticipants, specifically those who refused, tended to have, and to report, distinctly more signs of ill health. This excess is balanced to some extent by the apparent better health of those who moved. The data from

Table V  
Percentage of Miners Receiving DOL Black Lung Benefits Awarded Under  
Different Regulations by Final Status at Round 4

	Exam- ined	No contact	Moved	Re- fused	No show
Number	2906	322	336	409	474
Benefits approved under less restric- tive regulations	1.9	8.4	5.7	9.3	3.6
Benefits approved under more restric- tive regulations	0.8	0.6	0.3	1.5	1.1
total approved benefits	2.6	9.0	6.0	10.8	4.6

the DOL on black lung benefits confirm that bias may be present, but its actual extent is hard to judge in the absence of medical information.

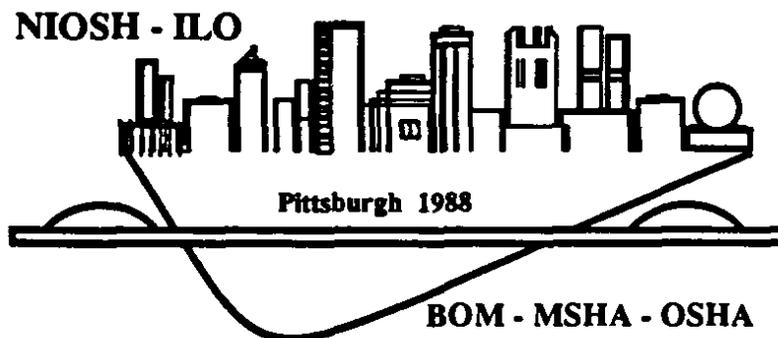
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