

DUST CONCENTRATIONS AND PREVALENCE OF PNEUMOCONIOSIS IN THE UNITED STATES
AND GREAT BRITAIN: A RE-EXAMINATION AND COMPARISON OF DATA PRIOR TO 1970

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The U.S. coal dust standards are largely based on the results from the British long term medical and environmental study known as the Pneumoconiosis Field Research (PFR).¹ Specifically, the U.S. adopted a dust standard of 2.0 mg/m^3 (respirable dust) in 1972 as the concentration which all underground U.S. coal mines must not exceed to prevent the development of new cases of Coal Workers' Pneumoconiosis (CWP) (category 2/1 or greater). In a paper by PFR researchers Jacobsen et al.², it was described how the incidence of small rounded opacities of category 2/1 or greater over 35 years varied with average dust concentration. Figure 4 in that paper indicates that little or no incidence was expected at or below 2.0 mg/m^3 .

A question that must be asked is whether British epidemiological results on the incidence of CWP in relation to dust exposure are applicable to the U.S. mining situation. The National Coal Study (NCS) is a longitudinal epidemiological study designed to determine the prevalence and progression of CWP in U.S. coal mines. However, the NCS has not been in existence for a long enough period of time to enable a completely valid investigation of CWP incidence under the 2.0 mg/m^3 dust standard. In the interim, other approaches must be utilized to explore this question.

The purpose of this study is to compare prevalences of CWP in the two countries prior to 1970 as there is evidence that overall dust conditions were not dissimilar. This suggests that levels of disease should also have been similar. If this is found to be the case, evidence would exist to indicate that the British epidemiological data is indeed applicable to the U.S. Examination of this question is complicated by problems in the reading of X-rays. During the first round of the National Coal Study, it was reported that nearly 30% of those coal miners examined were diagnosed with CWP (all categories)³. However, a comparison of X-ray readings between British and

American radiologists indicated that on average the Americans were apt to classify a larger proportion of films with CWP (category 1 or greater) than the British (Figure 1).⁴ Recent re-reading of U.S. films has enabled adjusted prevalences to be calculated. The following is a report of the findings.

METHODS

Cohorts

British coal miners who participated in the second round of the PFR and U.S. miners who participated in Round One of the NCS comprised the study cohorts.

Dust estimates

An estimate of the dust concentration in British coal mines was determined by data from the standard thermal precipitator. These data, reported in Table 2 in Rogan et al.⁵, had to be converted to mass units using mass-number indices (MNI). A MNI represents the factor by which dust concentration data reported in particles $1-5 \mu\text{m}$ per cubic centimeter can be converted to mass units; MNI units are mg/m^3 per 1000 particles $1-5 \mu\text{m/cc}$. The results from side-by-side sampling with the thermal precipitator and a gravimetric sampler known as the MRE (Mining Research Establishment) sampler provided data to establish MNI's for each British coal mine studied. These values were reported by Jacobsen et al.²

Estimating the dust concentrations prior to 1970 in the U.S. is more difficult because little dust data exists. In 1968-1969 the Bureau of Mines collected 4,311 dust samples in 29 large and several small U.S. coal mines using the personal respirable dust sampler (10-mm cyclone pre-separator, pre-weighed filter, and battery operated pump). The average dust concentration of underground workers is reported. To directly compare these data with the British dust data, one must convert the dust concentrations from the personal respirable dust sampler to MRE-equivalent concentrations by

multiplying by a factor of 1.6.⁶
All results are reported in
MRE-equivalent concentrations.

X-ray readings from PFR and NCS

Rogan et al⁵ reported on the prevalence of CWP in 25 British coal mines in 1961. The mines were chosen to represent different coal seams and levels of dustiness. A medical examination comprised of a full size chest X-ray, lung function tests and a respiratory symptom questionnaire was given to all participating miners. A detailed work history and absentee information was also collected. Four film readers, two on each team, used the 1953 ILO classifications⁷ to classify the chest X-rays. Every X-ray was read independently by one of the doctors from each group in such a way that each read half of the total number of films. If these two independent readings were consistent, the common reading was reported. All other films (those that did not have two consistent readings) were classified by joint consultation of the four film readers. Their assessment was arrived at by general discussion in which each reader in turn gave his opinion of the film's category.⁸

In the prevalence study of CWP in U.S. coal mines Morgan et al³ studied 31 mines in 10 states (Round One of the National Coal Study). The mines were chosen to represent different coal seams and mining methods. Each miner was asked to participate in a medical examination that included chest X-rays and lung function tests. A medical questionnaire and detailed occupational history were recorded. Chest X-rays were classified by three radiologists. Each reader read every film independently using the 1968 UICC Classifications.⁹ If the three readers agreed or if two out of three agreed, that was the consensus reading reported. If none agreed, a fourth reader was consulted.

X-ray readings from the reading trial

X-ray readings from the first round of the NCS were compared with re-readings undertaken recently by a group of readers who independently read the first and third round films. These re-readings were undertaken as part of another analysis involving the examination of X-ray changes between Rounds One and Three of the NCS, an interval of about nine years. In the

analysis being presented here only the film readings for Round One are of interest.

Film readers from the British National Coal Board were chosen to re-read the films from the NCS because some of them had participated in the Interim Standards Study of the British PFR. These readers read 1261 film pairs for each miner from the first and third rounds of the NCS. The films were read side-by-side on the viewing box using the 1971 ILO classifications¹⁰. A median reading was derived from the average (rounded up to the nearest sub-category) of the middle two readings of the six after they had been ranked by abnormality level.

Statistical analysis

So that we can directly compare PFR to NCS prevalence rates, we calculated prevalence rates for NCS Round One based upon small rounded opacities only. We have already mentioned that in the first round of the NCS, prevalence of disease was based upon a consensus value. This value reflected the readings of small rounded or small irregular opacities, whichever was greater. The study reported by Rogan, et.al.⁵ was based on small rounded opacities only. When comparing the results from the reading trial to the NCS data, only data on small rounded opacities were used.

Evidence indicated that there was wide discrepancy in X-ray readings among the readers used in the first round of the NCS (Figure 1).⁴ Reader 2 read most similarly to the British readers. Therefore, the comparison of re-readings to the Round One NCS readings were tabulated for each reader. The results from the comparison was applied to the whole cohort.

RESULTS AND DISCUSSION

Cohort comparison

Rogan et al⁵ reported an overall prevalence of CWP (category 1 or greater) to be 12.3% in 30,800 British coal miners examined in 1961 (median survey data). Although the mean age was not reported, it can be estimated from other PFR publications that the average of these workers was 40-45 years old (Table 1).

Morgan et al³ reported on the findings of the first round of the

National Coal Study. The overall prevalence of category 1 or greater CWP was 29.9% in 9,078 U.S. coal miners examined in 1970 (median survey date). The average age for this cohort was 44 years old. The different classification schemes used to read the chest films may account for some of the difference seen in prevalence rates for the two countries. It has also been shown that the readers in the early days of the NCS were detecting far more CWP than readers are today for the same films.¹¹

Dust estimates

An estimate of the dust concentrations in British coal mines from 1953-1961 was determined from merging data presented in two papers by PFR researchers.^{2,5} From Table 2 it can be seen that the average dust concentration was about 3.7 mg/m³ for underground workers. This value appears to be fairly accurate at in a later publication, the mean dust concentration during 1953-1963 for British underground workers was reported to be 3.86 mg/m³.² The Bureau of Mines data on 29 large and several small U.S. coal mines represents the dust concentrations found during 1968-1969. The average dust concentration for underground workers was found to be 3.9 mg/m³-MRE.

X-ray readings

The results of the NCS Round One prevalence rate of disease delineated by reader is illustrated in Table 3. It shows that Readers 1 & 2 read an overall prevalence of CWP (category 1 or greater) of 16.8% and 11.9%, respectively, whereas Reader 3 read 32.3%. We compared the results from Readers 1, 2, and 3 to the re-readings undertaken by the independent group of readers to see how the readings compared. The results from this comparison are listed in Table 4. Reader 1 detected 50% more, Reader 2 detected 12% more, and Reader 3 detected 85% more prevalence of disease than the British. Reader 2 displayed the best agreement with the British readers. Reader 2 is the same person who read most similarly to the British readers in a previous study mentioned in the introduction.⁴ Because of this we use Reader 2's readings of the NCS Round One miners to calculate a comparable prevalence rate. That is not to infer that the miners examined in Round One

of the NCS had a disease prevalence of 3-4% (from Table 4). This value was based on a subgroup of the first round participants. The subgroup was younger than the population as these miners were examined at the first and third rounds of the NCS. To derive a prevalence rate of category 1 or greater CWP for all participants in Round One of the NCS, the X-ray readings of small rounded opacities from Reader 2 are used instead of the consensus values. This rate, shown in Table 3, is about 11.9%. This compares favorably to 12.3% prevalence rate reported by Rogan et al⁵ (Table 5).

Reading trial with "B" readers

Three certified "B" readers also participated in the reading trial described above. The film pairs were completely randomized before being given to the "B" readers for examination. The 1971 ILO classifications were also used by the "B" readers.¹⁰ The median reading was derived by ranking the three values by abnormality level and reporting the middle value. From a NIOSH internal report it was determined that these "B" readers were representative of all "B" readers at the time of the study. The results were similar to those found by Reger et al⁴; that is, the "B" readers displayed a wide discrepancy when reading the same film set. "B" readers found 10.9% while the British read 4.6% prevalence of category 1 or greater CWP. Table 6 compares the readings from the "B" readers to the three Round One NCS readers.

SUMMARY

From the information presented in Table 1 the cohorts described by Rogan et al⁴ and Morgan et al⁵ were about the same age and appeared to be exposed to approximately the same amount of dust. Yet the disease prevalence reported in these groups was vastly different. It was suspected that the readers in the first round of the NCS were reading at a higher sensitivity than those from the British studies. This was demonstrated by Attfield and Hudak's comparison of Round One to Round Two readers and by Reger et al's comparison of British to American readers^{11,4}. To correct the Round One readings, reading trials were conducted using a portion of the Round One films. It was determined that the results from Reader 2 alone were most

consistent with the results from the reading trials. Therefore, when the prevalence rate of CWP (category 1 or greater) was calculated for all participants in the first round of the NCS based on Reader 2's results, the prevalence rate was 11.9%. The similarity in prevalence rates of CWP in Britain and the U.S. prior to 1970 coupled with the similarity in exposure provides evidence that it may be valid to apply British dose-response information on CWP and dust levels to the U.S. situation when setting dust standards.

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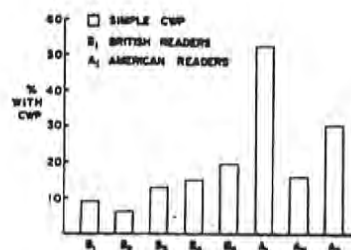


FIGURE I.

Diagnosis of Coalworker's Pneumoconiosis by 8 Readers of Chest X-rays⁴

TABLE 1

Comparison of Two Study Cohorts

type of study	Prevalence of CWP in working miners	
	British (Rogan, et.al.5)	U.S. (Morgan, et.al.3)
no. in study	30,800	9,078
mean age	40-45	44
Prevalence of CWP (category 1+)	12.3%	29.9%

TABLE 2

Average Dust Concentrations Found in British Coal Mines from 1953-1961

Coal Mine ID	Mean Dust Concentration (ppcc 1-5 μ m) ⁴	MNI ²	Mean Dust Concentration (mg/m ³ - MHE)
SC1	160	7.8	1.3
SC2	170	9.3	1.6
SC4	110	10.6	1.2
SC5	190	8.4	1.6
NH1	180	8.3	1.5
C1	230	13.9	3.2
D1	300	17.3	5.2
D2	350	13.7	4.8
Y1	210	12.3	2.6
Y2	220	16.5	3.6
L1	490	13.8	6.7
L2	240	14.0	3.4
NT1	540	13.9	7.5
W1	150	12.6	1.9
SWA1	110	38.2	4.2
SWA2	130	23.4	3.0
SMS1	210	17.1	3.6
SMS3	380	23.3	8.8
SWB1	130	28.4	3.7
K1	150	24.9	3.7

Grand Mean = 3.7 mg/m³

TABLE 3

Prevalence of CWP* From Round One of the National Coal Study
(based on small rounded opacities)

X-ray Reader	Prevalence
1	16.8%
2	11.9%
3	32.3%

*CWP (category 1 or greater)

TABLE 4

Comparison of Prevalence Rates of CWP* Between The Original Readings and Re-readings of Films From 1st Round NCS
(small rounded opacities only)

Reader 1 Median British Readers (n = 1256)	7.8%
Reader 2 Median British Readers (n = 1254)	4.5%
Reader 3 Median British Readers (n = 1254)	25.5%
*CWP (category 1 or greater).	3.9%

TABLE 5
Comparison of Two Study Cohorts

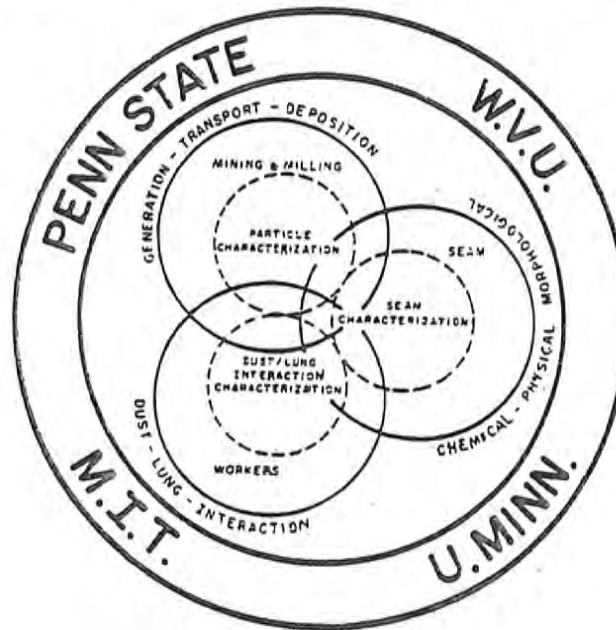
type of study	prevalence of CWP in working miners	
	British (Rogan, et.al.5)	U.S. (Morgan, et.al.3)
no. in study	30,800	9,078
mean age	40-45	44
mean dust conc.	3.7 mg/m ³	3.9 mg/m ³
adjusted prevalence of CWP (category 1+)	12.3%	11.9%

TABLE 6

Comparison of Prevalence Rates of CWP* Between The Original Readings and "g" readers' Re-readings of Films From 1st Round NCS
(small rounded opacities only)

Reader 1 Median "g" Readers (n = 1009)	10.1%
Reader 2 Median "g" Readers (n = 1007)	6.1%
Reader 3 Median "g" Readers (n = 1008)	30.1%
*CWP (category 1 or greater).	11.8%

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