

A SUMMARY OF RECENT FINDINGS ON OCCUPATIONAL LUNG DISEASE IN US UNDERGROUND COAL MINERS

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During 1992 a number of papers were published on aspects of respiratory disease in US underground coal miners. These included reports on trends in prevalence of coal workers' pneumoconiosis, the risks of developing coal workers' pneumoconiosis in relation to dust exposure, and the relationship between lung disease other than pneumoconiosis and dust exposure. The intent of this paper is to provide a summary of the essential findings from these investigations.

PREVALENCE AND INCIDENCE OF COAL WORKERS' PNEUMOCONIOSIS

Coal workers' pneumoconiosis (CWP) is usually detected in living miners through use of the chest x-ray. Deposits of dust in the lung, and the fibrotic tissue reactions to the dust, are manifested on the x-ray as small and large opacities. These abnormalities are quantified into degrees of severity using a standardized classification scheme (the International Classification of Radiographs of the Pneumoconioses of the International Labour Office). For small opacities, the scheme provides for a four-point scale of abnormality (0, 1, 2, 3), reflecting increasing profusion of the opacities on the x-ray. In this report, category 1 or greater small rounded opacities (CWP 1+) represents the earlier radiographic stages of pneumoconiosis. Large opacities, indicate the later and often disabling stage of pneumoconiosis, usually referred to as progressive massive fibrosis (PMF).

Information collected in a national surveillance program for underground coal miners (the Coalworkers' X-ray Surveillance Program (CWXP)) and a large epidemiologic study (National Study of Coalworkers' Pneumoconiosis (NSCWP)) provide a means to assess trends in CWP prevalence over the years following the reduction in dust levels mandated by the 1969 Federal Coal Mine Health and Safety Act (FCMHS). These programs are operated by the National Institute for Occupational Safety and Health (NIOSH), and are described in detail in Attfield and Althouse (1992) and Attfield and Castellani (1992). Both studies were divided

administratively into distinct time periods, and the results shown here reflect that division.

Figure 1 shows the prevalence of CWP 1+ as determined from data from the CWXP, plotted by time period and years in mining. There is evidence of a temporal reduction in prevalence. (The lack of an obvious decline in the early 1970s may be an artifact arising from use of different versions of the standard classification.) Figure 2 provides information in the same format for PMF, and shows a similar trend

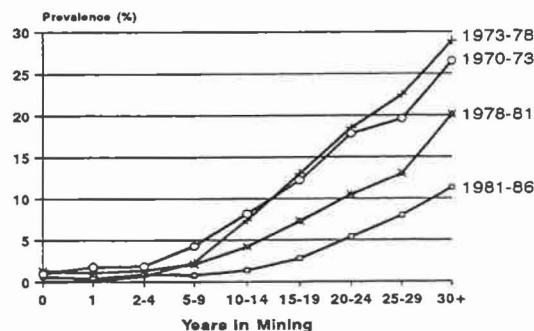


Figure 1. TEMPORAL TRENDS IN TENURE-SPECIFIC PREVALENCES OF CWP 1+ FROM SURVEILLANCE PROGRAM (CWXP)

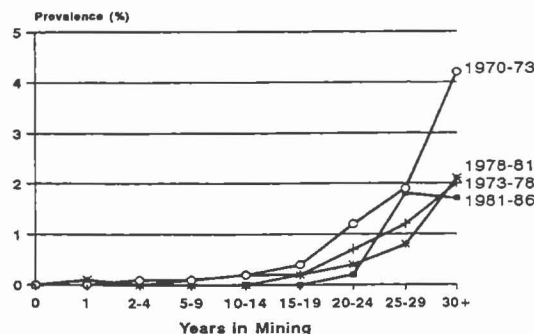


Figure 2. TEMPORAL TRENDS IN TENURE-SPECIFIC PREVALENCES OF PMF FROM SURVEILLANCE PROGRAM (CWXP)

towards lower prevalences over time.

Figures 3 and 4 likewise provide information on prevalence and tenure from the epidemiologic study. The same general trend of lower prevalences with time is obvious. See Attfield and Althouse (1992) and Attfield and Castellan (1992) for a full discussion of the reliability and other features of these results.

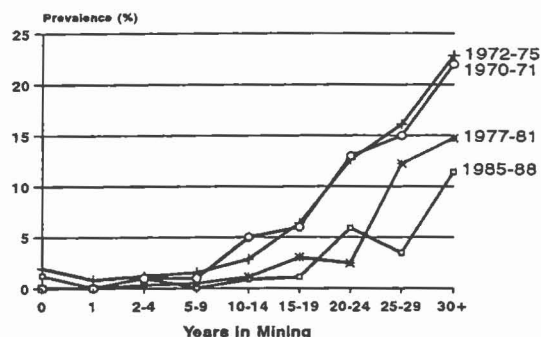


Figure 3. TEMPORAL TRENDS IN TENURE-SPECIFIC PREVALENCES OF CWP 1+ FROM EPIDEMIOLOGY STUDY (NSCWP)

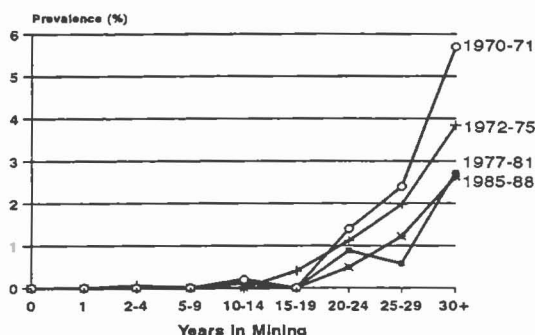


Figure 4. TEMPORAL TRENDS IN TENURE-SPECIFIC PREVALENCES OF PMF FROM EPIDEMIOLOGY STUDY (NSCWP)

Although Figures 1 - 4 reveal a fairly steady temporal decline in CWP prevalence, it would be unwise to conclude that CWP is no longer a problem for US coal miners. A recent update on prevalence of CWP in the CWXSP (Althouse, et al., 1992), which provided information for the period 1987-90, did not show the expected further decline in prevalence. Although it is too soon to tell with certainty, these statistics may be indicating that the principal gains from dust control initiated after 1969 have been made, and that further evaluation of the efficacy of the current 2 mg/m³ limit is necessary.

Moreover, some recent findings on the development of CWP over the period 1970 - 1988, a time when miners should not have been exposed to more than 3 mg/m³ (1970-72) and then 2 mg/m³ (1970 onwards) of dust, reveal that development and progression of the disease has been occurring (Attfield, 1993). In this, Table 1 shows

the incidence and progression of CWP over the study period, and indicates that about 5% (152/3162) of miners developed CWP. In addition, the progression rate of CWP was high, in that 15 of 37 miners suffered a worsening of their disease.

Table 1. Development and progression of CWP over a 10 - 18 year period after 1969

		Final x-ray category				
		0	1	2	3	All
Initial x-ray category	0	3010	141	10	1	3162
	1	1	21	15		37
	2		2	4	1	7
	3					0
	All	3011	164	29	2	3206

Taking all results together, it is evident that there has been a drop in CWP prevalence that occurred concurrently with the imposition of the limit on dust levels mandated in 1969. However, that fact that the downward trend appears to have ceased, and that CWP incidence and progression was observed in the longitudinal study, suggests that the existing limit on dust may not be sufficient to prevent CWP from occurring.

COAL WORKERS' PNEUMOCONIOSIS AND DUST EXPOSURE

It is not widely appreciated that the current 2 mg/m³ dust limit for underground coal mines was based on British data (Attfield, 1992). Because of the uncertainty inherent in extrapolating results arising from circumstances that may be different to those existing in the United States, the derivation of exposure-response information based on conditions in this country has long been an objective of NIOSH.

This aim was realized recently, following development of dust exposure estimates (Attfield and Morring, 1992), and their correlation with prevalence of CWP (Attfield and Morring, 1992a). Figure 5 shows the resulting curves for CWP 1+ by dust exposure and coal rank. All curves show a steadily rising prevalence of CWP with dust exposure (measured in gh/m³, derived as the product of dust concentration in mg/m³ and time worked in hours, and divided by 1000, effectively converting mg to g), with the slopes increasing with the rank of the coal mined (from high volatile bituminous to anthracite). The same basic picture is seen for PMF (Figure 6). Model fitting to the data led to predictions of CWP prevalence for miners aged 58 for various dust levels and ranks of coal. Exposure for a 40-year working life to 2 mg/m³ of high volatile 'A' bituminous coal was predicted to lead to a 12% prevalence of CWP 1+, and to 2% PMF. For further information on the exposure derivation, model fitting, and predicted prevalences see Attfield and Morring (1992) and Attfield and Morring (1992a).

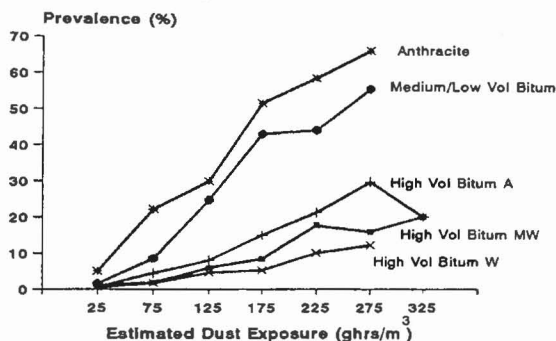


Figure 5. PREVALENCE OF CWP 1+ AGAINST CUMULATIVE DUST EXPOSURE FOR VARIOUS COAL RANK GROUPS.

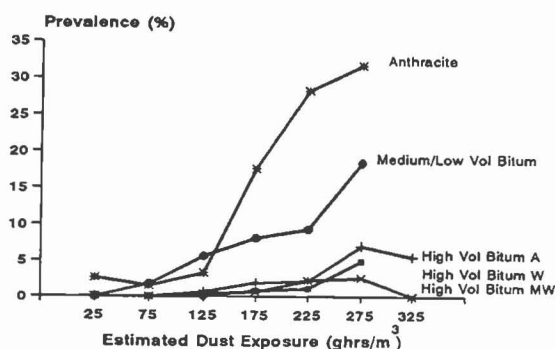


Figure 6. PREVALENCE OF PMF AGAINST CUMULATIVE DUST EXPOSURE FOR VARIOUS COAL RANK GROUPS.

When the current 2 mg/m³ dust limit for underground coal miners in the US was adopted, it was thought that it would lead to elimination of severe CWP. Since that time, additional British analyses have been completed which indicate otherwise (Attfield, 1992). The latest of these investigations was based on observations on 30,500 coal miners studied from 1953 to 1977. Risk of CWP incidence and progression was modeled against dust exposure, coal rank, age, and initial category of CWP. The results were compounded into working life-time risks of developing various categories of CWP by age 58 for given dust level and coal rank. For high volatile 'A' bituminous coal, the risk of CWP 1+ was predicted to be 9%, while that for PMF was about 1%. These figures compare quite well with those described above for US miners (12% and 2%).

OBSTRUCTIVE LUNG DISEASE AND DUST EXPOSURE

Coal workers' pneumoconiosis, as defined by dust deposits in the lung and the fibrotic reaction to them, has long been considered the 'classic' occupational disease of coal miners. Over the last 20 years, however, research on British miners has shown that dust exposure can

give rise to other pulmonary abnormalities, irrespective of the presence or absence of classic CWP. These abnormalities can be chest symptoms, or reductions in lung function, among others. These have important implications for health, as they can lead to disability and premature mortality.

A recent study has demonstrated that US miners can also suffer reductions in lung function with coal mine dust exposure (Attfield and Hodous, 1992). In this, the forced expiratory volume (FEV₁), which is a measure of how fast air can be exhaled, was found to be related to cumulative dust exposure. Figure 7 shows the observed data for never smokers for three exposure groups and age. Regression model fitting, taking into account age, height, geographical region, and smoking, confirmed a strong relationship between level of FEV₁ and dust exposure ($p < .001$). Based on the modeling, it was found that at certain (and not unrealistic) dust exposures, work in mining could give rise to similar effects on the lung as does cigarette smoking.

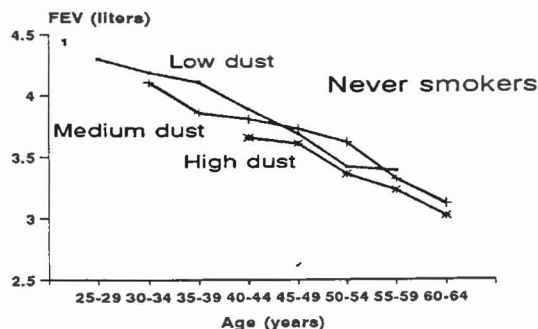


Figure 7. FORCED EXPIRATORY VOLUME IN 1 SECOND FOR THREE DUST EXPOSURE GROUPS. PLOTTED AGAINST AGE FOR NEVER SMOKERS.

Another recent analysis (Seixas et al., 1992) confirmed the association between exposure to coal mine dust and effects on lung function, regardless of CWP status. This study also suggested that miners experience a more severe reaction to the dust on entering mining for the first time, but that this moderates to a more moderate chronic effect with time. A companion paper (Seixas et al., 1993), based on changes in lung function over a 10 - 16 year interval, supported the concept of a non-linear change over time. There is also some evidence that miners may self-select themselves into and out of dusty jobs depending on their perceived reactions to the dust on first entering mining (Mannino, et al., 1991).

CONCLUSIONS

Tabulation of information on prevalence of CWP shows that there has been a reduction in disease levels over the period 1969 to the late 1980s, an interval that coincides with the

reductions in dust levels mandated by the 1969 Federal Coal Mine Health and Safety Act. However, the most recent information on prevalence, and results on CWP development since 1969, imply that the present dust limit of 2 mg/m³ may not be successful in eliminating CWP from the work force.

Recent studies of exposure response for CWP and dust exposure, both in this country, and in Britain, and study of CWP incidence and progression, indicate that some development of CWP is to be expected among miners that complete a full working life at the current 2 mg/m³ limit.

Recent findings on pulmonary function in US coal miners confirm those seen in British miners, and indicate that dust exposure can have deleterious effects on health apart from CWP.

Based on the above results, it remains imperative that mining engineers and mine operators take all possible steps both to control and to minimize dust levels, so as to ensure that miners can retire from mining after a working life without impairment or disability.

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