MSHA Exposure Limits for Coal Mine Dust and Quartz

Mine Safety & Health Law Special Institute

Energy & Mineral Law Foundation
and the
Department of Labor

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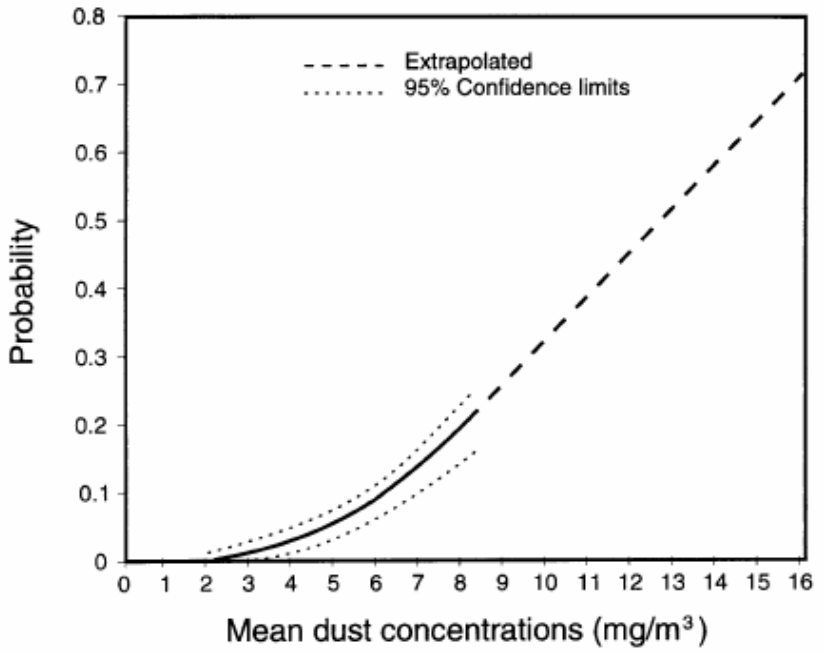
Bob Glenn, MPH, CIH
Crowell & Moring, LLP

Basis for the MSHA Coal Mine Dust Standard

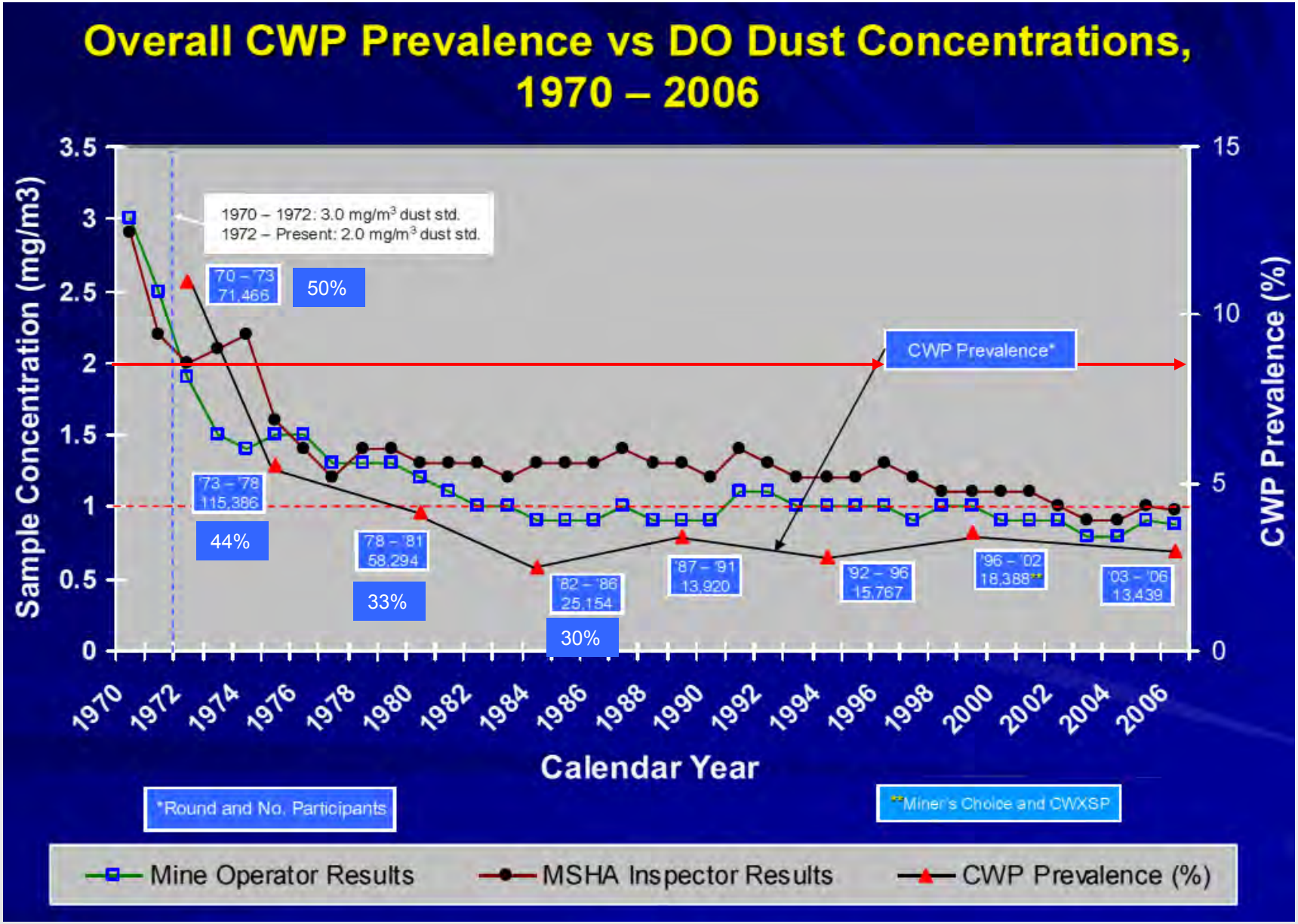
- The 2 mg/m^3 for respirable coal mine dust is based on studies of coal miners in the United Kingdom (initially 3 mg/m^3 1970-72)
  - Incorporated into the FCMSH&SA of 1969.
- Monumental studies were conducted by the Pneumoconiosis Field Research
  - 8-year follow up study of 1,429 Welsh miners and ex-miners Cochrane found:
    - The incidence of PMF was nearly zero among miners with category 0 or 1 when the study began
    - Whereas, incidence of PMF was 15% or 30%, respectively, among miners who had had simple CWP category 2 or 3 when the study began.
  - McLintock et al. found a similar relationship between increasing category of simple CWP and the development of PMF.
  - Jacobsen et al. suggested that the probability of progression to category 2/1 or greater was essentially zero for miners exposed to respirable coal mine dust at an average concentration of 2 mg/m3 over a 35-year working lifetime.



Source: Cochrane 1962; McLintock et al. 1971; Jacobsen et al. 1971

Respirable Coal Mine Dust Containing Quartz

- Congress recognized the increased hazard with exposure to CMD when quartz is present
- The FCMH&SA of 1969 required that a formula be developed when quartz in CMD was > 5%
- Regulations were adopted to require that when respirable dust contains > 5% the reduced standard will by computed by dividing the % quartz into 10 (equivalent to 0.1 mg/m^3)


Overall CWP Prevalence vs DO Dust Concentrations, 1970 – 2006
Sample Concentration (mg/m3)
CWP Prevalence (%)
3.5
3
2.5
2
1.5
1
0.5
0
15
10
5
0
1970 – 1972: 3.0 mg/m³ dust std.
1972 – Present: 2.0 mg/m³ dust std.
'70 – '73
71,466
50%
CWP Prevalence*
'73 – '78
115,386
44%
'78 – '81
58,294
33%
'82 – '86
25,154
30%
'87 – '91
13,920
'92 – '96
15,767
'96 – '02
18,388**
'03 – '06
13,439
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
Calendar Year
*Round and No. Participants
**Miner's Choice and CWXSP
Mine Operator Results
MSHA Inspector Results
CWP Prevalence (%)

Some Problems Interpreting the CWXSP Data

- CWXSP consisted of successive cross-sectional studies (rounds)
  - Not serial chest x-rays of the same miners
  - Cumulative dust exposures not calculated for each miner or job
  - Analyses of prevalence by tenure
- Disease prevalences for rounds of each study may not be strictly comparable because of differences in:
  - X-ray Classification Standards (UICC/Cincinnati); ILO 1970; ILO 1980; ILO 2000)
  - X-ray readers differed; variability between readers
  - Participation and groups of miners studied

Some Problems Interpreting the CWXSP Data

Table L–4. Observed and predicted prevalences of category 2+ from round 4 of the Coal Workers' X-ray Surveillance Program

Tenure (years)	Average number of miners	Mean age	Observed prevalences			Predicted prevalence
			1st readers	2nd readers	Mean	
10	3058	35	0.6	0.1	0.4	0.7
11	2182	36	1.0	0.1	0.6	0.7
12	3159	37	0.9	0.1	0.5	0.8
13	1755	38	0.9	0.0	0.5	0.8
14	1312	39	0.7	0.2	0.5	0.9
15	866	40	1.2	0.3	0.8	0.9
16	536	40	1.3	0.2	0.8	1.0
17	394	41	1.0	0.3	0.7	1.0
18	266	43	1.9	1.5	1.7	1.2

Some Problems Interpreting the CWXSP Data

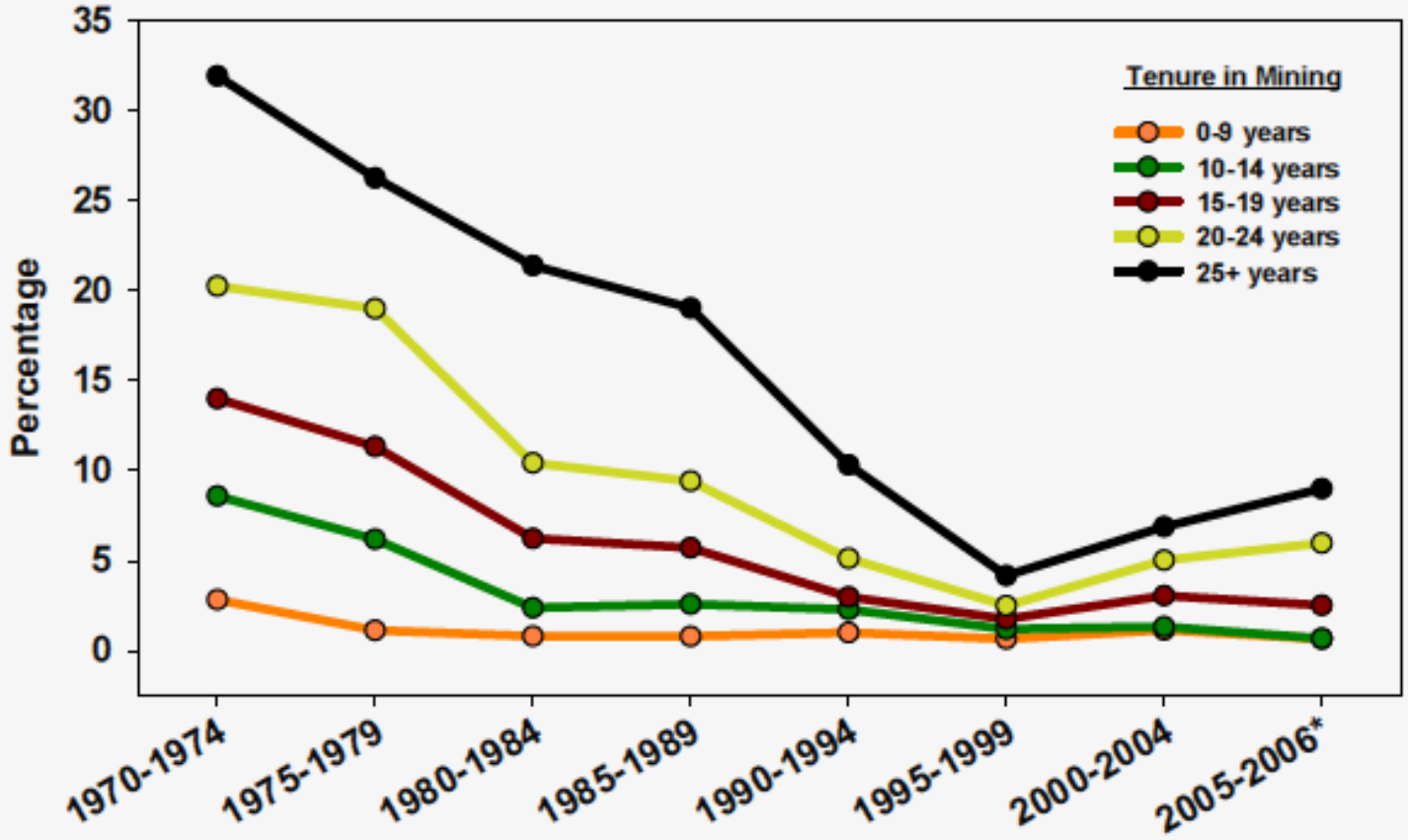
Table 2

Participation and Disease Rates for the Coal Workers' X-Ray Surveillance Program

Time Period	Number of X-Rays Processed by NIOSH[1]	Average Number of Underground Coal Miners for the Period[2]	Participation Rate	Number of X-Rays showing evidence of CWP[1]	CWP Disease Rate
1970-1974	122,425	152,066	81	13,259	11
1975-1979	116,014	150,474	77	3,156	3
1980-1984	49,289	131,112	38	1,080	2
1985-1989	17,830	91,122	20	546	3
1990-1994	15,523	69,424	22	458	3
1995-1999	14,629	50,319	29	283	2
2000-2004	15,236	31,826	48	604	4

1. Data provided by the NIOSH Underground Coal Mine System
2. Average calculated using the MSHA Address & Employment Data Sets

Percent of miners with CWP by tenure in mining, 1970-2006



Possible Reasons for the Increase

- Increased production leading to increased dust levels
- Miners working longer hours (longer shifts, more overtime)
- Change in mining technique
  - cutting into more silica-rich rock
- Inadequate compliance with dust standard
- Exposure limit is not protective
- Differences in biological potency of coal
  - Respirable Coal Mine Dust (RCMD) ≠ RCMD
- Changes in case ascertainment

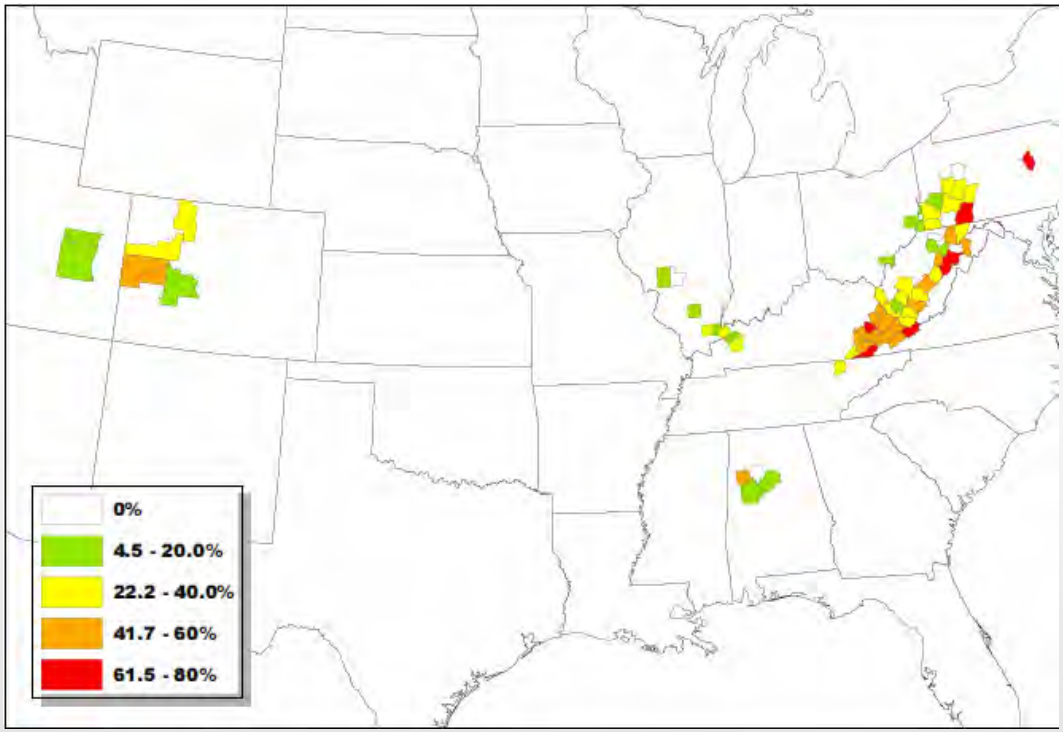
ORIGINAL ARTICLE

Rapidly progressive coal workers' pneumoconiosis in the United States: geographic clustering and other factors

V C dos S Antao, E L Petsonk, L Z Sokolow, A L Wolfe, G A Pinheiro, J M Hale, M D Attfield

Occup Environ Med 2005;**62**:670–674. doi: 10.1136/oem.2004.019679

- Rapidly progressive CWP defined as the development of PMF and/or an increase in small opacity profusion *greater than one subcategory* over five years
- Limitations
  - Interreader variability may have affected the Dx of rapidly progressive cases of CWP
  - Progression based on independent readings by different readers made at the time the x ray was taken
  - ILO Classification changed
  - Were there any regressions?



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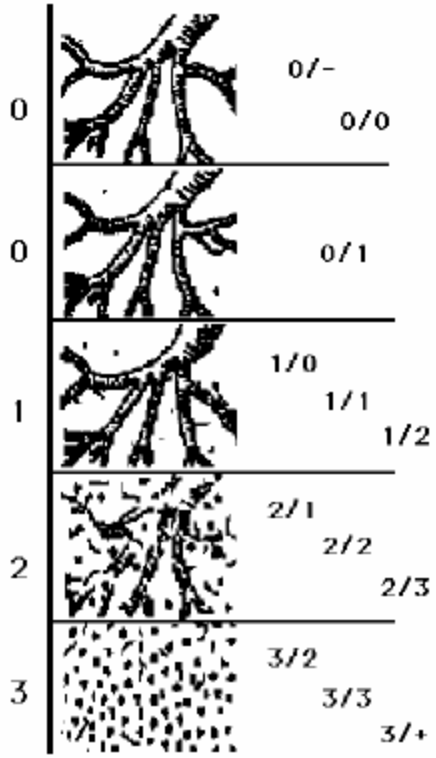

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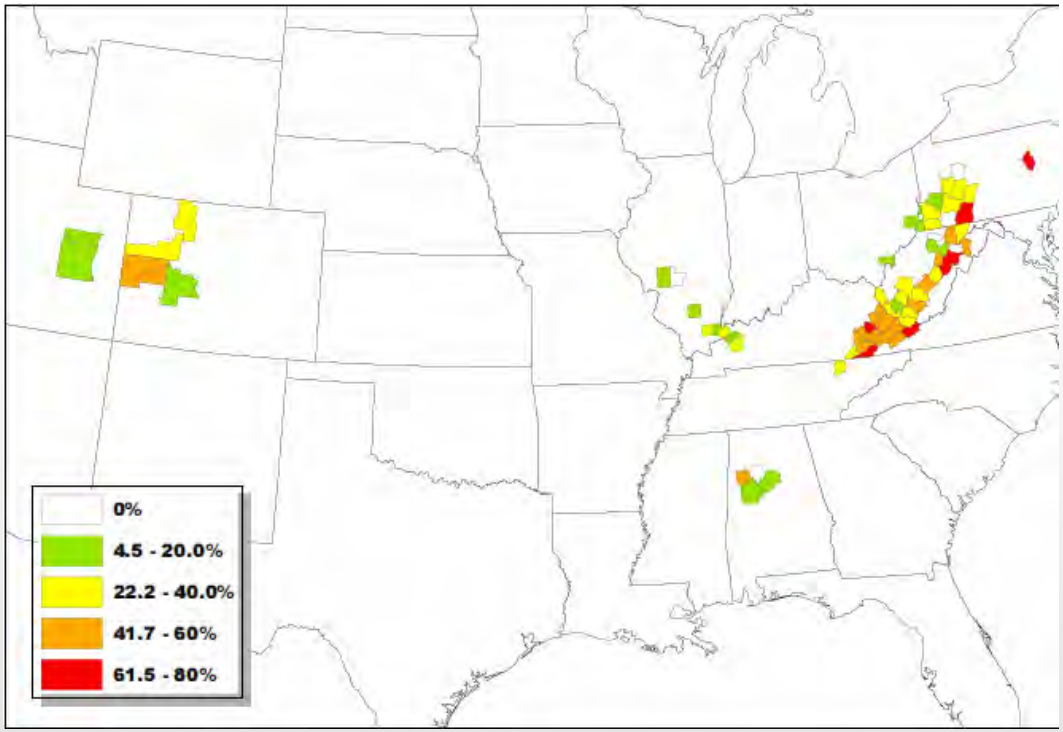
- Consider study redesign (Hodous and Attfield, 1990)
  - Use minimum of 3 blinded B Readers
  - Read films randomly w/o temporal order
  - Read paired films in temporal order
  - Analyze using median reading



MMWR
Morbidity and Mortality Weekly Report
Weekly August 25, 2006 / Vol. 55 / No. 33

Advanced Cases of Coal Workers' Pneumoconiosis — Two Counties, Virginia, 2006

- 328 UG miners examined
  - 11 miners had advanced cases
    - Five large opacities consistent with PMF
    - Six coalescence of small opacities on a background profusion of category 2
- Mean 47 years of age
- Mean 23 years UG
- Years at face for ≥ 20 yrs

TABLE 1. Age and tenure characteristics of 11 miners with advanced cases of coal workers' pneumoconiosis — Lee and Wise counties, Virginia, 2006

Miner	Age (yrs)	Year began coal mining	No. of years coal mining	No. of years working at coal face*
1	62	1963	43	33
2	61	1966	40	30
3	57	1970	36	36
4	52	1973	33	33
5	52	1973	33	33
6	54	1973	33	33
7	52	1974	32	29
8	46	1979	27	27
9	45	1981	25	25
10	42	1981	24	24
11	39	1989	17	17

* The cutting surface where coal is sheared from the wall and dust levels typically are greatest.

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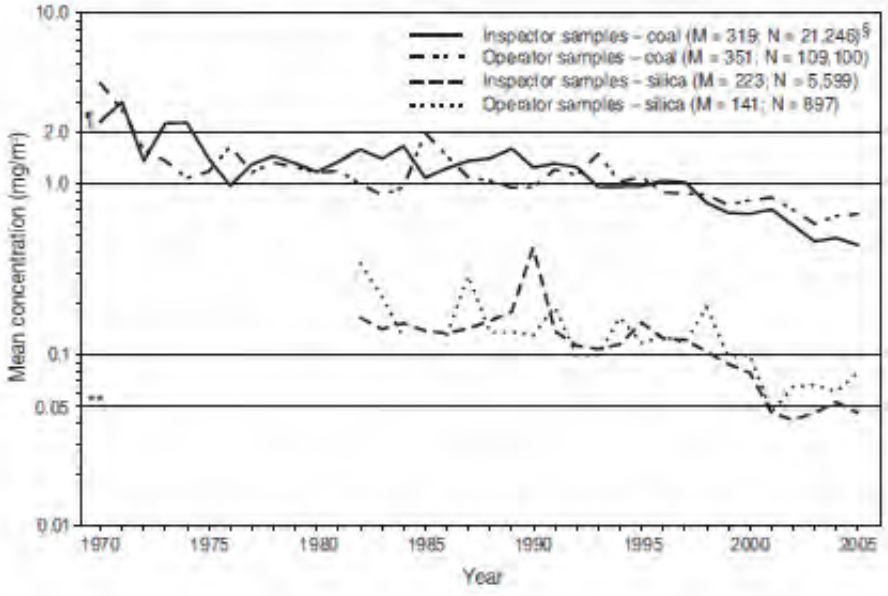
FIGURE. Mean concentrations of respirable coal mine dust and crystalline silica in coal mine dust* for underground workers at the coal face† — Lee and Wise counties, Virginia, 1970–2005



MMWR, April 18, 2003:

Pneumoconiosis Prevalence Among Working Coal Miners Examined in Federal Chest Radiograph Surveillance Programs — United States, 1996–2002

State	Underground miners: No. miners examined	Underground miners: CWP No.	Underground miners: CWP (%)	Underground miners: PMF No.	Underground miners: PMF (%)	Surface miners: No. miners examined	Surface miners: CWP No.	Surface miners: CWP (%)	Surface miners: PMF No.	Surface miners: PMF (%)	Average employment and estimated participation†: Underground miners No.	Underground miners (%)	Surface miners No.	Surface miners (%)
Alabama	2,308	25	(1.1)	3	(0.1)	524	5	(1.0)	1	(0.2)	3,904	(59.1)	2,200	(23.8)
Arizona	0	—	—	—	—	520	5	(1.0)	0	(0)	0	—	737	(70.6)
Arkansas	9	0	(0)	0	(0)	0	—	—	—	—	9	(100.0)	13	(0)
Colorado	1,655	24	(1.5)	3	(0.2)	180	3	(1.7)	0	(0)	1,655	(100.0)	712	(25.3)
Illinois	2,863	31	(1.1)	1	(0.0)	175	1	(0.6)	0	(0)	4,300	(66.6)	1,212	(14.4)
Indiana	816	5	(0.6)	0	(0)	397	2	(0.5)	0	(0)	816	(100.0)	2,836	(14.0)
Kentucky	3,073	106	(3.5)	9	(0.3)	1,253	34	(2.7)	3	(0.2)	19,220	(16.0)	13,910	(9.0)
Louisiana	0	—	—	—	—	112	0	(0)	0	(0)	0	—	168	(66.7)
Maryland	249	24	(9.6)	0	(0)	52	2	(3.9)	0	(0)	273	(91.2)	247	(21.1)
Montana	0	—	—	—	—	183	0	(0)	0	(0)	13	(0)	902	(20.3)
New Mexico	123	1	(0.8)	0	(0)	919	7	(0.8)	0	(0)	123	(100.0)	1,654	(55.6)
North Dakota	0	—	—	—	—	278	2	(0.7)	0	(0)	0	—	966	(28.8)
Ohio	530	9	(1.7)	0	(0)	406	10	(2.5)	0	(0)	1,952	(27.2)	2,241	(18.1)
Oklahoma	21	0	(0)	0	(0)	0	—	—	—	—	43	(48.8)	259	(0)
Pennsylvania	2,468	44	(1.8)	3	(0.1)	778	22	(2.8)	3	(0.4)	6,204	(39.8)	5,468	(14.2)
Tennessee	102	5	(4.9)	0	(0)	52	2	(3.9)	0	(0)	681	(15.0)	712	(7.3)
Texas	0	—	—	—	—	1,292	11	(0.9)	0	(0)	0	—	2,598	(49.7)
Utah	1,586	8	(0.5)	1	(0.1)	48	1	(2.1)	0	(0)	2,184	(72.6)	96	(50.0)
Virginia	1,749	150	(8.6)	11	(0.6)	743	28	(3.8)	1	(0.1)	6,771	(25.8)	3,718	(20.0)
Washington	0	—	—			81	0	0	0	(0)	0	—	580	(14.0)
West Virginia	3,069	232	(7.6)	17	(0.6)	1,221	58	(4.8)	5	(0.4)	18,289	(16.8)	8,939	(13.7)
Wyoming	26	0	(0)	0	(0)	1,252	3	(0.2)	0	(0)	95	(27.4)	4,771	(26.2)
Others§	0	—	—	—	—	0	—	—	—	—	8	—	550	(0)
Total	**20,647**	**664**	**(3.2)**	**48**	**(0.2)**	**10,466**	**196**	**(1.9)**	**13**	**(0.1)**	**66,540**	**(31.0)**	**55,489**	**(18.9)**

Coal Rank and Potency: Coal Mine Dust ≠ Coal Mine Dust

Coal rank: A classification of coal based on the fixed carbon, volatile matter, and heating value of the coal. Coal rank indicates the progressive geological alteration (coalification) from lignite to anthracite [EIA 1989].

TABLE 2

PNEUMOCONIOSIS IN BRITISH COAL MINERS IN 1950

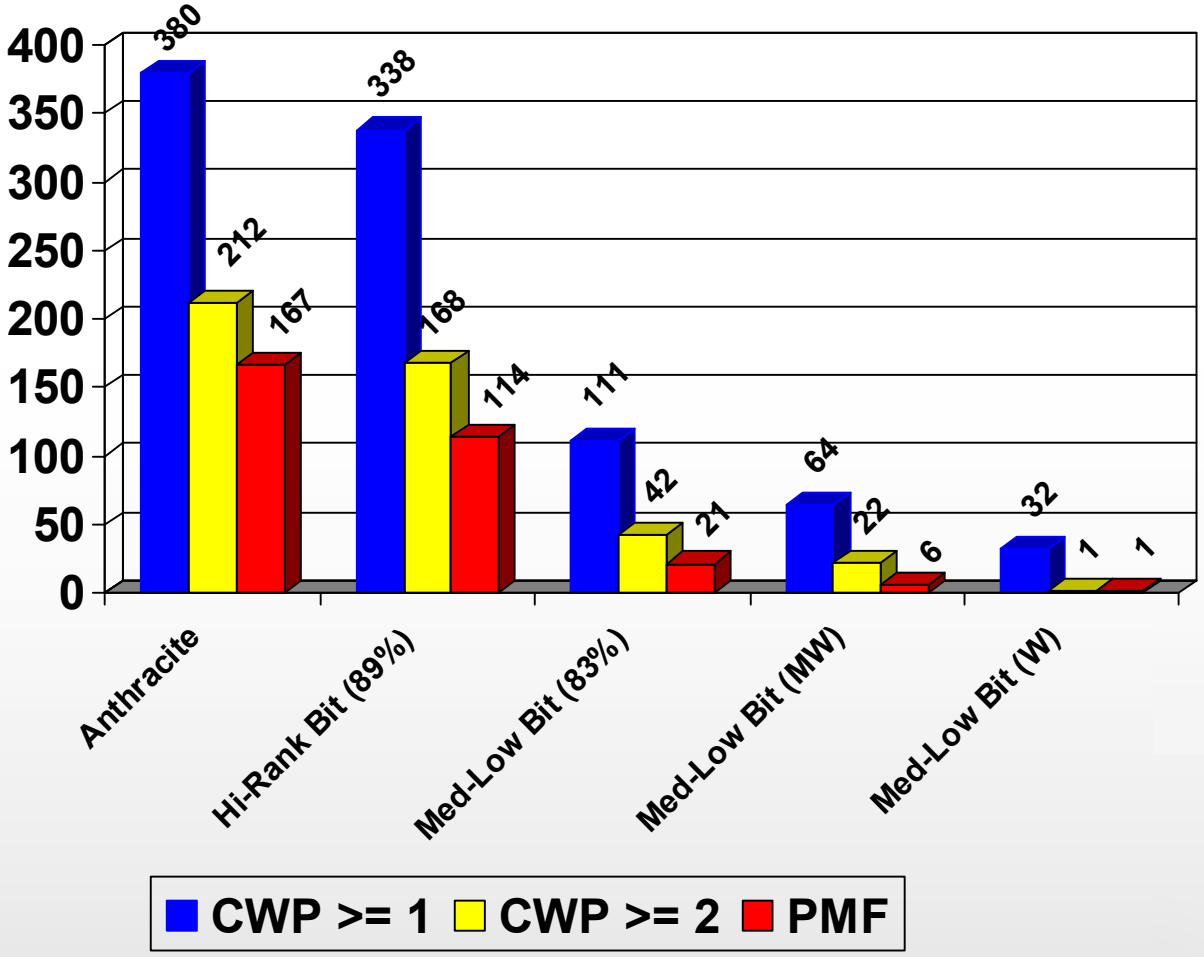
Area	Working Population (1000s)	Certified Cases (Annual Rate per 1000)	Claims (Annual Rate per 1000)
Wales, Monmouth, Forest of Dean, Bristol, and Somerset	105·9	18·91	32·58
Kent	6·0	14·20	18·00
N. Staffordshire, S. Staffordshire, Cannoch, Shropshire, and Warwick	54·5	5·33	6·53
Scotland	80·8	5·21	7·33
Lancashire and North Wales	56·3	3·60	6·04
Durham	106·8	2·19	3·40
Yorkshire	134·0	1·79	3·04
Northumberland and Cumberland	48·7	0·54	1·23
Nottinghamshire, Derbyshire, and Leicester	94·7	0·31	0·51

Rank of Coal Hypothesis

It appeared that the incidence of the disease was not uniform throughout the coalfield. Thus it was high in the anthracite or hard coal area, low in the bituminous or soft coal area, with semi-bituminous or steam coal mines occupying an intermediate position. These findings induced Hart and Aslett to suggest that the incidence of the disease was in some way related to the rank of coal that was mined. According to their report

Meiklejohn (1952), History of lung diseases of coal miners Great Britain: Part III, 1920-1952.

Coal Rank and Predicted Prevalence of Simple CWP and PMF* (cases/1,000)



* Attfield and Morring (1992). Excess (exposure-attributable) prevalence of simple CWP or PMF among U.S. coal miners at age 65 following exposure to respirable coal mine dust over a 45-year working lifetime.

Some Recommendations for Improving Epidemiology Studies of Coalworkers' Pneumoconiosis

- Increase participation of coalminers' in voluntary studies
  - Historically ranges from ~ 20-50%
    - Severely limits the prediction of disease endpoints
    - How do miners that participate differ from those that don't?
- Investigate exposure-response relationships
  - Respiratory morbidity (CWP and lung function) in carefully designed exposure-response studies (prospective design)
  - Including the effect of exposure patterns (intensity and duration) on the development of occupational respiratory diseases in coal miners
  - Assess the influence of dust composition and characteristics (e.g., coal rank, quartz concentration) on the development of simple CWP, PMF, and COPD in coal miners

Public Health Strategy for Eliminating Black Lung" Diseases

- Some Elements of the "Black Lung" Prevention Strategy
  - Control coal mine dust exposures to 'safe levels'
  - Enforce coal mine dust standard
  - Chest X-ray examinations to detect early simple CWP
  - Offer transfer to miners with early disease to prevent progression to serious disabling disease
  - For those that develop serious disease provide compensation (Safety Net)

Researchers have known since the 1960s that the risk of PMF increases as the category of simple CWP increases [Cochrane 1962]. The risk of developing PMF was shown to rise steeply among miners with simple CWP category 2 [Cochrane 1962]. Therefore, a logical occupational health strategy for the prevention of PMF (which was included in the Federal Coal Mine Health and Safety Act of 1969 [Public Law 91-173]) was to identify miners who had sufficient dust exposure to develop simple CWP category 1. These miners were then offered the option of working in a low-dust environment (≤1 mg/m^3) with increased frequency of environmental monitoring in the expectation that further disease progression would be prevented.

Participation Rates and Prevalence from NIOSH Coal Studies

NIOSH, 1995, Coal CD

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- Some Reasons for Failure of the "Black Lung" Prevention Strategy
  - What is 'safe'? For which diseases? Do we know?
  - Is there a credible enforcement strategy? Are we seriously focusing on the wrongdoers (duration and intensity)?
  - Is 30-50% participation in the chest X-ray program adequate? What are the hurdles to participation?
  - Are transfer provisions working to prevent serious disabling disease? Why do eligible miners choose not participate?

Occupational Exposure Limits for Respirable Coal Mine Dust

Country	Recommended Value (mg/m^3)	Comment
Australia	3.0	≤ 5% silica
Belgium	10 ÷ (% quartz + 2)	
France	5.0 (alveolar) 10.0 (inhalable)	Coal dust w/o silica
Italy	3.33	< 1% quartz
Netherlands	2.0	< 5% quartz
United Kingdom	3.8	At coalface
MSHA	2.0 10 ÷ % quartz	< 5% silica > 5% silica

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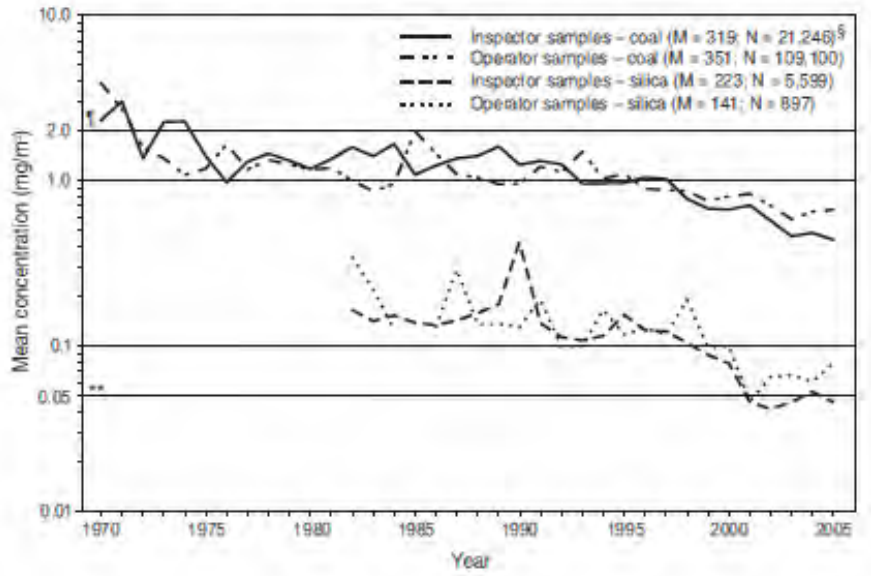

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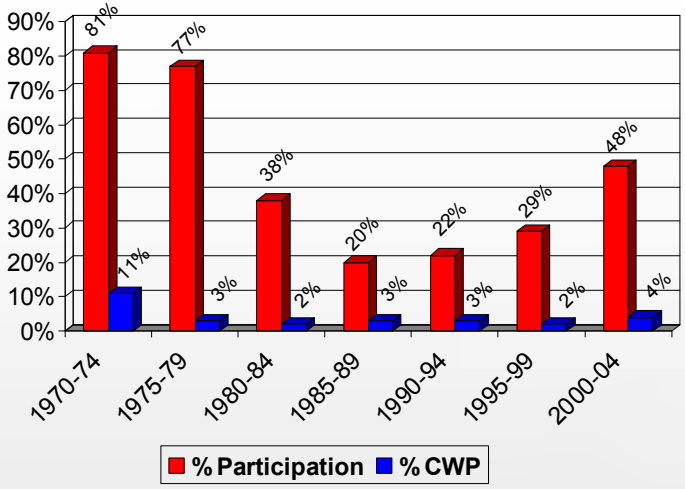

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Table 1

Part 90 Transfer Rates for the Coal Workers' X-Ray Surveillance Program

Time Period[1]	Number of Miners notified of eligibility of transfer[2],[3]	Number of Miners who exercised their transfer rights[4]	Transfer Rate
1980-1984	1606	327	20
1985-1989	506	84	17
1990-1994	397	73	18
1995-1999	200	43	21
2000- Sept 2003	560	81	14

1. Prior to 1980, the transfer data was not electronically tracked.
2. If a miner received more than one letter, they were only included in the time period when the first letter was mailed.
3. Data provided by the NIOSH Underground Coal Mine System
4. Data provided by MSHA Part 90 Mining Tracking System

Any analysis of the effectiveness of the transfer program would need to consider possible bias from the low rate of participation: only 23% of eligible coal miners (2,119 of 9,138 miners) elected to participate [Wagner and Spieler 1990].

Some Public Health Recommendations for Eliminating "Black Lung" Diseases

Control Exposure Enforcement Medical Surveillance Transfer Compensation

Problems with Program

- Medical X-ray Program
  - Initial exam is mandatory
  - All other exams are voluntary
- Transfer Program
  - Miner notified of early signs of CWP
  - Option to transfer or work in lower dust is voluntary with no expiration

Recommendations

- Medical X-ray Program
  - Mandatory participation
    - Decline to participate results in forfeiture of "Black Lung" benefits
- Transfer Program
  - Transfer option expires with a new round of examinations
  - Evidence of simple CWP ≤ 2/1 transfer is encouraged
  - Evidence of simple CWP ≥ 2/2 transfer is mandatory