Fontaine, Roslyn B - MSHA

From: Nat Noland [admin@indianacoal.com]
Sent: Monday, June 20, 2011 2:56 PM
To: zzMSHA-Standards - Comments to Fed Reg Group
Subject: "RIN 1219-AB64"
Importance: High
Attachments: RespirableDustCommentsFinal.pdf

2011 JUN 20 P 2: 56

The comments on the above-referenced rulemaking are attached hereto. Please advise if you have any problems opening the PDF file.

J. Nathan Noland
Indiana Coal Council, Inc.
317-638-6997

AB64-COMM-75

J. Nathan Noland, President

Office (317) 638-6997
Fax (317) 638-7031
admin@indianacoal.com

25 years

INDIANA COAL COUNCIL, INC.
150 West Market Street, Suite 400
Indianapolis, IN 46204
www.indianacoal.com

June 20, 2011

Ms. Roslyn Fontaine
Acting Director
Mine Safety and Health Administration
Office of Standards, Regulations, and Variances
1100 Wilson Boulevard, Room 2350
Arlington, VA 22209-3939

Re: RIN 1219-AB64; Comments on MSHA Proposed Rule for Lowering Miners Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors

Dear Ms. Fontaine:

The following comments regarding the above-referenced proposed rules are submitted by the Indiana Coal Council, Inc. ("ICC"), a trade association formed to foster, promote, and defend the interests of all Indiana coal producers and related business entities. All Indiana underground coal mines will be affected by these proposed rules. The ICC is also a member of the National Mining Association ("NMA") and, to minimize repetitive comments, the full comments of NMA are incorporated herein. ICC incorporates herein all comments of its members, including Black Panther Mining, LLC and Five Star Mining, Inc. (Collectively all the foregoing are referred to herein as "Comments/Objections.")

Pursuant to 30 U.S.C. § 811(a)(3), ICC's Comments/Objections state ICC's "written objections" to the proposed rulemaking concerning mandatory health and safety standards, as well as "the grounds are therefore." Further, pursuant to Section 811(a)(3), ICC hereby requests "a public hearing on such objections."

The ICC generally objects to the proposed rulemaking because MSHA fails to satisfy the requirements of Section 811(a)(6)(A): MSHA fails to demonstrate that the proposed rulemaking was based on "research, demonstrations, and experiments," fails to demonstrate that it "use[d] the latest available scientific data in the field," fails to demonstrate that the proposed rules are technologically feasible or economically feasible, and fails to demonstrate that such are based on experience gained under the Mine Act. In fact, the rulemaking is contrary to experience under the Mine Act, particularly in District 8.

Indiana currently produces approximately 36 million tons of bituminous coal annually, and one-third of the state's production is from underground coal mines. Indiana currently has 10 permitted underground coal mines, with 7 of those mines in active production status. Indiana's underground coal mines currently operate 36 Mechanized Mining Units ("MMUs"), with 26 MMUs utilizing fish-tail / split air, ventilation. Furthermore, Indiana's underground coal mines fall under the jurisdiction of Mine Safety and Health Administration ("MSHA"), District 8.

District 8's jurisdiction spans Illinois, Indiana, Iowa, Michigan, Minnesota, Northern Missouri and Wisconsin and the fact ICC's members are a part of District 8 is important. If this proposed rulemaking is implemented, the ICC's members—and all underground coal mines in District 8—would be asked to assume the compliance costs of a regulation that: (A) is completely rejected by medical evidence gathered in District 8; and (B) would be difficult, if not impossible, to comply with in District 8.

The facts are clear, simple, and unavoidable. District 8 sees some of the highest average respirable dust levels in the United States.[1] At the same time, Coal Workers' Pneumoconiosis ("CWP") has been virtually eliminated from District 8's underground coal mines, which operate in such conditions on a daily basis. In fact, District 8 has the lowest observed prevalence of CWP in the entire nation. Specifically, 0.4% of miners examined in the Enhanced Coal Workers Health Surveillance Program ("ECHWSP") were diagnosed with CWP (Category 1/0+). Moreover, the numbers used by ICC's members to claim victory over CWP in District 8 are inherently more reliable than the targeted and selective screenings upon which MSHA has built this proposed rulemaking.

Simply put, while the "hot spot" areas of prevalence for the disease, within Appalachia, were screened selectively and with limited participation by the general population of miners, District 8 saw the highest participation in the Coal Workers Health Surveillance Program ("CWHSP") of any district in the country. More specifically, medical screening data gathered by the National Institute of Occupational Safety and Health ("NIOSH") revealed that "[f]or the period of 2006 through 2010, there was an estimated employment [in District 8 underground coal mines] of 2,073. Of those 2,073 employed, there were 2,720 examined for a participation rate of 131%. The number of miners examined exceeds the estimated number of miners employed [in District 8]. This may be due to the incomplete mine rosters or fluctuation in employment."[2] Using NIOSH's own screening data, the rate of CWP for underground coal mines in District 8 was clearly shown to be lower than the background prevalence rate for chest opacities (Category 1/0+) both within North America and worldwide.

According to a study of the official publication of the American College of Chest Physicians,[3] the background prevalence for chest opacities graded as Category 1/0+ ranges from 0.21 to 11.7 percent of the general population. In North America alone, the background prevalence for

---

[1] *See* Table Summary of Average Concentration Levels of Respirable Dust, by MSHA District, Since 1986, attached as Exhibit A.

[2] *See* *http://www2.cdc.gov/drds/WorldReportData/FigureTableDetails.asp?FigureTableID=2551&GroupRefNumber=T02-17*

[3] *See* Meyer, John D., et al., "Prevalence of Small Lung Opacities in Populations Unexposed to Dusts: A Literature Analysis", CHEST (1997), attached as Exhibit B.

Category 1/0 + was approximately 1.6% of the general population. Meanwhile, the pooled background prevalence of Category 1/0+ disease was 5.3% of the general population. Again, District 8—which screened 131% of its miners—resulted in only 0.7% of miners being diagnosed as Category 1/0+. In terms of raw numbers, NIOSH data from January 1, 2005 through December 31, 2009, for both Indiana and Illinois combined revealed only one miner with Progressive Massive Fibrosis ("PMF"). The ICC has not sought out personally identifiable background medical history for this sole miner with PMF in District 8. However, it is entirely possible that the miner relocated to Illinois months or years after developing the disease—either from working in other parts of the country or from causes unrelated to the miner's profession. Ultimately, however, the primary fact that cannot be avoided is only 0.4% of miners screened in District 8 showed any signs of Category 1/0+ disease and that level of prevalence can be attributed to any number of sources, including causes completely unrelated to underground coal mining in Indiana and Illinois.

The underground coal mines in District 8 have shown, definitively, that the need does not exist for a nationwide rulemaking on an issue that is distinctly regional in nature **and** is based upon flawed research that uses selectively analyzed data gathered from a small group of miners in the regional areas that are known to have higher prevalence rates for the disease than other regions of the country. The reasons why MSHA focused so heavily on selective miner screening in regions with known higher prevalence rates and, then, used that information as the basis for a nationwide rulemaking is open for speculation. However, the fact such bias exists in MSHA's proposed rulemaking has been clearly exposed.[4]

Indisputable facts support District 8's coal operators' position here: a nationwide, comprehensive and complex regulatory enforcement effort is not necessary to eliminate CWP. ICC urges MSHA to withdraw the proposed rule and start anew.

No regulation aimed at eliminating a disease can do so effectively without first ensuring the benefit of preventative diagnosis for those at risk for the disease. CWP is not ended effectively with the creation of a complex regulatory scheme that monitors the dust on each shift with technology not intended for that purpose. CWP is not ended effectively by punishing mine operators with civil penalties of such magnitude that mines will go out of business. CWP is not ended effectively by overburdening MSHA with an anticipated additional 725,000 respirable dust samples to analyze each year. Rather, keeping the current regulatory structure in place can and will succeed in the fight against CWP, when it is combined with mandatory, universal screening participation for the disease for all miners.

Aside from the obvious problems with the underlying reasoning behind MSHA's proposed rulemaking, the Mine Act requires proposed rules concerning mandatory health and safety standards to be based upon "the latest available scientific data in the field" and the "feasibility of the standards," both from an economic and technical perspective. On these points, implementation of the proposed rule at Indiana's underground coal mines will have a devastating effect upon Indiana's coal industry and the ultimate beneficiaries of coal, America's general

[4] *See* Comments of the National Mining Association on "A Review of Information Published Since 1995 on Coal Mine Dust Exposures and Associated Health Outcomes" (the Post-1995 Report). (September 25, 2010).

public. At each mine, initial implementation would require the hiring of additional mine personnel and continuous personal dust monitors ("CPDM"), which are currently produced by a single vendor. Additional capital investments will be necessary for mantrips, computer equipment, and laboratory equipment to attempt to ensure compliance with the new standard. Realistically, however, compliance with the new respirable dust standard will be difficult, if not impossible, to maintain. The CPDM is not designed for single shift compliance sampling (as set forth under MSHA's proposed rule). Rather, the CPDM is intended as a guidance tool to aide miners in determining the conditions in which they are operating. If used as proposed by MSHA, the CPDM will result in hundreds of thousands of citations and/or orders and millions of dollars in civil penalties for mine operators nationwide.

Additionally, the ICC surveyed all Indiana underground coal mines to determine the expected economic impact from the rule proposal.[5] Initial first year expenses for all mines are estimated to be $63,447,185 and subsequent year expenses for all mines will exceed $38,423,817. This additional expense not only impacts the coal mine operators, but ultimately could affect coal's use to produce electricity and certainly impact electricity rate payers. All of this would be without sufficient scientific evidence that the new standards would improve coal miner health. Indeed, in District 8, these expenses would be incurred despite the fact that the disease the proposed rule is designed to prevent has already been virtually eliminated.

The estimated expenses discussed supra are direct compliance costs and do not reflect costs associated with lost production. These additional costs could be substantial and are dependent upon MSHA approval of ventilation plans after a mine exceeds the proposed one milligram standard. Exceeding the proposed dust standard would result in the shutting down of a section until a new revised plan could be submitted, reviewed, and approved. With over 100 MMU's in District 8 we are very concerned that MSHA will not approve revised plans in timely manner. Under existing regulations the turn around time on plan approvals in District 8 is very poor. Even after plan approval, the mine personnel will have to be trained on the revised plan requirements before production can commence. The downtime losses could be very extensive based on current experience.

Another part of the proposed rulemaking includes a prohibition of split air ventilation as means of ventilating the working faces for supersections in underground coal mines. The proposed rule seeks to set aside a rule which has been in place for well over 15 years. MSHA does not state, or set forth any evidence supporting that prohibiting split air face ventilation for each of two MMU's in a working section will improve air quality, or that such a prohibition is somehow correlated to CWP or required by experience under the Mine Act, much less could MSHA validate with experience and data that this prohibition should depend on whether one or two crews are working the supersection. Moreover, no consideration whatsoever has been given to the economic and operating impacts on Indiana underground coal mines which impacts are not included in the economic impact estimates previously set forth in these comments. MSHA does not even address much less demonstrate that the elimination of fishtail ventilation and requiring

[5] Notably, the surveyed costs strictly addresses the economic impact of lowering the respirable dust standard and does not include the economic impact of the repeal of split air ventilation, which is also a component of this proposed rulemaking and is anticipated to have a significantly detrimental economic impact on the underground coal mining industry.

permanent ventilation for each MMU is economically or technologically feasible. Specific comments / objections regarding the proposed ventilation requirements follow:

Fishtail ventilation for supersections was in use long before 1992 when it was specifically approved during 1992 rulemaking (57 FR 20868, 20883, May 15, 1992) which discussed the final rule allowing fishtail ventilation and the use of a supersection, stating "MSHA has long permitted supersections under existing § 75.319. This experience has shown that supersection mining can be done safely provided mining equipment is not being used to cut, mine . . . simultaneously in the same air current. To accommodate this type of mining, the current of air directed into the section must be split ('fishtailed') near the working places so that the two splits of intake air ventilate the faces. This provides a separate split of air for each set of mining equipment. The final rule continues to allow supersections with separate splits of air intake."[6]
Without a word concerning the history, background and experience of fishtail ventilation in supersections – the proposed regulation seeks to end fishtail split air face ventilation. The proposed Section 75.332(a)(1) requires that "each MMU" be ventilated by permanent ventilation controls, as opposed to each working section under the present rule, and defines two sets mining equipment "in a single working section as a single MMU" if only one production crew is employed," but as two MMU's if "two production crews are employed. . . ." *See* proposed Section § 70.2 Definitions. Just how or why two MMU's should be treated separately or as one

---

[6] The full discussion (57 FR at 20883) follows.

"Section 75.332 Working Sections and Working Places

Paragraph (a) of this section is derived from existing §§ 75.319 and 75.319-1, while paragraph (b) revises existing §§ 75.311 and 75.312. The final rule requires that each working section be ventilated with a separate split of intake air directed by overcasts, undercasts, or other permanent ventilation controls. This provides miners on each section with at least one fresh air intake not contaminated with gases or dust from another set of mining equipment. Keeping with existing practice, the final rule allows more than one set of mining equipment on a split, with the (Footnote 6, continued) condition that only one set at a time **may** be used for cutting mining, or loading coal or rock. Thus, one set **may** be repositioned or serviced while the other set is mining. The rule defines a set of mining equipment to include a single loading machine, a single continuous mining machine, or single longwall or shortwall machine. Thus MSHA considers a double drum longwall shearer to be one longwall machine. Also, consistent with existing Agency interpretations, MSHA does not consider a scoop a loading machine for purposes of requiring separate splits of air.

When two or more sets of mining equipment are simultaneously engaged in cutting, mining, or loading coal or rock from working places within the same working section, each set of equipment must be ventilated by a separate split of intake air. Thus, methane or dust produced during production activities by one set of equipment does not harm miners working with another set of equipment. This requirement also applies to longwall or shortwall sections if more than one longwall or shortwall mining machine is used.

A commenter expressed concern that paragraph (a) allows the use of a "super section"; that is, two sets of mining equipment operating simultaneously and sharing a common dumping point on the same section, with each set being ventilated by a separate split of intake air. MSHA has long permitted super sections under existing § 75.319. This experience has shown that super section mining can be done safely provided mining equipment is not being used to cut, mine, or load coal or rock material simultaneously in the same air current. To accommodate this type of mining, the current of air directed into the section must be split ("fishtailed") near the working places so that the two splits of intake air ventilate the faces. This provides a separate split of air for each set of mining equipment. The final rule continues to allow super sections with separate splits of intake air."

MMU depending on whether "only one production crew is employed . . ." is nowhere explained. The absence of an explanation is because there is no rational basis, and because the changes seek to address a non-existent problem, as set forth *infra.* More important – it is impossible to separate the air splits by permanent controls on a working section and haul coal to a single loading point. If MSHA believes otherwise, then it should demonstrate how such is possible, as well as technologically and economically feasible.

While in the preamble, 75 FR at 64449, it is stated: "MSHA believes that, together, proposed § 75.332 and the proposed MMU definition . . . would improve miners' health by reducing their exposure to respirable dust. . . ." – this is the only place in this entire proposed rulemaking that attempts to explain why the rule is being changed. No evidence, facts, science, experience or anything else is offered to support the change – only a "belief." Where there is a history of the practice and regulation allowing supersections with fishtail split air ventilation, more than a belief must be offered to support such dramatic change. Minimally, MSHA must demonstrate by investigation and data that the practice has adverse impacts on air quality which is somehow correlated to CWP, or how the elimination of fishtail ventilation would change such, or why two MMU's with one crew with fishtail ventilation would not have such adverse effect.

History and practice are to the contrary of any adverse impact by fishtail split air ventilation. Section 75.332(a)(1) implements the Federal Coal Mine Health and Safety Act of 1969 Section 303(r) (30 U.S.C. §863(r) that requires "each mechanized mining section" to be "ventilated by a separate split of intake air. . . ." The purpose was to prevent the smoke and gases if a fire occurred on one working section from flowing to another working section, and to prevent the gas and respirable dust generated from mining coal with one set of mining equipment from flowing over another set of mining equipment. Fishtail ventilation for working sections with two MMU's does not permit the contaminants from one MMU to flow over another MMU – and neither MMU is "down wind" of the other. The proposed amendments requiring a separate split of air by permanent ventilation for each MMU in the working section (where two MMU's are worked by a single crew) are not "based upon research, demonstrations, experiments" or other valid data or information as required by Section 811(a)(6)(A). Rather as set forth *infra*, the amendments seek to cure a non-existent problem and are based on confusion.

In fact, as will be demonstrated at the requested hearing, MSHA District 8 has encouraged the use of fishtail ventilation to lower exposure to respirable coal mine dust. Before the regulations required fishtail ventilation, many District 8 mines previously used single-split ventilation on working sections with two continuous miners. One continuous miner would cut and load coal while the other miner was being repositioned and readied for the next cut. If the mine operator had respirable dust compliance problems using single-split ventilation with two continuous miners, District 8 would recommend using fishtail ventilation. The use of fishtail ventilation lowered the respirable dust concentrations versus what had been found on single-split ventilation units that had two continuous miners. A reading of the proposed rules indicates that MSHA proposes the opposite of this experience.

Worse yet, the situation MSHA says it seeks to address – two MMU's ventilated by a single split of air – is not allowed under the present regulation. (See 1992 rulemaking, *infra.)* The 2010 preamble, 75 FR at 64449, states: "MSHA is proposing this change to address the situation where operators **operate two sets of** mechanized mining equipment on a working section ventilated **by a single split of intake air**, and mining activities from the upwind set of mining equipment expose miners working downwind to respirable dust and quartz. MSHA believes that, together, proposed § 75.332 and the proposed MMU definition, discussed elsewhere in the preamble related to proposed § 70.2, would improve miners' health by reducing their exposure to respirable dust." The "situation" addressed simply does not exist. Where there are two MMU's on a working section, there must be two splits of air – one for each MMU. *See* 57 FR at 20883, *supra*. The quantity of air generally is the same at each MMU and would be the same as at a single MMU working section. The air splits on the working section by the tailpiece provide two separate splits of intake air – one for each of the two continuous miners. Moreover, the preamble does not state where the respirable dust and quartz would come from to "expose miners working downwind." Only one continuous miner is on a split of air. No more dust and quartz would be generated on one side of a fishtail working section than would be generated on a working section that has one continuous miner.

MSHA does not address, much less demonstrate, that the elimination of separate splits of air for each MMU by fishtail ventilation and new the rule requiring permanent ventilation for each MMU is technologically required or feasible, or economically feasible. As will be demonstrated at the requested hearing, if the rule comes into effect as written at least one Indiana mine would close and probably others in similar circumstances. The mine employs 360 persons and mines about 3.5 million tons of clean coal. The mine could not convert the fishtail working sections into single-split sections. The mine does not have the reserve capacity in its ventilation system to add additional intake belt air splits and overcome the additional air loss because of the additional stoppings. The mine cannot mine enough coal to meet coal sale contracts with reduced MMUs. Adding additional shafts and another main mine fan is not warranted because of the remaining volume of reserves. The coal would not be mined. Additionally, the cost to mine coal per ton would increase because only four MMUs could operate. The outby maintenance costs for such items as belts, examinations, rock dust, pumping, roof control, and roadway maintenance would be spread over about two thirds of the production. *See also*, Herzog Testimony, 2/15/11 Hearing, Washington, D.C., Transcript, pp. 70-77.

In sum, we urge the MSHA to withdraw these proposed rules. There is no evidence in the proposal that the proposed changes will enhance miner health in MSHA District 8, as the disease has been statistically eradicated through heavy participation in screening for the disease and effective controls used to substantially reduce average dust concentrations during normal mining operations. The NIOSH study of CWP found that the incidence of CWP in the Illinois Basin was the lowest in the country. In fact, the proposed rule's only potential accomplishment within District 8 would be to effectively destroy the economic viability of coal mining in this region of the country. The proposed elimination of fishtail ventilation of supersections, but only if two MMU's are operated by a single crew, is based on what can at best be described as confused thinking, and is not based on "research," "experiments," "experience," or "scientific data" as required by Section 811(a)(6)(A).

Sincerely yours,

J. Nathan Noland

EXHIBIT A

Average of Concei Column Labels

Row Labels	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	Grand Total
1986	0.25	0.83				1.17	0.72	0.33			1.13	0.80
1987	0.23	0.76	1.09		0.36	1.00	0.92	0.31			1.05	0.86
1989	0.48	0.60	0.91	0.79	0.89	0.88	0.79	1.08	1.06	1.04	0.71	0.84
1990	0.67	0.68	0.62	0.67	0.78	0.84	0.75	1.09	0.89	1.06	0.83	0.76
1991	1.06	0.76	0.74	0.80	0.83	0.98	0.82	0.97	1.04	1.52	0.89	0.88
1992	0.44	0.75	0.77	0.91	0.78	0.86	0.71	0.96	0.85	1.03	0.81	0.82
1993	0.46	0.59	0.67	0.78	0.71	0.68	0.68	0.80	0.78	1.01	0.74	0.70
1994	0.38	0.69	0.74	0.81	0.81	0.71	0.73	1.06	0.89	1.13	0.88	0.79
1995	0.39	0.81	0.77	0.90	0.78	0.74	0.81	1.24	1.07	1.21	0.90	0.85
1996	0.38	0.74	0.75	0.88	0.71	0.72	0.68	1.25	0.97	1.22	0.96	0.82
1997	0.36	0.81	0.72	0.83	0.71	0.73	0.66	1.19	0.91	1.16	0.89	0.79
1998	0.36	0.72	0.68	0.78	0.68	0.73	0.67	1.21	0.83	1.07	0.83	0.76
1999	0.40	0.70	0.73	0.76	0.68	0.74	0.70	1.25	0.88	1.07	0.87	0.77
2000	0.44	0.64	0.71	0.76	0.66	0.64	0.70	1.21	0.78	1.02	0.77	0.73
2001	0.39	0.61	0.74	0.74	0.64	0.63	0.65	1.18	0.73	1.04	0.73	0.71
2002	0.41	0.60	0.71	0.68	0.60	0.60	0.58	1.18	0.69	1.07	0.69	0.67
2003	0.39	0.57	0.67	0.63	0.52	0.53	0.54	1.13	0.73	0.97	0.72	0.64
2004	0.31	0.55	0.72	0.64	0.55	0.58	0.58	1.13	0.68	1.01	0.70	0.65
2005	0.33	0.59	0.70	0.66	0.54	0.61	0.54	1.13	0.64	1.08	0.66	0.65
2006	0.29	0.66	0.68	0.74	0.57	0.62	0.58	1.05	0.70	1.11	0.62	0.69
2007	0.32	0.64	0.69	0.64	0.56	0.60	0.55	1.07	0.69	0.97	0.64	0.65
2008	0.33	0.56	0.63	0.56	0.53	0.54	0.48	0.89	0.63	0.96	0.57	0.59
2009	0.27	0.51	0.61	0.54	0.54	0.53	0.47	0.76	0.58	0.89	0.59	0.57
2010	0.35	0.49	0.60	0.50	0.54	0.54	0.51	0.74	0.59	0.81	0.54	0.56

EXHIBIT B

CHEST®

Official publication of the American College of Chest Physicians

CHEST ONLINE

Prevalence of Small Lung Opacities in Populations Unexposed to Dusts : A Literature Analysis

John D. Meyer, Syed S. Islam, Alan M. Ducatman and Robert J. McCunney

Chest 1997;111;404-410
DOI 10.1378/chest.111.2.404

ISSN:0012-3692

Prevalence of Small Lung Opacities in Populations Unexposed to Dusts*

A Literature Analysis

John D. Meyer, MD, MPH;[†] Syed S. Islam, MBBS, Dr.PH; Alan M. Ducatman, MD, MSc; and Robert J. McCunney, MD, MPH, MS

Objectives: Despite the wide use of the International Labor Organization (ILO) system for reading chest radiographs, little information is available regarding the prevalence of abnormalities in populations unexposed to dusts. Prevalence studies of radiographic changes consistent with dust inhalation, as classified by the system, would be more meaningful if there were better understanding regarding the extent of abnormalities in unexposed populations.

Design: To determine small opacity prevalence in unexposed populations, a review of articles published since 1970 that used the ILO system to classify radiographs of the unexposed, either as subjects or control subjects, was performed. Criteria for inclusion in this review included ascertainment of the lack of exposure of subjects to occupational dusts, and independent reading of radiographs by at least two readers certified in the ILO system (B readers) or experienced in its use. A total of eight published articles presenting data on nine study populations were included in this study.

Results: The prevalence of small opacities graded 1/0 or greater varied widely, with a range from 0.21 to 11.7%. A meta-analysis of the published data yielded a population prevalence of 5.3% (95% confidence interval [CI]=2.9 to 7.7%). The prevalence was significantly greater in Europe than in North America (Europe, 11.3%; 95% CI=10.1 to 12.5%; North America, 1.6%; 95% CI=0.6 to 2.6%). A subset of the studies contained information on gender that showed greater prevalence of lung opacities in male subjects than female subjects (male subjects, 5.5%; 95% CI=3.4 to 7.6%; female subjects, 3.5%; 95% CI=1.3 to 5.8%). Based on estimated age information, the studies were divided into two strata (mean age <50 years vs ≥50 years). The age-specific pooled prevalence was higher in the studies with mean age ≥50 years than studies with mean age <50 years in both Europe (11.7% vs 9.6%) and North America (2.3% vs 0.6%). Prevalence of lung opacities remained significantly higher in Europe than in North America in each age stratum. The large difference in the prevalence between Europe and North America could not be explained on the basis of age, gender, or smoking history, although available age and smoking data are less robust.

Conclusions: These results indicate that a background level of opacities consistent with the radiographic appearance of pneumoconiosis exists in populations considered to be free of occupational dust exposure. Environmental and unaccounted occupational exposures, as well as reader variability, all may play a role in the determination of small opacity prevalence in these subjects and may explain the large differences between Europe and North America. Thorough ascertainments of occupational and environmental exposures are essential to determine the true significance of opacities in populations who are not exposed to dust. *(CHEST 1997; 111:404-10)*

Key words: ILO classification; lung opacities; meta-analysis; nondusty; unexposed

Abbreviations: CI=confidence interval; ILO=International Labor Organization

*From the Department of Occupational Medicine, Boston University Medical Center Hospital (Dr. Meyer), the Institute of Occupational and Environmental Health, West Virginia University School of Medicine (Drs. Ducatman and Islam), Morgantown, and the Massachusetts Institute of Technology (Dr. McCunney), Boston.

[†]Currently at the Institute of Occupational and Environmental Health of West Virginia University School of Medicine, Morgantown.

Manuscript received July 31, 1995; revision accepted July 26, 1996.

Reprint requests: Dr. John D. Meyer, Institute of Occupational and Environmental Health, PO Box 9190, WVU School of Medicine, 3313 HSS, Morgantown, WV 26506-9190

The International Labor Organization (ILO) system for the classification of radiographic abnormalities was designed to reduce variability and improve comparability in epidemiologic studies of pneumoconiosis. Nevertheless, variability in classification of radiographs continues to be apparent.[1-3] The B-reading program for applying the ILO system in the United States has been subjected to recent scrutiny in response to this documented variability.[4-6] Findings suggest that rigorous quality assurance measures are required for consistent results in radiographic reading. Contributing to the problem of variability are low reading volumes among most certified ILO interpreters, and use of the ILO classification for other purposes, such as medicolegal disputes.[1,6] Variability in reading may affect assessment of the unexposed as well as workers with histories of dust inhalation.

Efforts at determining the prevalence of pneumoconiosis or chest radiograph opacities must contend with the following: (1) variability inherent in the application of the ILO system; (2) disparities in data collection or presentation (*eg*, assignment of differing cutoff values for abnormal radiographs or consensus vs independent readings); (3) demographic variables, such as age and smoking history, which may affect the frequency of parenchymal opacities; and (4) real dust exposure or other environmental differences in "unexposed" populations. Cigarette smoking has been associated with increases in the prevalence of opacifications in asbestos-exposed workers.[7] Age and smoking habits have been postulated to produce radiographic parenchymal abnormalities in unexposed populations indistinguishable from occupationally related pulmonary fibrosis.[8,9] Local variations in the extent of other pulmonary diseases, such as tuberculosis, may also affect prevalence figures.[10] Patient size and chest wall thickness influence radiographic quality and observer interpretation.[5] Within the extensive literature on the dust-related lung diseases, estimates of the population prevalence of radiographic features consistent with pneumoconiosis in unexposed populations differ by nearly two orders of magnitude.[11-13]

The purpose of this study is to review the published literature on the prevalence of radiographic abnormalities that may appear consistent with pneumoconiosis in persons without known exposure to dusts. Two sources of data, which differ only in the means by which unexposed subjects were chosen for study, were available for such an analysis. The first involves studies with the direct purpose of assessing parenchymal abnormalities in populations with little or no occupational exposures to fibrogenic dusts. The second includes cross-sectional studies of asbestos workers and other occupational cohorts at risk for pneumoconiosis that used a control group of unexposed workers for comparison. Both types of studies represent a resource for the determination of the prevalence of small opacities seen on radiographic examination of unexposed populations. This information is likely to be valuable in interpreting the results of population studies designed to assess pneumoconiosis and in communicating the significance of results to affected workers.

Materials and Methods

A listing of articles using the ILO classification of the pneumoconioses (1971 and 1980 revisions) for either epidemiologic studies of pneumoconiosis or evaluation of unexposed subjects was obtained through a MEDLINE search covering the years from 1971 to the present. Review and cross-checking of the bibliographies of relevant articles were also performed in an effort to reduce underascertainment. In addition, indexes of journals frequently publishing studies of pneumoconiosis (*Journal of Occupational Medicine* now *Journal of Occupational and Environmental Medicine, American Journal of Industrial Medicine, American Review of Respiratory Diseases, British Journal of Industrial Medicine* now *Occupational and Environmental Medicine, Chest,* and *Scandinavian Journal of Work Environment and Health*) were systematically searched for any relevant articles that may have been missing. The articles thus obtained were examined for the presence of either (1) an occupational control group without exposure to dusts or fibers or (2) an unexposed cohort in which the prevalence of radiographic opacities was determined. Articles were selected for further review if data on one of these populations were reported.

Criteria were developed for inclusion of results in this analysis to standardize comparisons across studies. These criteria included the following: (1) some specification of the age of control subjects or the unexposed population; (2) ascertainment of the lack of exposure to fibrogenic dusts and fibers; and (3) specification that radiographs were read independently by at least two readers either certified by examination in the ILO classification ("B" readers) or specifically noted as having experience in its use. This last criterion is consistent with guidelines developed by the ILO and other organizations[11-15] for reading of radiographs in epidemiologic studies. Radiographs scored as a profusion grade of category 1 or greater (1/0 or higher on the ILO 12-point scale), which indicates the definitive presence of small opacities,[14] were recorded and used in this analysis.

Results from studies meeting the above criteria were compiled and a meta-analysis performed following the procedures described by Frumkin and Berlin[16] and Velanovich.[17] Briefly, the prevalence of lung opacities (P) is a random variable with a variance of P(1-P)/n. The pooled prevalence was obtained as a weighted average, where weights were assigned as the inverse of the variances. Separate pooled prevalences were obtained for European and North American study populations: younger (mean age <50 years) and older (mean age ≥50 years) populations, as well as male and female subjects. A 95% confidence interval (CI) was calculated for each prevalence estimate. Of the nine study populations, three were in Europe and six were in North America. Two recently published articles from Finland[18,19] presented data on an unexposed population and included information on gender, age, and smoking. The other two European study populations did not include female subjects.[10,20] One North American study containing two populations did not provide information on gender.[21] We used seven populations for prevalence estimation in male subjects and five populations for prevalence estimation in female subjects. One North American study had zero cases observed among female subjects.[13] To avoid deletion of this study from meta-analysis, we substituted 0.5 to the numerator to carry out gender-specific meta-analysis.

Arbitrary substitutions such as this are useful for ratio measures to avoid complete deletion of a stratum.[22] Mean age, SD, and range were estimated from the reported age data across the studies using various statistical techniques outlined by Snedecor and Cochran.[23] Based on estimated mean age, studies were categorized into two groups (those ≥50 years vs <50 years).

Results

Among numerous studies on asbestos, silica, coal dust, and other pulmonary fibrotic disorders, only eight published reports described the prevalence of parenchymal opacities in unexposed persons and fulfilled the criteria noted above for review.[10-13,15-21] Two articles had two separate control groups within the study, with each reported separately.[13,21] Therefore, this meta-analysis contains data on nine unexposed populations reported in eight articles, including two from Zitting et al[18,19] reporting on the same unexposed population. Table 1 summarizes the source of exposed populations, number of readers, and prevalence of small lung opacities ≥1/0. The prevalence of opacities across these study populations ranged from 0.21 to 11.7%. The following methods were noted in individual studies for the resolution of interreader differences: median reading (two studies), consensus (three), average reading (one), and highest reading (one). Table 2 shows the distribution of age and smoking within European and North American studies. There were considerable variations in smoking, gender, and age distribution between studies. Because of these differences, a separate meta-analysis was performed by age and gender as well as for European and North American studies.

The overall pooled prevalence was 5.3% (95% CI, 2.9 to 7.7%) for opacities graded ≥1/0. When European and North American studies were analyzed separately, the pooled prevalence for three European populations was 11.3% (95% CI, 10.1 to 12.5%). The pooled prevalence for six North American populations was 1.6% (95% CI, 0.6 to 2.6%). To evaluate whether this large difference in prevalence between Europe and North America could be explained by differences in age, gender, or smoking, we stratified studies by age category (mean age ≥50 years and <50 years) and gender. The pooled prevalence in the older age group was greater than that of the younger age group in both Europe and North America, although in each age stratum, European studies reported significantly higher prevalence of lung opacities (Table 3). In the younger age group (<50 years), the European studies had a pooled prevalence of 9.6% (95% CI, 8.2 to 11.1%) compared to only 0.6% (−0.2 to 1.4%) in the North American populations. Only one European and three North American studies could be classified in the older age group. The European study had significantly higher prevalence than the pooled prevalence of three North American studies (11.7% vs 2.3%). The gender-specific prevalence estimate showed greater prevalence in male subjects than in female subjects and this is true across European and North American studies (Table 4).

If a large European study[19] is excluded, the overall pooled prevalence drops to 2.8% (95% CI, 1.6 to 4%). This population was in the older age category. However, this particular study had the lowest prevalence of smoking among all studies presented and had a greater proportion of female subjects, demographic factors that favor lower prevalence of lung opacities. Therefore, the drop in the overall pooled prevalence when this study is excluded cannot be explained on the basis of smoking and gender. It also appears unlikely to be due to age effect alone. Three North American study populations[13,21] who were in the similar age category had significantly lower prevalence of lung opacities compared with the large European study.[19]

Discussion

The ILO system was devised to standardize reporting and comparison between observers and between studies in epidemiologic studies of pneumoconiosis.[14,24] It provides a means by which outcome

Table 1—*Prevalence of Small Opacities (≥1/0) in Subjects Unexposed to Dusts*

Published Studies, First Author (yr)	Unexposed Population	No. of Readers	No. of Opacities >1/0 (% Opacities)	N
Europe				
Glover[10] (1980)	Men chosen from electoral rolls, N Wales	3	39 (9.7%)	402
Jakobsson[20] (1995)	White collar workers from asbestos cement plant, Sweden	5	2 (6.8%)	29
Zitting[19] (1995)	Representative sample of Finnish population over age 30 yr	2	408 (11.7%)	3,494
North America				
Epstein[11] (1984)	Adults admitted to a university medical center, Philadelphia	2	22 (11%)	200
Castellan[12] (1985)	Blue collar employees in nondusty jobs, southern United States	3	3 (0.21%)	1,422
Kilburn[13] (1986)	a. Stratified sample of population in Michigan	3	3 (0.25%)	1,167
	b. Long Beach, Calif census tract	3	29 (2.1%)	1,347
Kennedy[21] (1991)	a. Employed bus mechanics, Canada	2	3 (4.5%)	66
	b. Retired grain and civic workers	2	4 (4.8%)	83

Table 2—*Demographic and Smoking Distribution of European and North American Studies*

Published Studies*	N	Age, yr, Mean±SD (Range)†	M:F	% Current Smokers	% Current and Past Smokers
European					
Glover[10]	402	30.2 ± 16.6 (18-80)	NA‡	59	81
Jakobsson[20]	29	49 ± 5.67 (31-66)	NA	41	79
Zitting[19]	3,494	54.3 ± 13.47	1:2	17	34
North American					
Epstein[11]	200	44.2 ± 13.26 (15-84)	1:18	NA	NA
Castellan[12]	1,422	33.8 ± 12.07 (16-70)	1:1	47	61.5
Kilburn (a)[13]	1,167	42.4 ± NA (NA)	1:1	NA	69 M 50 F
Kilburn (b)[13]	1,347	51.0 ± NA (NA)	1:1	NA	60 M 40 F
Kennedy (a)[21]	66	56.2 ± 3.7 (45-67)	NA	18	73
Kennedy (b)[21]	83	69.7 ± 4.7 (56-84)	NA	13	85

*See Table 1.
†The mean age in years, SD, and range were derived statistically from the existing reports.
‡NA=not available.

variables may be reduced to a common metric across differing studies, to optimize uniformity of the reporting of results. It has been used to facilitate review and analysis of studies employing differing populations.[25] Ideally, uniformity of methods and criteria should apply across studies subject to review and analysis. It is possible, however, that these criteria are not met in ILO readings of chest radiographs. Incomplete documentation of the application of the ILO system, which may reflect inadequate implementation of standardized procedures, was noted in a recent report.[3] Misinterpretation of chest radiographs using ILO methods may lead to misdiagnosis of conditions consistent with pneumoconiosis.[2,26] Radiographic overdiagnosis should not be confused with exaggeration of prevalence; autopsy data suggest that pneumoconiosis is more prevalent than radiographs may detect.[27]

The most provocative finding of this analysis is the difference in prevalence between European and American studies. Although precise age distributions of the study populations were not available for both the European and North American study populations, an evaluation of the estimated mean ages and ranges does not indicate that the European study populations were significantly older than North American populations under consideration. Most of the study populations had an equal proportion of male and female subjects with the exception of the Zitting et al[19] study that has a significantly higher proportion of female subjects. However, as female subjects had a significantly lower prevalence of lung opacities, the difference in prevalence between Europe and North America could not be explained on the basis of gender. Similarly, the proportion of current and ever-smokers was significantly lower in the Zitting et al[19] study compared with other studies. The higher prevalence of opacifications in Europe compared with North America, therefore, cannot be explained on the basis of smoking. Confounding effects of environmental exposures, such as ambient air pollution or unaccounted occupational exposures,

Table 3—*Stratification of Studies by Mean Age of Study Population*

Mean Age yr	Studies*	Prevalence of Opacities ≥1/0, %	Pooled Prevalence, % (95% CI)
Europe			
<50	Glover[10]	9.70	9.6 (8.2-11.1)
	Jakobsson[20]	6.80	
North America			
<50	Epstein[11]	11.00	0.6 (−0.23-1.4)
	Castellan[12]	0.21	
	Kilburn (a)[13]	0.25	
Europe			
≥50	Zitting[19]	11.70	
North America			
≥50	Kennedy (a)[21]	4.50	2.3 (1.1-3.6)
	Kennedy (b)[21]	4.80	
	Kilburn (b)[13]	2.10	

*See Table 1.

Table 4—*Prevalence of Small Opacities ≥1/0 by Sex*

Study*	Male	%	Female	%
European populations				
Glover[10]	39/402	9.7	None	
Jakobsson[20]	2/29	6.8	None	
Zitting[19]	147/1101	13.3	261/2,393	9.8
Pooled prevalence		11.2		
(95% CI)		(8.0-14.4)		
North American populations				
Epstein[11]	10/71	14.0	12/129	9.3
Castellan[12]	1/720	0.14	2/702	0.28
Kilburn (a)[13]	3/584	0.5	0.5/583	0.09
Kilburn (b)[13]	25/673	3.7	4/674	0.6
Pooled prevalence		1.3		0.4
(95% CI)		(0.27-2.4)		(−0.18-1.02)

*See Table 1.

and reader variability may contribute to the large differences in proportion of opacities between Europe and North America. Differences between unexposed control groups on the same continent may also be due to these factors. Kilburn et al[13] hypothesized that undetermined exposures, such as unrecorded work in shipyards and oil refineries, may have elevated local rates of opacities of a California population in comparison to that of their Michigan control group. Bus mechanics used as one control group may have had occupational exposure to asbestos (from brake linings) and to other dusts.[21] Studies differed substantially in definition of exposure, ranging from 3 months[10] to 5 years[12] of work in a dusty job before a subject was considered exposed.

In regard to environmental factors, Glover et al[10] surmise that the high prevalence of opacities in workers exposed to slate dust as well as in unexposed workers may be due to high rates of healed tuberculosis in North Wales. A more striking observation of pneumoconiosis in those not occupationally exposed is the prevalence of abnormalities in high-altitude villages in Ladakh, where pulmonary opacity rates of 20 to 45% presumably result from dust storms and soot from indoor kitchens.[28] Data from the Mini-Finland Health Survey show lung small opacity profusion of ≥1/0 in 14.6% of men without a past or present industrial exposure.[18,19] Variations in both work and environmental factors among differing populations are therefore likely to substantially affect the estimation of occupationally related pulmonary opacifications.

Stratification of results by mean age demonstrates an increase in prevalence of opacities ≥1/0 after the fifth decade of life. It is important to consider age-related effects on small opacity profusion.[29] For example, subjects with abnormal radiographs in one US study were older than the population mean.[12] Age, collinearly related to both dust exposure and cigarette smoke, may correlate with increased profusion of opacities in those exposed to either factor.[8] The increased prevalence of opacifications seen in older workers in this survey suggests that at least some of the variability is due to cumulative environmental exposures and perhaps age itself. Therefore, the inclusion of age data does not entirely mitigate the problem of determining whether opacifications are due to environmental exposures, as age may be a surrogate marker for exposure.

The disparity between male and female subjects seen in this review may reflect true differences in opacity development by gender; however, they are more likely related to other factors differing between the sexes such as dusty jobs or smoking, since these risks were historically higher for male subjects. Unaccounted occupational exposures, occurring in military service, part-time work, full-time work not obtained by history, or hobbies, could produce the increase in opacities seen in male subjects. The differences between male and female subjects noted in these data are an important clue that not all the variability between and within study populations is random. Some of this variability appears to reflect unaccounted dust exposure.

Only one study[10] in this review stratified results by smoking history. It demonstrated a threefold increase in abnormalities in smokers when compared with nonsmokers. The absence of quantitative data on smoking limits the ability of an analysis to determine a dose-related effect of smoking on the prevalence of small opacities in the otherwise unexposed. In a comparison between smoking and nonsmoking workers exposed to acrylamide dust, as well as in those unexposed, parenchymal abnormalities were present in 20% of smokers compared with 2.2% of nonsmokers, suggesting that smoking plays a role in their development.[9] Our meta-analysis is unable to determine the effect of smoking alone on unexposed populations.

Finally, the question of variability in reading of radiographs remains. Methods for resolving inter-reader disagreement varied considerably among the studies reported herein, a finding consistent with the results of a recent report.[3] A twofold prevalence range in interpretation of radiographs at lower levels of profusion is apparent from studies of interobserver variability.[1,30,31] Population median value for opacities of category 1/0 or greater in a sample of over 105,000 US Navy workers was 1.71%, but the range for 23 certified observers reading randomly distributed radiographs was 0.05 to 10.93%.[32] This range is not very different from the range in the supposedly unexposed populations reviewed in this meta-analysis, a startling similarity in view of the many shipyard and other dust-exposed workers in the Navy population. The lack of description of interpreters, their habits, and quality assurance measures in many studies[3] may be hampering the ability to accurately make comparisons between studies. A sense of uncertainty has persisted as to the degree to which interstudy differences of exposed populations reflect disparities between populations or between the chest radiograph readers.[1-6,32] This phenomenon now appears also to be true for prevalence of opacities in unexposed populations. In particular, differences in opacity prevalence between European and North American populations may be partially accounted for by reader habit differences.

A range of variation exists in the determination of the prevalence of radiographic findings in populations considered to be unexposed to fibrogenic dusts. Dependence on historic prevalence figures for the unexposed may be confusing because of this wide range. Aggregation of current data suggests that there is a background level of opacifications in populations considered unexposed. A meta-analysis shows this prevalence to average 5.3% in existing studies, but the prevalence in any given unexposed population may differ from this figure depending on age, gender, past exposure status, and geographic location. The notably high prevalence of abnormalities in European studies compared with North American studies appears most likely to be due to differences in reader habits or unaccounted exposures, rather than demographic or smoking differences.

Recommendations

Variation among studies in the reported prevalence of opacities in unexposed populations indicates that factors independent of dust exposure are operating. Age and gender differences suggest that environmental factors also play a role. The use of a control group corresponding in age, geographic location, and gender to the exposed subjects can serve as a means by which baseline prevalence of opacities can be determined within a population and the added burden of prevalence due to occupational exposure can be more accurately assessed. In addition, radiographic interpreters should be formally blinded to the exposure status of the individuals whose radiographs they read. The need for closer attention to smoking history when compiling population results, both in exposed workers and in control subjects, should be apparent in light of the persistent controversy that this issue engenders.[8,9,25] Proper ascertainment of exposures from occupational and environmental sources is suggested to reduce misclassification of subjects and the resultant bias that this may introduce.

Close attention to quality assurance measures in using the ILO system is also recommended to more accurately determine the significance of radiographic abnormalities in the dust exposed. Adherence to recommendations for multiple readers in epidemiologic studies[14,15] and thorough description of the reading process, including the means by which interreader differences are reconciled,[3] may produce data that can be better compared across studies. Continuous feedback to readers in comparison to a gold-standard reading[33] can aid in assessment of reader variability within a study. Continuous feedback also promotes adherence to more uniform reading standards.

Among these recommendations, we believe the most important to be the use of unexposed control radiographs. The presence of blindly interpreted unexposed control radiographs within an epidemiologic study can serve the role of an internal comparison for reading and aid in the control of the reading process as well as in the interpretation of results.

ACKNOWLEDGMENT: We are grateful for the assistance and comments of Drs. Gary R. Epler and Theresa C. McLoud in researching and preparing this article.

References

1 Ducatman AM. Variability in interpretation of radiographs for asbestosis abnormalities: problems and solutions. Ann NY Acad Sci 1991; 643:1088-1120
2 Parker DL, Bender AP, Hankinson S, et al. Public health implications of the variability in the interpretation of "B" readings for pleural changes. J Occup Med 1989; 31:775-80
3 Mulloy KB, Coultas DB, Samet JM. Use of chest radiographs in epidemiological investigations of pneumoconiosis. Br J Ind Med 1993; 50:273-75
4 Attfield MD, Wagner GR. A report on a workshop on the National Institute for Occupational Safety and Health B-reader certification program. J Occup Med 1992; 34:875-78

5 Wagner GR, Attfield MD, Kennedy RD, et al. The NIOSH B-reader certification program. J Occup Med 1992; 34:879-84
6 Balmes JR. To B-read or not to B-read [editorial]. J Occup Med 1992; 34:885-86
7 Weiss W. Cigarette smoke, asbestos, and pulmonary fibrosis. Am Rev Respir Dis 1971; 104:223-26
8 Dick JA, Morgan WKC, Muir DFC, et al. The significance of irregular opacities on the chest roentgenogram. Chest 1992; 102:251-60
9 Weiss W. Cigarette smoking and small irregular opacities. Br J Ind Med 1991; 48:841-44
10 Glover JR, Bevan C, Cotes JE, et al. Effects of exposure to slate dust in North Wales. Br J Ind Med 1980; 37:152-62
11 Epstein DM, Miller WT, Bresnitz EA, et al. Application of ILO classification to a population without industrial exposure: findings to be differentiated from pneumoconiosis. AJR 1984; 142:53-8
12 Castellan RM, Sanderson WT, Petersen MR. Prevalence of radiographic appearance of pneumoconiosis in an unexposed blue collar population. Am Rev Respir Dis 1985; 131:684-86
13 Kilburn KH, Lilis R, Anderson HA, et al. Interaction of asbestos, age, and cigarette smoking in producing radiographic evidence of diffuse pulmonary fibrosis. Am J Med 1986; 80:377-81
14 International Labour Office. Guidelines for the use of ILO: international classification of radiographs of pneumoconioses, revised edition. Geneva: International Labour Office, 1980
15 American Thoracic Society. Health effects of air pollution. New York: American Lung Association, 1978
16 Frumkin H, Berlin J. Asbestos exposure and gastrointestinal malignancy: review and meta-analysis. Am J Ind Med 1988; 14:79-95
17 Velanovich V. Meta-analysis for combining bayesian probabilities. Med Hypotheses 1991; 35:192-95
18 Zitting AJ. Prevalence of radiographic small lung opacities and pleural abnormalities in a representative adult population sample. Chest 1995; 107:126-31
19 Zitting AJ, Karjalainen A, Impivaara O, et al. Radiographic small lung opacities and pleural abnormalities as a consequence of asbestos exposure in an adult population. Scand J Work Environ Health 1995; 21:470-77
20 Jakobsson K, Stromberg U, Albin M, et al. Radiologic changes in asbestos cement workers. Occup Environ Med 1995; 52:20-7
21 Kennedy SM, Vedal S, Muller N, et al. Lung function and chest radiograph abnormalities among construction insulators. Am J Ind Med 1991; 20:673-84
22 Kleinbaum DG, Kupper LL, Morgenstern H. Stratified analysis. In: Kleinbaum DG, Kupper LL, Morgenstern H, eds. Epidemiologic research: principles and quantitative methods. Belamont, Calif: Wadsworth, 1982; 330, 351
23 Snedecor GW, Cochran WG. Statistical methods. Ames, Iowa: Iowa State University Press, 1980; 34-6, 137-38
24 McLoud TC. Occupational lung disease. Radiol Clin North Am 1991; 29:931-41
25 Blanc PD, Gamsu G. Cigarette smoking and pneumoconiosis: structuring the debate [editorial]. Am J Ind Med 1989; 16:1-4
26 Reger RB, Cole WS, Sargent EN, et al. Cases of alleged asbestos-related disease: a radiological evaluation. J Occup Med 1990; 32:1088-90
27 Wagner GR, Attfield MD, Parker JE. Chest radiography in dust exposed miners: promise and problems, potential and imperfections. Occup Med. State of the Art Reviews 1993; 8:127-41
28 Saiyed HN, Sharma YK, Sadhu HG, et al. Non-occupational pneumoconiosis at high altitude villages in central Ladakh. Br J Ind Med 1991; 48:825-29
29 Morgan WKC. Prevalence of radiographic appearance of pneumoconiosis in an unexposed blue collar population [letter]. Am Rev Respir Dis 1985; 132:1139
30 Liddell FDK. Radiological assessment of small pneumoconiotic opacities. Br J Ind Med 1977; 34:85-94
31 Rossiter CE. Initial repeatability studies of the UICC/Cincinnati classification of the radiographic appearances of the pneumoconioses. Arch Environ Health 1972; 12:314-30
32 Ducatman AM, Yang WN, Forman SA. "B-readers" and asbestos medical surveillance. J Occup Med 1988; 30:644-47
33 Muir DCF, Julian JA, Roos JO, et al. Classification of radiographs for pneumoconiosis: the Canadian pneumoconiosis reading panel. Am J Ind Med 1993; 24:139-47