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## ORD — NIOSH Prevention Strategy and Selected Research

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### Introduction

In the publication, *Promoting Health/Preventing Disease: Objectives for the Nation*, the U.S. Public Health Service established 226 measureable objectives in 15 priority areas to be achieved by 1990.<sup>(1)</sup> One of the priority area sections dealt with objectives for occupational safety and health. Within the occupational safety and health section, the following national objective for the prevention of occupational lung diseases was established: "By 1990, among workers newly exposed after 1985, there should be virtually no new cases of four preventable occupational diseases — asbestosis, byssinosis, silicosis, and coal workers' pneumoconiosis." This focus on occupational lung diseases was considered necessary since the lung is both a target organ and a port of entry for toxic substances.<sup>(2)</sup> The potential for worker exposure is high; for example, an estimated 1.2 million workers each year are potentially exposed to free silica dust alone.<sup>(3)</sup> The recognition of chronic occupational lung diseases can be difficult, since the latent period for such diseases may be as long as 15 years for silicosis and 30 years or more for asbestos-related diseases. Other environmental and life-style factors, such as cigarette smoking, may contribute significantly to the respiratory disease process and obscure the association between exposure and disease.<sup>(4)</sup>

Once the 1990 objectives were inaugurated, the National Institute for Occupational Safety and Health (NIOSH) developed a suggested list of the top 10 work-related diseases and injuries.<sup>(2)</sup> These are: Lung Diseases, Musculoskeletal Injuries, Cancers (other than lung), Severe Traumatic Injuries, Cardiovascular Diseases, Reproductive Disorders, Neurotoxic Disorders, Noise-Induced Hearing Loss, Dermatologic Disorders, and Psychologic Disorders.

Three criteria were used to develop the list: The disease or injuries' frequency of occurrence; its severity in the individual case; and its amendability to prevention. The list was suggested with three purposes: To encourage deliberation and debate among professionals about the major problems in the field of occupational safety and health, to assist in setting national priorities for efforts to prevent health problems related to work, and to convey to a diverse audience the concerns of the leadership of NIOSH and the focus of the Institute's activities. The list is intended to be dynamic; it will

be reviewed periodically for necessary updating as knowledge increases and as exposure conditions change and are brought under better control.

After formulating the list of the 10 leading work-related diseases and injuries, the leadership of the Institute decided to develop prevention strategies for the first five. Since occupational lung disease was number one on the list, the Division of Respiratory Studies (DRDS) was given the task of developing the first prevention strategy. To do this a working group of scientists from throughout the Institute, chaired by Dr. John Hankinson, Chief, Clinical Investigations Branch, DRDS, was formed. A working group compiled a comprehensive document on the control of occupational lung diseases, focusing on the four diseases specified in the 1990 objective. As other strategy documents for the first five work-related diseases on the top 10 list were being developed, it was decided to hold a symposium for the purpose of presenting the documents to the entire occupational safety and health community for comment and critique. From the basic strategy, synoptic documents for each of the five conditions were developed, and panelists from throughout the occupational safety and health community were selected to review the documents and offer expert opinions in specialized areas of interest within the field of occupational safety and health.

The following individuals were selected as panelists for the occupational lung disease work group:

Henry A. Anderson, M.D.  
Charles E. Andrews, M.D.  
Michael P. Eriksen, Sc.D.  
David Fraser, Sc.D.  
Thomas J. Shepich  
Clinton W. Stallard, Jr., M.D.  
James L. Weeks, Sc.D.  
Hans Weill, M.D.  
John Wilson, M.D.

The goal of DRDS's occupational lung disease work group was to develop a prevention strategy for occupational lung diseases. This was accomplished by involving the panelists and the participants in an open forum. The group began with the presentation of the draft strategy for the prevention of occupational lung diseases and at the close, posed the following four questions:

\*Presenter of paper.

**TABLE I**  
**Lung Cancer Deaths (0) and SMR's by Fiber/cc-Years**  
**Exposure (f-y) for at Least 20 Years from Hire**  
**(Vermiculite Workers)**

McGill				NIOSH			
f-y Group	Mean	0	SMR*	f-y Group	Mean	0	SMR+
0-25	12.5	4	1.68	0-50	28.1	2	0.85
25-200	77.3	3	1.85	50-99	72.7	2	2.25
200-500	332.4	5	9.80	100-400	209.6	1	1.09
≥500	836.1	3	6.77	≥400	957.1	7	6.71

\*Reference Population: Montana males

+Reference Population: U.S. White male rates

1. Does the draft include all the essential elements of a prevention strategy?
2. Are the prevention strategies outlined in the draft necessary and complete?
3. What additional essential prevention strategies are needed?
4. What are the priorities of prevention strategies?

The initial focus of the prevention strategy was on the four lung diseases targeted in the 1990 objectives — asbestosis, byssinosis, silicosis, and coal workers' pneumoconiosis — with occupational lung cancer and occupational asthma considered for inclusion. To the extent that these diseases are representative of most occupational lung disease (since the lung responds to insult in a limited number of ways), it was the panel's opinion that prevention strategies developed for them would be applicable to other occupational lung diseases. The work group felt strongly that a generic strategy was needed and that occupational lung cancer and occupational asthma should also be addressed in the strategy.

To facilitate discussion of a national strategy, the group identified the essential prevention elements outlined in the draft document. Each of our panelists was assigned an element for discussion. These elements were: surveillance, regulatory enforcement, research needs, control technology and respirators, education and training, health promotion and smoking, and workers' compensation. Summaries of the deliberations of the occupational lung disease panelists on the elements of the strategy are given below with four health studies on the mining population recently completed by researchers at NIOSH.

## Discussion

### 1. Surveillance

#### Environmental

The symposium working group considered environmental surveillance to be the most effective means of identifying problem areas and sequentially measuring the impact of prevention strategies. Occupations likely to have a high incidence of occupational respiratory diseases clearly need

to be given special attention in terms of environmental surveillance.

#### Medical

While there was complete agreement on the need for disease surveillance to estimate the prevalence of occupational lung diseases, there were several different suggestions as to utilizable data sources:

1. Disability/impairment (workers' compensation data)
2. Insurance companies

**TABLE II**  
**Characteristics of Attapulgitite Study**  
**Population by Company**

	Company A	Company B
Age-years (S.D.)	37.1 (13.1)	38.8 (12.6)
Nonsmokers-(%)	39	32
Exsmokers-(%)	16	18
cigarettes/day (S.D.)	5.1 (5.6)	17.2 (15.2)
pack-years (S.D.)	29.3 (15.1)	24.9 (16.1)
Smokers		
cigarette/day (S.D.)	23.1 (12.4)	22.7 (8.3)
pack-years (S.D.)	19.5 (17.4)	18.8 (15.2)
Cumulative Respirable		
Dust (mg/m <sup>3</sup> × yrs)	10.3 (10.8)	7.8 (10.4)
Cumulative Total Dust	71.2 (94.5)	43.5 (69.3)

**TABLE III**  
**Prevalence of Pneumoconiosis by**  
**Age, Smoking, and Exposure**  
**(Attapulgitite Workers)**

	A	B
	%	%
Prevalence	4.2	9.8
Age		
<40	1.0	3.2
≥40	8.7	19.8
Smoking		
NS	3.0	5.1
Ex	3.8	9.6
S	5.4	12.9
Exposure		
Tenure-years		
0-5	0.7	
6-15	2.4	
15+	11.6	
Respiratory		
Dust-mg/m <sup>3</sup> × yrs.		
0-2	0	3.0
2-9	2.2	6.4
10+	11.4	20.8
Total		
Dust-mg/m <sup>3</sup> × yrs.		
0-5	0.8	4.2
6-40	1.0	8.4
>40	9.2	10.2

3. Company surveillance data as required by OSHA
4. Company surveillance data voluntarily collected by industry
5. State reporting systems

Most of the discussion centered around state reporting systems using local physicians and county health officers. The consensus was that hospitals should be required to record work histories and report occupationally related diseases in their discharge reports. Several difficulties were recognized as inherent to this surveillance method, the most significant being the reluctance of physicians and workers to report diseases because of potential litigation and reprisals. Crucial to the success of such reporting systems would be clear case definitions and physicians who are able to recognize patients suffering from diseases related to their work environments.

### **2. Regulatory Enforcement**

To meet the goal of prevention of occupational lung disease, there was agreement that regulatory enforcement is the most effective element in the strategy. There is a disparity in the nature of the legal framework from which OSHA and MSHA operate within the Department of Labor. The MSHA Act mandates a self-policing sampling requirement for operators, an inspector sampling 'audit' program, pre-operation filing of hazard control plans, and the right for inspectors to stop unsafe operations on-site. All of these were considered effective in a prevention strategy. At present, OSHA lacks the resources, and in some cases the legislative authority, to conduct a comparable program.

Both Acts squarely place the responsibility for providing a safe and healthful workplace on the shoulders of the employer. It is necessary that regulators establish a framework for technology transfer to assist operators to come into compliance and to educate management, safety personnel, and the workers themselves.

### **3. Research Needs**

A point of departure here is a solid information base, since science has a critical impact as it overlaps social management and regulatory factors. Currently, research needs are to:

1. Fine tune recognition of disease at the lower end of the disease spectrum;
2. Develop more sensitive techniques for detecting early changes at cellular levels;
3. Determine the exposure-response relation for silica and silicosis;
4. Delineate toxicity data for silica substitutes which are also believed to be potentially harmful;
5. Determine the exposure-response for asbestosis and determine the effects of fiber types in the disease process;
6. Determine whether smoking influences diffuse lung fibrosis — the current literature is confusing on this issue;
7. Develop methods for determining relative causality in carcinogen exposure. Currently, it is not possible to separate causal factors or predict probabilities because not enough is known about carcinogenic mechanisms;
8. Determine whether pleural plaques are predictive of mortality and/or morbidity for fiber exposed populations;
9. Develop information on the scope of the hypersensitivity pneumonitis problem;
10. Develop methods to predict susceptibility for occupational asthma or the other organic dust diseases;
11. Determine whether people who do not react acutely to organic dusts are more susceptible to chronic effects;
12. Determine if there are long term effects following acute responses to pulmonary irritants and if there are serious effects from low level, but episodic, exposures to irritant gases and fumes.

### **4. Control Technology and Respirators**

Discussion centered on minimizing exposure to workers by direct application of engineering design, ventilation, substitution, changes in work practices, and indirectly through the use of respirators, administrative procedures, and incentives.

The group felt that:

1. Research on new applications and methods of control technologies needs to be supported.
2. Implementation of the AEC ALARA principle (Atomic Energy Commission — As Low As Reasonably Achievable) should be considered in high hazard processes.
3. Predictive models to determine work place exposures before design or installation of process equipment need to be developed.
4. For more effective implementation of controls, it is imperative that engineers be trained in hazard recognition and principles of control.
5. Economic incentives such as lower insurance premiums should be explored as an incentive for industry to implement new controls.
6. "Sole remedy" concept of Workers' Compensation should not hold if the employer has not used available technology or cannot document compliance.
7. Respirators should not be considered a primary control mechanism since they rely on human intervention and have not been shown to provide the protection equivalent to that determined in laboratory tests.

### **5. Education and Training**

The panelists concurred that if training is to be effective, the occupational health professional must be appropriately

**TABLE IV**  
**Cement Workers Examined (1979-1982)**  
**Distribution by Age of Plant and Type of Process**

	Before 1941	1941-1960	1961-1978	All Ages
Wet	250 ( 9.1%)	545 (19.9%)	325 (11.9%)	1120 ( 40.9%)
Dry	202 ( 7.4%)	604 (22.1%)	570 (20.8%)	1376 ( 50.3%)
Dual	0 ( 0.0%)	242 ( 8.8%)	0 ( 0.0%)	242 ( 8.8%)
Total	452 (16.5%)	1391 (50.8%)	895 (32.7%)	2738 (100.0%)

trained and actively involved as a "change agent" in attempting to improve working environments and develop informed worker and management groups.

Training curricula should emphasize the fact that successful occupational health programs require simultaneous involvement of management, the Occupational Health Professional, production personnel, and workers for sustained effectiveness. Indeed, a successful program presupposes workers who are informed about work hazards and safe work practices and who are encouraged to work cooperatively to reduce hazards. Such programs must be tailored to small and medium-sized, as well as large, workplaces.

#### **6. Health Promotion and Smoking**

The malignant role and unprecedented societal cost of smoking places this issue forthrightly in our generic strategy. It is an important risk factor in at least three of the five strategies being discussed at this symposium. For these reasons, the working group felt it appropriate for NIOSH to be involved in anti-smoking activities in the workplace. When the question of implementation was raised, the most appropriate path was debated: to stop smoking altogether in the national perspective or just in the workplace. The course chosen as most prudent was a push for legislation at the state level, related to indoor air pollution, rather than for laws against smoking, specific to the workplace. Such state laws should state "all public places are designated as nonsmoking areas." Management could then declare a company a "public place." Management and labor should be encouraged to work together in this endeavor to develop appropriate nonsmoking policies.

#### **7. Workman's Compensation**

The subject of Workman's Compensation touched off a lively discussion: the consensus was that the present system, and/or conceivable modifications to the present system, are not going to be achievable as part of a prevention strategy. Although compensation does provide some financial relief for disabled workers, it essentially comes into play only after existing prevention systems have failed and physical remedies are nonexistent.

After conclusion of the symposium in Atlanta, the participants allowed a period of time to receive written input from the panelists and invited participants and have since re-

drafted the prevention strategy to reflect the comments and critiques from both the symposium and the written correspondence. The first five strategies will be published by the Association of Schools of Public Health (ASPH) in the near future. Prevention strategies for the second five work-related diseases on the top 10 list are now being prepared and will be presented at a symposium in October of 1986. It is the speaker's hope that other actions will be taken to further refine and ultimately implement the prevention strategy for the occupational lung diseases.

There are four health studies of mining populations, recently completed by the Division of Respiratory Disease Studies (DRDS) that I would now like to summarize for you. The first is a retrospective mortality & morbidity study of miners exposed to vermiculite contaminated with tremolite asbestos; the second, a morbidity study of workers exposed to attapulgite, a clay containing agglomeratic fibrous particles. These projects are the result of an on-going NIOSH interest in the health effects of fibrous materials. The third and fourth studies summarized are morbidity and mortality studies conducted in the Portland cement industry. Because of Yugoslavian studies which reported increased morbidity and mortality among cement workers, the Portland Cement Association asked DRDS to determine whether similar health risks exist in the U.S. cement industry.

#### **A. Vermiculite Studies**

Studies of environmental fiber-exposures, mortality, and radiographic findings of workers employed at a Libby, Montana vermiculite mine and mill were begun by DRDS in 1982.<sup>(5-8)</sup> The vermiculite concentrate was found to be contaminated with fibrous tremolite-actinolite. Of 599 fibers (length greater than 5  $\mu\text{m}$  and width greater than 0.45  $\mu\text{m}$ ) counted in 8 membrane filter air samples, 96% had an aspect ratio greater than 10, and 17% greater than 50. Compared to fibers in other asbestos industries (crocidolite, amosite, chrysotile) the fibers contaminating the vermiculite concentrate are very long and thin.

Individual cumulative fiber exposure was derived from 336 impinger samples collected during 1942-1967 and 4060 filter samples collected from 1967-1982. The estimate of exposure in the old dry mill working area was 168 f/cc before 1964, 33 f/cc in 1964-1971, and 16 f/cc in 1972-1974. A new wet mill was constructed in 1973, and exposures were estimated to be 2 f/cc in 1975-76, and 0.8 f/cc in 1977-1982.

A cohort of 575 white males was traced to Jan 1, 1980, and their vital status determined. Men were included if employed at least one year and if hired before 1970. The risk of death from lung cancer was estimated using a man-years analysis with respect to cumulative fiber-years exposure under control for latency. For greater than 20 years latency, the lung cancer standardized mortality ratio (SMR) was 0.85 at <50 f-y, 2.25 at 50-100 f-y, 1.09 at 100-400 f-y, and 6.71 at

≥400 f-y (Table I).<sup>(9)</sup> Our results indicate that the increase in the lung cancer risk over that expected in U.S. white males, for at least 20 years since hire, was 0.6% for each fiber-year of exposure. At 5 fiber-years, the increase was 2.9%.

Radiographic findings were evaluated from the most recent radiograph of 184 men employed at least 5 years and employed sometime during 1975-1982. The prevalence of small opacities was 10%, any pleural change was 15%, pleural calcification was 4%, and pleural change on the wall was 13%. A logistic model was estimated to predict the prevalence of radiographic findings from fiber-year, and the association with fiber-year was significant only for small opacities. Results indicated that at 5 fiber-years, the increase in the relative risk for small opacities (profusion greater than 1/0) was 1.3%.

### B. Epidemiological Study of U.S. Attapulgit Workers

Attapulgit is a sorptive and gelling clay with a wide variety of uses in absorbents (~65%) pesticides (15%), oil treatment (5%) and miscellaneous other uses (15%).

It is a hydrated magnesium aluminum silicate similar in chemical composition and structure to the asbestiform mineral palygorskite, but with a different morphology and size. Palygorskite has cross-sectional diameters of 100-300 Å and forms flexible laths (30% ≥ 5 μm). Attapulgit particles are 20-100 Å in diameter and 0.1 - 2.5 μm in length and tend to agglomerate.

Using the medical surveillance records from the two companies mining and milling U.S. attapulgit, we conducted a cross-sectional morbidity study of these workers. The major questions addressed in this study were: What is the prevalence of pneumoconiosis and is the occurrence of pneumoconiosis associated with exposure?

Table II summarizes some of the characteristics of the study population. Dust exposure was lowest in the mines (0.05 and 0.40 mg/m<sup>3</sup>) and highest in the mills in the bagging, shipping, and loading areas (2.71 & 2.64 mg/m<sup>3</sup>).

There were a total of 701 radiographs from both companies. The prevalence of unilateral and bilateral pleural thickening was 3.2% and 4.2% respectively. The prevalence of category 1/0 or greater pneumoconiosis was 6.4%. Over half were category 1/0. Of the 45 cases of pneumoconiosis, 16 were irregular opacities and 29 were rounded opacities. The prevalence of opacities (rounded and irregular combined) is associated with age but not smoking (Table III). Opacities are associated with exposure — a finding commonly seen in dust exposed populations — in both companies. Association alone does not necessarily imply causation. For example, there were no pre-employment x-rays, and there was a high prevalence in Company B of other dusty exposures. Although there was no consistent association with smoking, irregular opacities in the lower categories may be seen in smokers. The prevalence was higher in Company B, but exposures were higher in Company A. There were two other factors that minimize the association. Over 1/2 of the pneumoconiosis cases were borderline diagnostically and of those with category 1/1 or higher, over half (11/19) were rounded opacities (which is uncharacteristic of a fibrous exposure).

### C. Portland Cement Industry Studies

#### 1. Mortality Study

In 1978, DRDS was requested to investigate the health effects of cement plant and quarry exposures. Studies of environmental exposure, morbidity, and mortality were initiated.<sup>(10,11)</sup>

TABLE V  
Radiographic Abnormalities by Smoking Status  
Cement Workers and Controls

	Smokers		p*	Ex-smokers		p*	Nonsmokers		p*
	Total Prevalence			Total Prevalence			Total Prevalence		
Rounded Small Opacities									
Cement Workers	666	7 (1.1%)	0.01	382	4 (1.0%)	0.46	414	1 (0.2%)	1.00
Control Group B	701	0 (0.0%)		168	0 (0.0%)		523	2 (0.4%)	
Irregular Small Opacities									
Cement Workers	665	12 (1.8%)	0.002	383	3 (0.8%)	0.67	414	0 (0.0%)	1.00
Control Group B	701	1 (0.1%)		168	0 (0.0%)		519	0 (0.0%)	
Pleural Abnormalities									
Cement Workers	664	19 (2.9%)	0.0001	383	3 (0.8%)	0.67	412	2 (0.5%)	0.82
Control Group B	702	2 (0.3%)		168	0 (0.0%)		523	1 (0.2%)	

\*p value for testing the hypothesis that the cement workers have the same prevalence as control group B, using the Fisher's exact test.

A study of the mortality was conducted of all workers employed at least 5 years, sometime during 1950-1960 at 23 cement plants. Plants were included if they had been operating prior to 1950; in 1977 there were 48 such plants. Work histories were abstracted from company records, and 5,292 men met the inclusion criteria. Vital status was traced to Dec. 31, 1979, for 99.2% of the workers. The mortality experience of the white male cohort was compared to U.S. white males using a man-years analysis.

SMR's were not increased for neoplastic diseases, cardiovascular diseases, or non-malignant respiratory diseases. The SMR was computed with respect to tenure in a cement plant and was not significantly increased for any selected cause of death considered. The only significant finding was an increased SMR (357) from stomach cancer during 1965-1969, but this was based on a small expected number of deaths and could have been a chance occurrence. Additionally, the odds ratio for stomach cancer was not increased in a case-control analysis under control for nativity. The 1965-69 excess is probably explained by chance or by nativity as the SMR was only increased among those born before 1900. The nationality of one half of the stomach cancer cases who were born before 1900 was European or Mexican, while the nationality of all cases born after 1900 was the United States.

Conclusions are as follows:

1. There is no convincing evidence that U.S. cement workers are at risk of mortality from all causes, lung cancer, stomach cancer, non-malignant respiratory disease, or heart disease.
2. The DRDS morbidity study showed an association between cement plant exposure and symptoms of bronchitis, but exposure was not associated with airways obstruction. Results from the mortality study are consistent with the morbidity study. Chronic bronchitis in the absence of airways disease has not been found to be associated with premature mortality in other studies.
3. The increased stomach cancer risk in 1965-69 is probably a chance occurrence or explained by non-occupational factors. More work is needed, e.g., a larger number of cases would provide better statistical power and better control for gastric cancer risk factors.

## 2. Morbidity Study

The cement morbidity study was a cross sectional study which included 16 cement plants and 10 non-cement plants (soft drink companies, various machine or electrical parts manufacturing plants, and a dairy).<sup>(12)</sup> The cement plants were selected by stratifying on process type and age of the oldest kiln (Table IV). Two thousand seven hundred and thirty-six of the 2,738 workers examined were used in the study. The corresponding number of controls was 755. Because chest radiographs were not taken on these controls, a second nonexposed group of 1458 subjects from low expo-

sure plants in North Carolina (food and drink companies, synthetic textile mills, and electrical equipment manufacturing plants) was used for comparison with respect to radiographic abnormalities.<sup>(13)</sup>

A modified version of the MRC questionnaire was administered and simple spirometry was performed using methods recommended by the American Thoracic Society. After adjusting for confounding variables (age, smoking, etc.), using linear logistic analysis for symptoms and radiographic data and linear models analysis for ventilatory function data, the following results were obtained.

1. Cement workers had more dyspnea (odds ratio = 1.60), rounded opacities (odds ratio = 4.67), irregular opacities (odds ratio = 6.45), and pleural abnormalities (odds ratio = 5.03) than controls. Ventilatory function, however, was similar to that of controls, as were cough, phlegm, and other symptoms.
2. Crude prevalences by smoking status indicated that the excess radiographic abnormalities were confined to smokers and possibly ex-smokers (Table V).
3. Phlegm, wheezing, pleural abnormalities, and peak flow were related to amount of exposure.

Although a few symptoms appeared to be related to cement plant exposure, there was no consistent pattern. Ventilatory function was even less affected. The strongest effects were for radiographic abnormalities. However, even these had low prevalences, and no evidence of a relationship with asbestos could be found. Thus it was concluded that there was not sufficient evidence to suggest a change in the exposure limit for cement dust.

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