THE CURRENT STATUS OF SILICOSIS IN HARD ROCK MINING

Marcus M. Key, M.D.
Assistant Surgeon General
Director-Bureau of Occupational
Safety and Health

Howard E. Ayer
Assistant Director-Division
of Epidemiology and Special
Service, Bureau of Occupational
Safety and Health

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Silicosis among metal miners is an ancient disease, probably as old as mining itself. However, the primitive forms of mining were not productive of much silica dust, and the short life span of slaves used in mining probably precluded the development of more than a few sporadic cases of silicosis. Early diagnostic terms of miners' asthma and miners' phthisis suggested an occupational relationship and a tubercular component, but little attention was given to silicosis until the turn of this century when epidemics of silico-tuberculosis arose due to the great expansion of the mining industry in the United States, especially silver and gold mining.

The expansion was accompanied by mechanization and the introduction of pneumatic tools, which generated increasing amounts of fine silica dust. Mining communities were crowded and hygiene was poor. The tubercle bacillus would probably have flourished even without the predisposition of silicosis. As is so often the case in occupational health, biostatistical analyses first called attention to the problem, and environmental-medical studies later confirmed its existence. The bio-statistical analyses were occupational mortality statistics compiled by the Prudential Life Insurance Company in 1907, showing evidence of excessive mortality from tuberculosis and relationship to dust exposure.[1] The environmental-medical studies were undertaken in 1913-15 in the lead and zinc mining industry in the Joplin, Missouri, Mining District by the Public Health Service and the Bureau of Mines.[2] This study showed that two-thirds of the miners had silicosis and a high percentage of these had pulmonary tuberculosis. Dust exposures were massive compared to present day levels. Over the next two decades, similar studies were made in the Butte, Montana, District,[3] the Tri-State District of Oklahoma, Kansas, and Missouri,[4] and in Nevada, and California.[5] The results confirmed that silicosis was widespread and led to a National Silicosis Conference in 1936.[6] This Conference and its committee reports helped to define the etiology of silicosis and its relationship to tuberculosis and to recommend medical and engineering control methods. The medical controls were preemployment and periodic chest X-ray examinations. The engineering controls were wet drilling and ventilation. To monitor the effectiveness of engineering controls, measurements of airborne dust were necessary, and the chest X-ray examination served as the ultimate test of dust control.

The definition of silicosis in the 1930's is still applicable, but the theory of pathogenesis has changed. Silicosis was and is defined as a chronic dust disease of the lung caused by the pulmonary retention of particulate silica in the free crystalline state. The original "mechanical" theory of pathogenesis--that silica acts because of hardness and sharpness--has been discredited. A later theory--that the action is by chemical toxicity--is still plausible, but the most recent theory involves an immunologic mechanism.[7] Pulmonary infection, either tubercular or non-specific, is thought to play a role in the development of the complicated form of silicosis.[8]

By the end of the 1930's a large part of the metal mining industry had instituted major dust control practices. The onset of World War II brought about a certain amount of backsliding in the industry, and imposed major difficulties in the followup of preventive practices and in furthering research and studies on silicosis in metal miners.

In 1954, the Public Health Service began a revaluation of silicosis. A study of compensation and other records indicated that during a 5-year period, 1950-54, 10,362 cases of silicosis had been compensated or reported in 22 States from all industries.[9] Of those cases for which adequate employment histories were available, about

25% were accounted for by metal mining.

This revaluation gave rise to the 1958-61 Public Health Service-Bureau of Mines study of silicosis among metal miners, which was the last in-depth study of this problem in the United States.[10] The environmental phase was conducted by the Bureau of Mines and included 67 underground mines employing approximately 20,500 persons--14,000 of whom worked underground and 6,500 in surface operations. At the time of the study this group represented more than 50% of the working population of underground metal mines in the United States. The medical study included employees from 50 of the 67 metal mines and a large number of uranium mines. The mines included in the study represented virtually all metals mined in commercially significant quantities and represented all principal mining methods.

Of the 14,000 miners examined, 3.4% had X-ray evidence of silicosis and about one-third of these had the complicated form of the disease. This was in marked contrast with the prevalence revealed by earlier studies. Silicosis in the 1958-61 study was usually confined to older miners with more than 15 years experience, and there was no evidence of silicosis in miners under 35 years of age. Over one-half of all silicosis cases occurred among men who were classified as face workers.

The X-ray findings of typical silicosis showed a "snowstorm" of shadows in the lung fields which contrasted with the general absence of symptoms in the simple cases. The cardinal symptom in early silicosis was shortness of breath on exertion. Late symptoms, especially in the complicated form of the disease included cough and sputum, wheezing, and increasing breathlessness.

Pulmonary function testing was often normal in the early cases, but as a group simple silicotics had more airway obstruction than non-silicotics, and complicated silicotics had more than simple. Decrements in venilatory function were also observed for age and cigarette smoking.

In the 1958-61 Metal Mines Study, as in previous studies, dust concentrations were also measured. Actual quantitative assessment of dustiness in mines dates back to 1916, when the Kotze Konimeter was introduced in South Africa. The Greenburg-Smith Impinger is almost as old, going back to 1922.[11] With both these instruments, brief samples are taken and microscopic counts are made of collected dust particles. The "standard" dust sampling instrument in this country has been the impinger, in either the original one cubic foot per minute (cfm) model or the 0.1 cfm midget impinger.[12]

The dust sampling teams in the 1958-61 Metal Mines Study took 14,837 midget impinger dust samples underground, from which they determined 789 weighted average dust exposures. There was little past data on dustiness in these mines, and it was known that dustiness had been much higher prior to institution of dust controls in the 1930's. Therefore, a relationship between dustiness and silicosis was not attempted, although the medical and environmental data were far more extensive than those from which current dust limits were developed.

The silica dust limits in the United States come from a 1929 study in Barre, Vermont, granite cutting sheds.[13] In that 1929 study there were 220 dust counts, and 503 workers were given physical examinations. In exposure Group A, in which dust concentrations averaged 60 million particles per cubic foot (mppcf), all of the workers had at least early silicosis after 4 years exposure. In the "safe" Group D, there was one case of silicosis and two of early silicosis in 12 workers examined. There were 20 dust counts at Group D operations. In the 1958-61 Metal Mine Study, 87% of the 789 weighted average exposures determined underground would have fallen in Group D in the granite study; and only 4% in Groups A and B.

It was the judgment of Bureau of Mines personnel investigating environmental conditions in the 1958-61 study that the almost 15,000 dust samples were insufficient to classify the mining population by degree of dust exposure. More than 16 samples were required to determine each weighted average exposure. That amounted to one man-day of dust sampling and one man-day of dust counting for determination of each man-day of miner dust exposure. The expense and time involved in conducting such an environmental study is one reason why the silicosis study in metal mines has not been repeated since 1961. New, more efficient methods of determining weighted average dust exposures were required.

One way to increase efficiency of dust sampling is to take fewer samples, but have each sample include a full day of dust exposure. In the 1950's several developments occurred which made such a sampling method possible. The availability of rechargeable nickel-cadmium batteries led to the development of compact battery-operated sampling pumps which could be worn on the belt or carried in a pocket.[14] Dust collectors were developed that would remove "large" dust from the air in the same proportion as the protective areas of the human respiratory tract (nose, trachea and larger bronchi) remove them.[15] The fine dust passing one of these collecting devices would represent respirable mass method of dust sampling was adopted by the Bureau of Mines as a standard method for coal mine dust sampling in 1970, and sampling devices for coal mine dust sampling are now jointly approved by the Bureau of Occupational Safety and Health and the Bureau of Mines.

The routine coal dust sampling method can be used only for dust with less than 5 percent quartz. For the higher silica dust in metal mines, the limit will usually be 1 mg/m^3 or less (too small for routine weighings) and a quartz analysis of each sample will be necessary. Fortunately, relatively rapid, sensitive methods of quartz analysis have recently been developed, so that one man with an X-ray diffraction apparatus may be able to determine as many as 15-20 weighted average quartz exposures per day. This compares with the one weighted average dust exposure per day which can be done by counting 16 impinger samples.

There thus exists the possibility of simpler, more frequent monitoring of dustiness in metal mines. As far as we know, these methods are not yet being used to any extent in the metal mines. Nor do we know the extent to which miners are being followed by adequate medical examination procedures. To make appropriate recommendations, we should have some idea of the current incidence of silicosis among metal miners.

Certainly, as already pointed out, the silicosis problem is much less than it was 50 years ago, or even 30 years ago. Comparing prevalence in miners with 10-19 years at metal mines there was 13% silicosis in 1939 and 4% in 1960. For those with 20 or more years in metal mines the prevalence was 31% in 1939 and 18% in 1960. But 18% with silicosis is still more than we are willing to accept, particularly when one of three face workers with more than 30 years mining had silicosis in 1960. Much of this silicosis must have been due to the higher dust exposures prior to dust controls, but the 1958-61 investigators concluded that "...in recent years silicosis has been developing at a considerably slower pace than formerly, but that cases were still occurring."

Other indicators suggest that the situation as regards silicosis now is improving slowly, if at all. In Montana there were an average of 624 silicosis cases being paid benefits in 1950-54; and an average of 605 in 1963-67;[19] although in the later period the number employed in mining was only two-thirds that employed in the earlier period.[20]

The proportion of Social Security Disability awards for respiratory diseases in the metal mining States is elevated. In 1966, for those States (excluding Minnesota) in which more than 1% of the workers were in metal mining,[21] the disability awards for respiratory diseases averaged 10.6% of all awards, compared with 7.8% for the country as a whole.[22] And the Social Security awards may only be the tip of the iceberg, for the slower development of silicosis in recent years means that many--probably most--of the silicosis disabilities are occurring past age 65, where Social Security disability awards are not made.

A postponement of health effects until retirement is no longer an acceptable objective. The Occupational Safety and Health Act of 1970 directs the Secretary of Health, Education, and Welfare to "develop criteria..which will describe exposure levels..at which no employee will suffer impaired health or diminished life expectancy as a result of his work experience." It also directs "...studies of the effect of...exposure to industrial materials, processes, and stresses on the potential for illness, disease, or loss of functional capacity in aging adults." The Federal Coal Mine Health and Safety Act of 1969 likewise directed the Secretary of Health, Education, and Welfare to "establish...a level of personal (dust) exposure which will prevent new incidences of respiratory disease and the further development of such disease in any person." Neither of these Acts applies to metal mining, but it is clear that the Congress believes that no preventable occupational disease should occur at any age.

We have described the basis for present standards for silica dust. The margin of safety of these standards, or whether there is a margin of safety, is not known. For silicosis cases now occurring, it is not known whether the cases occur because miners were exposed for considerable periods of time above the limit, or whether the limit is inadequate in some respect.

The general research authority given to the new National Institute for Occupational Safety and Health, which comes into existence on April 28, may be used to look into these apparently continuing health problems of metal miners. Any such study would be conducted only after consultation with the Bureau of Mines, the Federal agency exercising statutory authority to prescribe standards affecting occupational health in metal mines. Resurveys of the metal miner health problems at 5-year intervals were recommended in the report on the 1958 to 1961 study, and a resurvey, even though belated, will undoubtedly be a high priority item for the new National Institute.

With or without such a research study to examine the health of miners and the adequacy of existing dust limits, it is the obligation of metal mine operators to do all possible to protect miners against silicosis. Appropriate dust control measures should be taken to reduce dust concentrations. The concentrations existing after dust controls should be monitored by air sampling. All operations should be kept as much below current dust limits as available technology will permit. Medical examination programs including preplacement and periodic chest X-rays should be continued or instituted at all mines. Similar recommendations have been made after each major study of silicosis in the metal mining industry, and are just as applicable today.

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