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Preventing pneumoconioses and eliminating silicosis: opportunities and illusions

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Introduction

In 1930 the first of this series of ILO-sponsored conferences was held in Johannesburg, South Africa. It was called the International Conference on Silicosis and focused on the need to do something about this disease that was rampant throughout the world. Recommendations for improved recognition and prevention of silicosis resulted from that meeting. While much has been achieved since that conference, it is still fitting to begin this 9th International Conference on Occupational Respiratory Diseases with consideration of where things stand in the area of silicosis prevention. I will begin by briefly describing silicosis-relevant experience from the USA, then move on to some of the basic questions we must confront to make further progress on silicosis elimination:

1. Why should we care about silicosis in 1997?
2. What are the results of international silicosis prevention efforts?
3. Why is silicosis prevention so difficult?
4. What would silicosis elimination mean?
5. How can the barriers to silicosis elimination be overcome?

Silicosis persists worldwide, despite long-standing knowledge of its cause — excessive exposure to respirable crystalline silica — and extensive knowledge of the means to control it. The historical experience of the USA is instructive. Silicosis came to national attention in the 1930s when hundreds of tunnelers died from acute and accelerated silicosis as a result of working on a hydroelectric project in Gauley Bridge, West Virginia. The infamous Hawk's Nest Tunnel was created by cutting through over 3 miles of high-quartz sandstone [1]. Although long recognized nationally and internationally as an important disease, the enormity of the tragedy at Hawk's Nest brought governmental hearings and a commitment to respond.

Part of the response was the convening of the first National Silicosis Confer-

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ence by then US Secretary of Labor, Francis Perkins [2]. An expert scientific report on silicosis prevention resulting from that conference indicated that the technologies for prevention had been developed but were not adequately applied. As Secretary Perkins subsequently observed, "Our job is one of applying preventive techniques and principles to every known silica dust hazard in American industry. We know the methods of control — let us put them into practice." The US Department of Labor made silicosis prevention a priority and disseminated technical and educational information.

Progress was made, and by the 1950s, experts were attributing current silicosis cases to past exposures: "...the current opinion [is] that most of the cases of silicosis represent a residue of old cases." [3]. Unfortunately, the declaration of victory was premature. Workplace overexposures continued, inevitably leading to new cases through the subsequent decades.

In the 1960s, the lung diseases of underground coal miners, particularly silicosis and coal workers' pneumoconiosis, received national attention. Prevention became a national priority embodied in legislation passed at the end of the decade.

By 1974, the recently formed National Institute for Occupational Safety and Health (NIOSH) issued recommendations on protecting workers from the risk of silicosis. Based on a review of the scientific literature, NIOSH recommended limiting exposure to 50 $\mu g/m^3$ through effective work practice modification and control technologies [4]. Recommendations focused on product labeling, housekeeping, health and hazard surveillance, and the use of protective equipment. In addition, NIOSH recommended abandonment of sand as an abrasive blasting agent because of the inherent hazardous nature of sandblasting.

Nevertheless, through the 1970s, 80s, and 90s, silicosis has continued to be recognized in surface miners, abrasive blasters, quarriers, rock drillers, construction workers, foundry workers, and others [5–7]. While the number of recorded deaths with silicosis fell steadily through the 1970s and into the 80s, these numbers have stabilized at over 200 deaths per year (see Fig. 1). As a result of concern about continuing death and disease from excess silica exposure, the US Departments of Health and Human Services (DHHS) and Labor (DOL) have joined with one another, and with numerous partners in industry and labor, to work on a national program for silicosis elimination. This national program is part of a growing international effort to eliminate silicosis throughout the world and is sponsored jointly by the International Labor Organization and the World Health Organization.

Why should we care about silicosis in 1997?

Crystalline quartz causes lung diseases that are often disabling and potentially fatal. In absolute numbers, deaths from silicosis in most countries are few compared to other conditions of significant public health interest. However, in order to better understand the dimensions of the problem, it is important to focus on

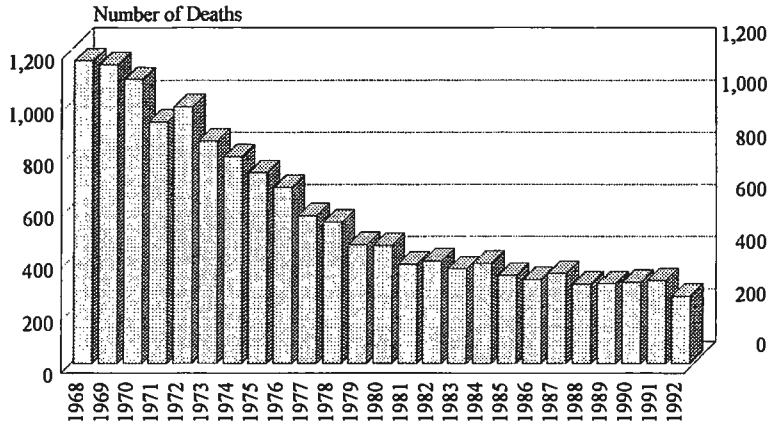

Fig. 1. Silicosis: number of deaths recorded on death certificates, US residents aged 15 years and over, 1968—1992. (Reproduced from [14].)

those truly at risk of disease. There are approximately 200,000 US workers exposed to respirable crystalline silica at or above the NIOSH recommended limit of 50 $\mu g/m^3$. For these workers, rates of both silicosis death and silicosis incidence are high, exceeding rates for prostrate cancer, female breast cancer, AIDS, firearm injuries, and childhood cancers in the populations at risk for those other conditions (see Fig. 2).

We are interested in increased prevention efforts, not only because of the significant impact on the population at risk, but also because of the other conditions associated with excess silica exposure. Like many occupational dusts, respirable silica causes accelerated loss of lung function. In addition, tuberculosis risk is increased in people with silicosis and probably increased in those exposed to silica. This risk takes on added importance in light of the current experience with multiple drug resistant tuberculosis. Furthermore, the International Agency for Research on Cancer recently classified crystalline silica from occupational sources as a carcinogen: "There is sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or crystabolite from occupational sources." [8].

What are the results of international silicosis prevention efforts?

Many countries have focused on silicosis prevention as a significant occupational health/public health goal. Some have met with significant success while others have found prevention efforts more challenging. There is no single ongoing source of international data on mortality or morbidity from silicosis. Nevertheless, information from various countries, while collected and reported without strict comparability, provides useful context as we move toward international cooperative efforts in silicosis prevention. As in the US, many countries showed significant reductions in reported or compensated cases of silicosis through the 80s (see

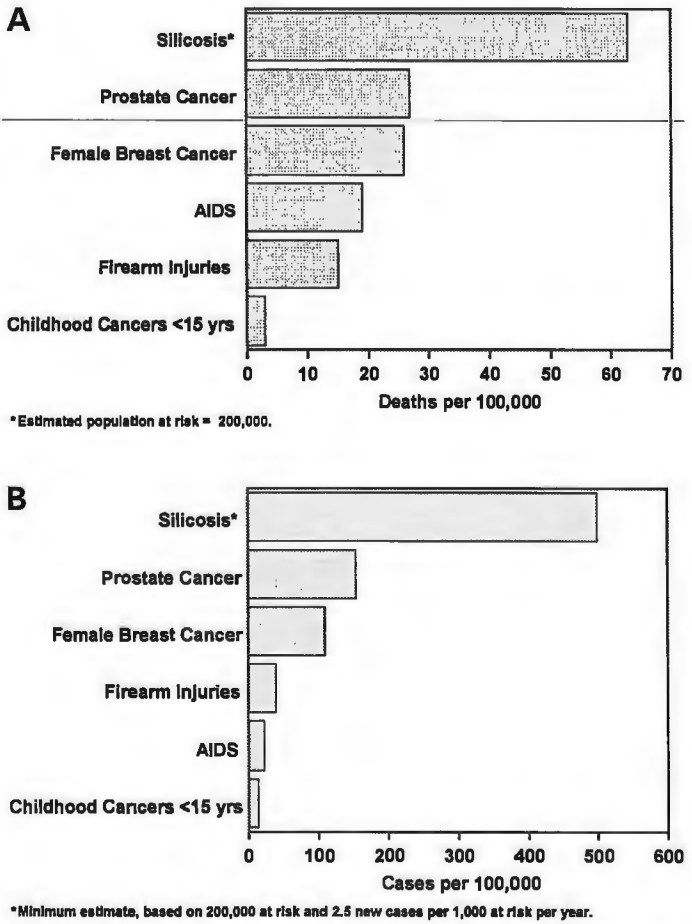

Fig. 2. Mortality (**A**) and morbidity (**B**): selected conditions, USA, 1994.

Fig. 3). The absolute numbers of new cases recognized in Sweden, Finland, and Switzerland are impressively few. Data from Germany, France, Poland, and the UK show similar patterns but with larger absolute numbers.

China, with by far the largest number of recognized silicosis cases, has engaged in a massive national campaign for silicosis prevention. The results of the effort can be expected to be seen in the coming years (see Fig. 4).

On balance, the collective experience from both the industrialized and industrializing world suggests that there are effective prevention strategies which, if applied, can result in documentable reductions in silicosis incidence and death.

One clear target of prevention efforts should be abrasive blasting that uses silica sand. This is an inherently hazardous process creating fine particles of biologically active respirable dust. Even well-designed personal protective equipment inevitably fails to protect workers adequately. Abrasive blasting with silica sand frequently causes death and serious disease from acute and accelerated silicosis.

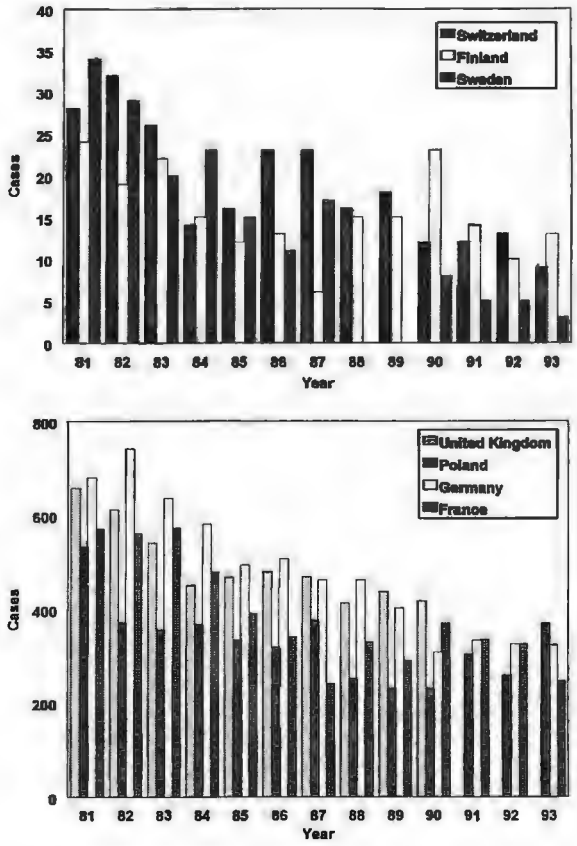

Fig. 3. Silicosis incidence.

There are economically and technologically feasible alternatives to the use of quartz for abrasive blasting. International experience demonstrates significant

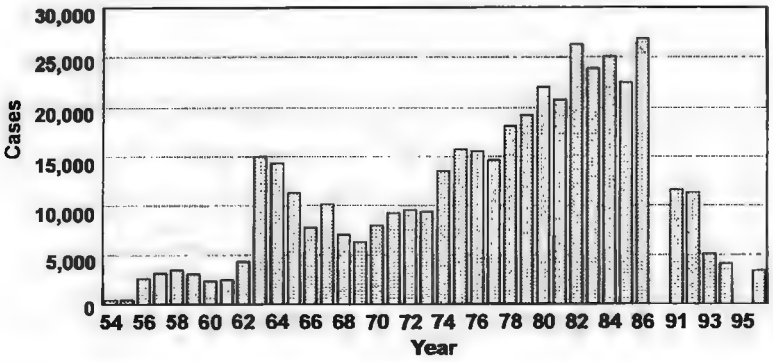

Fig. 4. Newly diagnosed cases of silicosis in China.

reductions in silicosis in regions where blasting with quartz has been banned or severely restricted.

Why is silicosis prevention so difficult?

Silicosis is remarkably resistant to total elimination. There are a diversity of possible reasons for this, some country-specific or pertinent to certain regions, and others more general. The most basic explanation for the persistence of silicosis is the potential for silica exposure wherever materials from the earth are mined, quarried, milled, or used. However, there are other important reasons that silicosis prevention is so difficult.

First, most silica effects occur after a long latency, or lag time, between exposure and disease. Except for acute or accelerated silicosis resulting from egregious exposure conditions, the disease we see today is often a result of conditions from the past and it is therefore tempting to attribute current disease to conditions that have already been controlled. Nevertheless, studies in the USA and elsewhere confirm that work place investigations triggered by silicosis case reports often discover conditions of continuing overexposure [9].

Second, recent scientific studies investigating exposure-response relationships, particularly those considering the development of silicosis after cessation of exposure and after retirement, confirm that crystalline quartz exposure even at moderate levels within current legal standards, pose significant health risks [10,11]. In addition, recent investigations of surface characteristics of quartz particles demonstrate higher levels of surface radicals and greater health risk from freshly fractured silica particles when compared to aged silica [12]. It is not surprising that drilling through quartz and using sand as an abrasive blasting agent have been found to be extremely hazardous or that countries severely restricting or banning the use of sand as an abrasive blasting agent have had the greatest success in controlling and preventing silicosis.

But the barriers to prevention posed by the ubiquitous and hazardous nature of respirable crystalline silica only partially explain the difficulty in preventing silicosis. There are significant economic, legal, social, and political barriers to prevention, as well. Quartz-containing materials are often relatively inexpensive, plentiful, and useful. Their use is critical to economic development, and the availability of adequate control technologies or protective equipment may be limited. There may be widespread ignorance of the continuing hazard posed by silica exposure, and the prevention of this chronic disease may seem less compelling than other more acute problems.

What would silicosis elimination mean?

The International Labour Organization (ILO) and the World Health Organization (WHO) have joined together in a commitment to eliminate silicosis. This word was chosen carefully and contrasts with the word eradicate which was the

goal of the successful worldwide effort against smallpox. To eliminate means to remove, to get rid of. Elimination implies that there is a possibly of recurrence even after the problem appears to be gone, in contrast with the concept of eradication, which implies that once the problem is gone it will not return. Since the potential for harmful exposure will continue no matter how successful prevention efforts are, the word elimination recognizes the need for a continuing process aimed at combating disease.

Silicosis elimination requires the control of exposures to eliminate current conditions which, if continued, would inevitably lead to future cases of silicosis. Silicosis elimination depends upon an effective and continuing commitment to a comprehensive process of disease prevention, including the following components: anticipation and recognition that a hazardous agent might be present; determination of the level of risk through evaluation of the work environment; control of the exposure through substitution of safer materials, effective engineering controls, and supplementary personal protective equipment; and ongoing monitoring to assure that exposures remain in control.

Anticipation requires knowledge of what materials contain quartz and what work activities liberate respirable silica. Anticipation is assisted by clear and effective product labeling with language or symbols understood by the workforce. Recognition of health risk requires exposure and process monitoring when hazardous exposures are present. Regulation and enforcement assist and provide impetus for the recognition and control of hazardous environments. Training and education of employers, workers, and inspectors is another essential prevention component.

Once a hazard is recognized, and ideally before disease is present, the work environment including equipment and the industrial process should all be evaluated. The evaluation of the health of the workforce can provide supplementary information but should not be used as a substitute for evaluation of the work
ınment.
:e these factors are evaluated, controls should be implemented. If possible,
should be substitution of less hazardous materials or elimination of the
ł altogether. If it is necessary to continue working with quartz-containing
ials, engineering and administrative controls should be implemented. Per-
protective equipment should be used only temporarily until other more
ve controls can be put in place.
:r controls are implemented, it is necessary to have ongoing hazard and
ı surveillance to assure the adequacy of the control program. Hazard sur-
ıce involves the periodic collection, analysis, and reporting out of informa-
bout potential health hazards for the purposes of prevention. There must be ongoing evaluation of trends in quartz-exposure levels to assure that exposure is minimized. It is only through comprehensive and continuing hazard surveillance that we will be assured that silicosis (risk) has been eliminated. Health surveillance can provide additional useful information to assure the continued health of the exposed group. Recommendations for establishing programs of

medical screening and surveillance of workers exposed to mineral dusts have been published recently [13].

Overcoming the barriers to silicosis elimination

While the technical and scientific approaches to silicosis prevention are standard, well-defined and well validated, critical nontechnical barriers to prevention may be more resistant to attack. Workers and employers must build the knowledge, skills, attitudes, and beliefs necessary to recognize silicosis as an important target for preventive efforts. Any real or perceived economic advantage of putting the health of workers at risk must be overcome. Effective legislation, regulation, and inspection are also necessary, but not sufficient, for silicosis elimination. There will never be enough inspectors to assure workplace hazards are under control. Employers, workers, and their representatives, must join together with government agencies to focus on this problem. The effort requires an ongoing commitment to continuous improvement in controlling exposures.

Conclusions

1. Silicosis remains a significant problem in many countries and regions. For those working in environments with exposure to respirable crystalline silica, silicosis risk may be significantly greater that the risks of other common and important diseases.
2. Failure to control current exposures to crystalline quartz will inevitably lead to future cases of silicosis.
3. Effective exposure control methods are well known and widely available.
4. Regulation, inspection and enforcement are necessary, but not sufficient, for silicosis elimination.
5. Barriers to prevention must be understood, confronted, and overcome.
6. Exposure monitoring and targeted intervention are key to progress.
7. Banning abrasive blasting with crystalline quartz is an important, significant step toward prevention.
8. National and international cooperation is needed to develop, disseminate and adopt effective strategies for silicosis prevention in order for silicosis elimination to become a reality.

Many examples of successful efforts to reduce, control, and elimination silicosis prove the possibility of achieving this goal. The persistence of this often disabling and sometimes deadly disease highlights the importance of a continuing commitment to prevention. Successful international elimination will require continual vigilance and commitment.

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References

1. Cherniack M. The Hawk's Nest Incident. America's Worst Industrial Disaster. New Haven, London: Yale University Press, 1986.
2. Rosner D, Markowitz G. Deadly Dust. Silicosis and the Politics of Occupational Disease in Twentieth-Century America. Princeton, NJ: Princeton University Press, 1991.
3. Trasko VM. Some facts on the prevalence of silicosis in the United States. AMA Arch Indust Health 1956;14:379–386.
4. US Department of Health, Education, and Welfare. Criteria for a Recommended Standard – Occupational Exposure to Crystalline Silica. HEW Publication No. (NIOSH) 75-120, 1974.
5. US Department of Health and Human Services. ALERT. Request for Assistance in Preventing Silicosis and Deaths in Construction Workers. DHHS (NIOSH) Publication No. 96-112, 1996.
6. US Department of Health and Human Services. ALERT. Request for Assistance in Preventing Silicosis and Deaths from Sandblasting. DHHS (NIOSH) Publication No. 92-102, 1992.
7. US Department of Health and Human Services. ALERT. Request for Assistance in Preventing Silicosis and Deaths in Rock Drillers. DHHS (NIOSH) Publication No. 92-107, 1992.
8. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Silica, Some Silicates, Coal Dust and para-Aramid Fibrils Volume 68, pp. 24 and 210. Geneva, World Health Organization, 1997.
9. Valiante DJ, Rosenman KD. Does silicosis still occur? JAMA 1989;262:3003–3007.
10. Steenland K, Brown D. Silicosis among gold miners: exposure-response analysis and risk assessment. Am J Pub Health 1995;85:1372–1377.
11. Kreiss K, Zhen B. Risk of silicosis in a Colorado mining community. Am J Ind Med 1996; 30:529–539.
12. Vallyathan V, Castranova V, Pack D, Leonard S, Shumaker J, Hubbs AF, Shoemaker DA, Ramsey DM, Pretty JR, McLaurin JL, Khan A, Teass A. Freshly fractured quartz inhalation leads to enhanced lung injury and inflammation. Am J Respir Crit Care Med 1995;152:1003–1009.
13. Wagner GR. Screening and Surveillance of Workers Exposed to Mineral Dusts. Geneva, World Health Organization, 1996.
14. US Department of Health and Human Services. Work-related Lung Disease Surveillance Report, 1996. DHHS (NIOSH) Publication No. 96–134.