Risk analysis

Silicosis in the twenty first century

D Sherson

The current permissible exposure limit is inadequate to protect workers

Silicosis (Latin, *silex*, flint) is perhaps the oldest occupational disease, probably existing in the paleolithic period. Hippocrates and Pliny refer to the disorder. Some of the most tragic and wanton examples of occupational disease were due to silicosis, for example, how table blade grinding in Sheffield (1886) robbed workers of 25 years of life, or the Gauley Bridge disaster in West Virginia (1931). Perusing a recent standard pulmonary medicine textbook would suggest that simple silicosis is no longer a problem as it is "not associated with impairment or disability and even without effect on longevity in many although not all".[1] Case closed, the silicosis story is over, or is it?

In this issue of *Occupational and Environmental Medicine*, t' Mannetje and coworkers answer this question with an elegant and resounding "no"![2] In a carefully designed pooled analysis a clear exposure-response relation for silicosis and mortality is shown. Increased mortality is also seen at exposure levels below the current US Occupational Health and Safety Administration's permissible exposure limit (PEL) of 0.10 mg/m^3 for respirable crystalline silica. This conclusion is the culmination of considerable new knowledge concerning dose-response relations and methodological developments in the past few decades. New knowledge has accumulated concerning associations between silica exposure and pneumoconiosis, *Mycobacterium tuberculosis*, and chronic obstructive pulmonary disease. A key development has been the classification of silica as a human carcinogen (class 1) in 1996 by the International Agency for Research on Cancer (IARC).[3] One of the silicosis related disappointments at the close of the past century was the failure to develop new treatments for pulmonary fibrosis based on the once promising tetrandrine and polyvinylpridine-N-oxide research.

All silicosis related questions have not yet been answered. There is a need for improved radiographic diagnosis of silicosis. Experience from asbestos has shown that negative chest radiographs do not exclude the presence of pathologically demonstrable interstitial fibrosis.[4] Accurate and standardised chest radiographs are key in the diagnosis and prevention of silicosis. The International Labour Office's existing guidelines and standard radiographs are over 20 years old. The new ILO digitised version is being prepared and will hopefully be available in the near future. Standardised chest radiographs are not only helpful in diagnosing pneumoconioses, but also other forms of interstitial lung disorders. There is increasing experience with the use of high resolution computed tomography (HRCT). HRCT appears to be more accurate in the assessment of mild cases of pneumoconiosis and can show nodular changes not seen with traditional radiographs. There have been preliminary attempts at standardising the use of HRCT in pneumoconioses. The use of spiral CT in patients with pneumoconioses is totally untested.

> "There is a need for improved radiographic diagnosis of silicosis"

Existing literature and data can be reviewed in four ways: traditional narrative reviews, meta-analyses of published studies, as well as retrospective or prospective pooled analyses of indivdual data. Experience with the new generation of observational epidemiologic studies, pooled analyses, has increased considerably since initial attempts 40 years ago. Occupationally related pooled analyses have been used to study effects of, for example, lead, pesticides, styrene, man made mineral fibres, and asphalt fumes. The first pooled exposure-response analyses for lung cancer and silica exposure were recently published by IARC.[5] Silica as an occupational carcinogen was reconfirmed, with excess lung cancer risk observed at levels of exposure below the current PEL. However, it is not known whether this type of retrospective pooled analysis can reduce the classic types of bias: selection bias, information bias, and confounding variables. Confounding by smoking or other occupational carcinogens as well as possible exposure misclassifications are some of the partially unsolved difficulties. Retrospective studies can have difficulties with lost data, original investigator recall bias, as well as varying definitions of subject characteristics and storage data methods. In the current retrospective study,[2] accurate radiological diagnoses and correct registration of cause of death were not validated. One study was excluded because of death certificate registration inaccuracies. With increasing international cooperation, more prospective pooled analyses are needed, with their important advantages of standardised study design, data collection, and analytical methods, with increased validity and reliability.

> "The age old question of individual susceptibility remains unanswered"

The genetic revolution of the twentieth century was not able to answer the intriguing questions concerning interactions between silica and autoimmune disorders, that were initially described almost 100 years ago. HLA studies unfortunately have not been helpful. Why is there an increased risk of scleroderma in silicotics (Erasmus syndrome) or rheumatoid arthritis in individuals with coal workers pneumoconiosis (Caplan's syndrome)? How can the associations between silica exposure and systemic lupus erythematosus, dermatomyositis, autoimmune haemolytic anaemia, and kidney disease be explained? Why do some individuals develop silicosis, while others with greater exposures do not? How do individual differences in mucosal function, particle deposition, and particle retention effect the development of silicosis or silicosis related disorders? Do individuals with mild forms of cystic fibrosis or α_1 antitrypsin deficiency have increased risk of developing particle related diseases? The age old question of individual susceptibility remains unanswered. Dose-response and pathophysiological aspects of silica related disorders need to be further elucidated. However, the current level of knowledge demands intensified preventive measures.

It has been estimated that approximately 5% (100 000) of the 2 million silica exposed workers in the USA are exposed to silica levels above the current PEL of 0.10 mg/m^3. Silica exposures can still be excessive in some industries, for example, construction, mining, abrasive blasting operations, and foundries. Exposure risks can be much greater in underdeveloped countries. Already in 1974 NIOSH recommended a time weighted average (TWA) of 0.05 mg/m^3 for respirable crystalline silica. Since

Abbreviations: HRCT, high resolution computed tomography; IARC, International Agency for Research on Cancer; ILO, International Labour Office; PEL, permissible exposure limit; REL, recommended exposure limit; TWA, time weighted average

then considerable dose-response data concerning human silica related morbidity (silicosis) and mortality (lung cancer and silicosis) at levels below the current PEL have been accumulated. Based on new data NIOSH has again recommended a REL (recommended exposure limit) of 0.05 mg/m^3.[6] Reducing the PEL from 0.10 to 0.05 mg/m^3 would reduce the estimated lifetime cumulative risk of death from silicosis from 13 per 1000 to 6 per 1000.[2] The current PEL is inadequate to protect workers. Current sampling and analytical methods to evaluate exposure levels of 0.05 mg/m^3 are now available. Thus the evidence now exists and the PEL should be lowered to 0.05 mg/m^3. The study of t' Mannetje *et al* in this issue of *OEM* should be one of the final nails in the current PEL's coffin.

Occup Environ Med 2002;**59**:721–722

Authors' affiliations
D Sherson, Department of Occupational and Environmental Medicine, Vejle County Hospital, Denmark

Correspondence to: Dr D Sherson, Department of Occupational and Environmental Medicine, Vejle County Hospital, 7100 Vejle, Denmark; Davshe@vs.vejleamt.dk

REFERENCES

1 **Murray JF**, Nadel JA, eds. *Textbook of respiratory medicine*. Philadelphia: WB Saunders Co., 2000:1819.
2 **d' Mannetje A**, Steenland K, Attfield M, *et al*. Exposure-response analysis and risk assessment for silica and silicosis mortality in a pooled analysis of six cohorts. *Occup Environ Med* 2002;**59**:723–8.
3 **IARC**. *Monographs on the evaluation of carcinogenic risks to humans: Silica, some silicates, coal dust and para-aramid fibrils. Vol. 68*. Lyon: World Health Organisation, International Agency for Reseach on Cancer, 1997.
4 **Kipen HM**, Lilis R, Suzuki Y, *et al*. Pulmonary fibrosis in asbestos insulation workers with lung cancer: a radiological and histopathological evaluation. *Br J Indust Med* 1987;**44**:96–100.
5 **Steenland K**, Mannetje A, Boffetta P, *et al*. Pooled exposure-response analyses and risk assessment for lung cancer in 10 cohorts of silica-exposed workers: an IARC multicentre study. *Cancer Causes and Control* 2001;**12**:773–84.
6 **NIOSH**. *Hazard review: Health effects of occupational exposure to respirable crystalline silica*. DHHS (NIOSH) publication no. 2002-129. Cincinnati, OH: National Institute for Occupational Health and Safety, 2002.

OEM web submission and review system

I am pleased to inform authors and reviewers of the new online submission and review system at *OEM*. Developed by Highwire Press (CA, USA), *Bench>Press* is a fully integrated electronic system which uses the internet to allow rapid and efficient submission of manuscripts. It also allows the peer review process to be conducted entirely online. The main aim is to speed up the frequently frustrating progress from submission to publication.

Authors can submit their manuscript in any standard word processing software. Standard graphic formats accepted include: .jpg, .tiff, .gif, eps, etc. (Please note: multi page powerpoint files are not accepted by the BMJ Publishing Group.) The text and graphic files are automatically converted to PDF for ease of distribution and reviewing purposes. Authors are asked to approve their submission before it formally enters the reviewing process. On approval, the submission is passed to the editor and/or reviewers via the web. All transactions are secure.

To access the system click on "SUBMIT YOUR MANUSCRIPT HERE" on the *OEM* homepage: http://www.occenvmed.com, or you can access the submission site directly at http://submit-oem.bmjjournals.com.

We are very excited with this new development and would encourage authors and reviewers to use the system where possible. It really is simple to use and should greatly improve on the current peer review process. Full instructions can be found on *Bench>Press* http://submit-oem.bmjjournals.com and *OEM online* at http://www.occenvmed.com. Please contact Natalie Davies, Project Manager, ndavies@bmjgroup.com.

Anne Cockcroft
Editor, OEM