Personal risk factors for silicosis in Hong Kong construction workers

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Silicosis is the most common occupational disease notified in Hong Kong. Annually, up to 200 cases—mostly from the construction industry—are reported. To elucidate the personal and behavioural risk factors for silicosis, we studied 215 silicosis patients in the construction industry and 173 controls from March 1990 through May 1992. We investigated occupational exposure to dust, work practice, education, vocational and safety training, work experience and personal habits (cigarette smoking, alcohol intake). No formal education, no vocational and safety training, current and past smoking, and the use of dust masks were found to be significant risk factors. Because of selection bias in the choice of controls in this study, risk factors identified in the logistic regression model have to be interpreted with caution. In addition to dust suppression on construction sites, on-the-job safety, health training and health maintenance programmes should be provided for construction workers. Health education should be aimed at increasing worker awareness of the danger of fibrogenic dusts, encouraging the proper use and maintenance of effective personal protective equipment, implementing dust supression measures, and discouraging smoking.

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Introduction

Silicosis is the most common occupational lung disease encountered in Hong Kong. For the past 30 years, more than 4000 cases have been notified to the Department of Health.[1] From 1988 to 1993, approximately 150 to 200 confirmed cases were reported annually. The inhalation of excessive concentrations of respirable dust containing free silica is a well-documented cause of silicosis. In Hong Kong, more than 90% of silicosis patients assessed for compensation have worked in the construction and quarry industries.[2,3] The construction industry—the biggest contributor to silicosis cases—is characterised by a dusty work environment, an unskilled labour force and a tight work schedule.[4] There are more than 100 occupations within this industry, many of which involve exposure to dust containing free silica. However, among those exposed, it is not obvious why certain workers develop the disease while others do not, even though they have worked in a similar environment. Risk-taking behaviour and personality types have been studied mostly in non-occupational settings,[5] and few studies on risk perception among labourers have been conducted.

In a study of pesticide risk among migrant farm workers, it was found that self-protective behaviour was most likely in those who received risk information, those with increased perceptions of control over their health and the occupational situation, and those who believed that precautionary methods were effective.[6] In another study among chemical workers, perceived hazards were found to vary directly with the extent of hazard communicated by new product labels.[7] In the prevention and control of silicosis, the use of personal protective equipment is as important as environmental dust control. Hence, it is important

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to determine whether certain personal attributes and worker personality traits are associated with risk-taking behaviour or improper work practice. To answer these questions, we studied 215 silicosis patients in the construction industry and 173 controls from March 1990 through May 1992 to evaluate their occupational exposures to dust, work practices, education, vocational and safety training received, work experience, smoking and drinking habits, and psychometric test scores.

Subjects and methods

During the 18-month study period, 215 silicosis patients (construction industry workers) who had been referred to the Hong Kong Government Chest Clinic, Wan Chai, for treatment and compensation assessment were interviewed. This represented all reported cases of silicosis during the period. Details of their occupational history (with special reference to dust exposure and use of dust masks), safety and vocational training and personal data (age, marital status, education, place of origin, smoking and drinking habits) were taken. Personality traits were assessed using a validated questionnaire (developed by Bortner[8] and translated into Chinese).[9] During the study period, 233 construction workers were invited for free medical and chest X-ray examinations by a team of physicians. After excluding 11 workers with early radiological evidence of silicosis and 49 workers with cardiovascular and pulmonary diseases, a total of 173 healthy controls (defined as a worker without cardiovascular and pulmonary diseases and with a chest radiograph of category 0/0 by the International Labour Organisation 1980 classification)[10] were recruited, and similar information was obtained by interview and psychometric tests.

Data were processed using an SAS program (SAS Institute Inc., Cary, US) on an IBM-4381 (IBM Inc., US) mainframe computer. Odds ratios of risk factors for silicosis were calculated using unconditional multiple logistic regression analysis.[11] The linear logistic model has been specifically developed so that parameters of the model are readily interpretable in terms of odds ratios. It is particularly suitable for case control study settings where the logit transformation of the disease probability is expressed as a linear function of regression variables whose values correspond to the levels of exposure to the risk factors. The odds ratio of a risk factor included in the model corresponds to the

Table 1. Listed occupations of case and control subjects

Occupation (present or previous job)	Cases (%)	Controls (%)	Total (%)
Stone splitter	103 (47.91)	24 (13.87)	127 (32.73)
Caisson worker	74 (34.42)	–	74 (19.07)
Labourer	20 (9.30)	5 (2.89)	25 (6.44)
Excavator	12 (5.58)	–	12 (3.09)
Plumber	1 (0.46)	21 (12.14)	22 (5.67)
Pneumatic driller	1 (0.46)	–	1 (0.26)
Jade polisher	1 (0.46)	–	1 (0.26)
Artisan	1 (0.46)	–	1 (0. 26)
Gemstone cutter	1 (0.46)	–	1 (0. 26)
Brewery worker	1 (0.46)	–	1 (0. 26)
Concretor	–	38 (21.96)	38 (9.79)
Bricklayer	–	3 (1.73)	3 (0.77)
Carpenter	–	31 (17.92)	31 (7.99)
Painter	–	19 (10.98)	19 (4.89)
Electrician	–	1 (0.58)	1 (0.26)
Renovator	–	13 (7.51)	13 (3.35)
Foreman	–	9 (5.20)	9 (2.32)
Heavy load coolie	–	2 (1.16)	2 (0.52)
Steel bender	–	3 (1.73)	3 (0.77)
Blacksmith	–	3 (1.73)	3 (0.77)
Safety officer	–	1 (0.58)	1 (0.26)
Total	215 (100)	173 (100)	388 (100)

exponent of its partial regression coefficient, e^{β}. The advantage of using multiple logistic regression analysis is that independent variables in the model are mutually adjusted for. The following variables were included in our model: age (as adjustment variable), educational level, having received formal vocational training, having received formal safety training, cigarette smoking status, drinking status, years of work in the construction industry, and the use of dust masks during work. Age as a potential confounding variable was included to ensure that the estimates of odds ratios for risk factors under study were free from possible confounding effects, and no specific meaning could be attached to its regression coefficient.

Results

All cases and controls were men with mean ages of 53.7 and 52.4 years, (range, 30 to 84 years and 31 to 77 years, respectively). Both were similar in respect of place of birth and marital status. Many more cases were unemployed compared with controls. Eighty-nine cases (41.4%) are now unemployed, mostly for health reasons and 20 have retired because of age. This contrasted with only seven unemployed and six retired workers in the control group. The cases were predominantly stone splitters and caisson workers (48% and 34%, respectively), and controls consisted mostly of concretors (21%), carpenters (18%), stone splitters (17%), plumbers (12%) and painters (11%) (Table 1). Odds ratios (a measure of the odds of having the disease to not having the disease if the risk factor is present) of risk factors obtained from the multiple logistic regression analysis were age-adjusted and mutually adjusted for each other (Table 2). Significant odds ratios were obtained for the following: no formal education (OR = 10.55), no vocational training (OR = 6.98), no safety training (OR = 4.79), current and past smoking (OR = 2.03 and 5.87, respectively) and the use of dust masks (OR = 0.07). The mean score for the psychometric test among cases was 43.9 (SD = 4.1) and that for controls was 43.4 (SD = 4.5), with no significant difference between the two groups. The odds ratios of selected risk factors for silicosis by stratified analysis are shown in the appendix.

Table 2. Age-adjusted odds ratios of risk factors for silicosis by unconditional logistic regression model

Risk factors for silicosis	Odds ratio (95% CI)
Educational level	
Completed secondary	1
Primary only	1.58 (0.40-6.20)
No formal education	10.55 (2.37-46.95)*
Vocational training	
Yes	1
No	6.98 (3.31-14.71)*
Safety training	
Yes	1
No	4.79 (1.19-19.29)*
Smoking status	
Non-smoker	1
Current smoker	2.03 (1.01-4.12)*
Ex-smoker	5.87 (2.79-12.36)*
Drinking status	
Non-drinker	1
Ex-drinker/current drinker	1.47 (0.85-2.53)
No. of years in construction industry	
Less than 5 years	1
5 to 9 years	1.45 (0.25-8.32)
10 years and more	2.12 (0.59-7.60)
Use of dust mask	
Yes	1
No	0.07 (0.03-0.15)†

*lower limit of 95% confidence interval > 1
†upper limit of 95% confidence interval < 1

Discussion

Although the aetiologic agent of silicosis was well known, we could not find any report on personal attributes and work practices which might contribute to silicosis among those occupationally exposed. Studies on risk-taking behaviour and personality have either focused on sexual behaviour, substance abuse, driving and other activities unrelated to work, or on cardiovascular and other non-occupational diseases among workers.[5,12,13] This study is unique in its assessment of personal and behavioural factors as determinants of silicosis in Hong Kong. We included all confirmed silicosis patients during the study period. Given the long latent period and the often asymptomatic nature of early silicosis, our cases were at a more advanced disease stage. There has been no local study on the incidence of silicosis. However, the number of reported cases has been remarkably stable in past years, suggesting that the report rate offers a reasonable estimate of the true incidence.

With the increased construction activity in Hong Kong, the number of cases and the population at risk will gradually increase in the future. Owing to the mobile nature of construction workers and the absence of a suitable sampling frame, controls could only be chosen from a volunteer group, with its inherent selection bias. Possibly, those who were more concerned about their health, or those who already had some health problems participated in our medical examination (which we offered as a means to obtain controls). There were also problems in ensuring the comparability of occupations in cases and controls, which resulted in selection bias, as different levels of dust exposure were experienced among different job types among both cases and controls.

There were many more stone-splitters among cases than in the control group. All of the caisson workers were cases and we were unable to recruit a single non-silicotic caisson worker as a control. This illustrates the extremely high dust hazard associated with these occupations, as reported in previous studies.[14,15] As these workers were constantly exposed to such high dust levels, it was not surprising that the use of masks was almost universal among this group. Environmental dust assessments showed that even with the use of dust masks, exposure to dust among caisson workers exceeded the recommended threshold value.[13] In our multiple logistic regression model, the odds ratio of 'not wearing dust masks' was significantly lower than unity, implying the wearing of dust masks as a risk factor for silicosis. This superficially anomalous finding could be explained by differences in job categories among cases and controls and the extent of dust exposure (cases being more exposed than controls and more likely to use masks) and possibly, the use of substandard dust masks by most workers engaged in dusty occupations—an observation previously made in a study on work accidents at construction sites.[16] The categories of 'no formal education', 'no vocational training' and 'no safety training' were significant, independent risk factors. Intervention could be of value not only in silicosis prevention, but in occupational health and safety promotion in general. We have examined the individual and combined effects of these variables by entering all possible variable combinations (i.e. any one at a time, any two at a time, and all three) into the model. Only small changes in the numerical value of the odds ratios were observed, but the statistical significance of these three variables persisted. Because all three variables related to education and training showed up as significant risk factors in the multiple logistic regression model, this means that they also act as independent risk factors (the effect of which has been adjusted for). There was a progressive but statistically insignificant increase in odds ratio (from 1.45 to 2.12) with increasing duration of exposure to dust (measured indirectly by the workers' number of years in the construction industry). The absence of a significant dose-response relationship could be due to insufficient sample size or to differences in levels of dust exposure among the many different categories in both cases and controls. For example, caisson workers might develop silicosis sooner than stone-splitters, who in turn might have a shorter latent period than other construction workers.

Although the odds ratio for current smokers was only marginally significant, it was twice that of non-smokers. This could possibly be explained by the association between smoking and other risk-taking behaviour. The fact that ex-smokers had a higher odds ratio for silicosis than did current smokers might be related to the anti-smoking counselling given to our silicosis patients at the Chest Clinic. Another finding worthy of attention was that 76 (35.4%) patients were still working in the construction industry, which implied that if environmental dust hazards were not removed, or if these workers did not adopt effective personal protective measures, their health would deteriorate through continued exposure. The personality trait scores among cases and controls were almost equal, suggesting that Type A or Type B personality profiles were not significant predictors of silicosis.

In theory, silicosis can be prevented by reducing airborne silicogenic dust concentrations to safe levels. Technology is available to achieve a level of 50 $\mu g/m^3$ in most situations. In Hong Kong, as in many developing countries, the rapid pace of construction and the physical constraints of the construction site environment have resulted in either unsatisfactory dust control measures or a complete lack of such measures. In a typical Hong Kong construction site, apart from the occasional use of wet methods, the wearing of dust masks (considered as a last resort in silicosis prevention in most developed countries) is often the only protection available to workers against exposure to hazardous dust levels. Effective methods of dust control include enclosure, isolation, local exhaust, and wet processes. Protective respirators are recommended only as a temporary measure when other control measures are not feasible. Medical surveillance techniques should be implemented, not as primary preventive measures, but for secondary prevention and to verify the adequacy of occupational hygiene standards.[17] The United States National Institute for Occupational Safety and Health (NIOSH) recommends chest X-rays and pulmonary function studies be conducted prior to employment placement and at least once every three years thereafter.[18] A chest X-ray lacks specificity for an individual patient, especially if performed without reference to previous records. However, combined with an occupational history, it is a sensitive diagnostic test for silicosis and is capable of detecting early changes. Remedial action can then be taken to improve the environment of the workplace and protect the worker from further exposure.[19] Although data on cost-benefit analysis are not available locally, regular medical surveillance including chest X-rays and lung function tests for the early detection of silicosis have been emphasized in the Programme of Action on Workers' Health which was endorsed by the World Health Assembly in 1980.[19]

A chest X-ray is useful as a means of detecting silicosis early because of the relatively high prevalence of silicosis among local construction workers. The radiation risk of a chest X-ray to the worker is minimal, and the benefits from the early detection of silicosis are two-fold: firstly, the affected worker is not further exposed to dust and hence the progression of the disease process is halted, and secondly, the management and regulatory authority (Government Labour Department) can act to enforce effective dust control measures. On-the-job safety and health education and training should also be provided to construction workers. These should include health education on the nature and causes of silicosis, the source of silicogenic dust, its relationship to the work process, practical and effective dust suppression measures and the use of a proper, effective and well-maintained dust mask, and education to combat cigarette smoking.

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Appendix

Odds ratios of selected risk factors for silicosis by stratified analysis.

Table i: Vocational training status among cases and controls, stratified by safety training status - No safety training

	Cases (%)	Controls (%)	Total (%)
No vocational training	193 (93.0)	99 (61.3)	292 (80.7)
Had vocational training	15 (7.0)	55 (38.7)	70 (19.3)
Total	208 (100)	154(100)	362 (100)
Odds ratio = 7.1 (95% confidence interval: 3.7-14.0); P < 0.001			

Table ii: Vocational training status among cases and controls, stratified by safety training status - Had safety training

	Cases (%)	Controls (%)	Total (%)
No vocational training	7 (100)	7 (36.8)	14 (53.8)
Had vocational training	0 (0)	12 (63.2)	12 (46.2)
Total	7 (100)	19 (100)	26 (100)
P = 0.005 (Odds ratio cannot be calculated)			

Table iii: Vocational training status among cases and controls

	Cases (%)	Controls (%)	Total (%)
No vocational training	200 (93.0)	106 (61.3)	306 (78.9)
Had vocational training	15 (7.0)	67 (38.7)	82 (21.1)
Total	215 (100)	173 (100)	388 (100)
Odds ratio = 8.4 (95% confidence interval: 4.4-16.2); P < 0.001			

Table iv: Safety training status among cases and controls, stratified by vocational training status - No vocational training

	Cases (%)	Controls (%)	Total (%)
No safety training	193 (96.5)	99 (93.4)	292 (95.4)
Had safety training	7 (3.5)	7 (6.6)	14 (4.6)
Total	200 (100)	106 (100)	306 (100)
Odds ratio = 1.9 (95% confidence interval: 0.5-6.4); P = 0.17			

Table v: Safety training status among cases and controls, stratified by vocational training status - Had vocational training

	Cases (%)	Controls (%)	Total (%)
No safety training	15 (100)	55 (82.1)	70 (85.4)
Had safety training	0 (0)	12 (17.9)	12 (14.6)
Total	15 (100)	67 (100)	82 (100)
P = 0.07 (Odds ratio cannot be calculated)			

Table vi: Safety training status among cases and controls

	Cases (%)	Controls (%)	Total (%)
No safety training	208 (96.7)	154 (89.0)	362 (93.3)
Had safety training	7 (3.3)	19 (11.0)	26 (6.7)
Total	215 (100)	173 (100)	388 (100)
Odds ratio = 3.7 (95% confidence interval: 1.4-9.9); P = 0.004			