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Characteristics of workers attending the pneumoconiosis clinic for silicosis assessment in Hong Kong: retrospective study

香港肺塵埃沉着病診所接受矽肺病評估的工人的特徵：回顧研究

Objective. To describe and analyse the baseline characteristics of workers attending the pneumoconiosis clinic for assessment of silicosis.
Design. Retrospective cross-sectional study.
Setting. Outpatient clinic.
Patients. One thousand and fifty-six patients with silica dust exposure attending the pneumoconiosis clinic for compensation assessment.
Main outcome measures. Baseline demographic characteristics, lung function parameters, and radiographic findings.
Results. Six hundred and forty-eight patients were diagnosed with silicosis, of which 10 were female. Excluding the data on female patients, the mean duration of dust exposure was 24.2 years. The majority of patients were involved in caisson work and stone splitting. Most newly diagnosed patients had simple silicosis. Less than a quarter (24.8%) had progressive massive fibrosis. Lung function parameters at diagnosis were within the normal range. Pulmonary tuberculosis remained an important co-existing disease.
Conclusion. The major cause of silicosis in Hong Kong is chronic silica dust exposure in the construction industry. Simple silicosis predominated at diagnosis, with normal lung function parameters seen in the majority of patients.

目的：描述並分析為檢查矽肺病而到肺塵埃沉着病診所就診的工人的基本特徵。
設計：回顧性橫面研究。
安排：門診診所。
患者：1056 名曾接觸矽土而到肺塵埃沉着病診所索償的患者。
主要結果測量：基礎人口統計學特徵，肺功能參數及放射照相結果。
結果：648名患者被診斷為患有矽肺病，其中10名為女性。不包括女性患者的資料，男性患者接觸矽土平均達24.2年之久。大多數患者與沉箱和採石工作有關。多數新診斷出的病人只有單純矽肺病。少於四份之一(24.8%)的患者累積有大塊的纖維組織。診斷時患者的肺功能參數在正常範圍內。肺結核仍是重要的並存疾病。
結論：香港矽肺病的主要成因是建築業中的長期矽土的接觸。診斷中發現單純矽肺病佔多數，大多數患者肺功能參數屬正常。

Key words:
Hong Kong;
Occupational diseases;
Pneumoconiosis;
Radiography;
Silicosis

關鍵詞：
香港；
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Introduction

The statutory pneumoconiosis compensation scheme was introduced in Hong Kong in 1981. Silicosis remains an important occupational disease in this locality. To date, more than a hundred new cases of silicosis are reported each year.[1] Data concerning the baseline characteristics of workers attending the pneumoconiosis clinic was limited. Knowledge of demographic characteristics, nature of work, and presenting symptoms associated with this condition is important, however, in alerting physicians to this occupational disease and was the focus of this research. Earlier diagnosis of this debilitating condition could then be made and appropriate advice given to workers to limit further exposure, avert complications, and promote rehabilitation.

Methods

Study population

All clinical records of workers with a history of silica dust exposure seeking pneumoconiosis compensation assessment between 1 January 1995 and 31 December 1999 were reviewed.

A 'confirmed' case of silicosis was defined as a subject who has been determined by the Pneumoconiosis Medical Board (PMB) to be suffering from silicosis. The PMB consisted of two medical practitioners with a special interest in pneumoconiosis compensation assessment, and one medical or senior medical officer from the Labour Department. The diagnosis of silicosis was based on a relevant occupational history involving significant exposure to silica-containing dust, and radiographic changes consistent with silicosis, with or without histological proof. The occupational history was obtained by nurses working in the pneumoconiosis clinic and was checked by the PMB. Radiographic films were viewed independently by the three members of the PMB. The radiographic criterion for the diagnosis of silicosis was the presence of round and/or irregular opacities in the lungs, with profusion greater than 1/0 according to the International Labour Office Classification 1980.[2] Other competing diagnoses were considered and excluded. In the case of a discrepancy in opinion, the decision made was that of the majority.

'Unconfirmed' cases of silicosis included those patients who had exposure to silica-containing dust but were not diagnosed by the PMB to have silicosis according to the established criteria. Workers with asbestos exposure only in their occupational history were excluded from the study.

Instrumentation

Spirometry was performed using a dry wedge-type bellow spirometer (Vitalograph PFT II plus, Buckingham, UK), with the results corrected for body temperature, pressure, and saturation. Diffusion capacity was measured by an automated lung function test system (Morgan Benchmark Transfer Test, Kent, UK). The same types of instruments were used throughout the study period.

Data collection and analysis

The clinical records and radiographic findings of the study population were reviewed. For the spirometric tracings, acceptability was judged according to the criteria of the American Thoracic Society (ATS), 1994.[3] Unacceptable tracings were excluded from the lung function analysis. Similarly, the diffusion capacity of carbon monoxide (DL_{CO}) using the single breath test was analysed according to the ATS criteria.[4]

For the radiographic abnormalities, the chest X-ray films were classified according to the International Classification of Radiographs of Pneumoconioses, 1980.[2] For the small opacities, the predominant type of opacity was recorded for analysis. If there was co-dominance of different types of small opacities, both were recorded.

The data were analysed by two-sample *t*-test for continuous data, and Chi squared test for the categorical variables. Analysis of covariance was used to adjust for age, height, and smoking duration when comparing the mean lung function parameters between the workers with and without silicosis. A P value of less than 0.05 was taken to be statistically significant.

Results

Baseline demographic data

One thousand and seventy-four workers were assessed by the PMB during the study period. Data from 18 patients with a history of exposure to asbestos dust only was excluded from analysis. Of the remaining 1056 subjects, 962 subjects had exposure to silica-containing dust, whereas 88 had a history of mixed dust exposure to both silica and asbestos, and six workers had exposure to silica dust and coal dust.

Of the 1056 workers, 648 were diagnosed with silicosis whereas 408 cases were not confirmed. The job titles of the study population are listed in Table 1. As expected, only a minority of workers were female—there were 10 women in both the confirmed and unconfirmed groups. The mean age of female patients

Table 1. Job titles of workers attending the pneumoconiosis clinic for assessment

Principal job titles	Workers (No. [%])	
	Patients with confirmed silicosis, n=648	Patients with unconfirmed silicosis, n=408
Caisson worker	33 (5.1)	25 (6.1)
Stone splitter	43 (6.6)	23 (5.6)
Labourer	53 (8.2)	67 (16.4)
Caisson worker + stone splitter	89 (13.7)	56 (13.7)
Caisson worker + labourer	81 (12.5)	43 (10.5)
Labourer + stone splitter	118 (18.2)	68 (16.7)
Caisson worker + stone splitter + labourer	91 (14)	56 (13.7)
Caisson worker + stone splitter + shot firer	9 (1.4)	2 (0.5)
Stone crushing machine attendant + labourer	44 (6.8)	18 (4.4)
Machine mechanic (in quarry)	8 (1.2)	7 (1.7)
Welder in quarry/construction site	4 (0.6)	2 (0.5)
Labourer + ship demolition worker	1 (0.2)	1 (0.2)
Labourer + asbestos cement product maker	0 (0)	3 (0.7)
Glass worker	2 (0.3)	1 (0.2)
Gem/jade worker	29 (4.5)	4 (1)
Enamel worker	17 (2.6)	1 (0.2)
Tomb worker	3 (0.5)	1 (0.2)
Coal miner	5 (0.8)	1 (0.2)
Foundry worker	2 (0.3)	2 (0.5)
Others*	16 (2.5)	27 (6.6)

* Others included foreman, driver/carpenter/watchman in construction sites, surveyor, lift-truck operator

with silicosis was 65.1 years (standard error [SE], 3.9 years) with a mean duration of dust exposure of 22.3 years (SE, 4.3 years). The small number of female workers precluded any meaningful statistical analysis. The baseline demographic data of male workers are shown in Table 2.

Among the male workers, patients with a confirmed diagnosis of silicosis had a significantly longer duration of dust exposure than those with unconfirmed silicosis. A higher percentage also had a history of pulmonary tuberculosis (TB) and had retired from their dusty work. There was no statistically significant difference between the two groups in the mean duration of smoking or in the physical complaints reported. Presenting symptoms are shown in the Fig.

Radiographic abnormalities

With respect to the type of radiographic opacities identified in patients with silicosis, 65.1% and 31.9% had round and irregular opacities, respectively, while 2.9% had mixed opacities. The majority (69.1%) had grade 1 background profusion evident whereas only 2.3% had grade 3 profusion. Less than a quarter (24.8%) of these patients suffered from progressive massive fibrosis (PMF) at initial presentation. Approximately 40.9% of chest X-rays had abnormalities that could be ascribed to pulmonary TB, whereas 'eggshell' calcifications characteristic of silicosis were present in only 8% of the radiographs.

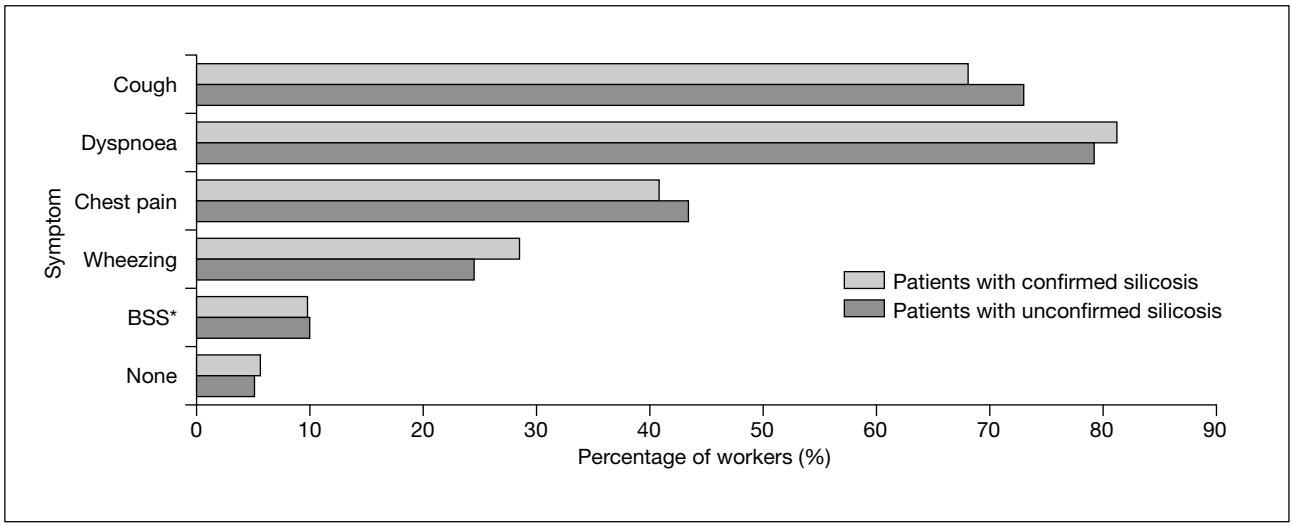
Lung function parameters

Only data from male workers were studied. Data from patients with a history of lobectomy or pneumonectomy (n=6), asbestos or coal dust exposure (n=94), and those with poorly performed spirometry (n=25) were excluded from the analysis. Hence, the lung function parameters of 911 male workers, including 591 patients with confirmed silicosis and 320 with unconfirmed silicosis were analysed in total.

Table 2. Baseline characteristics of male workers seen for silicosis assessment

	Patients with confirmed silicosis, n=638	Patients with unconfirmed silicosis, n=398	P value
Age (years)	57.4 (0.4)*	55.2 (0.6)	0.002
Height (m)	1.62 (0.002)	1.63 (0.003)	0.010
Ever-smokers (%)	89.2	88.4	0.788
Smoking duration in pack-years†	25.2 (1.0)	23.9 (1.3)	0.403
Duration of exposure (years)	24.2 (0.4)	21.3 (0.5)	<0.0005
Workers still working (%)	40.9	47.7	0.036
Workers with tuberculosis (%)	48.1	37.4	0.001
Workers without symptoms (%)	5.8	5.0	0.695

* Results are expressed as mean (standard error) where appropriate
† n= 635 for patients with confirmed silicosis and n= 397 for patients with unconfirmed silicosis



* BSS blood-stained sputum

Fig. Symptoms at presentation

Before adjustment by age, height, and smoking duration, the forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), and the DL_{CO} were significantly lower for the patients with confirmed silicosis, whereas the ratios of FEV_1/FVC were similar between the two groups. After adjustment by analysis of covariance, only the DL_{CO} between the two groups differed significantly (Table 3). The spirometric measurements of those newly diagnosed with silicosis were within the normal range, with a mean FVC of 97.9% predicted and a mean FEV_1/FVC ratio of 69.5%.

In order to assess whether the calculated effect of PMF on pulmonary function was diluted by the data of workers with simple silicosis, a separate analysis was performed. Comparisons of lung function parameters between patients with complicated silicosis (presence of PMF), and those with unconfirmed silicosis were undertaken. Forced expiratory volume in one second, FVC and DL_{CO} were all found to differ significantly between the two groups (Table 4).

Associated medical illness

Disregarding the history of pulmonary TB, which was the most commonly associated medical problem, 15.6% of the patients with confirmed silicosis and 13.7% of the patients with unconfirmed silicosis had other medical conditions (P=0.46).

Table 3. Comparison of lung function parameters between patients with confirmed and unconfirmed silicosis

(a) Before adjustment for age, height, and smoking duration

	Patients with confirmed silicosis*, n=591	Patients with unconfirmed silicosis*, n=320	P value
FEV_1† (L)	2.17 (0.03)	2.34 (0.05)	0.005
Predicted FEV_1 (%)	86.0 (1.0)	85.3 (1.5)	-
FVC‡ (L)	3.08 (0.03)	3.25 (0.04)	0.002
Predicted FVC (%)	97.9 (0.7)	97.6 (1.0)	-
FEV_1/FVC (%)	69.5 (0.6)	69.7 (0.9)	0.835
DL_{CO}§ (mL CO/min/mm Hg)‖	20.27 (0.29)	22.68 (0.48)	<0.0005
Predicted DL_{CO} (%)‖	82.3 (1.0)	88.1 (1.7)	-

(b) After adjustment by age, height, and smoking duration

	Patients with confirmed silicosis*, n=588	Patients with unconfirmed silicosis*, n=319	P value
FEV_1 (L)	2.23 (0.03)	2.24 (0.03)	0.752
FVC (L)	3.13 (0.02)	3.16 (0.03)	0.457
FEV_1/FVC (%)	70.1 (0.5)	68.6 (0.7)	0.095
DL_{CO} (mL CO/min/mm Hg)¶	20.65 (0.24)	21.91 (0.33)	0.002

* Results are expressed as mean (standard error) where appropriate
† FEV_1 Forced expiratory volume in one second
‡ FVC Forced vital capacity
§ DL_{CO} Diffusion capacity of carbon monoxide
‖ n= 503 for patients with confirmed silicosis and n= 253 for patients with unconfirmed silicosis
¶ n= 501 for patients with confirmed silicosis and n= 252 for patients with unconfirmed silicosis

Table 4. Comparisons of lung function parameters between patients with confirmed silicosis and progressive massive fibrosis and patients with unconfirmed silicosis (adjusted by height, age, and smoking duration)

	Patients with confirmed silicosis and progressive massive fibrosis*, n= 146	Patients with unconfirmed silicosis*, n=319	P value
FEV_1† (L)	2.06 (0.05)	2.27 (0.04)	0.002
FVC‡ (L)	3.04 (0.05)	3.19 (0.03)	0.01
DL_{CO}§ (mL CO/min/mmHg)‖	19.50 (0.48)	22.05 (0.34)	<0.0005

* Results are expressed as mean (standard error) where appropriate
† FEV_1 Forced expiratory volume in one second
‡ FVC Forced vital capacity
§ DL_{CO} Diffusion capacity of carbon monoxide
‖ n= 129 for patients with confirmed silicosis and n= 252 for patients with unconfirmed silicosis

Table 5. Requirement for bronchodilators

	Patients with confirmed silicosis, n=648	Patients with unconfirmed silicosis, n=408	P value
Inhaled bronchodilators (%)	11.9	8.8	-
Inhaled and oral bronchodilators (%)	10.3	8.6	-
Total (%)	22.2	17.4	0.069

Six percent of the patients with confirmed silicosis and 8% of the unconfirmed patients suffered from other pulmonary conditions, namely asthma, emphysema, bronchiectasis, pneumothorax, and bronchogenic carcinoma (1.9% of patients with confirmed silicosis and 1.7% of those with unconfirmed silicosis were found to have bronchogenic carcinoma in this study sample). Hypertension and diabetes mellitus were the next two most commonly associated medical problems.

Requirement for bronchodilators

Among the patients with silicosis, 22.2% required bronchodilators for their symptoms, whereas 17.4% of the patients with unconfirmed silicosis needed such treatment (Table 5). There was no significant difference (P=0.069) between the two groups in terms of bronchodilator use however.

Discussion

Study design

This study was a retrospective review involving workers who sought pneumoconiosis compensation assessment. Similar to other retrospective studies, some key information, such as the exact nature and composition of the silica dust or the dust exposure level, was unavailable. These factors were known to have an important bearing on lung function impairment.[5-8] In fact, dust level and dust content did vary with different jobs and in different work sites, and a number of workers had also worked in several types of jobs over their life-time. As an alternative, this study used 'years of dust exposure' as a surrogate marker which was undoubtedly suboptimal. Lack of more precise data has precluded adjustment of pulmonary function parameters by the dust exposure level.

Demographic characteristics

More than 94% of workers who presented for assessment complained of chest symptoms. The most common complaint was shortness of breath, followed by chronic productive cough, chest pain, and wheezing (Fig). These symptoms may have prompted patients to seek medical advice. Nonetheless, in the compensation assessment setting, the possibility that some workers might exaggerate their symptoms for secondary gain cannot be excluded. In fact, less than a quarter of workers required treatment of their symptoms, whether on a regular or as necessary basis. Hence, the data could not be generalised to all workers with silica dust exposure in Hong Kong.

The mean age of the patients with confirmed silicosis was older than that of the patients with unconfirmed silicosis, as was the mean duration of dust exposure. These two variables may not be independent of each other, however, as older workers are more likely to have a longer working history. Similarly, a higher proportion of patients with confirmed silicosis had retired from their dusty occupation, most probably as a result of their silicosis. The fact that patients with confirmed silicosis were older and approaching the age of retirement, however, would be an alternative explanation.

A high proportion of silica-exposed workers were ever-smokers. This bears an important clinical implication as smoking is known to have an additive deleterious effect on pulmonary function.[8,9] Smoking has been reported to lead to an accelerated decline of FEV_1 and possibly FVC in silica-exposed workers.[9] As the former parameter is an important determinant of respiratory disability and mortality,[9] advising silica-exposed

workers against smoking is an important health promotion target.

Comment on lung function data

In this study, the FEV_1, FVC, and DL_{CO} among the workers with or without silicosis were within normal limits (where the predicted values were derived from the general population). It is the rule rather than the exception that construction site workers, who comprised the majority of the study sample, are fit and healthy so that they can perform heavy manual tasks. Hence, their lung function parameters may be better than those of the general population at outset. Following this argument, values of slightly less than the 100% predicted may already be abnormal for this population.

With the exception for DL_{CO}, the adjusted mean lung function parameters of the patients with confirmed silicosis and those with unconfirmed silicosis were comparable. Several explanations may account for this observation.

Firstly, as in most studies of silicosis, histological proof was not required to confirm the diagnosis. It is possible that some misclassification of patients could have occurred.

Secondly, lung function impairment in silicosis may occur mainly in the presence of complications, such as the development of PMF. Ng et al[10] have reported a lower level of FEV_1 and FVC in association with the development of PMF. Similar findings have also been reported by Begin et al.[11] In their study of 94 workers (73 with silicosis and 21 without), those with PMF demonstrated a significant reduction of total lung capacity and vital capacity. The mechanism of pulmonary dysfunction as a result of PMF was proposed by Kinsella et al,[12] who found that silicosis in the absence of PMF did not cause significant emphysema and it was primarily the degree of emphysema that determined the level of pulmonary function. In agreement with these observations, silicosis was associated with a poorer FVC, FEV_1, and DL_{CO} only in the presence of PMF in this study. Nonetheless, the differences in mean lung function indices were not very marked.

Thirdly, chronic silica dust exposure by itself can lead to lung function impairment.[5-8] Irwig and Rocks[13] have speculated that the amount of total dust was the most important factor resulting in airway obstruction and respiratory symptoms in goldminers, irrespective of the presence of silicosis. Silicosis may then merely be a secondary manifestation of high dust exposure. Another study of South African gold miners showed that the duration of silica dust exposure was associated with significant reductions in FEV_1, FEV_1/FVC, and maximal mid-expiratory flow rate after controlling for age, height, smoking, and the direct effects of the underground environment.[14] In Singapore, quarry workers with high dust exposure were found to have a mean reduction of 5% in FEV_1 and FVC as compared with an internal control group with low dust exposure, and an external control group with no dust exposure.[15] A further study also reported that the duration of quartz exposure was an independent predictor of spirometric airflow limitation in Norwegian men.[16] The development of airflow limitation could be attributed to 'occupational bronchitis'. Thus, it is likely that silica exposure per se would have resulted in impaired lung function even in the absence of silicosis. As previously discussed, precise data on 'dust exposure level' were unavailable in this retrospective review. Inability to evaluate the pulmonary function indices according to this variable may mask any differences in pulmonary function between the groups.

Finally, this group of patients with unconfirmed silicosis was a highly selected group, with symptom, coming to seek medical advice and compensation. They may, hence, have pulmonary dysfunction due to causes other than silicosis. It was noted that a high proportion (37.4%) of these patients suffered from pulmonary TB, a far higher rate than that of TB in the general population. This high rate of TB may explain why those workers with radiological abnormalities mimicking silicosis were symptomatic and were referred to the pneumoconiosis clinic for assessment.

Despite the lack of significant difference in the spirometric measurements between the patients with newly diagnosed silicosis and those without, the results in this study did suggest that DL_{CO} may be a useful parameter to alert physicians to the early functional changes seen in silicosis (Table 3b). This DL_{CO} abnormality was even more evident in complicated silicosis (Table 4).

Conclusions

The results of this study indicate that silica dust exposure in the construction industry is the major cause of silicosis in Hong Kong. The job processes of caisson work and stone-splitting were particularly high risk. Silicosis in Hong Kong was mostly of the chronic type, with a mean duration of exposure of over 20 years. Most patients with silicosis were symptomatic and suffered from simple silicosis with no significant

lung function impairment on initial presentation. Pulmonary TB remained a commonly associated disease among this patient group and is an important condition with respect to the differential diagnosis of silicosis.

References

1. Notifications of silicosis attending the Pneumoconiosis clinic in Hong Kong 1956-1998. Chest Service, Department of Health, Hong Kong. Annual Report. 1998.
2. International Labour Office. Guidelines for the use of ILO International Classification of radiographs of pneumoconioses. Revised edition. Occup Safety Health Series 1980; 22:1-48.
3. American Thoracic Society. Standardization of spirometry, 1994 update. Am J Respir Crit Care Med 1995;152:1107-36.
4. American Thoracic Society. Single-breath carbon monoxide diffusing capacity (transfer factor). Recommendations for a standard technique. Am J Respir Crit Care Med 1995;152: 2185-98.
5. Musk AW, Peters JM, Wegman DH, Fine LJ. Pulmonary function in granite dust exposure: a four-year follow-up. Am Rev Respir Dis 1977;115:769-76.
6. Chia KS, Ng TP, Jeyaratnam J. Small airways function of silica-exposed workers. Am J Ind Med 1992;22:155-62.
7. Neukirch F, Cooreman J, Korobaeff M, Pariente R. Silica exposure and chronic airflow limitation in pottery workers. Arch Environ Health 1994;49:459-64.
8. Hnizdo E, Baskind E, Sluis-Cremer GK. Combined effect of silica dust exposure and tobacco smoking on the prevalence of respiratory impairments among gold miners. Scand J Work Environ Health 1990;16:411-22.
9. Hnizdo E. Loss of lung function associated with exposure to silica dust and with smoking and its relation to disability and mortality in South African gold miners. Br J Ind Med 1992; 49:472-9.
10. Ng TP, Chan SL, Lam KP. Radiological progression and lung function in silicosis: a ten year follow-up study. BMJ (Clin Res Ed) 1987;295:164-8.
11. Begin R, Ostiguy G, Cantin A, Bergeron D. Lung function in silica-exposed workers. A relationship to disease severity assessed by CT scan. Chest 1988;94:539-45.
12. Kinsella M, Muller N, Vedal S, Staples C, Abboud RT, Chan-Yeung M. Emphysema in silicosis: a comparison of smokers with nonsmokers using pulmonary function testing and computed tomography. Am Rev Respir Dis 1990;141: 1497-500.
13. Irwig LM, Rocks P. Lung function and respiratory symptoms in silicotic and nonsilicotic gold miners. Am Rev Respir Dis 1978;117:429-35.
14. Cowie RL, Mabena SK. Silicosis, chronic airflow limitation, and chronic bronchitis in South African gold miners. Am Rev Respir Dis 1991;143:80-4.
15. Ng TP, Phoon WH, Lee HS, Ng YL, Tan KT. An epidemiological survey of respiratory morbidity among granite quarry workers in Singapore: chronic bronchitis and lung function impairment. Ann Acad Med Singapore 1992;21: 312-7.
16. Humerfelt S, Eide GE, Gulsvik A. Association of years of occupational quartz exposure with spirometric airflow limitation in Norwegian men aged 30-46 years. Thorax 1998; 53:649-55.