OCCUPATIONAL RESPIRATORY DISEASES IN SINGAPORE

H S Lee, W H Phoon, S Y T Wang, K P Tan

ABSTRACT

Occupational respiratory disease statistics in Singapore from 1970 to 1993 were reviewed. Silicosis was the most common occupational respiratory disease in the 1970s and 1980s. About 78% of the cases were from granite quarries. With progressive reduction in dust levels and the closure of some quarries, there has been a decline in cases. From 1990 to 1993, occupational asthma was the most common occupational respiratory disease and more cases are expected with increasing awareness of the condition. The most common causative agent was isocyanates accounting for about 34% of cases. Of the asbestosis and malignant mesothelioma cases, about 70%-80% were from the one and only asbestos cement factory. With the closure of this factory and the increasing restrictions on the use of asbestos, cases of asbestosis are expected to decline in the long term. However, malignant mesothelioma cases may continue to surface because of the long latent period and the potential risk with low and brief exposures to asbestos. It is important to probe for possible occupational exposures (both present and past) in a patient with respiratory symptoms or disease.

Keywords: asbestosis, silicosis, asthma, mesothelioma, epidemiology

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INTRODUCTION

Historically, occupational lung diseases were among the first occupational diseases reported among miners by Agricola[1] and Paracelsus[2]. From 1971 to 1975, silicosis was the number one occupational disease in Singapore[3].

Today, occupational respiratory diseases are still an important group of diseases which our doctors should be aware of. A case of uncomplicated silicosis may needlessly be given a course of anti-tuberculosis treatment or undergo a bronchoscopy to exclude malignancy. A patient with occupational asthma may be treated for his asthmatic symptoms without the underlying cause of the asthma being removed. A patient suffering from malignant mesothelioma or severe asbestosis requiring frequent hospitalisations for breathlessness may be eligible for Workmen's Compensation or receive some financial assistance from the Workers' Fund administered by the Ministry of Labour (MOL). In such instances, knowledge of the diseases would enable the doctor to better manage the patient.

This paper presents the profile of occupational respiratory diseases in Singapore confirmed during the period from 1970 to 1993 and the type of industries from which they came.

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MATERIALS AND METHODS

The statistics on all notified and confirmed occupational diseases are kept by the Department of Industrial Health (DIH), MOL. Silicosis was a legally notifiable industrial disease under the Factories Act of 1970. Asbestosis, byssinosis and malignant mesothelioma were made notifiable since 1973. Occupational asthma was made notifiable since 1985. In addition, these diseases are also compensable occupational diseases under the Workmen's Compensation Act.

Under the Sand and Granite Quarries Regulations of 1971, all workers in sand and granite quarries were required to undergo pre-employment and annual chest X-ray (full size) examinations. This has been extended to all factory workers currently exposed to silica or asbestos under the Factories (Medical Examinations) Regulations of 1985. Factory workers exposed to raw cotton dust are required to undergo pre-employment and annual lung function testing ie forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1), pre-shift and post-shift on a Monday (after two non-working days). Any cases of suspected silicosis, asbestosis or byssinosis detected would be notified to the DIH. The DIH also has a long-term follow up programme for previously exposed asbestos workers. They are followed up every 5 years with a chest X-ray examination to look for any early development of asbestosis.

Each notification is investigated by doctors from the department. The diagnosis of silicosis is made on the basis of two chest X-ray radiographs (full size and about 6 months apart) showing reticular-nodular shadowing in both lung fields of profusion grade of at least 1/1 (according to the International Standard Classification of Radiographs of Pneumoconiosis[4]), a history of definite occupational exposure to silica and the exclusion of other causes of the radiological opacities. The diagnosis of asbestosis is made on the basis of the chest X-ray showing a reticular-linear shadowing of at least 1/1 on two films about 6 months apart, a reduced transfer factor (DLCO) or reduced forced vital capacity (FVC), a definite occupational exposure to asbestos and exclusion of other causes of the radiological findings. Occupational asthma is defined as asthma caused or aggravated by the work environment, documented by either a serial peak expiratory flow rate measurement or a specific bronchial provocation challenge test.

From time to time, surveys have also been carried out to

study the prevalence of specific occupational respiratory diseases in certain industries in Singapore.

RESULTS AND DISCUSSION

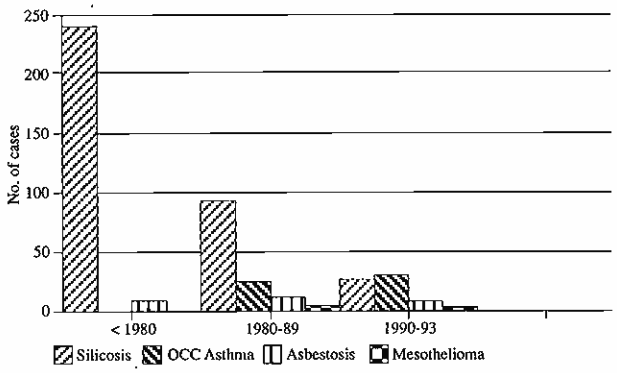
Disease trends over time

Silicosis was the most common occupational respiratory disease in the 1970s and 1980s (Fig 1). About 240 cases were confirmed in the 1970s. There was a marked decline to about 90 cases in the 1980s.

During the four-year period 1990 to 1993, there were marginally more cases of occupational asthma confirmed, making it the most common occupational respiratory disease in the 1990s. There were more cases of occupational asthma confirmed during these four years (n=29) than in the previous ten years (n=24) and this trend is expected to continue with increasing awareness of occupational asthma.

Twenty-six per cent of the 27 cases of asbestosis and 43% of the 7 cases of asbestos-related malignant mesothelioma were confirmed during the four years 1990-93. If this trend continues, there would be more cases of asbestosis and asbestos-related malignant mesothelioma confirmed in the 1990s than in previous decades. This would not be surprising for a long latency disease such as mesothelioma which has an average latency of 35 to 40 years from first exposure to asbestos. Since Singapore started industrialising in the 1950s and 1960s, cases of asbestos-related mesothelioma would be expected to surface in the 1980s and 1990s.

Fig 1 – Occupational Lung Diseases in Singapore 1970 - 1993



Silicosis

About 78% of the 358 silicosis cases confirmed were from granite quarries where they were exposed to silica (SiO_2) from the blasting, drilling and crushing of granite stones (Table I). The percentage of free silica in granite dust can vary from 10% to 40%. The high risk of silicosis among granite quarry workers has been highlighted in the past [5,6]. By 1979, all granite quarries had installed dust control measures as a result of the Sand and Granite Quarries Regulations of 1971. Dust levels have been significantly reduced (Table II). In a study of 201 workers in 5 granite quarries in 1988, the prevalence of respirator usage was about 60%-70% among drillers and crusher attendants who were the more highly exposed group[7]. In recent years, the government has stopped renewing the licenses of many quarries. The number of quarries declined from 25 in 1972 to 3 in 1993.

A recent survey of 219 currently employed workers from 6 operating granite quarries in 1990[8] showed that the prevalence of silicosis was 12.5% among drilling and crushing workers and 0.8% among maintenance and transportation workers. Among those first exposed to granite dust in 1979 or later, no cases of silicosis were noted. This may suggest that the reduction in dust exposure since 1979 has so far been successful in preventing silicosis among active quarry workers over ten years.

Table I – Cases of silicosis by industry 1970-1993

Industry	No. of cases (%)	
Granite quarries	278	(77.6)
Rubber factories	43	(12.0)
Kaolin quarries	11	(3.1)
Foundries	10	(2.8)
Brickworks	6	(1.7)
Others	10	(2.8)
Total	358	(100)

Table II – Respirable dust levels (8 hr TWA) of crusher workers at granite quarries (mg/m³)

Year	No.	Mean	%>1 mg/m³
1973	116	3.07	85.3
1976	141	1.27	42.5
1977	296	1.24	48.6
1978	291	1.12	50.1
1985	270	1.26	55.2
1986	217	0.99	34.6
1987	114	0.83	25.4

About 12% of silicotics were from the rubber industry where silica powder was used as a filler in the manufacture of rubber bales, sheets and products (Table I). Some of these cases have been reported earlier[9,10]. There were very few cases from sandblasting because this has been banned under the Factories (Abrasive Blasting) Regulations of 1974. Since then, sand has been substituted with copper slag or grit as a blasting material for use in industries such as shipbuilding and repair.

While the majority of silicotics had a normal life span and died from unrelated causes[11], there have been case reports of a rapidly progressive form of silicosis leading to progressive massive fibrosis and death[12,13]. Both were women who had been exposed to very high concentrations of silica dust for less than 10 years. One was working in a "kaolin quarry" where she was involved in the grinding and bagging of fine white clay which was sold to the rubber industry as a filler powder. The other was involved in mixing abrasive powder containing 90% free silica with detergent to make scouring powder.

It is expected that the number of new cases of silicosis confirmed would decline further and that such cases are likely to be mild (grade 1/1) and uncomplicated. They are likely to be asymptomatic with no clinical signs on examination and have normal lung function, being detected as a result of routine or incidental chest X-ray examination.

Asbestosis

Twenty-two (82%) of the asbestosis cases were from the one and only asbestos cement factory which was in operation from the 1950s to the early 1980s. Asbestos was mixed with cement to produce asbestos cement products such as roof tiles, ceiling boards and pipes. Due to the high exposures and long latent period, we would expect to encounter further cases from the cohort who had worked there. Four cases were involved in insulation work and one case was in the renovation/construction industry.

Besides insulation and renovation work, factory workers involved in the manufacture of gaskets and brake linings and mechanics repairing brake linings are still exposed to asbestos in Singapore. However, the exposure in the latter two industries

are generally low, and so far no cases of asbestosis have been confirmed from these industries.

Most cases of asbestosis confirmed here are symptomatic and have clinical signs and lung function impairment. The linear and irregular type opacities of asbestosis in the lower zones of the chest X-ray may not appear as obvious in the early stages. Our definition also includes lung function abnormality. The main complaint is progressive shortness of breath, particularly on exertion. Clinical examination often reveals crepitations in the lung bases and clubbing of the nails. The FVC and the DLCO are reduced.

The Factories (Asbestos) Regulations 1980 require notification before any process involving asbestos is undertaken in a factory. Preventive measures such as local exhaust ventilation and use of respirators are required for such work. Since October 1989, the import of all products containing crocidolite, amosite and amphiboles, and building materials containing chrysotile have been banned by the Environment Ministry. From April 1995, all newly registered vehicles will be required to have asbestos-free brake and clutch linings. With the increasing restrictions on asbestos usage, the incidence of asbestosis (which is related to relatively high exposures) is expected to decline in the long term.

Malignant mesothelioma

Five (71%) of the 7 cases of asbestos-related malignant mesothelioma were from the one asbestos cement factory where crocidolite or blue asbestos was used. A few of these cases have been reported earlier[14,15]. It is generally accepted that crocidolite exposure presents a far greater hazard than chrysotile in the development of mesothelioma[16]. While most of them were production workers who were directly exposed to high concentrations of asbestos, one was a clerk working inside the factory[15]. It has been reported that persons with low exposures to asbestos eg car mechanics[17] and even household contacts[18] may be at risk of mesothelioma.

The other 2 cases were from insulation work carried out in shipyards. Nowadays, the insulation for boilers in ships is asbestos-free. However, the old insulation may still be asbestos and this is often removed by contract workers. Our cases included both pleural as well as peritoneal mesotheliomas and the diagnoses were all confirmed by biopsy.

For the reasons stated earlier, it is likely that we would see a further modest increase in the number of cases of asbestos-related mesothelioma, although some cases may be misdiagnosed as lung cancer, and in others, the occupational exposure to asbestos may not be obtained. However, since occupational exposures to asbestos is responsible for 80% to 85% of malignant mesotheliomas[19], a case should be assumed to be occupational unless proven otherwise. A detailed occupational history and a knowledge of the industry is important. Recently, a case of malignant mesothelioma was confirmed in a truck driver who had been transporting asbestos roof tiles and ceiling boards for more than 30 years.

Occupational asthma

While silicosis and asbestosis are due to a single causative agent ie silica or asbestos respectively, more than 300 causes of occupational asthma have been reported[20]. Occupational asthma is the most common occupational respiratory disease in the industrialised countries[21,22]. The situation in Singapore has been reported previously[23]. There has been an increase in cases since it was made notifiable and compensable in 1985 and an Occupational Lung Disease Clinic was set up in 1988 in Tan Tock Seng Hospital. However, it is still under-reported due to a lack of awareness[23].

The most common causative agent is isocyanates, which account for about 34% of cases confirmed (Table III). This is also the most common causative agent in the industrialised countries[24]. Isocyanates are a group of reactive chemicals that are used as hardeners or curing agents in a polyurethane resin system such as polyurethane foam, paints, varnishes, and adhesives. Occupations at risk include spray painters, workers producing foam products and insulation workers. Other common causative agents are the colophony resin in soldering fumes and welding fumes. Four new causes of occupational asthma were reported from Singapore[25-28].

Table III – Occupational asthma by causative agent 1983-1993

Causative agent	No. of cases (%)	
Isocyanates	18	(34.0)
Solder fumes	6	(11.3)
Welding fumes	4	(7.5)
Drugs	4	(7.5)
Acid anhydrides	2	(3.8)
Amines	2	(3.8)
Grain dust	2	(3.8)
Wood dust	2	(3.8)
Others	13	(24.5)
Total	53	(100)

One should consider the possibility of occupational asthma in an asthmatic who is also a spray painter, solderer, welder, carpenter or chemical process worker. About 50% or more of cases continue to have persistent asthma even after removal from exposure to the causative agent[29]. Early diagnosis and removal from further exposure could result in a better prognosis.

The actual prevalence of occupational asthma is unknown. It has been estimated that 15% of male asthmatics in the United States and Japan are work-related[30]. Two cross-sectional studies done in Singapore among solderers in electronics factories[31] and foam mattress workers exposed to isocyanates[32] did not reveal any definite case of occupational asthma. This may be because we are studying a survivor population. Persons with occupational asthma would tend to leave their job. In a community-based case-control study involving 803 adult patients with asthma and 1,606 non-asthmatic controls in five outpatient polyclinics in Singapore, an increased risk of asthma was observed for service and manufacturing process workers[33]. Among this group, increased risks were observed for cleaners, textile workers, electronic workers and construction workers.

OTHER OCCUPATIONAL RESPIRATORY DISEASES

Byssinosis

So far there are no confirmed cases of byssinosis in the official statistics on occupational diseases in Singapore. There is currently only one factory using raw cotton in Singapore. Based on two previous studies, one in 1974 involving 100 workers and another in 1977 involving 54 workers[34], no worker was found to have symptoms of byssinosis. However, female workers had a significant fall in FEV1 over the shift on a Monday morning in the second study. These factories have been on an ongoing medical surveillance programme.

Chemical pneumonitis/bronchitis

From time to time, there have been incidents of workers having respiratory difficulty from inhalation of irritant gases and fumes. The most common was due to chlorine gas, accounting for 45% of the 40 cases. Others included ammonia, oxides of nitrogen and acid fumes. The more soluble gases such as ammonia and acid fumes tend to produce mainly upper respiratory tract

irritation. A moderately soluble gas such as chlorine may in addition cause acute bronchospasm or even pulmonary oedema although the latter is more common with insoluble gases such as oxides of nitrogen, phosgene and ozone.

These cases result from accidental leakage from cylinders and tanks where the gas may be stored under pressure. This may occur during sampling of the material or during maintenance operations. Another situation is when chemicals are wrongly mixed together resulting in a chemical reaction. This may happen with household chemicals. A woman who was cleaning a toilet accidentally mixed chlorox (sodium hypochlorite) with an acid cleaner. Immediately, she was tearing and choking and developed acute bronchospasm from the chlorine gas released.

In such cases, there is no problem relating the symptoms to the occupational situation. However, identifying the actual gas may be a problem to the clinician in the hospital. Communication with the workplace may be helpful in some cases. The DIH may also play a role in helping to identify the gas concerned. In any case, the patient should be observed for at least 24 hours to exclude any delayed pulmonary oedema. Some cases may develop what has been called a "reactive airways disease syndrome", in which they continue to have symptoms such as persistent cough or even asthma and are found to have non-specific bronchial hyperreactivity.

Occupational lung cancer

So far, no definite cases of occupational lung cancer have been confirmed in Singapore. Lung cancer is a common cancer and most cases are attributed to smoking. There are no specific characteristics of lung cancer caused by occupational causes. Another reason is that it is not listed as a notifiable or compensable occupational disease. But there are many known occupational causes of lung cancer. These include asbestos, arsenic, radiation, coal tar, insoluble zinc and lead chromates, etc. It should be noted that workers exposed to asbestos and who smoke are at an even higher risk of lung cancer than if they are exposed to either agent alone. More recently, there has been increasing evidence that silicotics have a higher risk of lung cancer[35]. An excess risk of lung cancer (standardised incidence ratio of 2.01, 95% confidence interval 0.92-3.81) was found among our Chinese silicotics from granite quarries which could not be explained by smoking alone[36]. Occupational lung cancer does occur in Singapore but these cases may not have been recognised.

Other pneumoconiosis

Besides, silicosis and asbestosis, other types of pneumoconiosis have been described. In a survey of welders in shipyards in Singapore in 1981, four out of 103 welders who had chest X-ray examinations were found to have evidence of siderosis[37] which is a benign pneumoconiosis due to iron. In a study of workers exposed to polyvinyl chloride (PVC) resin dust carried out in 1990, five out of 137 workers who had chest X-ray examinations were found to have PVC pneumoconiosis[38]. They were all among the 29 workers in the high exposure group.

Occupational chronic obstructive lung disease

It has now been accepted that asthma can be caused by occupational exposures. However, there is still controversy as to whether occupational exposures can lead to chronic airflow limitation, the main reason being the confounding effect of cigarette smoking among workers. As a result of numerous studies carried out, there is now considerable evidence that certain occupational exposures may lead to chronic obstructive lung disease[39,40]. Some of these exposures included inorganic dusts eg coal dust and silica; organic dusts eg grain, wood and cotton; irritant gases eg sulpur dioxide, chlorine and nitrogen oxides; and others such as cadmium fume and isocyanate vapour. The study of 26 polyurethane foam workers in Singapore who were highly exposed to isocyanate vapour showed that there was evidence of chronic airway obstruction, particularly in those with 10 or more years of exposure, which was not explained by smoking or asthma[32]. A symptom and lung function survey of granite quarry workers in Singapore found that the highly exposed group had a higher prevalence of chronic cough and phlegm, a mean reduction of 5% in FEV1 and FVC, suggestive of an occupational bronchitis which was independent of smoking, age or silicosis[41]. Cadmium battery workers in Singapore exposed to cadmium oxide dust were found to have a mild restrictive defect of lung function[42]. A follow-up study done three years later after improvements in the working environment showed improvement in the lung function[43]. Although chronic obstructive lung disease (COLD) is generally not considered as a compensable occupational disease, there is enough evidence to consider taking an occupational history as an integral part of the investigation of a patient with COLD[40].

CONCLUSION

Occupational respiratory diseases are an important group of respiratory diseases which should not be overlooked. Recognising the occupational aetiology of such cases is important in the management of the case and in the prevention of further cases. Sometimes this is obvious as in an acute chemical pneumonitis after an accidental exposure to irritant gases or fumes or in a patient who tells you he has asthma from the welding fumes he is currently exposed to. In the chronic occupational lung diseases such as asbestosis, lung cancer, malignant mesothelioma and COLD, the relevant exposure may have occurred several decades ago, and the patient is often unaware of any relationship between his present illness and his past occupational exposure. It is thus left to the alert physician to recognise the possibility of an occupational aetiology and probe for possible exposures in the occupational history.

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