



ASBESTOS IN THE WORK PLACE AND THE COMMUNITY

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Abstract—The fibrogenic properties of asbestos dust were detected early, later knowledge accumulated about the carcinogenic properties of the mineral and a hazard of bronchial carcinoma and mesothelial tumours was recognised.

Mortality studies have measured the effect of exposure on working populations. Recent analysis of data from a cohort of asbestos factory workers shows that even with low to moderate exposure there is excess mortality from cancer of the lung and pleura and other cancers, after more than 25 years' observation. The mesothelioma rate increases both with severity and length of exposure. Occurrence of these and other tumours appears to be dose-related. The markers of a community effect of asbestos dust in the environment are the occurrence of mesothelial tumours in neighbourhoods of a source of asbestos dust, and the presence of asbestos bodies or calcified asbestos pleural plaques in the general population. Conditions giving rise to neighbourhood mesothelial tumours may not now occur, but the importance of adequate control in all countries where asbestos is mined or manufactured is stressed.

INTRODUCTION

ALTHOUGH asbestos with its fire-resistant qualities has been known since ancient times its commercial exploitation dates only from the last twenty years of the nineteenth century. Chrysotile asbestos was first used in textile factories, a little later South African crocidolite and amosite were imported and used for manufacture of textiles, in cement products, and an ever-expanding list of objects. Anthophyllite asbestos is mined and used principally in Finland.

The fibrogenic properties of asbestos were soon recognised. In the early part of the century there were increasing numbers of reports of pulmonary fibrosis among workers, culminating in the well-known Home Office Survey conducted by MEREWETHER and PRICE (1930) who found approximately a third of a population of factory workers were suffering from pulmonary fibrosis. There is ample anecdotal information about the dusty conditions in the first factories, in the early days. Elderly workers will tell of clouds of dust, which even obscured visibility.

After the introduction of the regulations of 1931, dust sampling was undertaken in some factories for some processes both in the United Kingdom and in the United States but, due to the multiplicity of instruments used and the various methods of recording observations, the figures are confusing and difficult to compare. Nevertheless, without doubt the regulations caused a very marked improvement in factory conditions.

The recognised tumours associated with asbestos exposure are the mesothelioma of pleura and peritoneum, bronchial carcinoma, and possibly cancer of stomach and bowel. Case reports of lung cancer in asbestos workers date from the time in the 1930s when this was still a comparatively uncommon disease. The association

between the mesothelial tumour and exposure to asbestos was not recognised till much later when WAGNER *et al.* (1960) published their report on the South African series of 33 patients with this tumour, 32 had had contact with crocidolite asbestos.

ASBESTOS IN THE WORK PLACE

Mortality studies have been widely used to measure the effect of asbestos exposure in working populations. DOLL (1965) and KNOX *et al.* (1968) studied a textile factory in the north of England. SELIKOFF *et al.* (1970) have made a long-term mortality study of New York insulators and MACDONALD *et al.* (1971) studied the mortality of chrysotile asbestos mine workers in Canada.

Personal studies have been made of an East London asbestos factory (NEWHOUSE, 1969; NEWHOUSE *et al.*, 1972). This factory, a heavy user of crocidolite asbestos, as well as of amosite and chrysotile, kept a unique file of all employees. These records gave both personal details and details of jobs while employed. A cohort of male workers who started work at the factory any time between the implementation of the Asbestos Regulations of 1931 in April 1933 and the closure of the factory in 1968, and a smaller cohort of women who were first employed between 1936 and 1942, were established. The war-time period was chosen for the women because regulations during the war simplified the difficult task of establishing whether women who had changed their name on marriage were alive or dead. The mortality experienced by the workers was assessed by comparing the number of observed deaths with the number of deaths that would be expected in a similar population of England and Wales using the man years method of CASE and LEA (1955). Degree of dust exposure was categorised either as low-moderate (non-production workers and those working with low proportions of asbestos in the product were in this category) or as severe (a category which described openers, disintegrators and production workers in both scheduled and unscheduled jobs).

The analysis of mortality has now been extended to 31 March, 1970. Among the men no excess mortality was found in the group with low-moderate exposure and short periods of employment at the factory (Table 1), but in those with longer

TABLE 1. MORTALITY OF MALE WORKERS WITH LOW-MODERATE EXPOSURE TO ASBESTOS, LESS THAN 2 yr IN JOB

Follow-up years No. of men	10-14 734		15-19 583		20-24 365		25+ 179	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All causes	29	22.2	15	23.0	13	16.2	13	13.4
Cancer of lung and pleura (162, 163)	1	1.8	1	1.9	1	1.2	3	1.2
Other cancers	8*	3.1	2	3.1	1	2.0	1	1.8
Respiratory disease excluding cancer	6	3.3	3	3.4	2	2.5	2	2.0
Other unspecified	14	14.0	9	14.6	9	10.5	7	8.4
Pleural mesothelioma	0		0		0		1	
Peritoneal mesothelioma	0		0		1		0	

* $P < 0.05$.

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25+ 179	
Obs.	Exp.
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3	1.2
1	1.8
2	2.0
7	8.4
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periods of exposure (Table 2) and more than 25 yr of observation in the cohort there is a significant excess of mortality from cancer, which was not seen in the earlier study where there was a shorter period at risk in the cohort. Among the male

TABLE 2. MORTALITY OF MALE WORKERS WITH LOW-MODERATE EXPOSURE TO ASBESTOS, MORE THAN 2 yr IN JOB

Follow-up years No. of men	10-14 479		15-19 374		20-24 228		25+ 97	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All causes	17	19.1	15	18.4	13	9.6	16†	7.8
Cancer of lung and pleura (162, 163)	3	1.6	2	1.6	2	0.9	3*	0.7
Other cancers	2	2.6	1	2.5	1	1.3	8†	1.0
Respiratory diseases excluding cancer	1	2.9	3	2.8	2	1.4	3	1.2
Other unspecified	11	11.9	9	11.5	8	5.9	2	4.9
Pleural mesothelioma	0		0		0		2	
Peritoneal mesothelioma	0		0		1		2	

* $P < 0.05$.

† $P < 0.01$.

‡ $P < 0.001$.

workers with severe exposure (Tables 3 and 4) whether they were employed for short or longer periods, excess mortality from lung cancer is already apparent in the group followed up for 15 yr or longer. The relative risk of carcinoma of lung is highest in those with long and severe exposure.

Among the women workers, who were followed till 31 December, 1968, there was only a small group of 126 with low-moderate exposure, but there was a significant excess of lung cancer (Obs. 2, Exp. 0.3, $P < 0.05$). The experience of the severely exposed women, who were predominantly textile workers, is shown in

TABLE 3. MORTALITY OF MALE WORKERS WITH SEVERE EXPOSURE TO ASBESTOS DUST, LESS THAN 2 yr IN JOB

Follow-up years No. of men	10-14 845		15-19 708		20-24 540		25+ 324	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All causes	23	17.6	25	18.3	25†	13.0	32†	18.5
Cancer of lung and pleura (162, 163)	2	1.5	7†	1.8	3	1.3	8†	2.0
Other cancers	1	2.4	4	2.6	8†	1.9	6	2.7
Respiratory diseases excluding cancer	3	2.8	2	2.5	2	1.7	5	2.4
Other unspecified	17	10.9	12	11.4	12	8.1	13	11.4
Pleural mesothelioma	0		1		0		3	
Peritoneal mesothelioma	0		1		1		2	

† $P < 0.01$.

‡ $P < 0.001$.

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TABLE 4. MORTALITY OF MALE WORKERS WITH SEVERE EXPOSURE TO ASBESTOS DUST, MORE THAN 2 yr IN JOB

Follow-up years No. of men	10-14 482		15-19 414		20-24 281		25+ 127	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All causes	18	22.5	40†	21.9	32†	13.8	24†	12.6
Cancer of lung and pleura (162, 163)	3	2.1	16†	2.0	10†	1.2	7†	1.1
Other cancers	5	3.2	6	3.1	4	1.8	8†	1.7
Respiratory diseases excluding cancer	4	3.6	6	3.3	7†	2.1	3	1.9
Other unspecified	6	13.7	12	13.5	11	8.7	6	7.9
Pleural mesothelioma	0		1		1		0	
Peritoneal mesothelioma	0		2		3		2	

† $P < 0.01$.‡ $P < 0.001$.

Table 5. There is marked excess of cancer, both of lung and pleura and of other sites. As among the males, excess of mortality from chronic respiratory diseases which includes asbestosis, is only seen in those with severe and long exposure.

TABLE 5. MORTALITY OF WOMEN WORKERS WITH SEVERE EXPOSURE TO ASBESTOS DUST

No. of women	Less than 2 yr in job 557		More than 2 yr in job 239	
	Obs.	Exp.	Obs.	Exp.
All causes	55	49.9	56†	24.5
Cancer of lung and pleura (162, 163)	6†	1.0	14†	0.5
Other cancers	16	12.4	17†	6.1
Respiratory disease excluding cancer	10	7.4	11†	3.6
Other unspecified	23	29.1	14	14.3
Pleural mesothelioma	3		3	
Peritoneal mesothelioma	3		2	

† $P < 0.01$.‡ $P < 0.001$.

The number of deaths from pleural and peritoneal tumours in each exposure category are indicated in the tables. By relating the number of deaths due to these tumours to the number of years-at risk in the cohort, excluding the period before the tenth year during which there is no observable excess mortality from any cause, a 'mesothelioma rate' was obtained (Table 6). It will be seen that the rate increases both with severity of exposure and with length of exposure in the job.

If the excess annual death rates, both for lung cancer and other cancers, are calculated (Table 7) a similar progression is observed. These figures suggest that the risk of mesothelial tumours as well as of bronchogenic lung cancer is strongly related to both the degree and the length of exposure to asbestos dust, and that

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25+ 127	
Obs.	Exp.
24†	12.6
7‡	1.1
8‡	1.7
3	1.9
6	7.9
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TABLE 6. NUMBER OF DEATHS (*n*) AND MESOTHELIOMA RATE (*r*) PER 100,000 SUBJECT-YEARS (*sy*) AFTER MORE THAN 10 YEARS' FOLLOW-UP

Length of employment		Low-moderate			Exposure Severe			Laggers		
		<i>n</i>	<i>sy</i>	<i>r</i>	<i>n</i>	<i>sy</i>	<i>r</i>	<i>n</i>	<i>sy</i>	<i>r</i>
Men	less than 2 yr	2	7899	25	8	11193	71	4	2550	157
	more than 2 yr	5	4926	102	9	5851	154	4	1530	261
Women	less than 2 yr	0	931	—	6	7176	84	—	—	—
	more than 2 yr	0	640	—	5	3538	141	—	—	—

TABLE 7. EXCESS ANNUAL DEATH RATES FOR CANCER AMONG MALE WORKERS PER 100,000 SUBJECT YEARS AFTER MORE THAN 10 YEARS' FOLLOW-UP

Length of employment	Exposure			
	Low-moderate		Severe	
	Lung cancer	Other cancer	Lung cancer	Other cancer
Less than 2 yr	—2	25	119	84
More than 2 yr	105	92	506	227

although there may be no critical level where the cancer risk can be confidently said to be eliminated, strict control of factory hygiene and dust suppression may minimise the risk.

ASBESTOS IN THE ENVIRONMENT

The evidence that asbestos dust can cause biological effects in the community rests on, firstly, the development of mesothelial tumours in persons with no occupational or other exposure to asbestos except residence near a source of asbestos dust, such as mine, factory or dockyard, secondly, the demonstration of asbestos bodies in the lungs of members of the general public, and thirdly, radiological evidence in the community living in the vicinity of a mine or large commercial user of asbestos of those pleural changes which are commonly associated with asbestos exposure.

Eleven of WAGNER'S (1960) series of 33 patients with mesothelial tumours in the Cape Province of South Africa had had no occupational exposure, but had been born and lived some years on the asbestos mine fields. Among the London Hospital series of 76 cases (NEWHOUSE and THOMPSON, 1965) 11, significantly more than in the control series, had had no occupational or other contact with asbestos but had lived within half a mile of an asbestos factory. In these instances, exposure occurred usually more than thirty years before death, and it may have been considerable. A patient suffering from a peritoneal mesothelioma interviewed recently, recalled playing with handfuls of asbestos on waste ground near a factory as a small boy, some forty years before he developed his tumour.

THOMPSON (1965) examined the lungs of an unselected series of autopsies in Cape Town, while a parallel investigation was carried out in Miami. In both cities asbestos bodies were found in basal lung smears in approximately 30 per cent of the male lungs and 20 per cent of the female. Similar observations have now been made in the United States, Europe and the United Kingdom. The highest counts are found in occupationally-exposed men (ASHCROFT, 1968) with lesser numbers in women

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and rural dwellers. If the newer techniques of electron microscopy are used, chrysotile asbestos fibres or fibrils can be identified in nearly all the lungs of adult urban dwellers (LANGER *et al.*, 1971).

It was an investigation in Finland that drew attention to widespread presence of calcification of the pleura in communities exposed to asbestos dust. KIVILUOTO (1965) found several hundred persons with radiological evidence of pleural calcification among rural people living in the vicinity of two open cast anthophyllite asbestos mines. In Bulgaria, BURLIKOFF and MICHAILOVA (1970) found calcified pleural plaques among peasants cultivating tobacco in areas where the natural rock contained a considerable proportion of anthophyllite asbestos.

In an attempt to define the quantity of asbestos dust in air in urban areas SELIKOFF *et al.* (1972) using high volume samplers and electron microscopy techniques quantified the asbestos content of air near building sites in Manhattan where asbestos spraying was being undertaken. Measurable but minute amounts of asbestos were detected, the maximum concentration downwind of the source was 80×10^{-9} g/m³.

A recent report of an ADVISORY COMMITTEE ON ASBESTOS CANCERS (1973) states that at present there is no evidence of lung damage from fibrosis by the low levels of asbestos exposure encountered by the general public in urban areas. Nor do they find evidence for an increased risk of cancer resulting from asbestos contamination of water, beverages or food.

However in the past asbestos pollution from crocidolite mines and factories using crocidolite has resulted in the occurrence of mesothelial tumours in the neighbourhood populations. These conditions probably do not now arise in developed countries, but asbestos products, particularly asbestos cement piping, are very widely used and many countries are developing their own manufacturing industries. It is important that there is wide knowledge of the asbestos hazard and that all users of asbestos, whether in mining or milling, ship building and repairing or manufacturing, practise scrupulous industrial hygiene and control of effluvia and waste products.

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