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RELATIONSHIP BETWEEN EXPOSURE TO ASBESTOS AND PLEURAL MALIGNANCY IN BELFAST

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Belfast is an industrial city and shipbuilding port. The city and surrounding residential area has a population of about three-quarters of a million people. The largest employers of labor during the first half of this century were the linen and shipbuilding industries, both of which have declined in recent years. Major unemployment has been prevented by diversification of industry. There is no asbestos mining or processing in the area. The working population is stable because of a system of work permits which prevents the entrance of transient labor from other parts of the British Isles or abroad. Although asbestos has been used in the shipyards and, more recently, in the building industry, asbestosis has not yet been regarded as a common industrial disease. Successful claims for industrial injuries benefit for asbestosis are less than ten per year and deaths due to this cause are seldom recorded.

McCaughey had already (1958) reported 15 cases of pleural mesothelioma. When the association between pleural mesothelioma and exposure to asbestos was recognised elsewhere, we then decided to investigate the effects of exposure to asbestos in Belfast more closely. With his cooperation the following lines of investigation have been pursued.

- (1) Exhaustive search for further patients with mesothelioma;
- (2) Investigation of the evidence of exposure to asbestos of patients with mesothelioma. (a) by obtaining occupational histories; (b) by histological examination of the underlying lung;
- (3) Analysis of information obtained in a comparable way from control groups of the population;
- (4) Study of the causes of illness and death in men handling asbestos in their work;
- (5) Study of Belfast as an environment in which asbestos is used and cases of mesothelioma occur.

The investigations are not complete and some of the earlier results have already been reported elsewhere (McCaughey *et al.*, 1962; Elmes *et al.*, 1965). This paper is another interim report.

Methods

- (1) Seeking patients with mesothelioma. All the likely people (pathologists, chest surgeons, and physicians and doctors interested in occupa-

tional disease) were asked to notify us of all suspected cases of mesothelioma of the pleura. All these cases were investigated, histological and autopsy material was examined wherever possible and the diagnosis confirmed or rejected. The diagnosis has only been accepted after histological confirmation by W. T. E. McCaughey.

(2) Exposure to asbestos.

(a) Occupational history. When the patient was still alive and well enough, he was interviewed and a full retrograde occupational history obtained. When not alive, the next of kin were visited and an occupational history obtained either from them or from companions at work.

(b) Histological data. Whenever histological material from the lung near the mesothelioma or from the other side of the chest was available this was submitted to W. T. E. McCaughey who searched it for asbestos bodies under standardized conditions.

(3) Control patients. Matched controls for the mesothelioma group were obtained by picking from the biopsy or autopsy register the nearest entry concerning a patient of the same age and sex to the mesothelioma patient's entry. If the diagnosis of mesothelioma was based on a biopsy the nearest patient of the same age and sex in the biopsy register was taken. If the diagnosis was made at autopsy then the nearest patient of the same age and sex in the autopsy register was taken. The same procedure was then used in obtaining an occupational history for these patients as for the mesothelioma patients.

For the patients with mesothelioma who came to autopsy, controls for lung histology were obtained from the autopsy register by choosing the nearest patient of the same age and sex dying of nonmalignant disease. The lung sections from these patients were examined for asbestos bodies under the same standardized conditions as was used for the mesothelioma patients.

Three further studies were made:

(a). Twenty patients, with asbestos bodies in the lungs, were chosen at random from relevant autopsy material, and 20 matched controlled patients were selected as previously. These 40 people were then investigated for occupational exposure to asbestos by the method described above. This was carried out without the investigator knowing which patients had asbestos bodies in the lungs.

(b). The lungs from 200 recent autopsies on men without malignant disease of the lung were investigated by the standardized technique for asbestos bodies. One hundred of these men had died aged 50 to 59 years and 100 aged 60 to 69 years.

(c). The lungs from 100 men dying of carcinoma of the bronchus were examined by the standardized technique for asbestos bodies. Matched controls for the most recent 50 of these were also studied.

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4. Asbestos Workers. The work of handling asbestos, and other materials used in heat and fire insulation is all done by men belonging to a single branch of the Transport and General Workers Union. Although these men are employed at various times by any of the contractors undertaking insulating work, the men remain at insulating work for most of their lives. The Union agreed to a complete survey of the health of this branch, and the first part of the investigation has been an investigation of causes of death. So far the cause of death of men who were branch members in 1957 have been investigated. The names are kept on the books after retirement because of pension arrangements. Their relatives have been interviewed, and the date and place of death determined. Details of hospital visits were also noted and then every effort has been made to collect all the hospital documents belonging to each man including biopsy and autopsy reports. The material was analyzed, and histological material reviewed wherever possible.

5. Belfast as an environment. The authors have visited the shipyards and various factories in Belfast, and seen asbestos being handled. Additional information has been obtained from the Medical Inspector of Factories and from the various other doctors and officials concerned with industrial hygiene. Data for the import of raw and manufactured asbestos and boiler composition was obtained from the Belfast Harbour Commissioners. Finally, the homes of all the patients with pleural mesothelioma were plotted on the map and photographed both before and after the exclusion of those cases with obvious occupational exposure. It was not found possible to get accurate information about the number of men employed in the different industries during the last 50 years in relation to the working population of Belfast as a whole.

TABLE 1
INDUSTRIAL EXPOSURE, ASBESTOS BODIES AND MESOTHELIOMA OF THE PLEURA

Patients with	Exposure			Total
	Heavy	Light	None	
Mesothelioma	8	24	10	42
Matched controls	2	7	33	42
Asbestos bodies	2	12	6	20
No asbestos bodies	1	4	15	20

Combining the light and heavy groups the differences are significant: Between Mesothelioma and controls $P < 0.001$; Between Asbestos bodies and none $0.02 > P > 0.01$.

TABLE 2
ASBESTOS BODIES AT AUTOPSY AND MALIGNANCY OF PLEURA AND LUNG

Patients	Number examined	Per cent with bodies	Significance of difference
With mesothelioma	24	88	$\chi^2 = 19.05$
Matched controls	24	25	$P < 0.0005$
With carcinoma of bronchus	100	20	
Most recent 50 of these	50	18	$\chi^2 = 0.94$
Matched controls	50	26	$0.4 > P > 0.3$
Without cancer of lung			
Aged 50 to 59	100	14	$\chi^2 = 5.18$
Aged 60 to 69	100	27	$0.05 > P > 0.02$

Results

(1) Number of patients with mesothelioma.

Including W. T. E. McCaughey's original 15 cases, 45 cases of pleural mesothelioma had been detected in Belfast up to July 1964. Of these, three of McCaughey's original cases died before 1950 and it proved impossible to obtain enough clinical details to include them in the rest of the investigation. The patients were diagnosed between the ages of 38 and 88 (mean 59 = 10.9 years standard deviation). There were only 2 women.

(2) Exposure to asbestos.

(a) Occupational histories (TABLE 1). There are significantly more patients in the mesothelioma group who had been exposed to asbestos. The numbers who had actually been employed full time on insulating work (classified under "Heavy") were not enough to be significant. The predominance of patients employed in occupations such as shipyard plumber and boiler repairer, known to be exposed to asbestos dust intermittently, is very marked in the mesothelioma group.

(b) Histological evidence (TABLE 2). There is a highly significant difference between the mesothelioma and the control group similar to the difference in occupational histories. Over three-quarters of the mesothelioma lungs contained asbestos bodies whereas only a quarter of the control lungs contained bodies.

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(a) Occupational bodies in the lung. the patients with exposure and only a history (TABLE 1).

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TABLE 3
CAUSES OF DEATH IN 20 ASBESTOS WORKERS

Malignant disease 16 cases	
3	Peritoneal mesotheliomas
2	Pleura mesotheliomas
7	Bronchial carcinomas
1	Bronchial carcinoma or mesothelioma
1	Malignant ascites with lung shadow
1	Bladder carcinoma
1	Small intestine carcinoma
Nonmalignant disease 14 cases	
6	Cor pulmonale due to asbestosis
1	Bronchopneumonia with severe asbestosis
1	Suicide
3	Coronaries
2	Cerebral hemorrhages
1	Mesenteric thrombosis

Mean age 55.3 years (range 37-66 years).

(3) *Comparable information about other groups of the population.*

(a) Occupational histories of patients dying with and without asbestos bodies in the lung. This study was done "blind." About three-quarters of the patients with asbestos bodies in the lung had a positive history of exposure and only a quarter of those without asbestos bodies had a similar history (TABLE 1).

(b) Histological evidence. Of the 200 autopsies on patients without pulmonary malignancy, one in five had asbestos bodies in the lung. The asbestos bodies were more frequent in patients between 60 and 69 years than in the age group 10 years younger than this. The patients with carcinoma of the bronchus showed about the same incidence of asbestos bodies in the lung as the various control groups.

(4) *Causes of death in asbestos workers.*

Of 43 deaths recorded in the Union records in the last seven years, reliable information is available in 30 so far (see TABLE 3). The average age at death was 55.3 years and the oldest was only 66 years. The incidence of malignant disease (over half of the deaths were due to this) is very high but until a proper control series has been investigated the significance of this finding cannot be determined. Three cases of peritoneal tumor were brought to light by this investigation. Complete autopsies are not

available on two of these patients so that a sure diagnosis cannot be made, but the histological and clinical picture is entirely consistent with peritoneal mesothelioma.

(5) *Belfast as an environment.*

Belfast Lough is a narrow inlet and runs inland from the Irish Sea in a southwest direction for about 12 miles. The prevailing wind is south-westerly and the heavier industrial areas, including the shipyards, are grouped around the inland end of the loch with the residential areas on the periphery. The most densely populated residential area is close to the industrial but, except on the north shore, on the windward side of it. Most

of the industrial area is one small factory the shipyards.

Most of the insulators based on the of their time working yards until slum clearance the outskirts of Belfast countered except in a tal exposure would be a history of more than plotted on the map cause.

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SHIPBUILDING and ASBESTOS IMPORTS.
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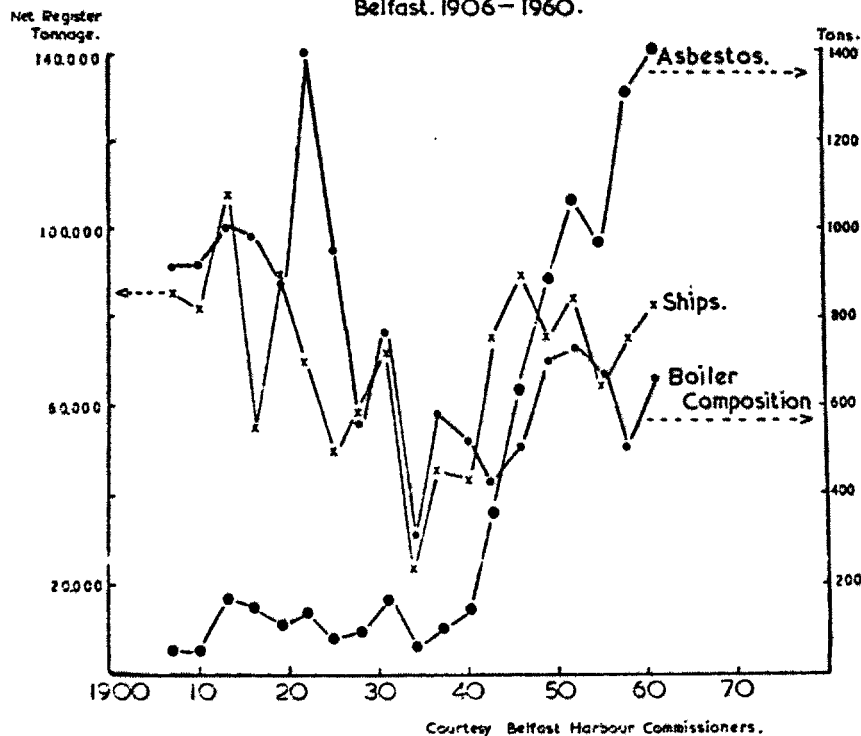


FIGURE 1. Shipbuilding and Asbestos Imports. Belfast 1906-60.

Raw and manufactured asbestos includes both material used for insulation and building materials such as corrugated roofing. Boiler composition is a powder of 85 per cent magnesia and 15 per cent asbestos fiber. It is mixed with water on site to form a thick paste and used to insulate boilers and steam pipes. Tonnage of a ship built is recorded against the year the ship is commissioned. Insulating work may have been done on it over a year before this.

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Most of the insulating work for the province is done by a group of contractors based on the shipyards, and the workers they employ spend much of their time working on ships. They lived in the area south of the shipyards until slum clearance and rehousing has recently scattered them over the outskirts of Belfast. No cases of manifest asbestosis have been encountered except in asbestos workers so that the only index of environmental exposure would be those cases of pleural mesothelioma who did not give a history of more than a light industrial exposure. When their homes were plotted on the map there was no grouping to suggest an environmental cause.

The importation of asbestos and asbestos goods including boiler composition which is a mixture of 85 per cent magnesia and 15 per cent asbestos fiber into Belfast is shown in FIGURE 1. For the earlier years the volume of material imported correlates fairly well with the activity of the shipyard. But the recent and very marked rise in imports is an indication of the very rapid increase in the use of asbestos in the building industry. As this latter increase is too recent to be manifest by an increase in malignant disease, no attempt has yet been made to investigate the effects of asbestos on workers in the building industry.



The use of asbestos both for insulating boilers and steam pipes, and in the provision of fireproof layers in modern buildings is increasing. The precautions introduced for the protection of workers in the asbestos manufacturing industry may have reduced the incidence of pulmonary fibrosis and right sided heart failure, but the problem of malignant disease remains. The investigations described above have been carried out in an area where pulmonary fibrosis and cor pulmonale due to asbestosis is not common: nevertheless, there is a high incidence of pleural mesothelioma. This tumor is invariably fatal and runs a prolonged course usually associated with a lot of pain which is not amenable to palliative treatment. It usually affects workers before their retiring age. The association between this tumor and exposure to asbestos is clearly shown by our data which relates mesothelioma both to a history of exposure to asbestos and the presence of asbestos bodies in the lungs. Three-quarters of the patients with mesothelioma had a history of exposure to asbestos at some time in life and three-quarters of those examined had asbestos bodies in the underlying lung. In carefully matched control groups the incidence of asbestos exposure and of asbestos bodies in the lung is only one in four. The methods of detecting both previous exposure to asbestos and the presence of asbestos

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in the lungs used in this study are not very efficient, and our data indicate that in both instances about one quarter of the patients were incorrectly recorded as negative. This means that we have underestimated the statistical correlation between asbestos and mesothelioma but it does not alter our conclusion. The two additional facts which arise from this part of the study are:

- (1) That the majority of the patients with mesothelioma were not directly employed in the insulating industry. A history of intermittent or casual exposure only was obtained in most of the cases and sometimes this had occurred many years ago.
- (2) That about a fifth of the male population of Belfast had asbestos bodies in the lungs at autopsy.

These two facts indicate that the exposure to asbestos needed to induce mesothelioma is much less than that acquired by the insulating worker and that the population at risk is very much larger than previously suspected. Without further information it is impossible to say how large, but it appears that about a quarter of the male and a smaller proportion of the female population of this industrial area may have been exposed to sufficient asbestos to cause mesothelioma in susceptible individuals. Although the lungs of the older men surveyed showed more frequent evidence of exposure than the younger, evidence derived from the increasing use of asbestos indicates that the population at risk may be increasing.

The information derived from the study of deaths of insulation workers is incomplete but presents a different aspect of the problem (TABLE 3). About half the deaths so far investigated occurred in men who had started in the industry before the dangers of asbestos were first appreciated. There were two cases of classical fibrosis and cor pulmonale derived from this era. But one man died of cor pulmonale after only 18 years in the industry, and left it only at the time of his terminal illness. There is a high incidence of carcinoma of the lung. The other statistics failed to show that exposure to asbestos was a significant cause for carcinoma of the lung. Presumably other factors such as smoking and atmospheric pollution are more important causes in the population of Belfast as a whole. Among asbestos workers carcinoma of the lung is at least as important as the more specific mesothelial tumor of pleura or peritoneum. This investigation is not sufficiently advanced to confirm the relationship between asbestos and other alimentary tumors (Selikoff *et al.*, 1964).

Summary

A study of 43 cases in Belfast has revealed a relationship between exposure to asbestos at work and the development of mesothelial tumor of the pleura.

Evidence has been produced which indicates that the exposure associated

with this tumor need quarter of the male population exposure.

Among asbestos workers a cause of death as in asbestos may be exposure secondary neoplasia.

This work was carried out by the Department of Pathology, Trinity College, Dublin.

The home visits and the work of Dudgeon and Mrs. MacCaughey and their colleagues for cases, to the employees for information of imports.

ELMES, P. C., W. T. E. McCaughey, W. T. E. 1964
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quarter of the male population of this area may have received sufficient
exposure.

Among asbestos workers carcinoma of the lung is at least as frequent
a cause of death as mesothelioma but the increasing widespread use of
asbestos may be exposing a wide section of the population to the risk of
secondary neoplasia.

Acknowledgments

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Pathology, Trinity College, Dublin).

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ployees) for information and to the Belfast Harbour Commission for figures
of imports.

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