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FROM THE INSULATION INDUSTRY HYGIENE RESEARCH PROGRAM

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The International Agency for Research on Cancer of the World Health Organization has just issued its Scientific Publication No. 8, Biological Effects of Asbestos, consisting of the Proceedings of a Working Conference held at the Agency's Headquarters in Lyon, France, October 2-6, 1972. In view of the considerable interest in the health problems associated with insulation work, we are devoting this entire issue to the publication of a paper from the IARC volume by Dr. Irving Selikoff, Dr. E. Cuyler Hammond and Mr. Herbert Seidman which treats the problem of cancer risk associated with insulation work.

Cancer risk of insulation workers in the United States[1]

I. J. SELIKOFF, E. C. HAMMOND & H. SEIDMAN

In 1963, information became available which indicated that asbestos insulation workers employed in the construction industry were subject to a significant cancer hazard associated with their work (Selikoff *et al.*, 1964). Studying the mortality experience of the 632 members on the rolls of the New York–New Jersey branches of the insulation workers' union on 1 January 1943, for the 20-year period ending 31 December 1962, it was found that death from cancer was almost three times as frequent as expected. The death rate from cancer of the bronchus and pleura was 6.8 times as high as that for the general US white male population, both age and date being taken into consideration; and cancer of stomach, colon and rectum was found to be three times as common. Attention was called to the occurrence of pleural and peritoneal mesotheliomas (Selikoff *et al.*, 1965a).

These studies were subsequently extended to investigate the interrelationships between asbestos exposure and cigarette smoking in the production of lung cancer, the significance of mesothelioma (Selikoff *et al.*, 1970) and to obtain further evidence on the possible relationship between asbestos exposure and the occurrence of gastro-intestinal cancer.

The data were insufficient, however, to resolve a number of questions which are important for a full evaluation of the problem and to provide guidance for the establishment of needed administrative and industrial control measures. To obtain such additional information, we have continued and widened our investigations.

CURRENT STUDIES

Using approaches and methods previously reported (Selikoff *et al.*, 1964; Selikoff *et al.*, 1965b), we have studied the experiences of three cohorts of workers exposed to asbestos insulation materials.

1. *New York–New Jersey cohort.* We have continued our surveillance of the New York–New Jersey insulation workers. By 31 December 1962, 262 had died; thus, 370 were still alive on 1 January 1963. Each has been followed up until 31 December 1971.

Two additional groups of workers have been investigated:

2. In one study, we registered *the entire membership of the insulation workers union in the United States and Canada*[2] on 1 January 1967 (17,800; including members of the New York–New Jersey

[1] From the Environmental Cancer Research Project of the American Cancer Society and the Mount Sinai School of Medicine of the City University of New York.

locals mentioned above), and recorded many characteristics for each man including date of birth and onset of insulation work. Each man has since been observed until 31 December 1971.

3. A third group consisted of *the entire workforce (1941–45) of a factory in an eastern US city* which manufactured amosite asbestos insulation materials (including insulating block and pipe covering, and asbestos mattresses), for use by insulation workers in the construction industry, especially in ship construction and repair. The plant opened its doors in June 1941 and remained in business until November 1954. Very few of the production workers studied by us had had any prior occupational exposure to asbestos. Between 1941 and the end of 1945 a total of 933 men were hired; of these, some worked for as little as one day, while others worked until 1954 when the plant closed. Results of physiological studies of men in this plant have been reported (Bader *et al.*, 1961). Recently, we have traced the entire group up until 31 December 1971 in order to evaluate the cancer risk among them. Eight hundred and seventy-seven (94%) were fully traced, and the remainder were partially traced for varying periods. We have analysed their mortality experience in relation to the duration of employment, age at onset of employment and lapsed period from onset of employment.

FINDINGS IN INSULATION WORKERS IN THE CONSTRUCTION INDUSTRY

The experiences of the two cohorts of insulation workers in the construction industry (New York–New Jersey and US–Canada cohorts) amply confirm the cancer risk first identified in 1963. By 31 December 1971, 430 of the original 632 (New York–New Jersey cohort) had died, 421 after reaching 20 years from onset of employment. One hundred and eighty-nine (45% of the 421 total deaths) died of cancer, whereas 47.2 such deaths had been expected (Table 1).

The average age of the insulation workers throughout the United States and Canada (US–Canada cohort) was much lower, and they therefore had considerably less work experience than that of the New York–New Jersey cohort (Hammond & Selikoff [1]). Nevertheless, the excess of cancer deaths was very much the same, these deaths occurring among the older men who had longer work experience. Relatively few deaths were found among the younger men, despite the large number in the cohort. 144.09 cancer deaths were expected and 459 occurred, representing 41% of the total of 1092 deaths observed in the period 1967–71 (Table 2).

Lung cancer

Bronchogenic carcinoma was found to be a leading cause of death among asbestos insulation workers, accounting for approximately 45% of fatal neoplasms. In the first two series reported, it was responsible for 20% of all deaths and was almost three times as common as were pleural and peritoneal mesothelioma. Recent histological studies of tumours from these patients show the distribution of cell types to be that of lung cancer found in the general population (Kannerstein & Churg, 1972), and our clinical experience indicates that their prognosis was equally poor. These findings stress the urgency of preventive measures, such as dust control

[a] International Association of Heat and Frost Insulators and Asbestos Workers, AFL–CIO.

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PURPOSES OF THE INSULATION INDUSTRY HYGIENE RESEARCH PROGRAM

1. To develop improved methods for minimizing exposure of insulation workers to dusts and fumes encountered in their work.
2. To disseminate knowledge of these improved methods of dust control wherever they may be applied advantageously and to offer cooperation, advice and assistance toward their universal adoption.

Table 1[a]. Expected[b] and observed number of deaths among 623 New York–New Jersey asbestos insulation workers 1 January 1943–31 December 1971, twenty or more years after onset of first exposure to asbestos

	1943–51		1952–61		1962–71		Total, 1943–71	
	Expected	*Observed*	*Expected*	*Observed*	*Expected*	*Observed*	*Expected*	*Observed*
Total cancer: all sites	11.3	28	18.3	57	17.6	104	47.2	189
Lung cancer	1.5	13	3.5	23	5.1	48	10.1	84
Pleural mesothelioma	*n.a.*[c]	1	*n.a.*	2	*n.a.*	5	*n.a.*	8
Peritoneal mesothelioma	n.a.	1	n.a.	3	n.a.	20	n.a.	24
Cancer of stomach, colon, rectum, oesophagus	4.1	7	5.0	18	3.9	16	13.0	41
Cancer all other sites	5.7	6	9.8	11	8.6	15	24.1	32
Asbestosis	n.a.	1	n.a.	10	n.a.	22	n.a.	33
All other causes	65.1	44	89.4	94	78.3	61	232.8	199
Total all causes	76.4	73	107.7	161	95.9	187	280.0	421
Person-years of observation	3726		4406		2898		11,030	

[a] 632 members were on the union's rolls on 1 January 1943. Nine died before reaching 20 years from first employment. All others entered these calculations upon reaching the 20-year from onset of first exposure point.
[b] Expected rates are based upon age-specific death rate data of the US National Office of Vital Statistics from 1949–67. Rates were extrapolated 1943–48 from rates for 1949–55, and for 1968–71 from rates for 1961–67.
[c] US death rates not available, but these are rare causes of death in the general population.

and the avoidance of cigarette smoking (Selikoff *et al.*, 1968; Hammond & Selikoff[1]).

Gastro-intestinal cancer

In our initial reports (Selikoff *et al.*, 1964; Hammond *et al.*, 1965) attention was called to the then unexpected finding of a moderate excess of gastro-intestinal cancer among New York insulation workers. Nevertheless, relatively few deaths were studied and firm conclusions were not considered warranted. We have now collected additional data, and these give the same indication very much at the same level of excess, i.e., at two or three times expected deaths (Tables 1 & 2). These findings were made for cancer of the oesophagus, stomach, and of the colon and rectum. A similar excess has been found among insulation workers in Belfast (Elmes & Simpson, 1971). Taken together, these experiences suggest that the increase is real. While they are not responsible for a major proportion of excess deaths (lung cancer, mesothelioma and asbestosis account for more), the incidence of gastro-intestinal cancer is nevertheless substantial: in the New York–New Jersey group 13.0 deaths were expected and 41 occurred; and in the US–Canada survey, 27.3 were expected and 55 occurred. Moreover the finding may be of considerable theoretical importance, in view of the dearth of useful hypotheses concerning the etiology of gastro-intestinal cancer in general, and of cancer of the colon and rectum in particular.

Other neoplasms

The knowledge that a number of tissues are subject to asbestos-induced cancer, coupled with the observation that fibres and fibrils may be found in many organs, admits the possibility that a neoplastic effect exists for sites other than those heretofore identified. Examination of this hypothesis is hampered by the infrequency of some such tumours in general and by the as yet inadequate number of observations available. We do not at present find it useful, therefore, to comment on this question, although we have been particularly interested in cancer of pancreas, brain and oro-pharynx, in genito-urinary cancer, and lymphoma and leukaemia.

RISK WITH FACTORY EXPOSURE TO ASBESTOS INSULATION MATERIALS

In 1964, Smith (1965) called attention to the multiplicity of materials to which insulation workers were exposed. It seemed justified to seek evidence on whether asbestos insulation materials *per se* were specifically related to various diseases. If not, investigation of other insulation materials would be required. We therefore studied the work force of the insulation materials factory noted above, in which exposure was only to asbestos insulation, and not to other insulation materials used in the construction industry (e.g., fibrous glass, calcined diatomaceous earth, rock wool, etc.)

Four hundred and eighty-four deaths are known to have occurred among the 877 men fully traced up to 31 December 1971. The distribution of deaths strongly resembled that seen among insulation workers who install such materials, despite the fact that observation of this cohort has reached only 25–26

	Total		Distribution by duration from onset of exposure			
			Less than 20 years		20 years and more	
	Expected	Observed	Expected	Observed	Expected	Observed
Total deaths	805.63	1092	178.94	211	626.69	881
Cancer: all sites	144.09	459	26.31	51	117.78	408
Lung cancer	44.42	213	7.03	22	37.39	191
Pleural mesothelioma	n.a.[b]	26	n.a.	2	n.a.	24
Peritoneal mesothelioma	n.a.	51	n.a.	3	n.a.	48
Cancer of stomach	6.62	16	0.97	1	5.65	15
Cancer of colon, rectum	17.51	26	2.51	3	15.00	23
Cancer of oesophagus	3.21	13	0.44	1	2.77	12
All other cancers	72.33	114	15.36	19	56.97	95
Asbestosis	n.a.	78	n.a.	5	n.a.	73
All other causes	661.54	555	152.63	155	508.91	400
Number of men	17,800		12,681		5,119	
Person-years of observation	86,300		62,673		23,627	

[a] Expected deaths are based upon age-specific death rate data of the US National Office of Vital Statistics. Rates for 1968–71 were extrapolated from rates for 1961–67.
[b] US death rates not available, but these are rare causes of death in the general population.

years from onset. Thus, lung cancer accounted for 73 deaths, although only 11.41 were expected; and gastro-intestinal cancer for 26, with 12.86 expected (including oesophagus). Mesothelioma caused seven deaths, and asbestosis 27 (Table 3).

These data indicate that asbestos insulation materials are capable of causing the disease patterns seen among insulation workers; there is no need to invoke the influence of other insulation materials.

EPIDEMIOLOGIC VARIABLES

Lapsed period from onset of exposure

It has long been inferred, on the basis of rather limited data, that asbestos cancer largely occurs more than twenty years from onset of exposure.

Experiences in the cohorts studied indicate that lung cancer may occur in considerable excess as early as 10–14 years from onset, with 0.65 expected deaths *versus* 10 observed among those working in the amosite factory for more than one year (Table 5b). Moreover, death rates for lung cancer were significantly increased in the US–Canada insulation workers cohort 15–19 years from onset (4.86 deaths were expected and 18 occurred) (Table 4).

On the other hand, in terms of numbers, most deaths from lung cancer occurred among insulation workers 30–39 years from onset of exposure, or

Table 3. Expected[a] and observed deaths among 933[b] amosite asbestos factory workers first employed 1941–45, and observed to 31 December 1971

	Before 1952		1952–61		1962–71		Total, 1941–71	
	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed
Total deaths	69.99	88	108.27	146	121.24	250	299.49	484
Total cancer: all sites	9.81	15	18.72	44	21.63	84	50.16	143
Lung cancer	1.49	3	3.71	22	6.21	47	11.41	73
Pleural mesothelioma	n.a.[c]	1	n.a.	0	n.a.	2	n.a.	3
Peritoneal mesothelioma	n.a.	0	n.a.	0	n.a.	4	n.a.	4
Cancer of stomach	1.45	3	1.84	4	1.29	4	4.58	11
Cancer of colon, rectum	1.56	2	2.61	5	2.88	8	7.05	15
Cancer of oesophagus	0.27	0	0.45	0	0.51	0	1.23	0
All other cancers	5.04	6	10.11	12	10.74	19	25.89	37
Asbestosis	n.a.	3	n.a.	7	n.a.	17	n.a.	27
All other causes	60.17	70	89.55	95	99.61	149	249.33	314

[a] Expected rates are based upon age-specific death rate data of the US National Office of Vital Statistics from 1949–67. Rates were extrapolated for 1941–48 from rates for 1949–55, and for 1968–71 from rates for 1961–67.
[b] 933 men were employed. In 5 cases, ages were not known and these men have been excluded from these calculations. 877 men were traced to death or to 31 December 1971. 51 men were partially traced and remain in the calculations until lost to observation.
[c] US death rates not available, but these are rare causes of death in the general population.

fully the effects of asbestos exposure unless observation was possible for at least 40 years from the onset of work exposure.

Age at onset

A number of methodological difficulties are encountered in studying the effect of age at onset on lung cancer rates. Not the least are the secular changes in cigarette smoking habits in the past 50 years (Hammond, 1966), and the concurrent increases in lung cancer death rates in the general population, which must be taken into account.

With these in mind, there seem to be no striking variations in the incidence of lung cancer as a result of differences in age at which asbestos work exposure first began (Table 6).

among 17,200 asbestos insulation workers in the US and Canada, 1 January 1967–31 December 1971: relation to elapsed period from onset of work exposure

Years from onset	Lung cancer			Pleural mesothelioma
	Expected deaths[a]	Observed deaths	Ratio	Observed deaths
<10	0.48	0	—	0
10–14	1.69	4	2.4	0
15–19	4.86	18	3.7	2
20–24	7.55	25	3.3	4
25–29	8.50	41	4.8	7
30–34	6.24	44	7.1	4
35–39	3.53	23	6.5	1
40–44	4.04	24	5.9	3
45–49	3.72	17	4.6	4
50+	3.81	17	4.5	1
Total	44.42	213	4.8	26

[a] Expected deaths are based upon age-specific death rate data of the US National Office of Vital Statistics. Rates for 1968–71 were extrapolated from data for 1961–67.

Table 5a. Age at onset of employment, 1941–45, of 933 workers in an amosite asbestos insulation factory

Age at employment	Duration of employment			
	Total	<3 months	3–11 months	1 + years
15–19	94[a]	42	30	21
20–24	114	35	34	45
25–29	120	28	48	44
30–34	114	32	40	42
35–39	106	27	40	39
40–44	101	30	38	33
45–49	83	29	21	33
50–54	90	26	27	37
55–59	55	14	21	20
60–64	30	6	12	12
65–69	16	6	4	6
70–74	4	1	3	—
75–79	1	—	—	1
Unknown	5	2	3	—
Total	933[a]	278	321	333

[a] Includes one man with unknown length of employment.

Table 5b. Lung cancer among 326 amosite asbestos workers employed for 1 year or more starting 1941–45, and observed to 31 December 1971.[a] Expected and observed deaths[b]

Attained years from first employment	Attained ages													
	Total		<40		40–49		50–59		60–69		70–79		80–89	
	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.
1–9	0.68	2	0.02	0	0.09	0	0.30	2	0.22	0	0.05	0	—	—
10–14	0.65	10	0.02	0	0.07	0	0.19	4	0.29	5	0.08	1	—	—
15–19	0.72	11	0.01	0	0.07	0	0.20	3	0.26	4	0.17	4	0.01	0
20–24	1.03	8	—	—	0.10	2	0.29	5	0.39	1	0.22	0	0.02	0
25–29	1.01	14	—	—	0.06	1	0.27	4	0.37	7	0.26	6	0.05	0
	4.09	45	0.05	0	0.39	3	1.25	18	1.53	17	0.78	11	0.09	0

Seven were omitted, four because of prior occupational exposure to asbestos and three who had not been traced after the first year. Five were partially traced and remained in the calculations only to the date of last observation. All others entered the calculations after first year from onset.

[b] Expected rates are based upon age-specific death rate data of the US National Office of Vital Statistics from 1949–67. Rates were extrapolated for 1941–48 from rates for 1949–55, and for 1968–71 from rates for 1961–67.

Table 6. Expected and observed deaths of lung cancer among 17,800 asbestos insulation workers, 1 January 1967–31 December 1971; distribution by age at onset of exposure

Age at onset of exposure	Deaths of lung cancer		
	Expected[a]	Observed	Ratio
< 25	18.19	102	5.61
25–34	15.20	66	4.34
35–44	8.78	38	4.33
45 +	2.25	7	3.11

[a] Expected deaths are based upon age-specific death rate data of the US National Office of Vital Statistics. Rates for 1968–71 were extrapolated from rates for 1961–67.

In one cohort, it was possible to study the effect of differences in length of exposure. While all the insulation materials factory employees started work between 1941 and 1945, approximately one-third of these worked for less than three months, another third for three to eleven months, and the remaining third for a year or more (Table 5a). All worked in the same factory and had similar exposure to the same asbestos starting at the same point in time. The only significant variable was duration of exposure. All were traced to the end of 1971.

Our findings indicate that duration of exposure, and thus presumably total dose, has an important influence on lung cancer rates. Those with less

Table 7. Expected and observed deaths of lung cancer among 876 amosite asbestos factory workers, first employed 1941–45, and observed to 31 December 1971.[a] Distribution by duration of employment

Duration of employment	Number of men	Person-years of observation	Deaths of lung cancer		
			Expected[b]	Observed	Ratio
< 3 months	256	5,869	3.55	13	3.66
3–11 months	294	6,158	3.58	15	4.19
1 + years	326	6,912	4.09	45	11.00
Total	876	18,939	11.22	73	6.51

[a] This table excludes 57 men. Ten died during first year of employment, 39 could not be traced after the first year, 7 had prior occupational exposure to asbestos and 1 had employment of uncertain duration. Seventeen men of the 876 were partially traced and remained in the calculations until lost to observation.

[b] Expected rates are based upon age-specific death rate data of the US National Office of Vital Statistics, 1949–67. Rates were extrapolated for 1941–48 from rates for 1949–55, and for 1968–71 from rates for 1961–67.

Table 8. Mortality experience of 337 asbestos insulation workers 1 January 1963–31 December 1971, analysed by duration of shipyard employment

Cause of death	Shipyard employment					
	None (98)		Up to two years (112)		Three or more years (121)	
	Observed	Expected[a]	Observed	Expected	Observed	Expected
Total cancer: all sites	25	3.6	28	4.8	29	5.8
Lung cancer	11	1.2	9	1.4	17	1.9
Pleural mesothelioma	2	n.a.[b]	2	n.a.	0	n.a.
Peritoneal mesothelioma	0	n.a.	0	n.a.	4	n.a.
Cancer of stomach, colon, rectum, oesophagus	3	0.8	2	1.0	5	1.3
Cancer all other sites	3	1.8	9	2.4	2	2.9
Asbestosis	4	n.a.	11	n.a.	5	n.a.
All other causes	8	16.2	18	20.3	21	26.0
Total deaths	37	20.0	57	25.1	55	32.4

[a] Expected deaths are based upon age-specific death rate data of the US National Office of Vital Statistics. Rates for 1968–1971 were extrapolated from rates for 1961–1967.

[b] US death rates not available, but these are rare causes of death in the general population.

industry work, 1 January 1967–31 December 1971

	Workmen registered in union locals in south-west, mid-west and central states		Workmen registered in shipyard locals	
	Expected	Observed	Expected	Observed
Total deaths	316.28	446	39.56	34
Total cancer: all sites	56.24	172	7.91	16
Lung cancer	17.47	79	2.67	9
Pleural mesothelioma	n.a.[b]	10	n.a.	2
Peritoneal mesothelioma	n.a.	13	n.a.	1
Cancer of stomach	2.56	6	0.36	0
Cancer of colon, rectum	6.75	12	0.98	0
Cancer of oesophagus	1.26	6	0.20	1
All other cancers	28.30	46	3.70	3
Asbestosis	n.a.	26	n.a.	3
All other causes	259.94	248	31.65	15
Number of men	7,289		462	
Person-years of observation	35,310		2,244	

[a] Expected deaths are based upon age-specific death rate data of the US National Office of Vital Statistics. Rates for 1968–71 were extrapolated from rates for 1961–67.
[b] US death rates not available, but these are rare causes of death in the general population.

than three months of work showed a definite increase in lung cancer risk (13 observed *versus* 3.55 expected), and those with three to eleven months' exposure much the same increase; while workers employed for one year or over had a much more substantial increase (45 observed, 4.09 expected) (Table 7).

Fibre type

Crocidolite was not used for insulation work in the United States during the period covered by our study. Indeed, very little crocidolite was imported into the United States until after the Second World War (Selikoff *et al.*, 1970). Thus, exposure to this fibre cannot explain the cancer risk observed.

Both chrysotile and amosite have been used in insulation materials in the US, the former since the turn of the century (Selikoff *et al.*, 1965b) and the latter since the mid-1930's (Selikoff *et al.*, 1972). Amosite has been used principally in ship insulation and chrysotile in general construction and industrial work, although it is also found in some shipyard materials.

It is difficult to compare the relative disease potential of the two varieties of fibres in insulation work, since cohorts which differ in this respect may also differ in other respects, including type and intensity of exposure, duration of exposure and lapsed period om onset of exposure. Nevertheless, two sets of observations are available which may be of interest. We have compared the mortality experience of insulation workers in the New York–New Jersey group according to their duration of shipyard employment (ship insulation being fairly important in the New York harbour area, especially between 1939 and 1945). Of the 370 men in the union on 1 January 1963 who were survivors of the 1943 cohort, we were able to obtain histories of shipyard employment by personal interview from 337. The results indicate that the mortality experience in men with shipyard employment, with its greater potential for amosite exposure, did not differ substantially from that of men in the same union, at the same period of time, without such employment (Table 8).

In the US–Canada survey, each union member was registered in a specific union local, several of which were engaged entirely in shipyard work. Others, in the central and mid-western parts of the country, had no such experience. This is not to say that individual members of these locals did not, in the past, do some shipyard work, but it is unlikely to have constituted a major part of their work-history.

We have analysed the mortality experience of men in the two groups of locals between 1967 and 1971. There does not seem to have been any significant difference between them (Table 9). At least as reflected in these two sets of data, construction industry insulation work, with its preponderance of chrysotile exposure, was no more or less hazardous than was shipyard work, with its wider use of amosite materials.

a serious cancer risk has been demonstrated among asbestos insulation workers in the United States. Approximately one death in five, an extraordinary incidence, has been the result of lung cancer. Gastro-intestinal cancer was more than doubled in incidence, and mesothelioma was responsible for 7% of all deaths.

An increased incidence of lung cancer was seen as little as 10–14 years from the onset of work exposure; we suspect that this tends to be associated with more intense exposure, as among factory workers. However, the greater increase occurred 30–45 years from onset, especially among the less intensely exposed insulation workers. It would be difficult to evaluate fully the effects of asbestos exposure without observation for at least 40 years from onset of exposure.

Data have been presented indicating that these risks are associated with the asbestos insulation materials *per se*.

We were not able to find evidence that the use of chrysotile in insulation work was associated with a greater risk than was amosite, or *vice versa*. We have no knowledge of the comparative effect which crocidolite might have; it was not used in US insulation work.

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REFERENCES

Bader, M. E., Bader, R. A. & Selikoff, I. J. (1961) Pulmonary function in asbestosis of the lung. An alveolar-capillary block syndrome. *American Journal of Medicine*, 30, 235–242

Elmes, P. C. & Simpson, M. J. C. (1971) Insulation workers in Belfast. 3. Mortality 1940–1966. *British Journal of Industrial Medicine*, 28, 226–236

Hammond, E. C. (1966) Smoking in relation to the death rates of one million men and women. In: *Epidemiological Study of Cancer and Other Chronic Diseases*, Bethesda, National Cancer Institute Monograph 19, pp. 127–204

Hammond, E. C., Selikoff, I. J. & Churg, J. (1965) Neoplasia among insulation workers in the United States with special reference to intra-abdominal neoplasia. *Annals of the New York Academy of Sciences*, 132, 519–525

Kannerstein, M. & Churg, J. (1972) Pathology of carcinoma of the lung associated with asbestos exposure. *Cancer*, 30, 14–21

Selikoff, I. J., Churg, J. & Hammond, E. C. (1964) Asbestos exposure and neoplasia. *Journal of the American Medical Association*, 188, 22–26

Selikoff, I. J., Churg, J. & Hammond, E. C. (1965a) Relation between exposure to asbestos and mesothelioma. *New England Journal of Medicine*, 272, 560–565

Selikoff, I. J., Churg, J. & Hammond, E. C. (1965b) The occurrence of asbestosis among insulation workers in the United States. *Annals of the New York Academy of Sciences*, 132, 139–155

Selikoff, I. J., Hammond, E. C. & Churg, J. (1968) Asbestos exposure, smoking and neoplasia. *Journal of the American Medical Association*, 204, 106–112

Selikoff, I. J., Hammond, E. C. & Churg, J. (1970) Mortality experiences of asbestos insulation workers. In: Shapiro, H. A., ed., *Pneumoconiosis. Proceedings of the International Conference, Johannesburg, 1969*, Cape Town, Oxford University Press, pp. 180–186

Selikoff, I. J., Hammond, E. C. & Churg, J. (1972) Carcinogenicity of amosite asbestos. *Archives of Environmental Health (Chicago)* (in press)

Smith, K. W. (1965) Trends in the health of the asbestos worker. *Annals of the New York Academy of Sciences* 132, 685–690