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SNAKES DIDN'T WORK?

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 25–30

Table 2. Expected[a] and observed deaths among 17,300 asbestos insulation workers in the United States and
1 January 1967–31 December 1971

	Total		Distribution by duration from onset of expo			
			Less than 20 years		20 years and m	
	Expected	Observed	Expected	Observed	Expected	Ob
Total deaths	305.53	1092	178.94	241	326.69	
Cancer: all sites	144.09	459	26.31	51	117.78	
Lung cancer	54.12	213	7.33	22	37.39	
Pleural mesothelioma	n.a.[b]	26	n.a.	2	n.a.	
Peritoneal mesothelioma	n.a.	51	n.a.	3	n.a.	
Cancer of stomach	6.62	16	0.97	1	5.65	
Cancer of colon, rectum	17.51	26	2.51	3	15.00	
Cancer of oesophagus	3.21	13	0.44	1	2.77	
All other cancers	72.33	114	15.06	19	56.97	
Asbestosis	n.a.	78	n.a.	5	n.a.	
All other causes	661.54	555	152.63	155	508.91	
Number of men	17,300		12,331		5,119	
Person-years of observation	36,300		32,673		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 e
polated 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 12.36 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 occ
more than twenty years from onset of exposure.

Experiences in the cohorts studied indicate th
lung cancer may occur in considerable excess as ea
as 10–14 years from onset, with 3.65 expected dea
versus 10 observed among those working in
amosite factory for more than one year (Table
Moreover, death rates for lung cancer were signi
cantly increased in the US–Canada insulation wo
kers cohort 15–19 years from onset (4.86 deaths wer
expected and 18 occurred) (Table 4).

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

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	69.98	38	108.27	146	121.24	250	299.49	484
Total cancer: all sites	9.31	15	18.72	44	21.53	84	50.16	143
Lung cancer	1.49	3	3.71	23	6.21	47	11.41	73
Pleural mesothelioma	n.a.	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	1.34	4	1.29	4	4.08	11
Cancer of colon, rectum	1.56	2	2.61	6	2.38	8	7.05	16
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	25.39	37
Asbestosis	n.a.	3	n.a.	7	n.a.	17	n.a.	37
All other causes	50.17	70	39.55	95	39.81	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 extra-
polated 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.

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.

Duration of exposure

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 376 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	5,369	3.55	13	3.66
3–11 months	294	6,153	3.83	16	4.18
1+ years	325	6,312	4.09	45	11.00
Total	376	17,829	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 376 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, 1948–67. Rates were extrapolated for 1941–46 from rates for 1948–56, and for 1968–71 from rates for 1961–67.

Table 8. Mortality experience of 887 asbestos insulation workers 1 January 1968–31 December 1971, analysed by duration of shipyard employment

Cause of death	Shipyard employment					
	None (98)		Up to two years (118)		Three or more years (121)	
	Observed	Expected[a]	Observed	Expected	Observed	Expected
Total cancer: all sites	16	8.3	28	4.8	29	5.8
Lung cancer	11	1.2	9	1.4	17	1.6
Pleural mesothelioma	2	n.a.[b]	2	n.a.	0	n.a.
Peritoneal mesothelioma	0	1.0	3	0.5	4	n.a.
Cancer of stomach, colon, rectum, oesophagus	3	0.8	2	1.0	5	1.0
Cancer all other sites	0	1.3	3	2.4	3	2.9
Asbestosis	1	n.a.	11	n.a.	3	n.a.
All other causes	8	6.2	13	20.3	21	26.6
Total deaths	37	20.3	57	25.1	66	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.

Table 9. Expected[a] and observed deaths among asbestos insulation workers in shipyard and construction 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	56.34	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.

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

Fibre type

Crocidolite was not used for insulation work in he United States during the period covered by our tudy. Indeed, very little crocidolite was imported nto 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 urn 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 from 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.

SUMMARY

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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