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MORTALITY EXPERIENCES OF ASBESTOS INSULATION WORKERS

1943 - 1968*

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On December 31, 1942, there were 632 members of the Asbestos Workers Union in the New York area (New York and Newark, New Jersey locals of the International Association of Heat and Frost Insulators and Asbestos Workers, I.A.H.F.I.A.W.). From January 1, 1943, to December 31, 1962, another 890 men joined the union. We have followed each of these 1,522 men prospectively to the present. Four hundred and four died by December 31, 1968. Analyses of these deaths demonstrate that serious risks have been associated with work in this trade.

own observations and those of others² indicate that trade practices are essentially uniform through the country, the data which follow may be taken to represent mortality experience in this trade for the United States and Canada; direct study of all United States union insulation worker deaths, 1967-1968, supports this.³

Exposure: There is scattered information recorded concerning variation in insulation materials used in the United States, 1870-1969^{4,5}; it would appear that some materials (rs, hair-felt, cork, mineral wool) have sharply decreased while others (as, fibrous glass, plastics) have increased.⁴ Table 1 lists material currently used.

TABLE 1: INSULATION MATERIALS (U.S.)-1969⁶

1. Minerals Containing Asbestos	
Product	Asbestos Content
Blankets	100%-amosite
Moulded	95%-amosite (5% filler)
Insulation block	(a) 85% magnesia: 10-15% amosite + chrysotile
	(b) 85% cal. silicate: 10-15% amosite
	(c) 85% cal. silicate: 10-15% amosite + chrysotile
	(d) 85% calcined diatomaceous silica
	10-15% amosite + chrysotile
	(e) 85% calcium silicate: 10-15% chrysotile
Finishing 'cements'	(a) 100% chrysotile
	(b) 50% chrysotile, 50% cement
Sprayed asbestos	10-15% asbestos-variable
2. Fibrous Glass and/or Mineral Wool	
Block, rolls, prefabricates, high temperature insulation, finishing cements, mineral wool and cement.	
3. Plastics	
Polystyrenes and polyurethanes: prefabricated, powdered and foamed in place.	
4. Other	
Cork, glass flakes, adhesives (epoxy and solvents; asphalt base and solvent, wheat paste, silicones, magnesia, Portland cement).	

MATERIALS AND METHODS

The procedures followed in this study have been described.^{1,2} Briefly, these men install insulation in the construction and (to a limited extent) in the shipbuilding industries. Approximately 10% of United States union insulation workers are in the New York-New Jersey locals and since our

The quantity of asbestos used annually in insulation materials has not changed very much in the past fifty years—12,100 tons in 1920 and 16,000 tons in 1955 (Table 2).⁴ There are currently, however, more insulation workers than previously; pre-

* This study was supported by the Health Research Council of the City of New York.

sumably, less asbestos per workman is now the case. Asbestos exposure varies by type of installation (Table 3); about 40% of an insulation

TABLE 2: ASBESTOS USED IN INSULATION MATERIALS IN THE U.S., 1920-1965

Year	Short Tons
1920	12,300
1925	19,200
1930	16,600
1935	7,400
1940	13,600
1945	14,800
1950	12,700
1955	12,200
1960	13,000
1965	16,100

TABLE 3: USE OF ASBESTOS INSULATION (%) VARIATION BY CONSTRUCTION TYPE, 1969

Construction	Fibrous Glass	Asbestos	Other
Commercial (Schools, factories)	75	10	15
Power process (Power plants, boiler rooms)	20	60	20
Marine	20	70	10

worker's time is spent in work using asbestos materials (Table 4).

TABLE 4: USE OF ASBESTOS BY INSULATION WORKMEN IN THE U.S., 1969

Material	Volume % of Total	Application % of Time
Asbestos	35	43
Fibrous glass	45	40
Other	20	17

Exposure of insulation workers in the United States cannot necessarily be equated with that of similar workmen in other countries. For one thing, besides variations in working conditions, the type of fiber and materials used may be different. Until 1930, chrysotile was almost the only asbestos used, amosite making its appearance later and crocidolite practically not at all (see below). Second, spraying of insulation has not been, until recently, widely used in this country, in contrast to some other areas and, in so far as this affects exposure, would not be reflected in our mortality observations. Finally, because of union jurisdictional agreements, the men we have studied are restricted to insulation against temperature changes; acoustical insulation and fireproofing are the work of men in other trades and variables peculiar to such work would not be demonstrated by our data.

OBSERVATIONS

632 MEMBERS OF THE UNION ON DECEMBER 31, 1942

Three hundred and eighty of these men were dead on December 31, 1968. Age, year and sex specific expected death rates were available to mid-1967;^{1, 11} observed rates by cause are compared in Table 5. All deaths to December 31, 1968 are tabulated in Table 6, by cause.

TABLE 5: EXPECTED AND OBSERVED DEATHS AMONG 632 NY-NJ INSULATION WORKERS, JANUARY 1, 1943 TO APRIL 30, 1967*

	Expected**	Observed
All causes	251.0	349
Lung Cancer	8.9	66
G.I. Cancer	11.2	37
Pleural Mesothelioma	...	6
Peritoneal Mesothelioma	...	14
All other Neoplasms	25.0	21
Asbestosis	...	27

* Of workmen reaching 20 years from first exposure. In addition seven men died before reaching this point.

** Based on United States Mortality data.^{1, 11}

*** United States data not available, but these are rare causes of death in general population.

TABLE 6: CAUSES OF 380 CONSECUTIVE DEATHS AMONG 632 INSULATION WORKERS, JANUARY 1, 1943 TO DECEMBER 31, 1968

	Before 20 Years from First Exposure	After 20 Years from First Exposure
Lung cancer	0	72
Pleural Mesothelioma	0	6
Peritoneal Mesothelioma	0	16
Gastrointestinal Cancer	0	37
Oropharynx/Larynx Cancer	1	5
Cancer of Pancreas	0	3
All other Neoplasms	0	19
Asbestosis	0	30
All other causes	6	185
	7	373

LUNG CANCER

One in five deaths was caused by lung cancer. Despite the recent rise in prominence of mesothelioma, this remains the most important asbestos-associated neoplasm among insulation workers. It is of interest, therefore, that there appears to be a special relationship to

TABLE 7: PLEURAL AND PERITONEAL MESOTHELIOMA AMONG NYC ASBESTOS INSULATION WORKERS,*
 JANUARY 1, 1943 TO DECEMBER 31, 1968

	Number	Mesothelioma		Bronchogenic Carcinoma 72	Asbestosis 30
		Pleural 6	Peritoneal 16		
Age at Onset (Years)	Mean	25.2	20.0	25.4	24
	Median	21	19	25	24.5
	S.D.	± 5.4	± 4.3	± 6.36	± 5.6
	Range	17-25	16-30	16-54	14-36
Age at Death (Years)	Mean	56.0	62.7	63.8	66.7
	Median	55	60	64	66
	S.D.	± 2.4	± 10.2	± 7.25	± 8.02
	Range	54-60	50-83	39-83	53-79
Lapsed Period (Years)	Mean	34.8	43.0	38.7	42.8
	Median	34.5	40.5	39	44
	S.D.	± 2.3	± 8.9	± 8.5	± 7.69
	Range	32-38	32-61	22-60	30-59

*In addition, we have observed 2 peritoneal mesotheliomas found at autopsy, in men who had died of bronchogenic carcinoma.

cigarette smoking among asbestos insulation workers¹⁰ (see below). Overall lung cancer death rates were seven times expected.*

MESOTHELIOMA

Twenty-two of the 380 deaths were due to mesothelioma, 6 pleural and 16 peritoneal. Two occurred 1943-1954; 20, 1955-1968; average lapsed period from onset of exposure was longer and average age at death was greater for peritoneal than for pleural mesothelioma.

Peritoneal mesothelioma does not seem to be related to cigarette smoking—we have seen 4 such cases in men who never smoked cigarettes. In the 3 cases of pleural mesothelioma for which we personally recorded smoking histories, all had smoked cigarettes.

The preponderance of peritoneal mesothelioma among our cases, as in the series of Eusticknap and Smither,¹¹ is not necessarily contradictory to the observations of Wagner,¹² Hourihane¹³ and others in which pleural neoplasms were largely seen. It may, rather, reflect the derivation of the cases—consecutive series with regular occupational exposure on the one hand, against random cases, many with non-occupational environmental ex-

*There are, in addition, three men found to have lung cancer during our survey, and who are now alive following therapy.

posure, on the other. It may be that in those people who develop mesothelioma in association with asbestos exposure, the site of the mesothelioma tends to vary to some extent with the intimacy and duration of exposure—pleural with lesser exposure and peritoneal with greater.

GASTROINTESTINAL CANCER

As in our first observations,¹ we have continued to see more deaths due to cancer of the stomach and colon than expected. However, the ratio is only 3 times expected and, with so few deaths, we are not yet certain of the relationship.

CANCER OF PANCREAS; OROPHARYNGEAL CANCER

The same insecurity noted with gastrointestinal cancer is associated with these as well. We are, however, concerned that the incidence of both of these neoplasms will be increased among asbestos workers. As a practical measure, we now inspect the oral cavity during all clinical examinations of asbestos workers; one cancer of the lip has been discovered and successfully excised.

It is of interest that 2 of the 3 recent deaths of tongue cancer, were in men who never smoked cigarettes.

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Age at Death (Years)					
Mean		56.0	62.7	63.8	66.7
Median		55	60	64	66
S.D.		±2.4	±10.2	±7.25	±8.02
Range		54-60	50-83	39-83	53-79
Lapsed Period (Years)					
Mean		34.8	43.0	38.7	42.8
Median		34.5	40.5	39	44
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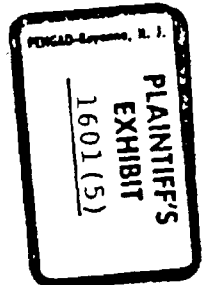
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ASBESTOSIS

Thirty deaths of the 380 were due to respiratory insufficiency with cor pulmonale.

890 MEN ENTERING UNION AFTER DECEMBER 31, 1942 -

Fifty-four of these men had prior insulation work experience before entering this union in 1943 or later; 836 did not. By and large, therefore, the men in this group are younger and would not be expected to have yet achieved a lapsed period from onset of exposure sufficient to have brought them to a period of serious risk of neoplastic death. This theoretical consideration has so far been confirmed by our experience (Table 8).

TABLE 8: ONSET OF EXPOSURE AND DEATHS OF NEOPLASM AMONG 890 MEN WHO JOINED INSULATION WORKERS' UNION, 1943-1962

Year Onset of Asbestos Insulation Exposure	Number	Deaths 1943-1968	
		Total	Neoplasm
1 ≤1929	8	3	3
2 1930-1942 . .	46	2	1
3 1943-1947 . .	164	9	4
4 '5-1952 . . .	250	5	0
5 '3-1957 . . .	186	5	0
6 '3-1962 . . .	236	0	0
	890	24	8

- 1: CA Lung (32), CA Lung (), Leukemia (31).
 - 2: CA Lung (31), Pancreatitis.
 - 3: CA Lung (21), Asbestos Peptic Ulcer, CA Pancreas (20), CA Tongue (), CA Colon (17), Pulm. embolism, Cirrhosis, Coronary.
 - 4: Accident, Coronary, Cong. Heart Failure, Coronary, Coronary.
 - 5: Pneumonia, Rheumatic H.D., Coronary, Cirrhosis, S.B.E.
 - 6:
- () = years from onset of exposure.

MULTIPLE NEOPLASMS

We have seen several instances of more than one primary neoplasm in the same individual (lung-lung; lung-larynx, etc.). These have been too infrequent to warrant more than brief recording except perhaps for two men who died of bronchogenic carcinoma and were found, at autopsy, to also have peritoneal mesothelioma.

EFFECTS OF CIGARETTE SMOKING

There appears to be an important influence of cigarette smoking on the incidence of lung

cancer among asbestos insulation workers.¹⁰ On January 1, 1963, there were 370 men still alive of our original 632 cohort (all now with long-lapsed periods from onset of exposure and very much at risk). Eighty-seven never smoked cigarettes: one died of lung cancer by December 31, 1968. Two hundred and eighty three had a history of cigarette smoking —27 have died of lung cancer (Table 9).

TABLE 9: CIGARETTE SMOKING AND LUNG CANCER IN ASBESTOS INSULATION WORKERS. EXPERIENCE OF 370 MEN FOLLOWED PROSPECTIVELY JANUARY 1, 1963 TO DECEMBER 31, 1968

	No History of Cigarette Smoking	History of Cigarette Smoking
Number of men	87	283
Expected lung cancer deaths to 4.30.67	0.18	2.98
Observed deaths to 4.30.67	0	24
Observed deaths to 12.31.68	1	27
Total cases to 12.31.68	1	30*

*3 men still alive (all cigarette smokers).

Computations suggest that an asbestos worker who smokes cigarettes has 90 times the risk of dying of lung cancer compared with a man who neither works with asbestos nor smokes cigarettes.

AGE AT ONSET OF EXPOSURE

Table 10 records the mortality experience of the 632 men, by age category at onset of exposure.

FIBER VARIETY AND MESOTHELIOMA; EVIDENCE FROM PRESENT OBSERVATIONS

Crocidolite seemed initially to be unique among asbestos varieties in having a special relationship to mesotheliomas. It has been considered desirable to obtain further evidence on this question, by study of populations exposed to other fiber varieties.^{11,12} It may be useful, therefore, to evaluate the experiences of N.Y.-N.J. insulation workers in this regard.

CROCIDOLITE EXPOSURE OF INSULATION WORKERS IN THE UNITED STATES

There is no crocidolite mined in the United States: all must be imported either from South Africa, Bolivia or Australia. It has been possible, by review of import data, to accurately calculate crocidolite use.

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TABLE 10: MORTALITY EXPERIENCE OF 632 NYC INSULATION WORKERS, BY AGE AT ONSET OF EXPOSURE

	Age at Onset of Exposure			Total
	≤20	21-30	30+	
Cancer of Lung	14 (5.7%)	52 (17.3%)	6 (7.1%)	72
Pleural Mesothelioma	3 (5.3%)	5 (2.7%)	0 (1.2%)	6
Peritoneal Mesothelioma	10 (5.3%)	5 (2.7%)	1 (1.2%)	16
Gastrointestinal Cancer	12 (4.9%)	17 (5.7%)	8 (9.4%)	37
All other neoplasms	6	15	7	28
Asbestosis	11 (4.5%)	15 (5.0%)	4 (4.7%)	30
All other causes	45	92	54	191
Deceased 12.31.68	101	199	80	380
Alive 12.31.68	145	102	5	252
Total	246	301	85	632

TABLE 11: ESTIMATED U.S. ASBESTOS FIBER CONSUMPTION

Year	Crocidolite	Amosite	Canadian Chrysotile	Other	Total
1920	No data	No data	152,000	4,000	156,000
1925	No data	No data	200,700	4,100	204,800
1930	1,907		198,200	8,500	208,407
1935	501		154,200	20,500	175,201
1940	8,058		225,900	36,300	270,268
1945	8,700	4,500	355,800	9,000	378,000
1950	8,500	5,400	687,400	27,400	728,700
1955	11,700	18,000	699,100	11,500	740,400
1960	19,500	19,500	605,800	24,600	669,580
1965	17,100	21,400	661,100	20,100	719,700

Total Amosite and Crocidolite*

1930	1,907
1931	823
1932	212
1933	233
1934	152
1935	501
1936	1,432
1937	2,928
1938	3,282
1939	6,129

*Source: U.S. Department of Commerce.

Very little crocidolite entered this country until World War II (Table 11). Asbestos used here was almost entirely chrysotile. The largest asbestos manufacturer in the United States first used crocidolite in 1929 (for sheet packing, not insulation). This company never used crocidolite for the manufacture of insulation at any time (1929-1968), employing it only in two product lines (asbestos cement pipe, and packings).¹ These data are consistent with an analysis of insulation materials used in past decades on the United States west

coast, where only chrysotile and amosite were found.² During these same years, 1920-1940, more than 267,000 tons of chrysotile were used for insulation purposes.

This is not to say that it can be proven that crocidolite was never used before 1930 for insulation in the United States. Rather, if any was so utilized, it could only have been in very small amounts. Therefore, crocidolite exposure of United States insulation workers before 1930 and probably before 1940 is unlikely to have occurred to any significant

extent and, as seen in Table 1, is still a very minor affair.

MESOTHELIOMA AMONG UNITED STATES INSULATION WORKERS

The first mesothelioma reported in which occupational asbestos exposure was described, occurred in an insulation worker, a member of the I.A.H.F.I.A.W., in 1946.¹⁷ It is not known whether cases occurred before then, but they have been noted since.¹⁸ We have seen 22 cases, 1947-1968, in our group of men, as detailed above. *Every one has occurred in an insulation worker who began work before 1930 (Table 12). The mean lapsed period from onset of exposure to death*

of mesotheliomas among the 836 men in our study who began work in 1943 or later (Table 8).

These considerations are relevant only to conditions in the United States, among insulation workers. They do not disprove a special role for crocidolite elsewhere, in other circumstances. They should, however, engender caution in relying on other asbestos varieties always to be significantly less likely to cause mesothelioma. The relative mesothelioma hazard for each fiber variety is still to be defined in humans. At this time our data suggest that it would be prudent to regard all fiber varieties as potentially hazardous, and to utilize appropriate industrial hygiene measures for all.

TABLE 12: LAPSED PERIOD FROM ONSET OF EXPOSURE TO DEATH OF 22 CASES OF MESOTHELIOMA, 1947-1968, AMONG 632 INSULATION WORKERS FOLLOWED PROSPECTIVELY FROM JANUARY 1, 1943

Patient	Site	Year Onset Employment	Year of Death	Age at Death	Years from Onset
1. A.C.	Pleural	1922	1947	60	25
2. A.M.	Pleural	1923	1956	58	33
3. A.S.	Pleural	1929	1951	54	32
I.B.	Pleural	1929	1963	54	34
F.C.	Pleural	1927	1964	53	37
T.C.	Pleural	1928	1956	56	38
E.M.	Peritoneal	1910	1949	61	39
8. F.S.	Peritoneal	1923	1956	50	33
9. M.C.	Peritoneal	1924	1956	52	32
10. H.H.	Peritoneal	1918	1959	60	41
11. J.B.	Peritoneal	1905	1963	86	58
12. H.D.	Peritoneal	1925	1963	66	38
13. W.N.	Peritoneal	1919	1964	63	45
14. A.C.	Peritoneal	1918	1964	68	46
15. J.D.	Peritoneal	1924	1965	58	41
16. J.L.G.	Peritoneal	1929	1965	53	36
17. J.O.C.	Peritoneal	1917	1966	79	49
18. G.V.	Peritoneal	1924	1967	59	43
19. H.C.	Peritoneal	1929	1967	57	38
20. J.P.	Peritoneal	1929	1968	58	39
21. R.B.	Peritoneal	1907	1968	83	61
22. A.T.	Peritoneal	1929	1968	56	39

was 34.8 years for pleural mesothelioma and 43.0 years for peritoneal.

As detailed, crocidolite exposure of United States insulation workers, to the extent that it occurred, could not have been very extensive before 1940. Therefore, if a long lapsed period is required for asbestos-induced mesothelioma, crocidolite exposure alone cannot easily explain the mesotheliomas seen among insulation workers in the United States. Of course, it may be that crocidolite's virulence makes for shorter lapsed periods between onset of exposure and death. But if this is so, it is difficult to explain the absence

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