

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 change; 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 by December 31, 1968. Age, year and sex specific expected death rates were available to mid-1967;<sup>1, 10</sup> 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.<sup>1, 10</sup>
- \*\*\* 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

the Department

of others<sup>1,5</sup> indicate...ly uniform through...flow may be taken...ce in this trade for...direct study of all...on worker deaths,

ed information re-insulation materials...o-1969<sup>1, 2</sup>; it would...as, hair-felt, cork, increased while others...e increased.<sup>1</sup> Table

ite + chrysotile...osite + chrysotile...lica

chrysotile

wool and cement.

at paste, silicones,

annually in insula-very much in the...1920 and 16,000...re currently, how-...m previously; pre-

by the Health Re-New York.

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

Number	Mesothelioma			
	Pleural 6	Peritoneal 16	Bronchogenic Carcinoma 72	Asbestosis 30
<i>Age at Onset (Years)</i>				
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
<i>Age at Death (Years)</i>				
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
<i>Lapsed Period (Years)</i>				
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 workers<sup>10</sup> (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 Enticknap and Smither,<sup>11</sup> is not necessarily contradictory to the observations of Wagner,<sup>12</sup> Hourihane<sup>13</sup> 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,<sup>1</sup> 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.

Asbestosis	30
	24
	24.5
	±5.6
	14-36
	66.7
	66
	±8.02
	53-79
	42.8
	44
	±7.69
	30-59

and died of broncho-

be that in those  
oma in associa-  
the site of the  
to some extent  
on of exposure—  
and peritoneal

CANCER

we have con-  
to cancer of the  
ected. However,  
ected and, with  
et certain of the

OPHARYNGEAL

d with gastro-  
d with these as  
cerned that the  
coplasms will be  
workers. As a  
inspect the oral  
examinations of  
r of the lip has  
ully excised.  
e 3 recent deaths  
men who never

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 1948-1952 . . . . .	250	5	0
5 1953-1957 . . . . .	186	5	0
6 1958-1962 . . . . .	236	0	0
	890	24	8

- 1: CA Lung (32), CA Lung (41), Leukemia (31).
- 2: CA Lung (31), Pancreatitis.
- 3: CA Lung (21), Asbestosis, Peptic Ulcer, CA Pancreas (20), CA Tongue (20), 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. On January 1, 1963, there were 370 men 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 AMONG ASBESTOS INSULATION WORKERS. EXPERIENCE OF 370 MEN FOLLOWED PROSPECTIVELY JANUARY 1, 1963, TO DECEMBER 31, 1968

	No. History of Cigarette Smoking	History of Lung Cancer
Number of men	87	283
Expected lung cancer deaths to 4.30.67	0.18	2.4*
Observed deaths to 4.30.67	0	24
Observed deaths to 12.31.68	1	27
Total cases to 12.31.68	1	32*

\*3 men still alive (all cigarette smokers).

Computations suggest that an asbestos worker who smokes cigarettes has 95 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. It may be useful, therefore, to evaluate the experiences of N.Y.-N.J. insulation workers in regard.

CROCIDOLITE EXPOSURE OF INSULATION WORKERS IN THE UNITED STATES

There is no crocidolite mined in the United States; all must be imported from South Africa, Bolivia or Australia. It is possible, by review of import statistics, to accurately calculate crocidolite