



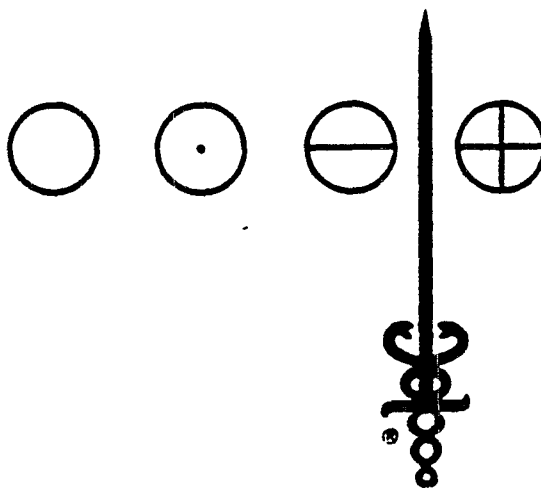
**Cancer Risk of Insulation Workers in the United States**

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**ENVIRONMENTAL CANCER RESEARCH PROJECT**

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## Cancer Risk of Insulation Workers in the United States\*

Irving J. Selikoff, M.D., E. Cuyler Hammond, Sc.D.  
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In 1963, information became available indicating that asbestos insulation workers employed in the construction industry were subject to a significant cancer hazard associated with their work (Selikoff, Churg and Hammond, 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 January 1, 1943, for the 20 year period ending December 31, 1962, it was found that death of 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 the general U.S. white male population, both age and date being taken into consideration, and cancer of stomach, colon and rectum three times as common. Attention was called to the occurrence of pleural and peritoneal mesotheliomas (Selikoff, Churg and Hammond, 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, Hammond and Churg, 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 important for full evaluation of the problem and to provide guidance for establishment of needed administrative and industrial control measures. To obtain such required added information, we have continued and widened our investigations.

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### Current studies

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

A) New York-New Jersey Cohort -- We have continued our surveillance of the New York-New Jersey insulation workers. 262 had died by December 31, 1962. 370 were still alive on January 1, 1963. Each has been followed through December 31, 1971.

Two additional groups of workers have been investigated. B) In one study, we registered the entire membership of the insulation workers union in the United States and Canada\* on January 1, 1967 (17,800; including members of the New York-New Jersey locals mentioned above), recording many characteristics for each man including date of birth and onset of insulation work. Each man has since been observed through December 31, 1971.

C) A third group consisted of the entire workforce (1941-1945) of a factory in an eastern U.S. city which manufactured amosite asbestos insulation materials (including insulating block and pipe covering, asbestos mattresses). These products were then used 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. Starting in 1941, a total of 933 men were hired to the end of 1945, some working for as little as one day and others to 1954, when the plant closed. Results of physiological studies of men in this plant have been reported (Bader, Bader and Selikoff, 1961). Now, for the evaluation of cancer risk among them, we have traced the entire group through December 31, 1971. 877 were fully traced (94%) and the remainder partially traced for varying periods. We have analyzed their mortality experience in relation to the duration of employment, age at onset of employment and lapsed period from onset of employment.

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\*International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO.

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 U.S.-Canada cohorts) amply confirm the cancer risk first identified in 1963. By December 31, 1971, 430 of the original 632 (New York-New Jersey cohort) had died, 421 after reaching 20 years from onset of employment. 189 (45% of the 421 total deaths) died of cancer whereas 47.2 such deaths had been expected (Table 1).

Insulation workers throughout the United States and Canada (U.S.-Canada cohort) were a much younger group, with considerably less work experience (Hammond and Selikoff, 1972). The excess of cancer deaths, nevertheless, was very much the same, these deaths occurring among the older men, those with 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, 41% of the total of 1,092 deaths observed 1967-1971 (Table 2).

Lung Cancer

Bronchogenic carcinoma was a leading cause of death among asbestos insulation workers. It accounted for approximately 45% of fatal neoplasms. In these two series reported, it was responsible for 20% of all deaths and was almost three times as common as pleural and peritoneal mesothelioma. Recent histological studies of tumors from these patients showed distribution of cell types to be that of lung cancer in general (Kannerstein and 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 and avoidance of cigarette smoking (Selikoff, Hammond and Churg, 1968; Hammond and Selikoff, 1972).

Gastro-intestinal cancer

In our initial reports (Selikoff, Churg and Hammond, 1964; Hammond, Selikoff and Churg, 1965b) 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 remain in the same direction, and very much at the same level of excess, two or three times expected deaths (Table 1 and 2). These findings were present for cancer of esophagus, stomach, and 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 not responsible for a major proportion of excess deaths (exceeded by lung cancer, mesothelioma and asbestosis) the influence is nevertheless substantial; in New York-New Jersey 13.0 deaths were expected and 41 occurred and in the U.S.-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 on the etiology of gastro-intestinal cancer in general, and 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 fibers 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 tumors 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, oro-pharynx, genito-urinary cancer, and lymphoma and leukemia.

#### Risk with factory exposure to asbestos insulation materials

In 1964, K. W. 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 the disease observed. If not, examination of other insulation materials would be required. We, therefore, investigated the workforce of the insulation materials factory noted above, which had been exposed in the factory only to

asbestos insulation, but not to other insulation materials used in the construction industry (fibrous glass, calcined diatomaceous earth, rock wool, etc.).

484 deaths are known to have occurred among the 877 men fully traced to December 31, 1971. The distribution of deaths strongly resembled that seen among insulation workers installing such materials, despite the fact that observation of this cohort has only reached 25-30 years from onset. Thus, lung cancer accounted for 73 deaths, although only 11.41 were expected; gastro-intestinal for 26, with 12.86 expected (including esophagus). Mesothelioma caused three deaths, and asbestosis 27 (Table 3).

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

#### Epidemiological Variables

##### Lapsed period from onset of exposure.

It has long been inferred, from 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 even as early as 10-14 years from onset, with 0.65 expected deaths vs. 10 observed among those working in the amosite factory more than one year (Table 5b). Moreover, death rates for lung cancer were significantly increased in the U.S.-Canada insulation workers cohort 15-19 years from onset. [4.68 deaths were expected and 18 occurred (Table 4)].

On the other hand, in terms of numbers, most deaths of lung cancer occurred among the insulation workers during and after the 30-39 year from onset decade. Therefore, circumstances may exist in which it would be difficult to fully evaluate the effects of asbestos exposure if opportunity for observation were not available for at least 40 years from onset of work exposure.

#### Age at onset

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

With these in mind, there seems to be no striking variation as a result of differences in age at which asbestos work exposure first began (Table 6).

#### 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 1941-1945, approximately one-third worked for less than three months, another third 3-11 months, and the remaining third for a year or more (Table 5a). All worked in the same factory, with like 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. While even those with less than three months of work had definite increase in lung cancer risk (13 observed versus 3.55 expected), and those with 3-11 months much the same, workers employed for a year or over had much more substantial increase (45 observed, 4.09 expected). (Table 7.)

#### Fiber type

Crocidolite was not used for insulation work in the United States during the period covered by the experiences of insulation workers we have studied. Indeed, very little crocidolite for any use was imported into the United States until after the second world war (Selikoff, Hammond and Churg, 1970). Exposure to this fiber therefore cannot explain the cancer risk observed.

Both chrysotile and amosite have been used in U.S. insulation materials, the former since the turn of the century (Selikoff, Churg and Hammond, 1965b) and the latter since the mid-1930's (Selikoff, Hammond and Churg, 1972). Amosite has been used principally in ship insulation, 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 fibers in insulation work, since cohorts which differ in this respect may also differ in other respects as well, 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 having been fairly important in the New York harbor area, especially 1939-1945). Among the 370 men in the Union, January 1, 1963, survivors of the 1943 cohort, we were able to obtain history of shipyard employment by personal interview in 337. The results have been reported (Selikoff, Hammond and Seidman, 1971). They 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, in the same period of time, without such employment (Table 8).

In the U.S.-Canada Survey, each Union member was recorded as being registered in a specific Union local. Several of these locals were engaged entirely in shipyard work. Others, in the central and midwestern parts of the country, had no such opportunity. 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 been a major part of their work-history.

We have analyzed the mortality experience of men in the two groups of locals, 1967-1971. 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 not more, or less, hazardous than shipyard work, with its wider use of amosite materials.

Discussion

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.

Increased incidence of lung cancer was seen in as little as 10-14 years from onset of work exposure. We suspect that more intense exposure, as among factory workers, tends to be associated with earlier appearance of asbestos lung cancer. On the other hand, especially among the less intensely exposed insulation workers, although early lung cancer increase was seen, the greater increase occurred 30-45 years from onset. In such circumstances, it would be difficult to fully evaluate the effects of asbestos exposure without observation for at least 40 years from onset of exposure.

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

We were not able to detect evidence suggesting that chrysotile was associated with greater risk than amosite, in insulation work, or vice versa. We have no knowledge of the comparative effect crocidolite might have; it was not used in U.S. insulation work.

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Table 1

Expected\* and observed number of deaths among 623 New York-New Jersey asbestos insulation workers, Jan. 1, 1943-Dec. 31, 1971, twenty or more years after onset of first exposure to asbestos.

|                                             | 1943-1951 |        | 1952-1961 |        | 1962-1971 |        | Total 1943-1971 |        |
|---------------------------------------------|-----------|--------|-----------|--------|-----------|--------|-----------------|--------|
|                                             | Exp.      | Obsrv. | Exp.      | Obsrv. | Exp.      | Obsrv. | Exp.            | Obsrv. |
| <u>Total Cancer: all sites</u>              | 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                        | **        | 1      | **        | 2      | **        | 5      | **              | 8      |
| Peritoneal mesothelioma                     | **        | 1      | **        | 3      | **        | 20     | **              | 24     |
| Cancer of stomach, colon, rectum, esophagus | 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     |
| <u>Asbestosis</u>                           | **        | 1      | **        | 10     | **        | 22     | **              | 33     |
| <u>All other causes</u>                     | 65.1      | 44     | 89.4      | 94     | 78.3      | 61     | 232.8           | 199    |
| <u>Total all causes</u>                     | 76.4      | 73     | 107.7     | 161    | 95.9      | 187    | 280.0           | 421    |
| Person-years of observation:                | 3,726     |        | 4,406     |        | 2,898     |        | 11,030          |        |

632 members were on the Union's rolls on Jan. 1, 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.

\*Expected rates are based upon age-specific death rate data of U.S. National Office of Vital Statistics from 1949-1967. Rates were extrapolated 1943-1948 from rates for 1949-1955 and for 1968-1971 from rates for 1961-1967.

\*\*U.S. death rates not available but these are rare causes of death in the general population.

Table 2

Expected\* and observed deaths among  
17,800 asbestos insulation workers  
in the United States, January 1, 1967-December 31, 1971

|                             | Distribution by duration from onset of exposure |          |                    |          |                   |          |
|-----------------------------|-------------------------------------------------|----------|--------------------|----------|-------------------|----------|
|                             | Total                                           |          | Less than 20 years |          | 20 years and more |          |
|                             | Expected                                        | Observed | Expected           | Observed | Expected          | Observed |
| <u>Total deaths</u>         | 805.63                                          | 1,092    | 178.94             | 211      | 626.69            | 881      |
| <u>Cancer: all sites</u>    | 144.09                                          | 459      | 26.31              | 51       | 117.78            | 408      |
| Lung cancer                 | 44.42                                           | 213      | 7.03               | 22       | 37.39             | 191      |
| Pleural mesothelioma        | **                                              | 26       | **                 | 2        | **                | 24       |
| Peritoneal mesothelioma     | **                                              | 51       | **                 | 3        | **                | 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 esophagus         | 3.21                                            | 13       | 0.44               | 1        | 2.77              | 12       |
| All other cancers           | 72.33                                           | 114      | 15.36              | 19       | 56.97             | 95       |
| <u>Asbestosis</u>           | **                                              | 78       | **                 | 5        | **                | 73       |
| <u>All other causes</u>     | 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            |          |

\*Expected deaths are based upon age specific death rate data of the U.S. National Office of Vital Statistics. Rates for 1968-1971 were extrapolated from rates for 1961-1967.

\*\*U.S. death rates not available, but these are rare causes of death in the general population.

Table 3

Expected\* and observed deaths among 933\*\*  
 amosite asbestos factory workers first  
 employed 1941-1945, and observed to Dec. 31, 1971.

|                                | Before 1952 |          | 1952-1961 |          | 1962-1971 |          | Total, 1941-1971 |          |
|--------------------------------|-------------|----------|-----------|----------|-----------|----------|------------------|----------|
|                                | Expected    | Observed | Expected  | Observed | Expected  | Observed | Expected         | Observed |
| <u>Total deaths</u>            | 69.98       | 88       | 108.27    | 146      | 121.24    | 250      | 299.49           | 484      |
| <u>Total cancer: all sites</u> | 9.81        | 15       | 18.72     | 44       | 21.63     | 84       | 50.16            | 143      |
| Lung cancer                    | 1.49        | 3        | 3.71      | 23       | 6.21      | 47       | 11.41            | 73       |
| Pleural mesothelioma           | ***         | 1        | ***       | 0        | ***       | 2        | ***              | 3        |
| Peritoneal mesothelioma***     |             | 0        | ***       | 0        | ***       | 4        | ***              | 4        |
| Cancer of stomach              | 1.45        | 3        | 1.84      | 4        | 1.29      | 4        | 4.58             | 11       |
| Cancer of colon,<br>rectum     | 1.56        | 2        | 2.61      | 5        | 2.88      | 8        | 7.05             | 15       |
| Cancer of esophagus            | 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       |
| <u>Asbestosis</u>              | ***         | 3        | ***       | 7        | ***       | 17       | ***              | 27       |
| <u>All other causes</u>        | 60.17       | 70       | 89.55     | 95       | 99.61     | 149      | 249.33           | 314      |

\*Expected rates are based upon age-specific death rate data of U.S. National Office of Vital Statistics from 1949-1967. Rates were extrapolated 1941-1948 from rates for 1949-1955 and for 1968-1971 from rates for 1961-1967.

\*\*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 Dec. 31, 1971. 51 men were partially traced and remain in the calculations until being lost to observation.

\*\*\*U.S. death rates are not available, but these are rare causes of death in the general population.

Table 4

Deaths of lung cancer and pleural mesothelioma  
among 17,800 asbestos insulation workers  
in the U.S. and Canada, Jan. 1, 1967-Dec. 31, 1971:  
relation to elapsed period from onset of work exposure.

| <u>Years from<br/>onset</u> | <u>Lung cancer</u>          |                            |              | <u>Pleural<br/>Mesothelioma</u> |
|-----------------------------|-----------------------------|----------------------------|--------------|---------------------------------|
|                             | <u>Expected<br/>deaths*</u> | <u>Observed<br/>deaths</u> | <u>Ratio</u> | <u>Observed<br/>deaths</u>      |
| < 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          | 3                               |
| 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                              |

\*Expected deaths are based upon age specific death rate data of the U.S. National Office of Vital Statistics. Rates for 1968-1971 were extrapolated from data for 1961-1967.

Table 3

Expected\* and observed deaths among 933\*\*  
amosite asbestos factory workers first  
employed 1941-1945, and observed to Dec. 31, 1971.

|                                | Before 1952 |          | 1952-1961 |          | 1962-1971 |          | Total, 1941-1971 |          |
|--------------------------------|-------------|----------|-----------|----------|-----------|----------|------------------|----------|
|                                | Expected    | Observed | Expected  | Observed | Expected  | Observed | Expected         | Observed |
| <u>Total deaths</u>            | 69.98       | 88       | 108.27    | 146      | 121.24    | 250      | 299.49           | 484      |
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| Pleural mesothelioma           | ***         | 1        | ***       | 0        | ***       | 2        | ***              | 3        |
| Peritoneal mesothelioma***     |             | 0        | ***       | 0        | ***       | 4        | ***              | 4        |
| Cancer of stomach              | 1.45        | 3        | 1.84      | 4        | 1.29      | 4        | 4.58             | 11       |
| Cancer of colon,<br>rectum     | 1.56        | 2        | 2.61      | 5        | 2.88      | 8        | 7.05             | 15       |
| Cancer of esophagus            | 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       |
| <u>Asbestosis</u>              | ***         | 3        | ***       | 7        | ***       | 17       | ***              | 27       |
| <u>All other causes</u>        | 60.17       | 70       | 89.55     | 95       | 99.61     | 149      | 249.33           | 314      |

\*Expected rates are based upon age-specific death rate data of U.S. National Office of Vital Statistics from 1919-1967. Rates were extrapolated 1941-1948 from rates for 1949-1955 and for 1968-1971 from rates for 1961-1967.

\*\*933 men were employed. In 5 cases, ages were not known and these men have been excluded from these calculations. 977 men were traced to death or to Dec. 31, 1971. 51 men were partially traced and remain in the calculations until being lost to observation.

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| <u>Years from<br/>onset</u> | <u>Expected<br/>deaths*</u> | <u>Lung cancer</u>         |              | <u>Pleural<br/>Mesothelioma</u> |
|-----------------------------|-----------------------------|----------------------------|--------------|---------------------------------|
|                             |                             | <u>Observed<br/>deaths</u> | <u>Ratio</u> | <u>Observed<br/>deaths</u>      |
| < 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                              |

\*Expected deaths are based upon age specific death rate data of the U.S. National Office of Vital Statistics. Rates for 1968-1971 were extrapolated from data for 1961-1967.

Table 5a

Age at onset of employment, 1941-1945, of 933 workers  
in an amosite asbestos insulation factory.

| <u>Age at employment</u> | <u>Duration of employment</u> |                     |                    |                  |
|--------------------------|-------------------------------|---------------------|--------------------|------------------|
|                          | <u>Total</u>                  | <u>&lt;3 months</u> | <u>3-11 months</u> | <u>1 + years</u> |
| 15-19                    | 94*                           | 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*                          | 278                 | 321                | 333              |

\* Includes 1 man with unknown length of employment.

Table 5b

Lung cancer among 326 amosite asbestos workers employed for 1 year or more starting 1941-1945, and observed to Dec. 31, 1971.\* Expected and observed deaths.\*\*

Attained ages

| Attained years from first employment | 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    | 0.06  | 0    | --    | --   |
| 10-14                                | 0.65  | 10   | 0.02 | 0    | 0.07  | 0    | 0.19  | 4    | 0.29  | 5    | 0.06  | 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    | 0.03  | 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, because of prior occupational exposure to asbestos (4) or not having been traced after first year (3). Five were partially traced and remained in the calculations only to date of last observation. All others entered calculations after first year from onset.

\*\*Expected rates are based upon age-specific death rate data of U.S. National Office of Vital Statistics from 1949-1967. Rates were extrapolated 1941-1948 from rates for 1949-1955 and for 1968-1971 from rates for 1961-1967.

Table 6

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

| <u>Age at<br/>onset of exposure</u> | <u>Deaths of lung cancer</u> |                 |              |
|-------------------------------------|------------------------------|-----------------|--------------|
|                                     | <u>Expected*</u>             | <u>Observed</u> | <u>Ratio</u> |
| < 25                                | 18.19                        | 102             | 5.61         |
| 25-34                               | 15.20                        | 66              | 4.34         |
| 35-44                               | 8.74                         | 38              | 4.33         |
| 45+                                 | 2.25                         | 7               | 3.11         |

\*Expected deaths are based upon age specific death  
rates of the U.S. National Office of Vital Statistics.  
Rates for 1968-1971 were extrapolated from rates for  
1961-1967.

Table 7

Expected and observed deaths of lung cancer among 876  
amosite asbestos factory workers, first employed  
1941-1945, and observed to Dec. 31, 1971.\*  
Distribution by duration of employment.

| Duration of<br>employment | Number of Men | Person-years<br>of observation | Deaths of lung cancer |               |
|---------------------------|---------------|--------------------------------|-----------------------|---------------|
|                           |               |                                | Exp.**                | Observ. 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       |

\*This table excludes 57 men. 10 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. 17 men of the 876 were partially traced and remained in the calculations only until lost to observation.

\*\*Expected rates are based upon age-specific rate data of U.S. National Office of Vital Statistics, 1949-1967. Rates were extrapolated 1941-1948 from rates for 1949-1955 and for 1968-1971 from rates for 1961-1967.

Table 8

Mortality experience of 337 asbestos insulation workers  
Jan. 1, 1963 - June 30, 1971, analyzed by duration  
of shipyard employment

| Cause of death                                  | Shipyard employment |           |                       |           |                           |           |
|-------------------------------------------------|---------------------|-----------|-----------------------|-----------|---------------------------|-----------|
|                                                 | None (98)           |           | Up to two years (118) |           | Three or more years (121) |           |
|                                                 | Observed            | Expected* | Observed              | Expected* | Observed                  | Expected* |
| Total cancer, all sites                         | 24                  | 3.6       | 28                    | 4.6       | 28                        | 5.6       |
| Cancer of lung, pleura,<br>trachea and bronchus | 14                  | 1.1       | 11                    | 1.4       | 17                        | 1.6       |
| Lung cancer                                     | 12                  | +         | 9                     | +         | 17                        | +         |
| Pleural mesothelioma                            | 2                   | †         | 2                     | †         | 0                         | †         |
| Peritoneal mesothelioma                         | 5                   | †         | 7                     | †         | 4                         | †         |
| Stomach, colon, rectal cancer                   | 3                   | 0.7       | 2                     | 0.9       | 5                         | 1.1       |
| Cancer all other sites                          | 2                   | 1.8       | 8                     | 2.3       | 2                         | 2.9       |
| Asbestosis                                      | 4                   | †         | 11                    | †         | 5                         | †         |
| All other causes                                | 7                   | 15.0      | 17                    | 17.8      | 20                        | 24.8      |
| Total deaths                                    | 35                  | 18.6      | 56                    | 22.4      | 53                        | 30.4      |

\*Expected deaths are based upon age specific rates for U.S. white males in 1967.

†United States data not available, but figure should be only slightly less than 1.1, 1.4 and 1.6, respectively.

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

Table 9

Expected\* and observed deaths among asbestos insulation workers in shipyard and construction industry work, January 1, 1967-December 31, 1971.

|                                | Workmen registered in<br>Union locals in southwest,<br>midwest and central states |                 | Workmen<br>registered in<br>shipyard locals |                 |
|--------------------------------|-----------------------------------------------------------------------------------|-----------------|---------------------------------------------|-----------------|
|                                | <u>Expected</u>                                                                   | <u>Observed</u> | <u>Expected</u>                             | <u>Observed</u> |
| <u>Total deaths</u>            | 316.28                                                                            | 446             | 39.56                                       | 34              |
| <u>Total cancer: all sites</u> | 56.34                                                                             | 172             | 7.91                                        | 16              |
| Lung cancer                    | 17.47                                                                             | 79              | 2.67                                        | 9               |
| Pleural mesothelioma           | **                                                                                | 10              | **                                          | 2               |
| Peritoneal mesothelioma        | **                                                                                | 13              | **                                          | 1               |
| Cancer of esophagus            | 1.26                                                                              | 6               | 0.20                                        | 1               |
| Cancer of stomach              | 2.56                                                                              | 6               | 0.36                                        | 0               |
| Cancer of colon, rectum        | 6.75                                                                              | 12              | 0.98                                        | 0               |
| All other cancers              | 28.30                                                                             | 46              | 3.70                                        | 3               |
| <u>Asbestosis</u>              | **                                                                                | 26              | **                                          | 3               |
| <u>All other causes</u>        | 259.94                                                                            | 248             | 31.65                                       | 15              |
| Number of men                  | 7,289                                                                             |                 | 462                                         |                 |
| Person-years of observation    | 35,310                                                                            |                 | 2,244                                       |                 |

\*Expected deaths are based upon age specific death rate data of the U.S. National Office of Vital Statistics. Rates for 1968-1971 were extrapolated from rates for 1961-1967.

\*\*U.S. death rates are not available, but these are rare causes of death in the general population.