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Cover Photo: The Davis Building, Hartford, Connecticut, was explosively demolished on October 10, 1974. The film strip from which this frame was taken was supplied by Ralph Eno, WFSB-TV, Hartford.

Asbestos and Mesothelioma Incidence in Connecticut

Leonard Bruckman and Robert A. Rubino

State of Connecticut, Department of Environmental Protection

Barbara Christine

State of Connecticut, Department of Health

The relationship between asbestos consumption and mesothelioma incidence in Connecticut has been investigated.

Asbestos has many industrial applications; however, several of these result in the dissipation of this material (e.g., vehicle brake and clutch lining erosion). In Connecticut, asbestos manufacturing operations contribute approximately 10 tons of airborne asbestos fibers each year, while vehicle brake and clutch lining erosion add another 2 tons. The demolition, especially the "explosive demolition" of buildings which have been fireproofed and/or insulated with asbestos-containing materials may be the most significant future source of asbestos emissions unless adequate precautions are taken.

Occupational asbestos fiber exposure has been known to cause asbestosis, lung cancer, and cancer of the lining of the stomach and lung (mesothelioma) for some time. Recently, the previously rare mesothelial malignancy has been linked to nonoccupational asbestos fiber exposure as well.

There were 133 Connecticut residents diagnosed with mesothelioma between 1935 and 1972. Although subject to diagnostic error, available statistics suggest that the combined sex age-adjusted mesothelioma incidence rate (AAR) per 100,000 Connecticut population has exhibited a possible 10-fold increase since 1935, rising from 0.02 during 1940 to 1949 to 0.25 from 1960 to 1969. The trends for both men and women also showed sharp increases over the same time period (1940 to 1970). The rapid rise in Connecticut's mesothelioma incidence rate closely follows the increase in the State's cumulative asbestos consumption and suggests a linearly increasing cause-effect relationship.

Asbestos is the name commonly used to describe several fibrous, naturally occurring silicate minerals consisting of approximately 40–60% silica combined with oxides of magnesium, iron, and other metals. The minerals, which differ in their chemical and physical properties (e.g., fiber diameter, flexibility, tensile strength), can be divided into two major categories: serpentines (chrysotile) and amphiboles (anthophyllite, crocidolite, tremolite, amosite, grunerite, and actinolite).^{1,2}

Sources of Airborne Asbestos Fibers

The mining and milling of asbestos materials, the milling and beneficiation of metal ores that contain asbestos, the manufacture of products containing asbestos (there are currently over 3000 different commercial uses of asbestos), the consumption of the many asbestos containing products (e.g., the erosion of vehicle brake linings and clutch facings), the demolition of asbestos containing structures, the disposal of asbestos waste materials, and the weathering of asbestos containing rock outcroppings are the major sources of airborne asbestos fibers. In Connecticut, asbestos manufacturing operations, assuming that reasonably efficient asbestos control equipment (e.g., 95% removal efficiency or better) is employed, contribute approximately 10 tons of airborne asbestos fibers each year, while the erosion of vehicle brake and clutch linings add another 2 tons annually.³

Notwithstanding EPA's current regulations covering the demolition of asbestos containing structures, perhaps the largest potential future source of asbestos emissions might be the demolition of buildings which have been fireproofed and/or insulated with asbestos materials.^{4,5} The authors feel

that the portion of EPA's regulations pertaining to the demolition of structures which contain any boiler, pipe, or load-supporting structural member that has been insulated or fireproofed with friable asbestos materials (i.e., any material that contains more than 1% asbestos, by weight, and that can be crumbled, pulverized or reduced to powder, when dry, by hand pressure) has several shortcomings. The subject regulation does not clearly state what requirements a demolition operator must meet in order to ascertain whether a structure to be demolished *does* or *does not* contain friable asbestos materials.

The inherent difficulty in determining whether a building to be demolished contains any asbestos materials and the associated costs involved in removing such materials if present lead the authors to believe that some type of formalized testing procedure is necessary. Briefly, this test might entail taking samples from the walls, insulation covering load-supporting structural members, and the floor and ceiling tile, of at least one floor of the structure to be demolished, and in addition the insulation covering the boiler and pipes. A composite sample should then be created and analyzed to determine its asbestos content. This "Asbestos Evaluation Test" should be performed by a licensed, independent engineer with access to laboratory facilities.

Furthermore, although the asbestos fibers incorporated into wallboards, floor, and ceiling tiles, are usually considered to be tightly bound and, therefore, unable to escape (i.e., non-friable asbestos materials) the authors feel that these materials might be a significant source of asbestos emissions if the structure to be removed were "explosively" demolished. The Judd Building located in Hartford, Connecticut, was recently demolished using the explosive demolition technique (see Figure 1). This demolition procedure appears to be rapidly gaining popularity judging from recent events elsewhere (Miami, St. Louis, etc.). The amount of asbestos fiber dust that might be released by a structure that has been demolished in such a manner is unknown at this time, but would appear to be potentially large and should be quantified as soon as possible.

Health Effects—Occupational and Nonoccupational

Although occupational exposure to asbestos has been shown to cause asbestosis (a debilitating scarring of the lungs), lung cancer, and cancer of the lining of the stomach and lung (mesothelioma), adverse health effects due to ambient concentrations have yet to be adequately demonstrated.⁵ However, recently the previously rare malignant condition known as mesothelioma has been linked to nonoccupational as well as occupational asbestos fiber exposure.⁶⁻¹⁴

Asbestos enters the body primarily through inhalation, but may also be introduced through the ingestion of asbestos contaminated food and water supplies. Once in the body, asbestos fibers are not readily removed and may remain dormant for many years. However, after 20 or 30 years malignancies, especially mesothelioma, induced by past asbestos fiber exposure may become clinically apparent. This long time interval between one's first exposure to asbestos and the early signs of mesothelioma, in addition to the rapid increase in United States asbestos consumption since the turn of the 20th century, only emphasizes the potential problem created by asbestos for individuals who have been occupationally and/or non-occupationally exposed.

Occupational Asbestos Air Quality Standard

The U.S. Department of Labor has recently proposed a new standard to protect workers and their families from the adverse health effects resulting from excessive asbestos fiber exposure.^{9,15} The Labor Department's Occupational Safety and Health Administration indicated that the current standard of 5 fibers (greater than 5 microns in length) per cubic

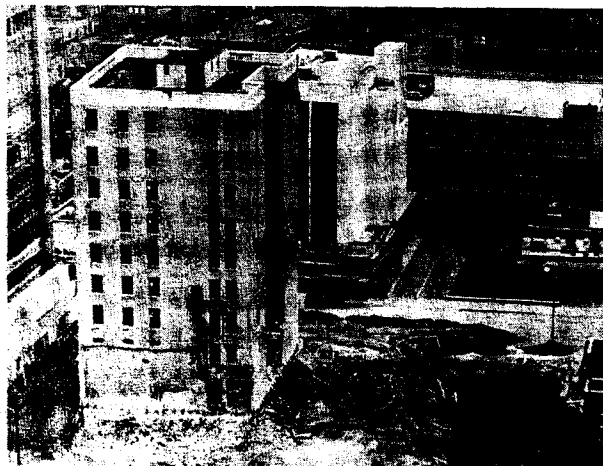


Figure 1. Explosive demolition of the Judd Building, Hartford, Connecticut. Photos courtesy of the *Hartford Times*: photographer, Ellery Kingston.

centimeter of air sampled (5 fibers_{>5μ}/cc) would not prevent either asbestosis or asbestos-related cancers. The Labor Department's newly proposed standard of 0.5 fibers_{>5μ}/cc would further reduce a lower standard (i.e., 2 fibers_{>5μ}/cc) scheduled to take effect sometime in 1976.^{15,16}

Ambient Asbestos Air Quality Standard

Although the importance of asbestos in most portions of the economy cannot be denied, numerical standards have been proposed in lieu of EPA's qualitative no visible emissions standard, with the objective of protecting the general public from excessive airborne asbestos fiber concentrations.^{3,10} In Connecticut, the criteria of mesothelioma was selected as the basis for developing an ambient asbestos air quality standard of either 30 ng/m^3 or its fiber equivalent of 30,000 fibers/ m^3 (i.e., total asbestos fibers of all sizes), based on a 30 day average sample).³ Mesothelioma incidence was chosen as the basis for developing Connecticut's proposed asbestos standard for the following reasons:¹⁸⁻²⁰

- the high frequency of lung cancer in the general population makes it difficult to relate a given case of bronchiogenic carcinoma to asbestos exposure with the high degree of probability that exists for mesothelioma; and
- some investigators suggest that the smaller asbestos fibers (i.e., those fibers less than 5 μ in length) most likely encountered in the ambient air may be incapable of producing lung cancer, however, it has not been demonstrated that these shorter asbestos fibers are incapable of inducing mesothelioma.

Connecticut's proposed asbestos ambient air quality standard is based on a 30 day average sampling period instead of the usual 24 hr duration because a 1 month averaging time is more manageable from a monitoring standpoint and is not sensitive to short-term perturbations in air asbestos emissions, but at the same time provides the public with a high degree of protection from the adverse health effects caused by excessive asbestos fiber concentrations. Compliance with the proposed standard can be easily and accurately evaluated using Connecticut's newly developed low volume, continuous 30 day particulate ambient air sampler (lo-vol).²¹ Connecticut has recently conducted an ambient air asbestos survey of the State. Total suspended particulate matter samples were collected using membrane collection filters (8 in. $\times$ 10 in.; Gelman metricel GN-6; 0.45 μ pore size; non-nylon reinforced) and the lo-vol. Subsequent asbestos determinations were made by the Batelle-Memorial Institute using electron microscopy. The results of this survey will be reported at a later date.

The 0.5 fiber/ cc proposed occupational asbestos standard is equivalent to a general public exposure of approximately 6000 ng/m^3 assuming that:^{3,22}

- 20 asbestos fibers greater than 5 μ in length are approximately equivalent to 1 ng of asbestos; and
- occupational exposure concentrations, which are based on an 8 hr day 5 day week, can be related to exposure levels for the general public by dividing the occupational levels by 4.2 (i.e., 24 hr/8 hr $\times$ 7 days/5 days = 4.2).

Thus, disregarding the fact that the aforementioned equivalent occupational standard is essentially for a 1 day exposure period and the proposed Connecticut ambient standard is

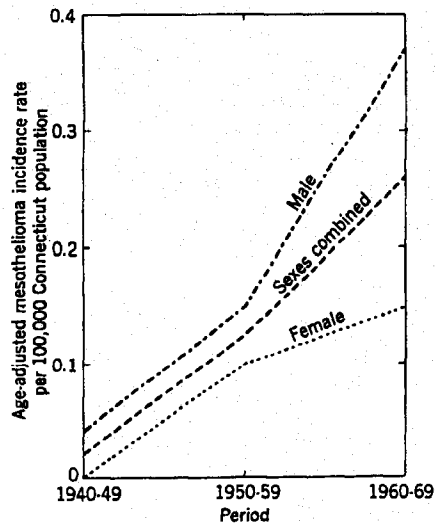


Figure 2. Connecticut mesothelioma incidence by 10 year period.

based on a 30 day interval, Connecticut's standard is approximately $\frac{1}{200}$ of the occupational standard. This difference does not seem unreasonable since ambient standards are designed to protect all segments of the general population which include many susceptible groups of people, such as infants and the elderly, who must non-voluntarily and continuously endure the ambient environment. Consequently, ambient air quality standards are usually well below corresponding occupational standards. Furthermore, it has not yet been adequately demonstrated that the newly proposed occupational asbestos standard is low enough to protect the worker exposed to asbestos fiber dust on the job from contracting mesothelioma.

Incidence of Mesothelioma in Connecticut

All cases of mesothelioma diagnosed in residents of Connecticut from 1935 to 1972 were identified through the resources of the Connecticut Tumor Registry located in the Connecticut State Department of Health. The Registry routinely received reports on all cancer patients admitted to a hospital within the state. If a Connecticut resident is known to be admitted to a hospital outside the state, the specific institution involved is contacted for more information. In addition, all death certificates for Connecticut residents, on which cancer is mentioned, are sent to the Registry. Detailed description of the operations of the Connecticut Tumor Registry have been published.^{23,24}

There were 133 Connecticut residents diagnosed with mesothelioma from 1935 through 1972. Eighty-nine of these were men and 44 were women (Table I).

Table I. Mesothelioma, number and percent of cases by primary site and sex, Connecticut 1935-1972.

Table 1. Mesothelioma, number and percent of cases by primary site and sex, 1935-72																				
Primary site	No. by sex		Period and sex																Total	
			1935-39		1940-44		1945-49		1950-54		1955-59		1960-64		1965-69		1970-72			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	No.	%
Pleura	57	27			1		2		1	2	7	5	11	3	25	10	10	7	84	63.2
Lung	11	3							5		1	1	5	1		1			14	10.5
Perit	15	7					1			1	2		5	4	1	1	6	1	22	16.5
Testis	2									2									2	1.5
Other	4	7	1									3	2	1	1	3			11	8.3
Total	89	44	1		1		3		6	5	10	9	23	9	27	15	16	8	133	100.0

Table II. Mesothelioma, number and percent of cases by occupational group and sex, Connecticut 1935-1972.

Occupation	Male	Female	Total	
			No.	%
1. Outside work (e.g., carpentry, gardening, etc. . .)	10		10	7.5
2. Industry (including shipbuilding and printing)	33	3	36	27.1
3. Maintenance	12	32	44	33.0
4. Plumbing, chemical, etc. . .	7	1	8	6.0
5. Public works	7		7	5.2
6. Office, Professional	13	6	19	14.3
7. Armed services	1		1	0.8
8. Other	2		2	1.6
9. Unknown	4	2	6	4.5
Total	89	44	133	100.0

The trend in men mounted through the 10 yr period covering 1960 to 1969 from an age adjusted rate (AAR), obtained using the indirect method,²⁵ of 0.04/100,000 Connecticut population for the interval between 1940 and 1949 to 0.37 from 1960 to 1969. No mesotheliomas were diagnosed in Connecticut women until the period 1950 to 1959 when 12 were reported yielding an AAR of 0.1/100,000. The trend for females increased slightly to 0.15 in 1960 to 1969 (Figure 2; Table II). The combined-sex AAR rose from 0.02/100,000 during 1940 to 0.25 from 1960 to 1969, over a 10-fold increase. The increase in cases over the years may in part reflect an increased awareness of this type of tumor and an attempt by pathologists to classify all malignancies. Though increases in both occupational and nonoccupational asbestos fiber exposure are expected to have occurred over the last 40 years, only 4 people were reported with known exposure to asbestos. Eight others were felt to have experienced some exposure. Occupation at the time of diagnosis was obtained from hospital admission records and the usual occupation from death certificates. It was found that 44 individuals (33.0%) worked in the home or in like occupations. Thirty-six (27.1%) were reported to have worked in manufacturing industries. Nineteen (14.3%) worked in offices as professionals or clerical employees (Table III). Of the remaining individuals it is interesting to note that one person was listed as a toll collector. Unfortunately, complete occupational histories of each of those individuals afflicted with mesothelioma are not available at this time.

Approximately 58% of those afflicted with mesothelioma resided in urban areas, 34% lived in suburban locations and 7% inhabited semi-rural regions. This represented a lower percentage of urban residents, respectively, than would have been expected from the average population distribution within the State over the entire period under study (Table IV).

Table III. Mesothelioma, number of cases and age-adjusted rate per 100,000 population, by sex and period of diagnosis: Connecticut 1940-1969.

Sex	Period					
	1940-1949		1950-1959		1960-1969	
	No.	Rate	No.	Rate	No.	Rate
Male	4	0.04	18	0.15	50	0.37
Female			12	0.10	24	0.15
Combined	4	0.02	30	0.13	74	0.25

The fact that the age of almost all of the Connecticut residents diagnosed with mesothelioma was at least 40 years appears to substantiate the reported extended lag period between exposure to asbestos and mesothelioma induction (Figure 3). The short elapsed time from the date of diagnosis to death (almost always less than 3 years) indicates the serious nature of this type of malignancy (Figure 4).

Relationship between Mesothelioma Incidence and Asbestos Consumption

Cumulative United States asbestos consumption has increased rapidly since the beginning of the 20th century and is projected to exceed 60 million tons by 1980;²⁶ Connecticut's asbestos consumption has been estimated by proportionally allocating total U.S. consumption using the appropriate Connecticut to United States population ratio (Table V; Figure 5). A plot of both cumulative U.S. and Connecticut (estimated) asbestos consumption and Connecticut's com-

Table IV. Mesothelioma, number of cases, and percent distribution by place of residence and average Connecticut population distribution, 1935-1972.

Place of Residence	Sex			Percent	Average Connecticut population distribution in percent
	Male	Female	Combined		
Rural	5	4	9	6.8	21.5
Suburban	26	19	45	33.8	41.0
Urban	58	20	78	58.6	37.5
Unknown		1	1	0.8	
Total	89	44	133	100.0	100.0

bined-sex mesothelioma AAR/100,000 population as a function of time suggests that the sharp increase in mesothelioma incidence closely followed the rapid rise in the State's cumulative asbestos consumption for comparable intervals (i.e., 1940 to 1970) (Figure 6). Furthermore, a plot of the mesothelioma AAR between 1940 and 1970 as a function of Connecticut's asbestos consumption over the same time period suggests a linearly increasing cause-effect relationship which warrants further investigation. Cumulative asbestos consumption seems to relate to mesothelioma incidence. This might be partially explained by the persistent nature of as-

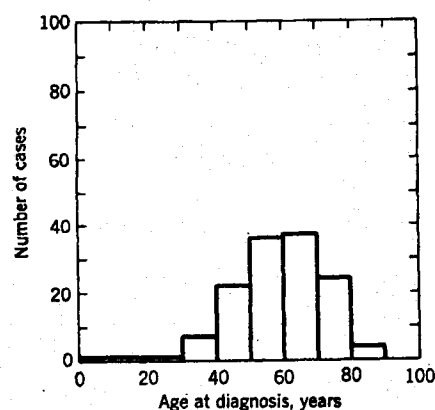


Figure 3. Connecticut mesothelioma incidence by age at diagnosis.

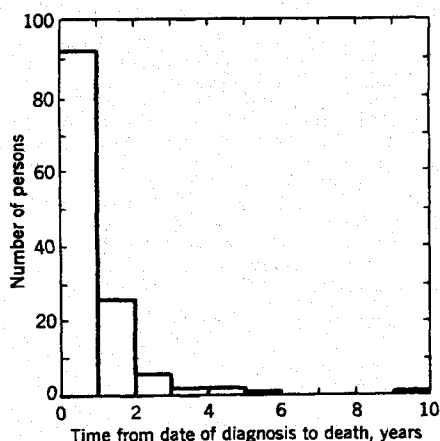


Figure 4. Time from date of mesothelioma diagnosis to death.

bestos in the environment and expected associated increases in background asbestos levels in different environmental media, such as air and water supplies, with increasing asbestos usage. Unfortunately, the relationships among asbestos consumption, environmental asbestos levels, and asbestos-related disease cannot be completely quantified at this time due to an insufficient data base. Therefore, the authors strongly recommend that the rate of environmental sampling for asbestos in different media, especially the atmosphere, be initiated and continued so that future cause-effect trends can be accurately determined.

Table V. Asbestos consumption.¹⁸

Period	Apparent Consumption, short tons ^a	
	United States	Connecticut ^b
1890-1899	64,500	800
1900-1909	265,000	3,200
1910-1919	986,500	12,300
1920-1929	1,999,500	26,000
1930-1939	1,880,000	24,400
1940-1949	4,654,000	60,500
1950-1959	7,417,000	100,100
1960-1969	7,561,000	109,600

^aA short ton is equivalent to 2000 lb.

^bEstimated by proportionally allocating total United States asbestos consumption using the appropriate Connecticut to United States population ratio.

Conclusions

The most significant potential source of airborne asbestos fibers in the future may be the demolition, especially the "explosive demolition," of large structures which have been fireproofed and/or insulated with asbestos-containing materials. The amount of asbestos fiber dust released by a building demolished in this manner should be quantified as soon as possible.

Connecticut's proposed asbestos air quality standard of 30 $\mu\text{g}/\text{m}^3$ (or 30,000 total asbestos fibers/ m^3 of air sampled), 30 day average is expected to reduce state asbestos-related fatalities to 2/yr.³ This standard is approximately $1/200$ of the newly proposed occupational asbestos standard (0.5 fibers/ $>5\mu$ /cc), however, this difference does not seem unreasonable since:

- ambient standards are designed to protect all segments of the general population, including the most susceptible groups and are, therefore, normally well below occupational standards; and
- the newly proposed occupational asbestos standard may not adequately protect the worker from contracting mesothelioma.

There were 133 Connecticut residents diagnosed with mesothelioma between 1935 and 1972. The combined-sex mesothelioma incidence rate per 100,000 Connecticut population has exhibited a 10-fold increase since 1935, rising from 0.02 during 1940 to 1949 to 0.25 from 1960 to 1969. The trends for both men and women also demonstrated sharp increases over the same period. The rapid rise in Connecticut's mesothelioma incidence rate closely follows the increase in the State's cumulative asbestos consumption for comparable intervals (i.e., 1940 to 1970) and suggests a linearly increasing cause-effect relationship which warrants further investigation.

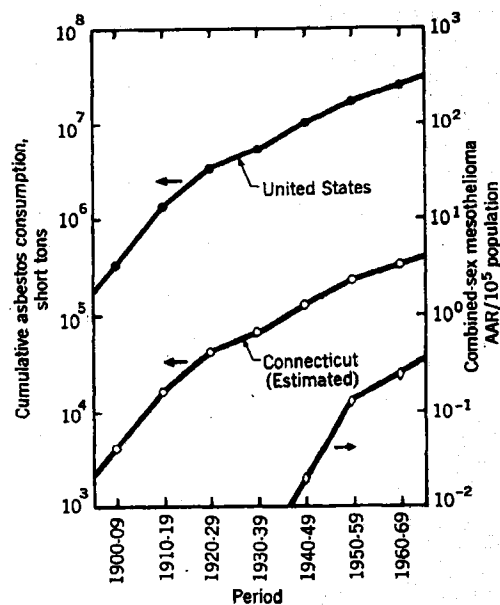


Figure 5. Cumulative asbestos consumption and Connecticut mesothelioma incidence as a function of time.

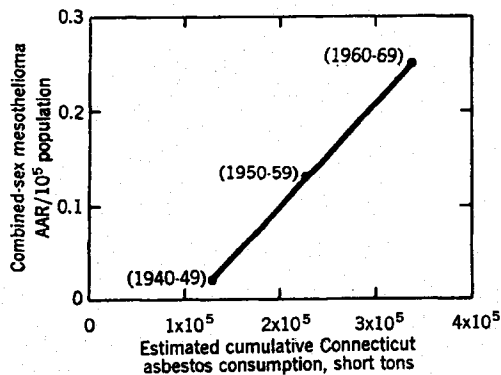


Figure 6. Connecticut mesothelioma incidence as a function of Connecticut's cumulative asbestos consumption.

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Mr. Bruckman is principal air pollution control engineer in Air Compliance, Monitoring, and Mr. Rubino is assistant director of Air Compliance, Engineering, State of Connecticut Department of Environmental Protection State Office Building, Hartford, CT 06115. Dr. Christine, who was a consultant to the Cancer Programs, State of Connecticut Health Department, died in 1975.