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Mesothelioma among Employees with Likely Contact with in-Place Asbestos-Containing Building Materials[a]

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When construction workers completed their tasks, care of new buildings became the responsibility of maintenance employees. Sometimes obviously, and at other times insidiously, asbestos-containing building material (ACBM) deteriorated or was physically damaged, necessitating repair or replacement. Not identified as a public health priority, such maintenance was often deferred when it was not cosmetically necessary.

Although the health hazard of asbestos exposure from thermal asbestos insulation during building maintenance work was recognized as early as 1932,[2] and concerns were raised about the potential health hazard of spray-applied ACBM in 1932[3] and 1953,[4] quantitative industrial hygiene assessment of exposure circumstances was not begun until the 1970s.[5,6] Health investigations have begun describing asbestos-associated diseases among workers exposed to ACBM during the course of their usual work.[7–12]

In 1984 the United States Environmental Protection Agency (EPA) conducted a national survey of buildings to estimate the extent of friable ACBM in existing structures. They concluded that approximately 31,000 schools and 733,000 public and commercial buildings were likely to contain such materials.[13] Priority has been placed upon addressing the ACBM in schools.

The Wisconsin Division of Health (WDOH) within the Wisconsin Department of Health and Social Services (WDHSS) has served as the lead agency for the U.S. Environmental Protection Agency's (EPA) School Asbestos Programs since 1979.

Wisconsin has 429 public-school districts containing 1,923 schools with a total of 2,230 buildings. There are an additional 986 private-school districts containing 1,014 schools with 1,142 buildings, and 18 government-school districts (state, county) with 28 schools and 107 buildings. All these schools are regulated under the Asbestos Hazard Emergency Response Act (AHERA).

Under AHERA regulations, all school districts were required to submit asbestos management plans to WDOH for review by October 1988. The WDOH developed and maintains a computerized database program for storing data abstracted

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during the management plan review. TABLE 1 summarizes the status of ACBM identified from the inspections done to prepare the AHERA management plans.

Significantly damaged friable thermal system insulation was reported from 37% of the public-school districts, but from only 15% of the private-school districts. Significantly damaged friable surfacing ACBM was reported by 4% of public- and 1% of private-school districts. While 96% of public- and 86% of private-school districts reported nonfriable miscellaneous ACBM (primarily floor and ceiling tile), only 2% of public and 0.2% of private districts found significantly damaged miscellaneous materials.

Wisconsin Occupational Exposure and Disease Surveillance

No national occupational exposure or disease surveillance program exists in the United States. The fragmented and unreliable status of our ability to characterize the impact of past and future work-site exposures on the public's health was characterized first in 1984 congressional testimony[14] and later in a 1987 report from the National Academy of Sciences.[15]

TABLE 1. Asbestos-Containing Materials in Wisconsin Schools: Summary of 1989 AHERA Plan Reviews

	Thermal		Surfacing		Miscellaneous	
	Friable	Damaged	Friable	Damaged	Friable	Damaged
Public-school districts (n = 411)	326 (79%)	153 (37%)	78 (19%)	16 (4%)	91 (22%)	9 (2%)
Private-school districts (n = 872)	424 (49%)	130 (15%)	105 (12%)	8 (1%)	48 (5%)	2 (0.2%)

To begin to address occupational and environmental health surveillance needs in Wisconsin, the WDHSS entered into a five-year (1984–1988) cooperative agreement with the National Institute for Occupational Safety and Health (NIOSH). The intent was to evaluate existing Wisconsin data systems for utility in occupational disease and injury surveillance and to pilot selective sentinel disease surveillance.

In 1987 the pilot surveillance activities were expanded under the NIOSH Sentinel Event Notification System for Occupational Risks (SENSOR) initiative to include sentinel physician reports and investigative intervention.

METHODS

Surveillance Data Systems Utilized

1. Wisconsin Vital Statistics Registration System (VSRS)[16]

The Vital Statistics Registration System in Wisconsin was converted to a computer data base beginning in 1959. Cause of death is coded by a certified

nosologist using current International Classification of Disease (ICD) codes. Usual occupation of the deceased, coded by a certified nosologist using the United States Bureau of the Census Codes, became part of the initial electronic file. Beginning in 1981, usual industry was coded and added to the VSRS. Multiple cause of death coding has been employed since 1973.

2. Cancer Reporting System (CRS)[17]

In 1978, Wisconsin implemented a statutorily mandated, population-based, state-wide, Cancer Reporting System (CRS). All primary neoplasms, except basal cell and squamous cell carcinoma of the skin, are reportable. The system is maintained by the Wisconsin Center for Health Statistics and obtains information from all acute-care general medical-surgical hospitals in the state. Each hospitalization is reported. The CRS identifies duplicate reports, and then serially updates each case record to reflect the most current and definitive diagnoses including

TABLE 2. ICD Cause of Death Codes Reviewed to Identify Mesotheliomas

ICD-7 (1958–1967)	ICD-8 (1968–1978)	ICD-9 (1979–)
158	—	—
—	158.9	158.9
—	—	162
—	163.0	163.0
197.9	—	—
—	199.1	199.1
—	—	199.9
211	—	—
212	—	—
—	212.3	—
—	212.4	212.4
227	—	—
—	228	—
—	—	229.9

findings at autopsy, if performed. The ICD-9 extension codes for Oncology histology (morphology) are utilized. Annually, the VSRS records are electronically searched to identify CRS fatalities. Identified matches are then incorporated into the CRS data system.

Physicians and pathology laboratories began reporting nonhospitalized patients with cancer in 1987.

3. Wisconsin Mesothelioma Surveillance

The VSRS and the CRS form the basis of Wisconsin's mesothelioma surveillance system.

The electronic VSRS spans three International Classification of Disease (ICD) coding revisions; ICD-7 (1958–1967), ICD-8 (1968–1978), and ICD-9 (1979–present). Unfortunately, until ICD-9, there were no codes specific for either pleural or peritoneal mesothelioma.

State nosologists were asked to identify the ICD codes most likely to have been used for mesothelioma during the periods of the different ICD revisions (TABLE 2). For the years 1959–1982, death certificates in the VSRS with these codes were identified and the individual microfilmed death certificate reviewed. Certificates with any mention of mesothelioma as a contributing cause of death were flagged.

Beginning in 1983, a system was instituted whereby, upon receipt of a death certificate with any mention of mesothelioma, a nosologist would flag the certificate at the time it was coded and the epidemiology program was notified.

The CRS informational base was searched for all mentions of ICD-9 extension, Oncology histology (morphology) codes, 9050–9053, which are indicative of mesothelioma. Cases that were not duplicates of the VSRS-identified cases were added to the surveillance system.

It was feasible to reconstruct lifetime occupational histories from medical records (since 1983, all Wisconsin in-patient medical records must contain an occupational history) augmented by interviews with next-of-kin and treating physicians. State data sources, such as professional licensure records and public employee service records, could be used to verify reports concerning length of service and public employment classification. For school employees, current AHERA building asbestos inspection reports could serve to verify the presence of ACBM and its current status in school buildings.

Descriptive Epidemiology

This report is the first investigation to utilize the Wisconsin mesothelioma surveillance system. We chose to investigate mesothelioma deaths in which usual occupation or industry on the death certificate identified public building custodian/janitor/maintenance workers as well as commercial or manufacturing facility maintenance and repair employment.

Additionally, because there is public health concern that school teachers may be exposed to asbestos released from friable ACBM and therefore be at risk of developing mesothelioma, we investigated deaths of mesothelioma among school teachers.

We began by reviewing the death certificate information on usual occupation and industry found in the mesothelioma surveillance system. This review led to 41 detailed mesothelioma case investigations.

For this investigation, lifetime occupational histories were reconstructed utilizing four sources of information. First, CRS data and medical records were sought and, when available, reviewed to verify the diagnosis and to identify occupational history and asbestos exposure references. Second, self-administered questionnaires were sent to next-of-kin requesting information including demographics, smoking history, educational attainment (including names of schools attended), military service, father's occupation, employment history since first job, and whether the informant believed the individual had been exposed to asbestos and how. Third, a telephone interview with the next-of-kin was attempted to obtain the exposure information contained in the questionnaire when the self-administered questionnaire was not returned, or when information provided was incomplete or additional specific detail was desired. Fourth, for public employees, personnel and pension fund offices were queried to verify dates of public employment.

TABLE 3. Mesothelioma as a Cause of Death: Wisconsin Vital Records, 1959–1988

Years of Death	Sex		All
	Female	Male	
1959–1963	3 (75%)	1 (25%)	4
1964–1968	4 (57%)	3 (43%)	7
1969–1973	6 (32%)	13 (68%)	19
1974–1978	13 (36%)	23 (64%)	36
1979–1983	25 (23%)	86 (77%)	111
1984–1988	48 (27%)	133 (73%)	182
All	99 (28%)	259 (72%)	359

RESULTS

Mesothelioma Surveillance

The mesothelioma surveillance system (1959–1989) contains 573 mesothelioma reports (160 females and 413 males). This includes 410 deaths with mesothelioma identified as an underlying or contributing cause of death (397 Wisconsin residents and 13 nonresidents who died while in Wisconsin institutions). The CRS contains an additional 77 deaths among those with diagnoses of mesothelioma for which the death certificate did not specifically mention mesothelioma (74 residents and 3 nonresidents). The vital status of the remaining 63 Wisconsin residents and 23 nonresidents is unknown.

Because the CRS was not in existence for all the years covered by the surveillance system, mortality trends were examined utilizing only the information obtained from the VSRS. TABLE 3 summarizes the 359 deaths in Wisconsin residents (1959–1988) which identified mesothelioma as an underlying or contributing cause on the death certificate. Data on some, but not all, deaths from 1989–1990 are available.

The mesothelioma case mortality for the period 1979–1988, during which the CRS was fully operational, is summarized in TABLE 4. This includes all deaths among Wisconsin residents with diagnoses of mesothelioma, whether or not the death certificate mentioned mesothelioma. The CRS identified 19% more mesothelioma deaths than did the death certificates alone.

Mesothelioma among Maintenance Workers

TABLES 5, 6, 7, and 8 summarize the occupational information obtained from the 29 detailed investigations of those identified as performing maintenance work.

TABLE 4. Deaths among CRS Mesothelioma Cases: 1979–1988

Years of Death	Sex		All
	Female	Male	
1979–1983	32 (23%)	105 (77%)	137
1984–1988	64 (29%)	160 (71%)	224
All	96 (27%)	265 (73%)	361

TABLE 5. Mesothelioma Deaths among School Maintenance Employees Identified by Usual Occupation and Industry on Death Certificate (DC)

Case 1

Type: Pleura Sex: Male Age: 61 Year of death: 1979 DC Occupation: Custodian DC Industry: Public schools

Lifetime Occupational History

1944–1947 U.S. Army Corps of Engineers; built bridges in Europe
1947–1967 Cement and masonry work; laid sidewalks, curbs, driveways for city, worked outdoors
1968–1979 General maintenance for public school district; cleaning, washing walls, ceilings, floors, minor repairs

Case 2

Type: Pleura Sex: Male Age: 73 Year of death: 1980 DC Occupation: Painter DC Industry: School board

Lifetime Occupational History

1925–1941 Painting; owned sign-writing business
1941–1946 Machine operator; cold metal forge company, stamping metal parts for military equipment
1946–1968 School district paint crew; 75% indoors, painting logos on gym floors, washed and maintained walls and ceilings during school year, painted exterior and interiors full time during school recesses
Comments: Reported being present during school renovations involving removal of asbestos materials. Employed in same school district as Case 4.

Case 3

Type: Pleura Sex: Male Age: 65 Year of death: 1983 DC Occupation: Maintenance engineer DC Industry: Technical college

Lifetime Occupational History

1935–1941 Part-time clerking jobs; pumped gasoline at small family-run station
1942–1946 U.S. Army; drove truck in Europe
1946–1951 Carpenter; building barns, some residential framing
1952–1980 Maintenance; vocational school, last 8 years supervised all maintenance staff. Participated in and later supervised annual cleaning and repair of boilers
Comments: Maintenance department handled all but major renovations

(TABLE 5. *Continued*)

Case 4

Type: Pleura Sex: Male Age: 74 Year of death: 1984 DC Occupation: Construction supervisor DC Industry: School board

Lifetime Occupational History

1925–1942	Residential construction; father's building company
1942–1945	Machine shop; military equipment manufacturing plant
1945–1948	Carpenter contractor
1948–1957	City building inspector
1957–1969	School district general contractor; supervised for district the building of 5 schools; participated in multiple major repair and reconstruction projects, including ceilings

Comments: Calcified pleural plaque noted; awarded worker's compensation. Employed in same school district as Case 2.

Case 5

Type: Pleura Sex: Male Age: 68 Year of death: 1985 DC Occupation: Custodian DC Industry: School system

Lifetime Occupational History

1936–1940	Odd jobs, surface labor at coal mine
1941–1945	U.S. Army Infantry in Europe, shot in left lung
1946–1949	Carpenter; low-income home construction
1950–1952	School; studied printing
1952–1953	Shipping department; metal parts plant
1953–1955	Machine operator; metal parts manufacturing
1955–1975	School custodian; general maintenance, carpentry, painting, plumbing repairs
1975–1980	Public library; maintenance and repair

Comments: Colon cancer removed in 1954.

Case 6

Type: Pleura Sex: Male Age: 62 Year of death: 1986 DC Occupation: Custodian DC Industry: Public school

Lifetime Occupational History

1941–1945	U.S. Navy; catapult operator on aircraft carrier and battleship in Pacific
1946–1947	Telephone company; installing dial telephone systems
1947–1949	Clerk in store; part-time residential construction during summers
1950–1960	Paper manufacturing company; extrusion machine operator
1960–1961	Automobile tire sales
1961–1970	Sheet-metal shop; manufactured dryers for paper companies
1971–1986	Public school custodian; helped clean boilers each year; cleaning and maintenance during school year; building repair during summer.

Comments: Wife believes asbestos was used in the paper industry dryer machines, but in the assembly area of the plant not the sheet-metal shop. He did not recall handling or seeing asbestos used in the sheet-metal shop.

Case 7

Type: Pleura Sex: Male Age: 52 Year of death: 1987 DC Occupation: Facilities repairman DC Industry: University

Lifetime Occupational History

1950–1972 Fishing tackle manufacturing; assembled lures
1972–1987 University maintenance, facilities repair; ACBM repair performed
Comments: Worker's compensation awarded; friable asbestos containing thermal and surfacing material abated at the school; employed at same university facility as Case 10

Case 8

Type: Pleura Sex: Male Age: 73 Year of death: 1987 DC Occupation: Cabinet maker DC Industry: Board of education

Lifetime Occupational History

1937–1955 Street car/bus carpenter; repaired wooden seats, overhead compartments, rails
1955–1977 School board maintenance worker; worked in district-wide maintenance shop where all trades were housed; built cabinets in shop then installed in schools; repaired vandalism to schools; responsible for repair of all woodwork in schools; did painting
Comments: Street-car work done in large single-room building where all types of public transit repairs were done. Wife believes their private home hot water heating system had ACBM

Case 9

Type: Pleura Sex: Male Age: 77 Year of death: 1987 DC Occupation: Power plant employee DC Industry: Elementary school

Lifetime Occupational History

1935–1940 Public service power plant; general labor, flue blower
1940–1941 Truck driver; beer delivery
1941–1957 School custodian; did every kind of maintenance including repair of broken pipes; kept boiler functioning
1958–1972 Tavern; owner/operator
1972–1974 Managed a drugstore
Comments: Public-service power plant across from asbestos products manufacturing facility; lived within 1 mile of this asbestos-using plant (1935–1940)

Case 10

Type: Pleura Sex: Male Age: 56 Year of death: 1989 DC Occupation: Custodian DC Industry: University

Lifetime Occupational History

1950–1953 U.S. Army Air Corp; Korea, supply officer
1953–1966 Manufacturing/assembling juvenile furniture, cribs etc.
1966–1967 Night watchman; publishing company
1967–1973 Papermill; grinder room, debarking logs, chipping logs
1974–1977 Back injury (disability); part-time self-serve gas station
1977–1978 Unemployed
1978–1989 Maintenance custodian at university; cleaning, vacuuming, light bulbs
Comments: Maintained auditorium with crumbling acoustical asbestos ceiling, heavy dust; vacuum bags had to be emptied by hand; very dusty. Employed at same facility as Case 7.

TABLE 6. Mesothelioma Deaths among Public Building Maintenance Employees Identified by Usual Occupation and Industry on Death Certificate (DC)

Case 1

Type: Pleura Sex: Male Age: 65 Year of death: 1974 DC Occupation: Plumbing inspector DC Industry: City

Lifetime Occupational History

1926–1940	Plumber; repairs in residential buildings and some work installing pipes under streets
1941–1943	Shipyard; steamfitter/pipefitter building submarines
1944–1954	Master plumber; new construction and repairs
1954–1974	City plumbing inspector; visited work sites to assure new and renovated plumbing met codes

Case 2

Type: Pleura Sex: Male Age: 60 Year of death: 1981 DC Occupation: Superintendent of building DC Industry: County

Lifetime Occupational History

1942–1945	U.S. Navy; engineering aboard aircraft carrier
1946–1948	Theater; building maintenance
1949–1949	Tannery; laborer
1950–1980	County stationary engineer; initially full time in boiler room, then job expanded to include general maintenance in all county buildings; last 8 years located only in county courthouse doing maintenance and custodial work

Case 3

Type: Pleura Sex: Male Age: 79 Year of death: 1983 DC Occupation: Captain DC Industry: City fire department

Lifetime Occupational History

1923–1925	Tractor assembly company
1926–1957	City fire department; did all jobs, promoted to captain in charge of firehouse
1957–1977	Building maintenance; did all general repairs and custodial work in sheltered workshop building
Comments:	Interstitial fibrosis on chest X-ray in 1979. Wife reports that for 2 years while working for fire department subject did part-time work with a furnace company doing service calls and may have been involved with one or two furnace installation jobs. She also reported that recently an outside contractor was brought in to do asbestos abatement in the workshop building he maintained.

Case 4

Type: Pleura Sex: Male Age: 70 Year of death: 1985 DC Occupation: Building inspector DC Industry: City

Lifetime Occupational History

1932–1939	Store clerk; CCC forestry camp
1939–1945	U.S. Army; Infantry (Europe, Africa, Italy)
1946–1948	Bar supplies sales
1948–1951	Railroad; brakeman
1952–1953	Brewery warehouseman

1953–1958	Residential construction; carpenter, concrete laying
1959–1962	Manufacturing; aluminum pots & pans
1962–1966	Residential construction
1967–1972	City building inspector
1972–1984	Mobile home construction (part-time in Texas); applied liquid roofing material
1984	Return to Wisconsin

Case 5

Type: Pleura Sex: Male Age: 64 Year of death: 1988 DC Occupation: Maintenance DC Industry: County

Lifetime Occupational History

1942–1946	U.S. Army; radio operator in Alaska, some time spent as radioman on an army boat.
1946–1950	Bricklayer for residential construction
1951–1966	Switchman for railroad
1967–1970	General construction labor; built high school
1971–1978	Aerospace industry; missile parts
1979–1987	County courthouse; general maintenance and repairs
Comments:	Calcified pleural plaques noted on autopsy

Case 6

Type: Pleura Sex: Male Age: 76 Year of death: 1989 DC Occupation: Electrical inspector DC Industry: City

Lifetime Occupational History

1932–1939	Bank clerk; teller
1939–1941	City employee; electric meter reader
1941–1943	U.S. Air Force; flight simulator training instructor, no overseas duty
1943–1979	City employee; electricians union, did work in city electric power-generating plant, city building electrical systems repair & maintenance; also electric wiring inspector for city

Case 7

Type: Pleura Sex: Male Age: 53 Year of death: 1989 DC Occupation: Electrician DC Industry: County

Lifetime Occupational History

1953–1956	U.S. Marines; infantry radioman (Korea)
1956–1959	Machinery manufacturing; personnel office
1959–1963	Railroad; electrician apprentice
1963–1966	Automobile manufacturing; personnel office, time sheets
1966–1971	Electrician for electrical contractor; worked around insulation in ceilings, walls
1971–1983	Maintenance electrician for county; worked with cables, conduits, around ACBM
Comments:	Became ill in 1983, malignant mesothelioma confirmed at autopsy; worker's compensation awarded.

TABLE 7. Mesothelioma Deaths among Private Building Maintenance Employees Identified by Usual Occupation and Industry on Death Certificate (DC)

Case 1

Type: Pleura Sex: Male Age: 51 Year of death: 1982 DC Occupation: Building services DC Industry: Bank

Lifetime Occupational History

1939–1963 Farming
1963–1975 Bank building maintenance and painting; for initial 5 years did all pipe repair work needed
1975–1977 Maintenance supervisor for all bank properties

Comments: Building maintenance crews handled all maintenance and repairs except major construction renovations; awarded worker's compensation; retired in 1977 owing to diabetic vasculitis

Case 2

Type: Pleura Sex: Male Age: 69 Year of death: 1986 DC Occupation: Supervisor paint shop DC Industry: Hospital

Lifetime Occupational History

1935–1946 Pioneer Corps in Israel
1946–1958 Palestine Electrical Corporation; maintenance
1958–1960 Emigrated to U.S.; cook, house painting
1960–1973 Chair company; upholstering
1973–1986 Hospital; supervised housekeeping and maintenance for hospital

Case 3

Type: Pleura Sex: Male Age: 67 Year of death: 1987 DC Occupation: Custodian DC Industry: Church

Lifetime Occupational History

1937–1941 Plastering and masonry work (residential)

1942–1946	U.S. Army Air Corps; parachute packer
1946–1964	Master sand plasterer (no drywall)
1964–1982	Custodian (church); maintained boilers, did painting, helped remove bowling alley from church basement (including tearing out old pipes)

Case 4

Type: Pleura Sex: Male Age: 82 Year of death: 1988 DC Occupation: Janitor DC Industry: Fur company

Lifetime Occupational History

1924–1930	House painter; interiors and exteriors
1930–1964	Truck driver; delivered live animals (hogs, chickens) to markets; delivered dressed meat to retail stores
1964–1969	Fur company; janitor/custodian; included maintaining and stoking coal-fired furnace and general building repairs

Case 5

Type: Pleura Sex: Male Age: 77 Year of death: 1989 DC Occupation: Maintenance DC Industry: Hospital

Lifetime Occupational History

1928–1930	Meat market; service counter
1931–1937	Assembler; metal furniture manufacturing, hospital beds
1938–1939	Cheese factory
1940–1946	Shipyard, manufacturing submarines; labor inside boats
1946–1959	Dairy; whey processing; boiler room attendant; adjusted valves, gauges
1959–1967	Disability for impaired vision
1967–1977	Hospital custodian/maintenance; windows, floors; no climbing
Comments:	Shipyard work involved working between hulls

TABLE 8. Mesothelioma Deaths among Industrial Maintenance Employees Identified by Usual Occupation and Industry on Death Certificate (DC)

Case 1

Type: Pleura Sex: Male Age: 49 Year of death: 1978 DC Occupation: General maintenance DC Industry: Industry

Lifetime Occupational History

1944–1950	Naval shipyard; pipefitter
1950–1955	Maintenance pipefitter; asbestos products plant
1955–1957	U.S. Army; medical corps in Washington State
1957–1961	Maintenance pipefitter; asbestos products plant
1961–1976	Maintenance pipefitter; automobile manufacturing plant
Comments:	Father was a shipyard pipefitter; worker's compensation awarded; asbestosis with many ferruginous bodies noted at autopsy

Case 2

Type: Pleura Sex: Male Age: 36 Year of death: 1979 DC Occupation: Maintenance DC Industry: Landscaping

Lifetime Occupational History

1962–1966	Farming
1966–1968	Department store clerk
1969–1970	Metal casting company; iron grills for fences, lawns
1970–1979	Landscaping for construction company; spreading gravel, hauling dirt, outside work
Comments:	Lived with parents; father worked 1941–1970 at an asbestos pipe-producing plant; brother and brother-in-law also worked at the same plant.

Case 3

Type: Pleura Sex: Male Age: 45 Year of death: 1980 DC Occupation: Maintenance DC Industry: Cheese company

Lifetime Occupational History

1953–1954	Shipyard; general labor (yard built PT boats)
1955–1956	U.S. Army; radioman
1956–1958	Telephone company; repaired telephones
1959–1966	Maintenance, hospital; repaired boiler and pipes, general building maintenance
1966–1967	Maintenance, chair-manufacturing company
1967–1978	Maintenance, soda bottling company
1967–1979	Maintenance, part-time, then full-time general building maintenance for cheese marketing company

Case 4

Type: Pleura Sex: Male Age: 62 Year of death: 1981 DC Occupation: Maintenance man DC Industry: Manufacturing

Lifetime Occupational History

1935–1940	Farming, CCC camp in Northern Wisconsin
1940–1945	Railroad; general labor, laid rail ties

1946–1947 U.S. Marines; cook in Pacific
1947–1980 Maintenance, fertilizer plant; helped build plant, then hired to maintain building & equipment, handled asbestos siding and roofing materials during repairs

Case 5

Type: Pleura Sex: Male Age: 57 Year of death: 1981 DC Occupation: Building service man DC Industry: Paper mill

Lifetime Occupational History

1943–1946 U.S. Navy; seaman on battleship in Pacific
1947–1951 Residential construction
1952–1960 Paper mill; building services, swept floors, changed lights, other semi-skilled jobs moving roll stock
1960–1963 Paper mill wax line operator; feed & trim stock
1963–1972 Paper mill film extrusion machine operator; load & change rolls
1972–1974 Paper mill pumper; wax refinery
1974–1976 Paper mill graphic arts facility; load press cylinders
1976–1981 Paper mill building services; service of areas above 6 feet off ground, dusted & vacuumed pipes and lights, walls; outdoor grounds (care of grass & snow)

Case 6

Type: Pleura Sex: Male Age: 43 Year of death: 1987 DC Occupation: Maintenance supervisor DC Industry: Dairy

Lifetime Occupational History

1960–1963 Family farm work
1963–1964 Plastics factory laborer; packaging machine
1964–1967 U.S. Navy; engine boilerman in Pacific & Mediterranean
1968–1968 Multiple factory labor jobs
1969–1969 Welder apprentice; farm equipment manufacturing
1969–1979 Welder for dairy; maintenance, renovation & building projects
1979–1987 Maintenance supervisor for dairy
Comments: Participated in the demolition of three dairy plants which contained asbestos installations

Case 7

Type: Pleura Sex: Male Age: 66 Year of death: 1989 DC Occupation: Maintenance supervisor DC Industry: Leather products

Lifetime Occupational History

1944–1946 U.S. Army Infantry in Philippines
1946–1947 Drove school bus
1947–1948 Farming
1949–1954 Shipyard; in mold loft, pattern maker; construction of ore hauling ships
1954–1956 Janitor in public high school; cleaning & minor maintenance
1956–1985 Maintenance; leather products manufacturing plant; pipe & boiler maintenance, building repairs done, supervisor in later years

All 29 of the maintenance workers reviewed were male and all were diagnosed as having pleural mesothelioma. The mean duration of maintenance work was 20 years, with a range of 5 to 36 years.

Two school districts had each employed two of the ten school school maintenance workers.

Many occupational opportunities for potential asbestos exposure, in addition to maintenance work, were identified. However, for 10 (34%) of the 29 maintenance workers the only identifiable source of potential asbestos exposure was derived from their maintenance work. For five (17%), histories indicated some prior employment in occupations and industries with probable asbestos exposures: four had worked in shipyards and one person had shipyard and asbestos product manufacturing facility employment.

Opportunities for indirect occupational exposure were identified for ten who had spent time in the construction industry. Additionally, four had served aboard ship in the Navy, two of whom were likely to have spent time in the engine rooms of ships. One maintenance worker had household asbestos exposure and one had neighborhood exposure.

If it is assumed that asbestos exposure began on the first year of employment in maintenance work, it is possible to evaluate whether latency periods were sufficient to make it plausible that maintenance work asbestos exposures contributed to the occurrence of the mesotheliomas seen. The mean latency from onset of maintenance work was 26 years. For three individuals the latency was less than 15 years (9, 9, and 11 years). Such short latencies would be unusual, unless we consider the possibility of earlier asbestos exposure during construction work for two and that the third had a history of significant household asbestos exposure as a child. If these possible asbestos exposures are included in the assessment of latency, periods from first identified exposure all exceed 20 years.

Mesothelioma among School Teachers

TABLE 9 summarizes the occupational information obtained from investigation of the 12 school teachers. There were 6 male and 6 female teachers. All 6 males were diagnosed with pleural mesothelioma, while three of the six cases in females were of peritoneal origin. For 9 (75%) of the school teachers the only identifiable potential source of asbestos exposure was derived from in-place ACBM in their schools. One male teacher had spent one season in the merchant marine aboard an iron ore–hauling ship and had worked outdoors at a coal-burning electric generation plant while attending college. Two other teachers had worked in residential construction. Unexpectedly, two of the teachers were found to be sisters. In two instances, two teachers had taught for some time in the same school.

AHERA information was available concerning the schools in which 8 of the teachers worked. Among these, 6 taught in schools containing friable surfacing material as well as thermal insulation. Two others taught in schools that contained only friable thermal insulation. The status of any ACBM in the schools of the other 4 teachers was unknown.

DISCUSSION

Mesothelioma Surveillance

Consistent with worldwide observations over the past 30 years,[18–20] Wisconsin has experienced a markedly increasing prevalence of mesothelioma deaths among

TABLE 9. Mesothelioma Deaths among School Teachers Identified by Usual Occupation and Industry on Death Certificate (DC)

Case 1

Type: Peritoneum Sex: Female Age: 78 Year of death: 1968 DC Occupation: Teacher DC Industry: Teacher

Lifetime Occupational History

1908–1910 Grade school teacher in North Dakota
1911–1920 Teachers College; taught elementary school teacher-training courses
1920–1959 Teacher at 2-year teacher preparatory college

Comments: Father was a farmer; unmarried; no neighborhood exposures; sister of Case 2. Laparotomy identified normal ovaries and no primary tumor site; surgical tissue diagnosed as mesothelioma. Status of any ACBM in schools unknown.

Case 2

Type: Peritoneum Sex: Female Age: 68 Year of death: 1970 DC Occupation: Teacher DC Industry: Public Schools

Lifetime Occupational History

1923–1962 High school home economics teacher

Comments: Father was a farmer; husband was a menswear salesman; no neighborhood exposures; sister of Case 1; diagnosis confirmed at autopsy. 1989 AHERA inspection found significantly damaged friable thermal insulation and friable surfacing material in the school.

Case 3

Type: Pleura Sex: Female Age: 63 Year of death: 1980 DC Occupation: Waitress trainer DC Industry: Vocational school

Lifetime Occupational History

1932–1976 Hotel and restaurant waitress
1962–1976 Part-time teacher in vocational school; traveled 2–3 times a week to state vocational schools throughout Northeastern Wisconsin to conduct waitress/restaurant training courses
1977–1980 City parking ramp cashier

Comments: Father was a farmer and part-time carpenter; unmarried; no factories near home; status of any ACBM in schools unknown.

Case 4

Type: Pleura Sex: Male Age: 65 Year of death: 1980 DC Occupation: Music professor DC Industry: University

Lifetime Occupational History

1935–1942 Drove taxi; played piano in bands while in college
1942–1946 Traveled with armed services bands entertaining throughout Europe
1947–1953 Completed college; obtained Masters in Music; played piano in bands
1953–1978 Professor of music at a university

Comments: Father a history teacher; wife a teacher; no factories near home. Music practice rooms reported to have acoustical asbestos surfacing material; back of stage used surfacing ACBM; asbestos stage curtain

(TABLE 9. *Continued*)

Case 5

Type: Pleura Sex: Female Age: 66 Year of death: 1980 DC Occupation: Teacher DC Industry: School district

Lifetime Occupational History

1937–1942	Elementary school teacher
1943–1946	Office; secretarial work
1946–1955	Taught all grades in rural school
1955–1977	Elementary school teacher in different district
Comments:	Father was a farmer; husband ran a mink farm. Mastectomy in 1959; received radiation therapy. Mesothelioma on opposite side from mastectomy. 1989 AHERA inspections found friable thermal insulation and friable surfacing material in the schools she taught in in 1955–1977. Earlier school's ACBM status unknown.

Case 6

Type: Pleura Sex: Male Age: 81 Year of death: 1981 DC Occupation: School teacher DC Industry: Education

Lifetime Occupational History

1920–1974	Teacher at parochial schools in Texas, Oklahoma, South Dakota, Illinois, Minnesota, Wisconsin (history, math, Bible classes)
1920–1974	Carpenter during summers working on renovation, remodeling and new residential jobs
Comments:	Father was a farmer; wife a teacher; no military service; no neighborhood exposures. Status of any ACBM in schools unknown.

Case 7

Type: Pleura Sex: Male Age: 48 Year of death: 1981 DC Occupation: Professor of architecture DC Industry: University

Lifetime Occupational History

1950–1952	Summer construction work; driving wood pilings at dam sites
1953–1961	University degree program; part-time work at a cement plant and electrical supplies wholesaler
1961–1981	University professor of architecture; research on urban renewal
Comments:	Father was an engineer; commercial building, federal government projects in the Tennessee valley. While at cement company, subject helped with the cleaning of an old closed cement plant. Wife is an architect; home not near factories. University office contained asbestos covered pipes—since removed as part of an asbestos abatement project.

Case 8

Type: Pleura Sex: Male Age: 50 Year of death: 1984 DC Occupation: Teacher DC Industry: Public schools

Lifetime Occupational History

1953–1954	Seaman on iron ore boats; coal passer
1954–1955	Paper mill machine operator (Idaho)
1956–1958	U.S. Army medic; EKG technician at Hawaii hospital
1959–1966	College; part-time/full-time work for power plant; worked outside with coal piles and coal transport system. Cut up scrap metal with welding torch for short time
1966–1968	Teacher corps in Texas; training in special education
1968–1984	Teacher; special education classes; football coach
Comments:	Father ran shoe repair store. Wife reports the coach's room/office was in the basement of the school, had many pipes running through it from the boiler room nearby. Taught in same school as Case 10. 1989 AHERA inspection identified significantly damaged friable thermal insulation in all schools subject taught in.

Case 9

Type: Pleura Sex: Female Age: 80 Year of death: 1985 DC Occupation: Teacher DC Industry: Secondary school

Lifetime Occupational History

1925–1946 High school teacher (Latin)
1947–1956 Homemaker
1957–1960 Part-time Latin & history high school teacher
1960–1967 Full-time Latin & history high school teacher

Comments: Father ran a retail store; family lived in apartment on 2nd floor above store, basement unused but did have boiler and pipes which may have been covered with asbestos; husband was a high school teacher; no factories near residence. Taught in same school as Case 10. 1989 AHERA inspection found significantly damaged thermal insulation and surfacing material in school

Case 10

Type: Pleura Sex: Female Age: 49 Year of death: 1986 DC Occupation: Home economics teacher DC Industry: Education

Lifetime Occupational History

1958–1959 North Dakota high school teacher (home economics)
1960–1961 Interior decorator
1962–1963 Wisconsin high school teacher (home economics)
1964–1966 Part-time Wisconsin high school teacher (home economics)
1966–1984 Full-time Wisconsin high school teacher (home economics)

Comments: Father was a railroad depot agent; husband a teacher; no environmental exposure. 1989 AHERA inspection identified friable thermal insulation in all schools subject taught in and significantly damaged surfacing material in one. Taught in the same school as Case 9 (1962–63) and Case 8 (1964–66).

Case 11

Type: Pleura Sex: Male Age: 91 Year of death: 1987 DC Occupation: Professor emeritus DC Industry: University

Lifetime Occupational History

1920–1925 Waiter in restaurant while in school
1925–1965 Electrical engineer; professor of mathematics at University

Comments: No military service; father a farmer; no neighborhood industry. Status of ACBM in university unknown.

Case 12

Type: Pleura Sex: Male Age: 43 Year of death: 1987 DC Occupation: Teacher DC Industry: Elementary & high school

Lifetime Occupational History

1964–1969 6th grade teacher
1970–1972 U.S. Army meteorologist in Vietnam and Germany
1972–1972 Returned to school for reading specialist certificate
1973–1986 Special education teacher traveling to all district schools

Comments: Father a farmer; no neighborhood factories. 1989 AHERA inspections found friable thermal insulation in all schools subject taught in. Friable surfacing material in one school he began teaching at in 1973.

both sexes. The five years from 1984 to 1988 accounted for close to the same number of mesothelioma deaths (182) as occurred in the preceding 25 years (177). As seen in TABLE 3 nearly three-quarters of all cases occurred among males. The ratio of cases in males to those in females has doubled from 1.3 (1959–1973) to 2.8 (1974–1988) as the number of male cases increased earlier and more rapidly. Over the past decade (1979–1988), the ratio of male to female cases (3.0) has remained constant. The magnitude of the increase in cases among Wisconsin females, especially over the decade 1979–1988 is greater than that reported by others.[21] These differences may partly be due to our inclusion of data from more recent years (1986–1988). This observation in Wisconsin is undergoing further investigation.

When TABLE 3 is compared with TABLE 4, it can be seen that over the period of CRS full implementation (1979–1988) the death-certificate-only data underestimated mesothelioma deaths by 24% among females and 17% among males. Histopathologic study of surgical biopsy or autopsy tissue was used to establish the final diagnosis in 99% of the CRS mesothelioma deaths.

Mesothelioma Case Investigations

Epidemiologic analyses utilizing death-certificate characterization of usual occupation and industry have been useful in occupational and environmental health research.[22] We found usual occupation and industry as listed on the Wisconsin death certificate a useful starting point in identifying individuals for further investigation who were likely to have performed maintenance work or taught school for significant periods.

While the listing of maintenance work on the death certificate was confirmed by the in-depth interviews, it must be kept in mind that in the mesothelioma surveillance system there are certainly more individuals who had performed maintenance tasks than are discussed here. It is likely that instances occur where maintenance was not considered the usual occupation of the individual by the physician completing the certificate of death. The full assessment of the contribution of maintenance work to the occurrence of mesothelioma in Wisconsin will not be known until we have gathered full lifetime occupational histories on all the mesothelioma surveillance system reports.

We conclude that in the absence of access to complete lifetime occupational histories, usual occupation and industry as listed on the death certificate are useful in identifying individuals who are likely to have spent significant proportions of their employment in the identified occupation and industry, but will miss others with short-term employment which may add to the cumulative risk of disease.

Maintenance Employment

Building or industrial plant facility maintenance work often requires skills in multiple trades (such as plumbing, carpentry, painting, electrical work, and pipe and boiler repair and maintenance). We found that in 23 of the 29 cases, the work performed was of such a general nature.

Given the diversity of skills needed, it is not surprising that many of the maintenance workers had also worked in the construction industry and that five had worked in shipyards. General construction work has been identified as a possible source of intermittent asbestos and could have added to the cumulative lifetime asbestos exposure of our cases.[23–25]

All of the maintenance workers were likely to have performed tasks around thermal asbestos materials. It was commonly reported that periodic maintenance of boilers and pipes was performed either by the individuals or in their vicinity. Mention of acoustical or surfacing material was less common.

The patients reported in cases 7 and 10 in TABLE 5 were employed at the same university facility, which was known to have friable thermal and acoustical ACBM. A similar situation was described in the school district in which the patients in cases 2 and 4 in TABLE 5 had both worked. It is unlikely that these clusters are due to chance alone.

An unexpected observation was that four (17%) of the patients had served 4-year enlistments in the U.S. Navy. Two (one a boilerman and the other an engineer) spent time in the engine room and were probably exposed to asbestos aboard ship. The other two served aboard ship and may also have been indirectly exposed. A recent report of the mortality of United Kingdom military serviceman (those with more than 5 years of service) found an excess of mesothelioma among the Royal Navy servicemen (7 cases of mesothelioma).[26] Asbestos diseases have also been reported among long-term merchant seamen.[27,28] It is important to consider military service when investigating possible sources of asbestos exposure when mesothelioma develops.

School Teachers

This is the first report that systematically investigates possible sources of asbestos exposure among school teachers with mesothelioma. In 9 of the 12 cases, the only potential source of asbestos exposure identified was in-place ACBM.

It was unexpected to find two teachers who were sisters. The occurrence of more than one mesothelioma in a family is a very rare event. The world medical literature contains less than 10 reports of family clustering of mesothelioma.[29,30] In each instance, exposure to asbestos (occupational and/or environmental) has been identified. The two sisters in our series fit the pattern described in these reports—sharing a similar tumor site and histology. It was postulated by both Martensson[29] and Lynch[30] that a hereditary predisposing factor may exist which is especially sensitive to induction by asbestos. If such is the case, our sisters probably received their induction dose of asbestos from ACBM within their schools. AHERA reports indicate that friable thermal and surfacing material were present in the school of one of the sisters. The school in which the other sister taught no longer exists and no information is currently available whether ACBM was in the school.

Considering the rarity of mesothelioma and the more than 3,000 schools in the state, it was unexpected to find two school clusters of two cases among the 12 teachers investigated. In both instances significantly damaged thermal and surfacing ACBM was present in 1988–89. The status of ACBM at the time the teachers were in the schools is unknown.

CONCLUSION

Our investigation of mesothelioma cases in Wisconsin with school, residential, commercial and factory maintenance and repair employment identified asbestos exposure in every instance. For most, the opportunities for asbestos exposure came from multiple jobs, including maintenance work. However, in 10 (34%), the only identifiable likely source of asbestos exposure was to in-place ACBM, probably intermittently disturbed while maintenance activities were performed. We

conclude that building maintenance workers are at increased risk to develop mesothelioma from exposure to in-place ACBM.

We report 12 mesothelioma deaths among school teachers. For 9, the only likely source of asbestos exposure was to in-place ACBM. Two teachers, with similar peritoneal mesotheliomas, were sisters. All previous sibling clustering of mesothelioma reports have identified asbestos exposure to the siblings. This suggests that our two teachers must have been exposed to asbestos, most likely during each of their 40+ years of teaching.

Especially for the maintenance staff in the public school buildings, the high prevalence (36%) of significantly damaged friable thermal insulation described in our AHERA plan reviews represents a serious concern and underscores the need for strict operations and maintenance programs including repair and/or removal of such material. Rapid implementation of rigorous operations and maintenance programs is needed to prevent future asbestos exposure to the large existing maintenance work force and the even larger population of building residents whose health may be jeopardized by episodic environmental contamination by inadequate maintenance and operational precautions.

SUMMARY

The occurrence of mesothelioma is a sentinel event in occupational and environmental disease.[1] A mesothelioma surveillance system was established utilizing existing computerized Wisconsin vital statistics data maintained since 1959 and a Cancer Reporting System (CRS) established in 1978.

Review of the death certificate listing of usual occupation and industry from 487 mesothelioma deaths in Wisconsin from 1959 to 1989 led to the investigation of 41 persons with likely exposure to inplace asbestos-containing building materials (ACBM): 12 school teachers, 10 school maintenance employees, 7 public building maintenance workers, 5 private building maintenance workers, and 7 commercial and factory workers performing maintenance activities.

For 10 (34%) of the 29 maintenance workers the only source of asbestos exposure identified was their maintenance work. For five (17%) histories indicated some prior employment in occupations and industries with probable asbestos exposures. Opportunities for indirect occupational exposure were identified for ten who had been employed in the residential construction industry. One maintenance worker was exposed to asbestos in the household and another had neighborhood exposure.

For 9 (75%) of the school teachers, the only identifiable potential source of asbestos exposure was derived from in-place ACBM in schools. One teacher had spent a season in the merchant marine aboard an iron ore–hauling ship and 2 had worked in the residential construction industry. Two of the teachers were sisters, and in two instances, two teachers had taught in the same school facility.

We conclude that individuals occupationally exposed to in-place ACBM are at risk for the subsequent development of mesothelioma.

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