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Research Article

# Asbestosis Mortality in the United States, 1970-2014

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## Abstract

**Background:** Although asbestos use has been restricted in recent decades, asbestosis deaths continue to occur in the United States. Temporal trends in asbestosis deaths need to be closely examined and evaluated to provide crucial surveillance information to the local, state and Federal government levels for making public health recommendations. Asbestos is still used in specific products and is not banned entirely yet as a toxic material.

**Objective:** To describe the temporal trends in asbestosis deaths and death rates in the United States during 1970-2014.

**Materials and Methods:** Using 1970 - 2014 National Center for Health Statistics mortality data, asbestosis deaths aged 15 years and older were identified. The asbestosis death rates by year were age-adjusted to the 2000 United States standard population and 95% confidence intervals were calculated by Poisson analysis. The proportional mortality ratios were calculated by industry and occupation for 1985 - 2007.

**Results:** During 1970-2014, a total of 38,437 asbestosis deaths were identified. Of these deaths, 36,960 (96.2%) were males and 36,159 (96.1%) were white. The overall age-adjusted asbestosis death rate was 4.5 per million population and the rate for males (11.6) was 39-fold higher than that for females (0.3). The age-adjusted asbestosis death rate increased from 0.6 per million population in 1970 to 6.9 in 2000 and then it declined to 4.4 in 2014. Industry with the highest proportionate mortality ratio was ship and boat building (17.2) and occupation with the highest proportionate mortality ratio was insulation workers (99.4).

**Conclusion:** Asbestosis deaths increased from 1970 to 2000, but it declined between 2000 and 2014. However, the number of asbestosis deaths are still occurring at a yearly average of 1,259 deaths since 2000. These surveillance data suggest the need for more comprehensive asbestos exposure prevention and continuous monitoring of temporal trends in asbestosis deaths.

***Keywords:*** *Asbestos; Asbestosis; Mortality; Industry; Occupation; Proportionate Mortality Ratio*

## Introduction

Asbestosis is defined as a diffuse interstitial fibrosis of the lungs. In 1906, the first case of asbestosis was reported by Dr. H. Montague Murray in the testimony before the Departmental Committee on Industrial Disease in England [1].

Asbestosis is caused by inhalation and retention of asbestos fibers [2]. In addition to asbestosis, other asbestos-related disease includes malignant mesothelioma, lung cancer, nonmalignant pleural abnormalities including plagues, and other conditions.

Asbestos appears in nature in four major types including chrysotile, crocidoline, amosite, and anthophyline and all four forms are characterized by being fibrosis and can cause asbestosis [3]. Among four asbestos forms, only chrysotile, crocidoline, and amosite have commercial importance in most industrial countries [4]. Asbestos has been used in a variety of applications such as asbestos cement products (tiles, roofing, drain pipes), insulation and fireproofing, textiles for heat resistance, asbestos paper, and friction materials (brake linings and gaskets). Probably the most hazardous current exposures are during repair and demolition of old buildings and ships and related on-site maintenance jobs. Currently in the United States (U.S.), the construction industry is the major source of asbestos exposure to workers [3].

This report is to describe the updated trend in asbestosis mortality based on asbestosis deaths data available up to 2014 in the U.S. There are several previous reports on asbestosis mortality surveillance between 1970 and 2004 [2] and asbestosis-related years of potential life lost from 1999 to 2010 in the U.S. [5].

## Materials and Methods

The asbestosis mortality database from the National Center for Health Statistics, the U.S. Centers for Disease Control and Prevention was used for the multiple cause of death data obtained annually from all individual death certificates in the U.S. from 1970 to 2014. The respiratory mortality data have been compiled in the National Occupational Respiratory Mortality System [6] by the National Institute for Occupational Safety and Health.

For analysis of the mortality data, classification codes of asbestosis deaths using International Classification of Disease (ICD) by time period were ICD-8 code 515.2 for 1970-1978, ICD-9 code 501 for 1979-1998, and ICD-10 code J61 for 1999-2014 [7-9]. All U.S. residents at ages 15 years and older were included in the analysis. The asbestosis death rates per million population were adjusted to the 2000 U.S. standard population and 95% confidence intervals (CIs) were calculated by Poisson analysis [10].

The proportionate mortality ratios (PMRs) were calculated by industry and occupation. The PMR for asbestosis is defined as the observed number of asbestosis deaths in a specific industry or occupation divided by the expected number of asbestosis deaths. The specific industry and occupation codes used 3-digits codes based on the Bureau of Census Industry Code (CIC) and Occupation Code (COD) [11]. For this report, the PMRs were calculated only for industries and occupations with five or more asbestosis deaths in the 1985 - 2007 period which information on industry and occupation from death certificates were available.

## Results

For 1970-2014, a total of 38,437 asbestosis deaths were identified. Of these deaths, 36,960 (96.2%) were males and 36,159 (94.1%) were whites (Table 1). The overall age-adjusted death rate was 4.5 per million population per year and males (11.6) had a 39-fold higher rate than females (0.3).

| | | Death | | Age-adjusted death rate (95% Cl) |
|---|---|---|---|---|
| **Sex** | | **No.** | **%** | |
| | Male | 36,960 | 96.2 | 11.6 (11.5 - 11.7) |
| | Female | 1,477 | 3.8 | 0.3 (0.3 - 0.3) |
| **Race** | White | 36,159 | 94.1 | 4.7 (4.7 - 4.8) |
| | Black | 2,049 | 5.3 | 2.9 (2.8 - 3.0) |
| | Other | 229 | 0.6 | 1.4 (1.2 - 1.6) |
| | Total | 38,437 | 100.0 | 4.5 (4.4 - 4.6) |

***Table 1:*** *Number and percent distribution of asbestosis deaths and age - adjusted death rate (per million population) by sex and race, U.S. residents aged ≥15 years, 1970 - 2014.*

By age group, the age-specific death rate increased from 0.0 per million population in the 15-34 years to 23.2 in the oldest age group of 65 years and older (Table 2).

| Age Group (Years) | Death | | Death Rates (95% CI) |
|---|---|---|---|
| | No. | % | |
| 15 to 24 | 1 | 0.0 | 0.0 (0.0 - 0.0) |
| 35 to 34 | 4 | 0.0 | 0.0 (0.0 - 0.0) |
| 35 to 44 | 66 | 0.2 | 0.0 (0.0 - 0.1) |
| 45 to 54 | 695 | 1.8 | 0.6 (0.5 - 0.6) |
| 55 to 64 | 3,922 | 10.2 | 4.2 (4.0 - 4.3) |
| 65+ | 33,759 | 87.8 | 23.2 (22.9 - 23.4) |

***Table 2:*** *Number and percent distribution of asbestosis deaths and death rate (per million population) by age group, U.S. residents aged ≥15 years, 1970 - 2014.*

For 45 years since 1970, the asbestosis deaths were increased from 89 in 1970 to 1,493 in 2000, but the asbestos deaths declined from 1,493 in 2000 to 1,221 in 2014. The age-adjusted death rates also increased from 0.6 per million population in 1970 to 6.9 in 2000. Since 2000, the age-adjusted death rate declined from 6.9 per million population to 4.4 in 2014 (Table 3).

| Year | No. of Deaths | Age-adjusted death rate (95% CI) | Year | No. of Deaths | Age-adjusted death rate (95% CI) |
|---|---|---|---|---|---|
| 1970 | 89 | 0.6 (0.5 - 0.8) | 1993 | 999 | 5.1 (4.7 - 5.4) |
| 1971 | 83 | 0.6 (0.5 - 0.7) | 1994 | 1,040 | 5.3 (5.0 - 5.6) |
| 1972 | 140 | 0.9 (0.8 - 1.1) | 1995 | 1,169 | 5.8 (5.4 - 6.1) |
| 1973 | 119 | 0.8 (0.7 - 1.0) | 1996 | 1,176 | 5.7 (5.4 - 6.0) |
| 1974 | 115 | 0.8 (0.6 - 0.9) | 1997 | 1,171 | 5.6 (53 - 5.9) |
| 1975 | 127 | 0.8 (0.7 - 1.0) | 1998 | 1,221 | 5.8 (5.4 - 6.1) |
| 1976 | 147 | 0.9 (0.8 - 1.1) | 1999 | 1,265 | 5.9 (5.6 - 6.2) |
| 1977 | 167 | 1.1 (0.9 - 1.2) | 2000 | 1,493 | 6.9 (6.5 - 7.2) |
| 1978 | 243 | 1.5 (1.3 - 1.7) | 2001 | 1,454 | 6.6 (6.3 - 6.9) |
| 1979 | 309 | 1.9 (1.7 - 2.1) | 2002 | 1,473 | 6.6 (6.3 - 6.9) |
| 1980 | 339 | 2.0 (1.8 - 2.3) | 2003 | 1,471 | 6.5 (6.2 - 6.8) |
| 1981 | 318 | 1.9 (1.7 - 2.1) | 2004 | 1,470 | 6,4 (6.1 - 6.7) |
| 1982 | 428 | 2.5 (2.2 - 2.7) | 2005 | 1,423 | 6.1 (5.8 - 6.4) |
| 1983 | 476 | 2.8 (2.5 - 3.0) | 2006 | 1.344 | 5.7 (5.4 - 6.0) |
| 1984 | 445 | 2.5 (2.3 - 2.8) | 2007 | 1,401 | 5.8 (5.5 - 6.2) |
| 1985 | 534 | 3.0 (2.7 - 3.2) | 2008 | 1,346 | 5.5 (5.2 - 5.8) |
| 1986 | 702 | 3.9 (3.6 - 4.2) | 2009 | 1,262 | 5.1 (4.8 - 5.4) |
| 1987 | 710 | 3.9 (3.6 - 4.2) | 2010 | 1,318 | 5.2 (4.9 - 5.5) |
| 1988 | 769 | 4.2 (3.9 - 4,5) | 2011 | 1,252 | 4.9 (4.6 - 5.1) |
| 1989 | 878 | 4.7 (4.4 - 5.0) | 2012 | 1,219 | 4.6 (4.3 - 4.8) |
| 1990 | 948 | 5.0 (4.7 - 5.4) | 2013 | 1,238 | 4.5 (4.3 - 4.8) |
| 1991 | 946 | 4.9 (4.6 - 5.3) | 2014 | 1,221 | 4.4 (4.1 - 4.6) |
| 1992 | 959 | 4.9 (4.6 - 5.2) | 1970 - 2014 | 38,437 | 4.5 (4.4 - 4.6) |

***Table 3:*** *Number of asbestosis deaths and age - adjusted death rate (per million population) by year, U.S. residents aged ≥ 15 years, 1970 - 2014.*

Significantly elevated PMRs by industry and occupation are shown in Table 4. By industry, ship boat building had the highest PMR of 17.2 (95% CI 15.3 - 19.4) and the second highest PMR was 14.5 (95% CI 11.9 - 17.8) for miscellaneous nonmetallic mineral and product manufacturing. By occupation, insulation workers had the highest PMR of 99.4 (95% CI 85.8 - 115.3) and the second highest PMR was 19.1 (95% CI 15.4 - 23.7) for boilermakers.

| Industry and Occupation (Bureau of Census Classification Code) | No. of Deaths | PMR (95% CI) |
|---|---|---|
| **Industry** | | |
| Ship and boat building (368) | 272 | 17.2 (15.3 - 19.4) |
| Miscellaneous nonmetallic mineral product manufacturing (259) | 98 | 14.5 (11.9 - 17.8) |
| Lumber and other construction materials wholesalers (409) | 25 | 5.8 (3.8 - 8.6) |
| Industrial and miscellaneous chemicals (229) | 185 | 4.9 (4.2 - 5.7) |
| Labor unions (918) | 9 | 4.4 (2.0 - 8.3) |
| US navy (969) | 33 | 4.4 (3.0 - 6.1) |
| Rubber products, except tires, manufacturing (239) | 43 | 3.3 (2.4 - 4.4) |
| Petroleum refining (207) | 53 | 3.2 (2.4 - 4.2) |
| Structural metals and tank and shipping container manufacturing (287) | 54 | 2.9 (2.2 - 3.9) |
| Electric and gas and other combinations (059) | 20 | 2.9 (1,8 - 4.5) |
| Aluminum production and processing (268) | 26 | 2.8 (1.8 - 4.1) |
| Water transportation (609) | 39 | 2.7 (1.9 - 3.7) |
| Construction (077) | 1,097 | 2.4 (2.3 - 2.6) |
| Electric power generation transmission and distribution (057) | 78 | 2.4 (1.9 - 3.0) |
| Resin, synthetic rubber and fiber, and filaments manufacturing (217) | 15 | 2.3 (1.3 - 3.8) |
| **Occupation** | | |
| Insulation workers (640) | 182 | 99.4 (85.8 - 115.3) |
| Boilermakers (621) | 86 | 19.1 (15.4 - 23.7) |
| Riggers (756) | 14 | 17.4 (9.5 - 29.2) |
| Lay - out workers, metal and plastic (816) | 14 | 9.9 (5.4 - 16.5) |
| Pipelayers, plumbers, pipefitters, and steamfitters (644) | 383 | 9.8 (8.9 - 10.9) |
| Marine engineers and naval architects (144) | 10 | 7.6 (3.6 - 14.0) |
| Electrical and electronics repairs, industrial and utility (710) | 5 | 7.6 (2.5 - 17.7) |
| Plasterers and stucco masons (646) | 14 | 6.4 (3.5 - 10.7) |
| Sheet metal workers (652) | 85 | 6.0 (4.8 - 7.5) |
| Heating, air conditioning, and refrigeration mechanics and installers (731) | 24 | 4.4 (2.8 - 6.6) |
| Chemical processing machine setters, operators, and tenders (864) | 36 | 4.3 (3.0 - 5.9) |
| Chemical technicians (192) | 11 | 4.2 (2.1 - 7.5) |
| Electricians (635) | 180 | 3.9 (3.3 - 4.5) |
| Millwrights (736) | 48 | 3.7 (2.8 - 5.0) |
| Sailors and marine oilers (930) | 14 | 3.5 (1.9 - 5.8) |

***Table 4:*** *Asbestosis proportionate mortality ratios (PMDs) and 95% confidence intervals (CIs) for the fifteen industries and fifteen occupations with the highest significantly elevated PMRs, U.S. residents aged ≥15 years, 1985 - 2007.*

## Discussion

This is a descriptive study based on the 38,437 asbestosis deaths in the U.S. from 1970 to 2014. The annual age-adjusted death rates increased 12-fold from 1970 to 2000 but has declined since 2000. Majority asbestosis deaths occurred in white males (94.1%) which is similar to previous report on asbestosis mortality surveillance in the U.S. from 1970 to 2004 [2]. More white men than black men or other race were employed in construction and mining industry. Thus, white men had much higher risk to expose to asbestos and develop more asbestosis than black men and other race. PMRs were the highest in insulation workers among occupations and ship boat building among industries. Because insulation workers and ship boat building workers were exposed heavily to asbestos in their work places.

Since 2000, the declined trend in asbestosis death and age-adjusted death rate might be associated with several factors. First, asbestos use in the U.S. increased from approximately 1,000 metric tons in the early 1900s to a peak of 803,000 metric tons in 1973 [12]. However, the use of asbestos after peak year significantly decreased. Recent estimated asbestos consumption in the U. S. decreased from 1,180 metric tons in 2011 to 340 metric tons in 2017 [13]. Asbestos in the U.S. has been imported mostly from Brazil (77%), Canada (22%), and other countries (1%) [13]. Second, lowered exposure level to asbestos by the regulatory agency and a long latency period might also contribute to decrease asbestosis deaths. In 1971, the U.S. Occupational Safety Health Administration established a permissible exposure limit (PEL) for asbestos of 12 fibers per cubic centimeters (f/cc) and reduced to 5 f/cc in 1972, 0.2 f/cc in 1986, and 0.1 f/cc in 1994 [14]. A long latency period of about 15 to 45 years from initial exposure to development of asbestosis may influence risk of asbestosis among those who were exposed to lower asbestos levels after 1986.

The U.S. Environmental Protection Agency (EPA) first promulgated an asbestos standard in 1973 to ban the use of spray-applied material for insulating or fireproofing buildings [15]. In 1975, EPA banned installation of asbestos pipe insulation and asbestos block insulation on facility components, such as boilers and hot water tank. In 1989, the EPA issued a final regulation banning most uses of asbestos to end the importation, processing, manufacture and distribution of products containing asbestos. However, asbestos product manufacturing companies filed a lawsuit against the EPA in a landmark suit, Corrosion Proof Fittings vs EPA. On October 18, 1991, the Fifth Circuit of Appeals overturned the ban, claiming the EPA failed to demonstrate that a ban was the least burdensome alternative to regulating asbestos. The EPA was responsible to ban six categories of asbestos-containing products including flooring felt, rollboard, commercial paper, specialty paper, and new uses of asbestos. These six products and only spray-applied asbestos were banned [16].

Asbestosis is caused by asbestos. Environmental factors are associated with asbestosis through many environmental pathways of exposure to asbestos. Secondhand asbestos exposure can occur without even realizing it. Workers in mines, construction jobs, or shipyards where asbestos is used frequently can often bring asbestos home and then their families could be exposed to asbestos fibers which have been transported by workers' clothing, hair, and skin [17]. Individuals who live in old homes are at increased risk of asbestos exposure. Many home built before 1980 contained asbestos in old floor titles, ceiling titles, roof shingles and siding in the U.S. Urban air pollution is another common source of asbestos exposure. Asbestos is also used to make brake pads. Asbestos is released on braking which increases the concentration of asbestos in the air. For individuals living in areas of naturally occurring asbestos, there are many potential pathways for airborne exposure to asbestos. Children may be at risk when playing outside in dirt. Dust may also be released into the air from unpaved roads and driveway covered with crushed serpentine [18]. A recent study reported that smoking is associated with pulmonary asbestosis [19]. Smoking could be a compounding factor associated with asbestosis. Because smoking information is not available on the decedent's death certificates in the U.S., association between smoking and asbestosis could not be evaluated in this study. Although asbestos exposure in environmental setting is generally much lower than in occupational settings, future research is needed on the effects of low asbestos exposure level to cause asbestosis.

In the U.S., asbestos is not entirely banned yet. The U.S. is one of very few major industrialized nations that has not banned asbestos entirely in all of the known asbestos forms. More than 50 nations in the world have banned asbestos [16]. All 25 member countries of the European Union have banned nearly or totally banned use of asbestos since 2005. The United Kingdom banned asbestos in 1999, and Australia did the same in 2003 [16].

In the U.S., for the 45 years since 1970, a total of over 38,000 died from asbestosis. Since 2000, asbestosis deaths have been gradually declining, but still average 1,359 asbestosis deaths yearly occurred. Asbestosis deaths are expected to decline slowly in the future because of lowered asbestos PEL since 1994, downsizing of miners' workforce, the long latency period, and asbestos exposure control efforts by local, state, and Federal government.

The findings in this report are subject to strength and limitation. The strength in this study is use of the national asbestosis mortality data available up to 2014 for 45 years since 1970 in order to evaluate asbestosis mortality trend in the U.S. There are several limitations in the study. First, asbestosis deaths were not validated by medical records, or follow-up with health care providers, thus findings might be subject to misclassification. Second, the industry and occupation information was not available for the entire study period because not all states reported information on industry and occupation in the decedents' death certificates and also, they did not report them each year because of limited budget. Individual work history on asbestosis decedents is not reported on death certificates. Therefore, it is not possible to identify those industries and occupations where the decedents' exposures to asbestos occurred. Third, information on initial asbestos exposure level for decedents is not available in order to evaluate the latency period. Finally, inhalation of asbestos can cause diseases other than asbestosis, such as lung cancer and malignant mesothelioma, which are not considered in this report.

## Conclusion

The continuing occurrence of asbestosis deaths in the U.S. indicates the need for more efficient comprehensive efforts based on hierarchy of control measures for asbestos exposure prevention and intervention (i.e. engineering controls and policy regulations), and continue epidemiological monitoring of temporal trends in asbestosis deaths each year for closer examination of asbestosis hazards and health effects.

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## Conflict of Interest

I have no financial interest or no conflict of interest.

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