ORIGINAL ARTICLE

Trends in Mesothelioma Mortality in the United States Between 1999 and 2020

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ABSTRACT

Introduction: Mesothelioma is a rare but aggressive cancer primarily caused by asbestos exposure. In March 2024, the Environmental Protection Agency banned asbestos in the United States, but its use will take years to phase out. Therefore, asbestos remains a threat, and incidence may remain stable or slowly decrease due to the long latency between exposure and diagnosis. This study investigates mesothelioma mortality trends in the United States from 1999 to 2020, focusing on demographic and geographic variations.

Methods: Data on mesothelioma-related deaths from 1999 to 2020 were extracted from the Centers for Disease Control and Prevention database. Variables including race/ethnicity, sex, geographic density, and mesothelioma subtype were assessed. Age-adjusted mortality rates were calculated per 1 million individuals and standardized to the 2000 United States population. Joinpoint regression identified statistically significant changes in mortality trends over time.

Results: From 1999 to 2020, there were 54,905 mesothelioma-related deaths in the United States (age-adjusted mortality rate = 7.5). Pleural mesothelioma accounted for 8.1% of deaths, peritoneal for 4.6%, pericardial for 0.01%, other sites for 10.9%, and unspecified sites for 76.3%. Most deaths (81.3%) occurred in individuals aged over 65 years. Overall mortality decreased from 8.5 in 1999 to 5.7 in 2020 at −1.9% annually. Non-Hispanic Whites had the highest mortality, and male individuals experienced higher mortality than female individuals. Suburban and rural populations had the highest mortality rates.

Conclusions: The study highlights significant declines in mesothelioma mortality in the United States from 1999 to 2020, with variations across demographic and geographic groups. Continued monitoring and targeted interventions are necessary to address disparities and further reduce mesothelioma mortality.

Keywords: Mesothelioma; Epidemiology; Mortality; Rural; Disparities

Introduction

Mesothelioma is a rare and aggressive form of cancer that is primarily because of exposure to asbestos. Mesothelioma can be divided into three main anatomical subtypes: pleural (65%–70% of all mesotheliomas), peritoneal (30%), and pericardial (approximately 1%–2%).[1] The incidence of mesothelioma has been steadily decreasing, with about 3000 new cases diagnosed annually in the United States.[2,3] Owing to the 20- to 40-year

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latency period between exposure to asbestos and diagnosis of mesothelioma, most new diagnoses occur in older adults aged over 65 years. The prognosis for patients with mesothelioma is grim, with a median overall survival of 18 months in recent clinical trials.[4] In addition, three-year survival is only about 15%.[5] Treatment options have historically included chemotherapy with platinum-based chemotherapy doublet, radiotherapy, and surgical resection.[4] In addition, new immunotherapies and combinations of chemotherapy and immunotherapy have shown promise for patients with mesothelioma, leading to novel treatment options for patients.[4]

In March of 2024, the Environmental Protection Agency (EPA) formally banned the use of asbestos in the United States.[6] Nevertheless, it will take many years for its use to be completely phased out. Therefore, asbestos is still a threat, and cases may continue to rise owing to the long latency period between exposure and diagnosis of mesothelioma. Despite medical advancements, there is a lack of data regarding the impact of sociodemographic variables on the mortality of mesothelioma in the United States, especially with regard to urban and rural populations. Mazurek et al.[7,8] assessed mesothelioma trends in women in the United States, finding an increase in the number of deaths each year. Nevertheless, their study did not evaluate the impact of geographic density on mortality trends. In our study, we utilized a nationwide database linked to death certificates to assess mortality due to mesothelioma in the United States between 1999 and 2020, focusing on the impact of sociodemographic and clinical variables.

Materials and Methods

We queried the Centers for Disease Control and Prevention (CDC) Wide-Ranging Online Data for Epidemiologic Research (WONDER) database for mortality statistics related to deaths due to mesothelioma in the United States between 1999 and 2020. The CDC WONDER is a national database linked with death certificates that provides comprehensive United States mortality statistics and has been previously used in studies investigating cancer mortality trends.[9,10] International Classification of Diseases tenth edition codes C45.0 (mesothelioma of the pleura), C45.1 (mesothelioma of the peritoneum), C45.2 (mesothelioma of the pericardium), C45.7 (mesothelioma of other sites) and C45.9 (mesothelioma, unspecified site) were used to identify deaths due to mesothelioma. The data used for this study are publicly available from the CDC website (https://wonder.cdc.gov). This study did not require institutional review board approval because the CDC WONDER is a publicly available database that contains deidentified data, and as such, no consent was required. The data that support the findings of this study are available at https://wonder.cdc.gov.

We assessed mortality by demographic and clinical variables, which are defined by the CDC WONDER. Race/ethnicity included Hispanic, non-Hispanic White, and non-Hispanic Black or African American. We excluded non-Hispanic Asian and non-Hispanic American Indian/Alaskan Native owing to the small sample size and unreliability of data. Sex included male and female. Geographic density included urban (population ≥ 1 million), suburban (population 50,000–999,999), and rural (population $<$50,000), per the 2013 NCHS classifications.[11] Further, mortality was assessed by the anatomical subtype of mesothelioma as defined by the CDC WONDER. Subtypes of mesothelioma included pleura, peritoneum, and pericardium. Additional data was collected for mesothelioma at other sites and unspecified sites. We were unable to assess mortality by histologic subtype, as this variable is not accounted for in the database. For subgroup analysis, pericardial mesotheliomas were excluded owing to the small sample size. All variables were evaluated in the overall population and in individuals aged over 65 years when the sample size allowed for reliable data. Per the CDC WONDER, counts and corresponding rates and other measures are not revealed when the count falls below a ratio of the representative demographic population.

Mesothelioma age-adjusted mortality rates (hereafter referred to as mortality) per 1 million people were calculated and standardized to the year 2000 U.S. population.[12] Joinpoint regression was performed to assess for statistically significant changes in temporal trends, as performed previously.[9,10] This method separates the data into joinpoints that represent years in which the trend in mortality shifted. Joinpoint regression utilizes a Monte Carlo permutation method to determine whether changes in trendlines are statistically significant, meaning that there was an increase or decrease in the annual percentage change of mortality that was different from zero.[13] Joinpoint regression software (National Cancer Institute, Bethesda, MA) was utilized for statistical analysis.[14] All statistical tests were two-sided with p values less than 0.05.

Results

Between 1999 and 2020, there were 54,905 deaths in the United States due to mesothelioma, representing an overall mortality rate of 7.5 deaths per 1 million individuals (Table 1). Of these, 4455 (8.1%) were caused by pleural mesothelioma, 2509 (4.6%) were caused by peritoneal mesothelioma, 66 (0.01%) were caused by pericardial mesothelioma, 6009 (10.9%) were caused by mesothelioma of other sites, and 41,866 (76.3%) were

Table 1. Characteristics of the Study Population

	Overall Population			Age > 65 y	
	Deaths, n (%)	Mortality, n (%)		Deaths, n (%)	Mortality, n (%)
Characteristic	54,905	7.5	Characteristic	44,620	49.1
Anatomical subtype			Anatomical subtype		
Pleural	4455 (8.1)	0.6	Pleural	3654 (8.2)	4.0
Peritoneum	2509 (4.6)	0.3	Peritoneum	1472 (3.3)	1.6
Pericardium	66 (0.1)	0.0	Pericardium	32 (0.01)	0.0
Other site	6009 (10.9)	0.8	Other site	4987 (11.2)	5.5
Unspecified site	41,866 (76.3)	5.7	Unspecified site	34,475 (77.3)	38.0
Race/ethnicity			Race/ethnicity		
Non-Hispanic White	49,345 (89.9)	8.5	Non-Hispanic White	40,801 (91.4)	55.5
Non-Hispanic Black	2249 (4.1)	3.3	Non-Hispanic Black	1577 (3.5)	20.5
Hispanic	2455 (4.5)	4.3	Hispanic	1629 (3.6)	26.4
Non-Hispanic AI/AN	169 (0.3)	0.4	Non-Hispanic AI/AN	121 (0.3)	2.8
Non-Hispanic API	583 (1.1)	0.2	Non-Hispanic API	413 (1.0)	1.2
Unknown	104 (0.2)	NA	Unknown	79 (0.1)	NA
Geographic density			Geographic density		
Urban	12,507 (22.8)	6.2	Urban	9974 (22.4)	40.7
Suburban	33,066 (60.2)	8.2	Suburban	27,121 (60.8)	54.3
Rural	9332 (17.0)	7.2	Rural	7525 (16.9)	45.7
Sex			Sex		
Female	11,517 (21.0)	2.8	Female	8666 (19.4)	16.3
Male	43,388 (79.0)	14.0	Male	35,954 (80.6)	95.8

Note: Mortality was age-adjusted and assessed per 1 million individuals.
NA, not applicable; NH AI/AN, non-Hispanic American Indian/Alaskan Native; NH API, non-Hispanic Asian or Pacific Islander.

caused by mesothelioma of unspecified site. Most deaths (n = 44,620, 81.3%) occurred in individuals aged over 65 years. The overall mortality due to mesothelioma decreased from 8.5 in 1999 to 5.7 in 2020 at a rate of −1.9% annually (Fig. 1 and Table 2).

We assessed mesothelioma mortality in individuals aged over 65 years. Unspecified mesotheliomas had the highest average mortality between 1999 and 2020 at 38.0. The mortality initially increased from 1999 to 2011 at a rate of 1.4% annually, before decreasing between 2011 and 2020 at a −5.0% annually (Table 2). Pleural mesotheliomas had an average mortality rate of 4.0 between 1999 and 2020. The mortality rate decreased from 5.3 in 1999 to 2.8 in 2010 at a rate of −5.7% annually; the mortality then began to increase in 2010 to reach 5.7 in 2020 at a rate of 7.7% annually. For mesotheliomas of the peritoneum, the average mortality between 1999 and 2020 was 1.6. The mortality rate increased from 1.5 to 2.1 at a rate of 2.0% annually. Lastly, for mesotheliomas of other sites, the average mortality between 1999 and 2020 was 5.5, decreasing at a rate of −3.2% annually.

We evaluated overall mesothelioma mortality by geographic density in populations aged over 65 years (Fig. 2). Suburban populations had the highest mortality due to all mesotheliomas at 54.3, followed by rural populations at 45.7 and urban populations at 40.7. Urban populations experienced the steepest decrease in mortality between 1999 and 2020 (−2.0% annually), followed by suburban populations (−1.5% annually). Rural populations did not experience a statistically significant temporal trend. We also assessed mortality due to pleural mesothelioma by geographic density in individuals aged over 65 years. Suburban and rural populations experienced a mortality rate of 4.2, compared with 3.6 for urban populations. Urban populations initially experienced a decrease in mortality between 1999 and 2011 at a rate of −6.3% annually. Nevertheless, after 2011, the trend reversed, with an increase in the mortality rate at 8.7% annually until 2020. Suburban and rural populations experienced a similar trend.

Then, we assessed overall mesothelioma mortality by race/ethnicity in all age groups. Between 1999 and 2020, non-Hispanic White individuals experienced the highest overall mortality at 8.5, followed by Hispanic individuals at 4.3, and then non-Hispanic Black individuals at 3.3. non-Hispanic White individuals experienced the steepest decrease in mortality a rate of −1.7% annually, followed by non-Hispanic Black individuals at a rate of −1.6%. No statistically significant temporal trend was observed for Hispanic populations. We then assessed overall mesothelioma mortality by race/ethnicity in individuals 65 and older (Fig. 3). Similarly, with all age groups, between 1999 and 2020, non-Hispanic White individuals experienced the highest mortality at 55.5, followed by Hispanic individuals at

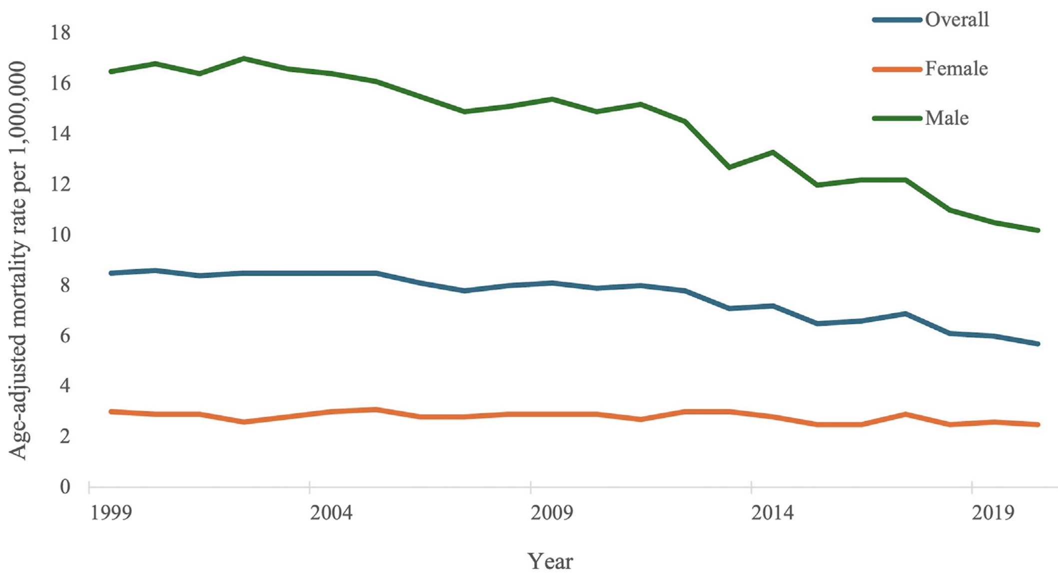

Figure 1. Trends in age-adjusted, overall mesothelioma-related mortality rates stratified by sex in the United States, all ages, 1999 to 2020. Overall: 1999 to 2011 APC: −0.8 (95% CI: −1.2 to −0.1), 2011 to 2020 APC: −3.4[a] (95% CI: −4.5 to −2.7); Female: 1999 to 2020 APC: −0.6[a] (95% CI: −1.1 to 0.0); Male: 1999 to 2011 APC: −1.1[a] (95% CI: −1.6 to −0.5), 2011 to 2020 APC: −4.1[a] (95% CI: −5.0 to −3.4). [a]Indicates that the APC is significantly different from 0 at an α of 0.05. APC, annual percentage change; CI, confidence interval.

26.4, then non-Hispanic Black individuals at 20.5. When assessing temporal trends, only non-Hispanic White populations saw a significant temporal trend, with a decrease of −1.1% annually between 1999 and 2020. There were no statistically significant mortality trends seen in the non-Hispanic Black and Hispanic populations.

Next, we evaluated the overall mesothelioma mortality by sex. Between 1999 and 2020, male individuals experienced a notably higher average mortality rate of 14.0, whereas female individuals experienced a 2.8 average mortality rate. In men, the mortality rate slowly decreased at a rate of −1.1% annually between 1999 and 2011; then, after 2011, it began to decrease at a steeper rate of −4.1% annually. No statistically significant temporal trends were identified in women.

Average mortality by state was evaluated between 1999 and 2020 in adults aged over 65 years (Fig. 4). States in the ninetieth percentile of mortality included Alaska (80.1), Washington (76.2), and Delaware (75.3). States in the tenth percentile of mortality included Arkansas (28.5), Hawaii (27.9), and Georgia (27.8).

Discussion

This nationwide study of mesothelioma mortality linked to death certificates reveals a number of important findings. First, the overall mortality due to mesothelioma in the United States has decreased between 1999 and 2020. Second, mortality due to pleural mesotheliomas in individuals aged over 65 years has increased since 2010 at a rate of 7.7% annually. Third, suburban populations experienced the greatest mortality due to mesothelioma at 54.0 during the study period. Fourth, non-Hispanic White populations experienced the largest mortality, twice as high as the next highest subgroup. Lastly, male individuals experienced a mortality rate almost four times higher than that of female individuals.

We assessed the overall mortality due to all anatomical subtypes of mesothelioma between 1999 and 2020, finding that the mortality decreased from 8.5 in 1999 to 5.7 in 2020. The reason for this trend may be linked with changes in incidence and survival that occurred during the same period. One study found that the incidence of pleural mesothelioma in the United States has decreased at a rate of −2.0% annually.[15] Another study found that, although the incidence of pleural mesothelioma has remained largely stable, the proportion of patients undergoing treatment increased from 37% to 54%, and 3-year survival improved from 9% to 15%.[5] Changes in the incidence of mesothelioma would likely be related to historical changes in asbestos exposure, given the 20- to 40-year latency period that occurs before the development of the disease.[16,17] Mesothelioma in younger populations is generally due to heritable syndromes, namely BAP1 tumor predisposition syndrome.[18] This subtype of mesothelioma is molecularly different from asbestos-related mesothelioma with a younger age of onset, different natural history course, and potentially better response to chemotherapy and better outcomes.[18–20] The leveling off or even decreasing incidence seen in mesotheliomas in older

Table 2. Trends in Mesothelioma Mortality Between 1999 and 2020

	Overall Population				
Characteristic	Average APC From 1999-2020	Segment 1 Years	Segment 1 Trend	Segment 2 Years	Segment 2 Trend
Overall mortality trend	−1.9[a] (−2.2 to −1.6)	1999-2011	−0.8[a] (−1.2 to −0.1)	2011-2020	−3.4[a] (−4.5 to −2.7)
Anatomical subtype					
Pleural	−0.6 (−1.7 to 0.6)	1999-2010	−6.6[a] (−10.4 to −4.2)	2010-2020	6.4[a] (3.5-11.6)
Peritoneum	1.7[a] (1.0-2.4)				
Pericardial	NA				
Other site	−3.7[a] (−4.5 to −3.1)	1999-2016	−5.5[a] (−6.7 to −4.8)	2016-2020	4.5 (−1.5 to 16.8)
Unspecified site	−2.0[a] (−2.4 to −1.7)	1999-2011	0.5 (−0.2 to 1.4)	2011-2020	−5.3[a] (−6.4 to −4.3)
Race/ethnicity					
Non-Hispanic White	−1.7[a] (−1.9 to −1.5)	1999-2011	−0.5 (−1.0 to 0.1)	2011-2020	3.2[a] (−4.1 to −2.6)
Non-Hispanic Black	−1.6[a] (−2.5 to −0.4)				
Hispanic	−1.4 (−2.5 to 0.1)				
Geographic density					
Urban	−2.1[a] (−2.6, −1.6)				
Suburban	−2.0[a] (−2.5, −1.5)	1999-2011	−0.4 (−1.2, 1.2)	2011-2020	−4.1[a] (−6.6, −2.9)
Rural	−1.1[a] (−1.7, −0.5)	1999-2012	0.4 (−0.4, 2.2)	2012-2020	−3.5[a] (−7.0, −1.9)
Sex					
Female	−0.6[a] (−1.1 to 0.0)				
Male	−2.4[a] (−2.7 to −2.1)	1999-2011	−1.1[a] (−1.6 to −0.5)	2011-2020	−4.1[a] (−5.0 to −3.4)
	Age > 65 y				
	Average APC from 1999−2020	Segment 1		Segment 2	
Characteristic					
Overall mortality trend	−1.4[a] (−1.6 to −1.1)	1999-2011	0.0 (−0.4 to 0.6)	2011-2020	−3.2[a] (−4.1 to −2.5)
Anatomical subtype					
Pleural	0.5 (−0.2 to 1.3)	1999-2010	−5.7[a] (−8.4, −3.7)	2010-2020	7.7* (5.7 to 11.3)
Peritoneum	2.0[a] (1.1- 3.2)				
Pericardial	NA				
Other site	−3.2[a] (−4.1 to −2.6)	1999-2016	−4.9[a] (−6.3 to −4.3)	2016-2020	4.7 (−1.7 to 17.1)
Unspecified site	−1.4[a] (−1.7 to −1.0)	1999-2011	1.4[a] (0.8 to 2.3)	2011-2020	−5.0[a] (−6.1 to −4.1)
Race/ethnicity					
Non-Hispanic White	−1.1[a] (−1.4 to −0.9)	1999-2011	0.3 (−0.2, 0.9)	2011-2020	−3.0[a] (−3.9 to −2.3)
Non-Hispanic Black	−0.7 (−1.7 to 0.6)				
Hispanic	−1.4 (−2.8 to 0.5)				
Geographic density					
Urban	−2.0[a] (−2.6 to −1.4)	1999-2011	−0.9 (−1.6 to 1.5)	2011-2020	−3.4[a] (−6.4 to −2.3)
Suburban	−1.5[a] (−1.8 to −1.2)	1999-2011	−0.2 (−0.8 to 0.6)	2011-2020	−3.2[a] (−4.5 to −2.4)
Rural	−0.3 (−1.1 to 0.5)	1999-2012	1.5[a] (0.5-3.9)	2012-2020	−3.1[a] (−7.3 to −1.2)
Sex					
Female	−0.1 (−0.8 to 0.7)				
Male	−1.9[a] (−2.2 to −1.7)	1999-2011	−0.5 (−1.0 to 0.1)	2011-2020	−3.8[a] (−4.7 to −3.1)

[a]Statistically significant trend at a p value of less than 0.05.
APC, annual percentage change; NA, not applicable.

adults may be attributed to decreases in workplace asbestos exposure beginning in the 1970s.[21] In addition, new treatment advancements have been made for pleural mesothelioma that may impact survival and mortality. In recent years, treatment options for patients with pleural mesothelioma have evolved, with the advent of immunotherapy for frontline treatment of unresectable disease per the CheckMate 743 trial.[22] Although this would not have a notable impact on our observed results given that immunotherapy was only available for pleural mesothelioma after 2017, it may play an impactful role in decreasing mortality in the future. Other reasons for the decrease in mortality could be owing to better characterization of mesothelioma, better and earlier detection of disease, improved supportive care measures, and improved access to guideline-directed multidisciplinary care.[4]

Asbestos is the most prominent risk factor for mesothelioma, accounting for at least 85 to 90% of all

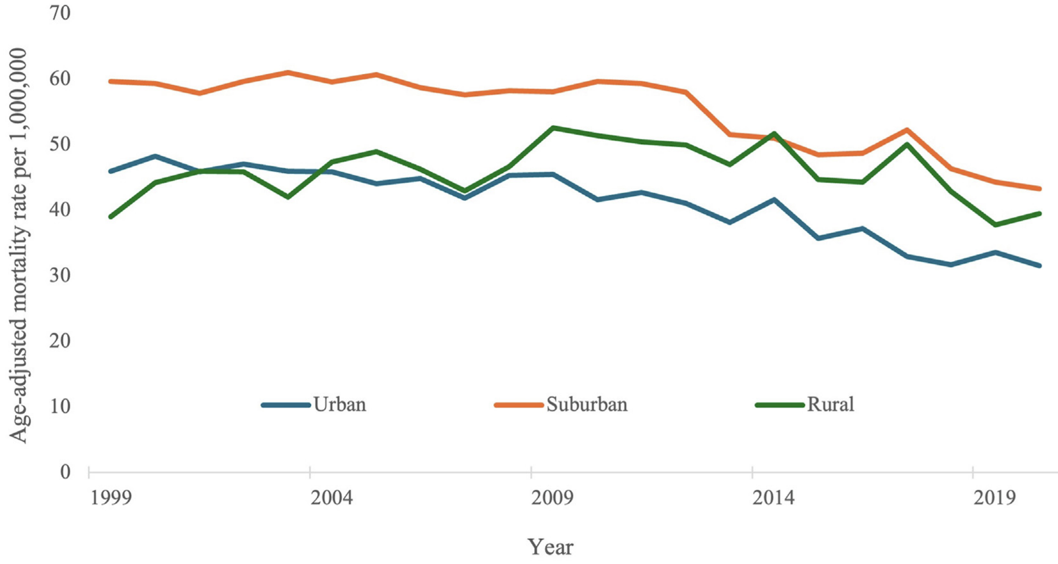

Figure 2. Trends in age-adjusted, overall mesothelioma-related mortality rates stratified by geographic density in adults aged over 65 years in the United States, 1999 to 2020. Urban: 1999 to 2011 APC: −0.9 (95% CI: −1.6 to 1.5), 2011 to 2020 APC: −3.4[a] (95% CI: −6.4 to −2.3); Suburban: 1999 to 2011 APC: −0.2 (95% CI: −0.8 to 0.6), 2011 to 2020 APC: −3.2[a] (95% CI: −4.5 to −2.4); Rural: 1999 to 2012 APC: 1.5[a] (95% CI: 0.5-3.9), 2012 to 2020 APC: −3.1[a] (95% CI: −7.3 to −1.2). [a]Indicates that the APC is significantly different from 0 at an α of 0.05. APC, annual percentage change; CI, confidence interval.

cases.[23] Given the well-recognized associations between asbestos, lung disease, and multiple cancer types, its use has been heavily regulated by the Occupational Safety and Health Administration and EPA.[7] In light of this, the EPA finalized the prohibition of chrysotile asbestos in March 2024 after decades of reducing the permissible exposure limit.[6,24] The use of asbestos in the United States peaked in 1973 at 803,000 metric tons; by 2021, the use of asbestos had declined to 320 metric tons.[25] Nevertheless, the use of asbestos continues to rise in developing countries, with corresponding increasing death counts due to mesothelioma.[26,27]

We elected to assess mortality in patients aged over 65 years because this is the main population that

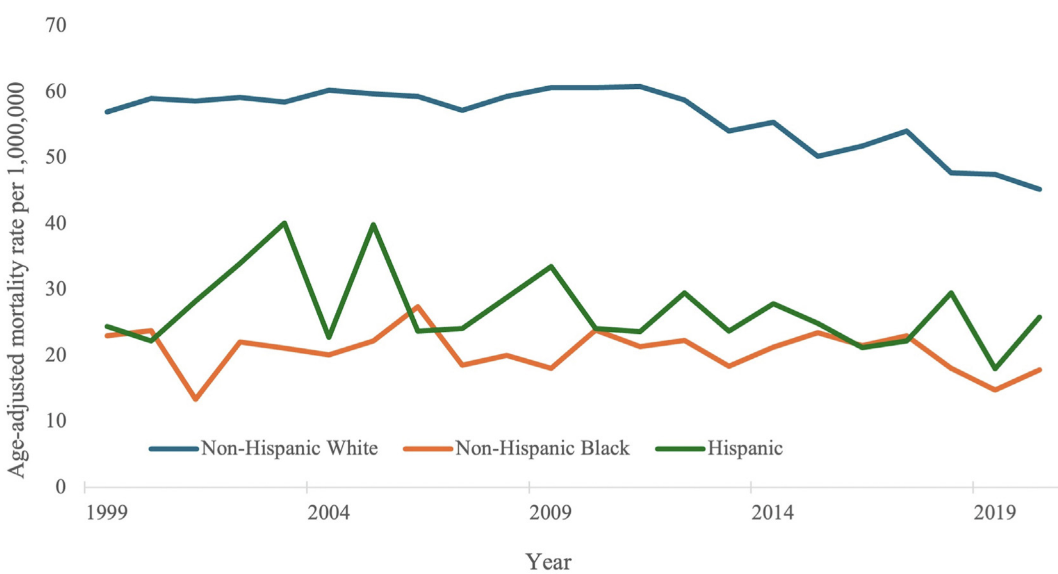

Figure 3. Trends in age-adjusted, overall mesothelioma-related mortality rates stratified by race/ethnicity in adults aged over 65 years in the United States, 1999 to 2020. Non-Hispanic White: 1999 to 2011 APC: 0.3 (95% CI: −0.2 to 0.9), 2011 to 2020 APC −3.0[a] (95% CI: −3.9 to −2.3); Non-Hispanic Black: 1999 to 2020 APC −0.7 (95% CI: −1.7 to 0.6); Hispanic: 1999 to 2020 APC −1.4 (95% CI: −2.8 to 0.5). [a]Indicates that the APC is significantly different from 0 at an α of 0.05. APC, annual percentage change; CI, confidence interval.

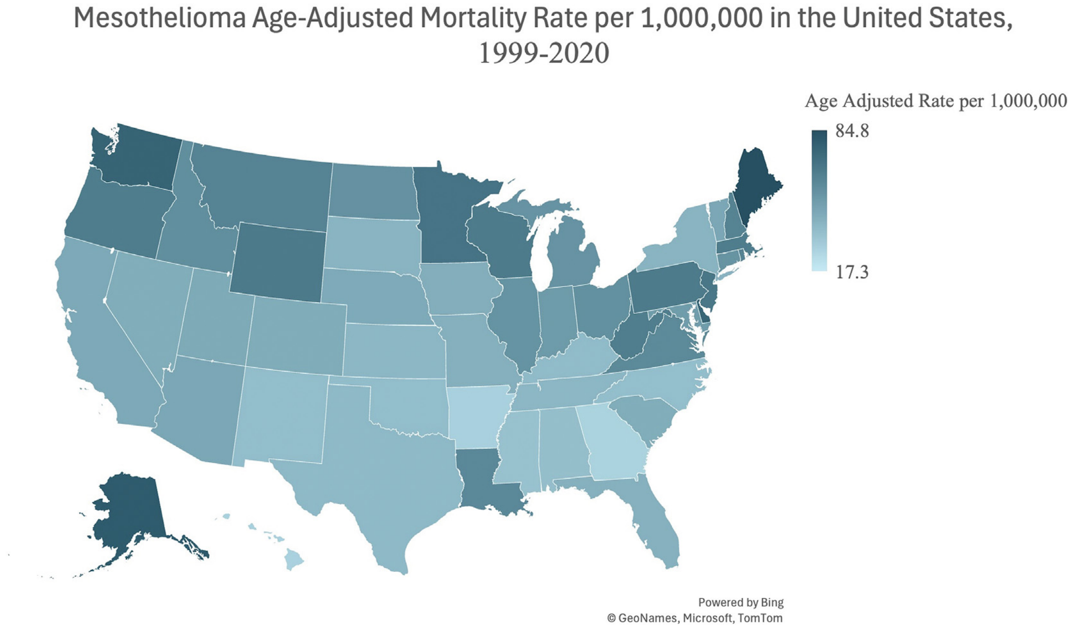

Figure 4. Age-adjusted mortality rates due to mesothelioma in the United States between 1999 and 2020.

mesothelioma affects, with an average age of 72 years, and past studies have shown that mortality is highest in these groups.[7,8] In the United States, most cases of mesothelioma are due to asbestos exposure approximately 30 years before the development of the disease.[16,17] This explains why 81% of the deaths in our study were in individuals older than 65; mesothelioma is generally quite rare in the younger population due to this latency period.[28] In addition, findings from our study reported that mortality due to pleural mesotheliomas in individuals aged over 65 years has increased at a rate of 7.7% annually since 2010. This is an alarming trend that needs to be further studied. The data may have been confounded given most deaths in the sample were due to an unspecified anatomical site with downtrending mortality, which may represent pleural mesothelioma. Urban areas may have improved mortality rates due to the existence of higher volume cancer centers and multidisciplinary teams providing multimodality treatments.[29] Judicious use of surgical interventions in this patient population and continued efforts to bolster supportive and palliative care efforts and geriatric oncology research, are necessary to further improve survival.

We assessed mesothelioma mortality by sex and race/ethnicity, finding that the non-Hispanic White population and male individuals had the highest mortality. These findings are in line with previous studies.[7,8] Although we cannot definitely explain this within the current data set given the lack of data regarding occupation, this finding is likely due to historically higher occupational exposure to asbestos in these populations–shipbuilding and construction workers are the largest occupational contributors to mesothelioma mortality, which are largely male-dominated occupations.[7] In addition, in our analysis of mesothelioma mortality by geographic density, we found that suburban populations had the highest mortality, followed by rural and then urban subgroups. Suburban populations may have the highest mortality due to greater employment in industries like shipbuilding, construction, and automotive. Further, in some suburban areas, better health care access could lead to higher diagnosis rates, leading to more reported cases of mesothelioma. Rural populations did not experience a significant decrease in mortality during the study period, whereas both suburban and urban populations did experience a significant decrease. This contrasts with long-term incidence trends observed in previous studies in the United States.[30] In women, incidence remained relatively stable over time in both urban and suburban areas; in men in urban areas, incidence decreased by 1.9% annually after 1992, whereas for men in rural areas, incidence remained stable after 1980.[30] The age-adjusted incidence was higher in urban populations than rural across the study period. This corresponds with previous studies assessing ambient asbestos exposure in the United States, which found higher concentrations in urban areas compared with rural areas.[30,31] The higher mortality in rural populations compared with urban populations in our study is likely due to systemic health care issues affecting rural populations, with rural populations not experiencing the same improvements as other populations in mortality over time.[32] The contrast seen in our results could stem from differences in treatment patterns seen in rural and urban populations; nevertheless, there are no published data assessing these differences. For instance, rural populations may experience barriers to accessing newer and multidisciplinary treatment modalities, including immunotherapy, which is typically prescribed at urban academic centers.[33]

To date, there are currently no screening guidelines in place for patients at high risk of developing mesothelioma. The most effective screening guideline would include those with known occupational exposure to asbestos or those at high risk for exposure due to their occupation and additional individuals who may have been exposed to asbestos (family contacts of asbestos-exposed workers, persons exposed to natural asbestos, etc.).[8] The results of studies using low-dose computed tomography scans have shown promise in identifying both early-stage and late-stage mesotheliomas.[34,35] Low-dose computed tomography may be used to identify pleural plaques, which are present in approximately 20% to 80% of patients with malignant pleural mesotheliomas.[34,36,37] In addition, it may identify pleural thickening, a less common finding. The most common finding is localized or diffuse pleural masses, present in 92% of patients, although there is an overlap between the description of malignant pleural mesothelioma on computed tomography and imaging features of pleural plaques.[34] In addition, the development of a screening computed tomography guideline is difficult due to the fact that many cases of pleural mesothelioma are discovered with minimal or no visible alterations to the pleura. Further large-scale, prospective studies should assess the value of low-dose computed tomography as a screening tool for mesothelioma.

Our study is not without limitations. We were unable to assess incidence with this data set because it relies on death certificates to produce mortality statistics. Further, 41,866 deaths, or roughly 75% of deaths due to mesothelioma in our sample were of an unspecified anatomical site, which is due to incomplete information on death certificates used to capture the data. Previous estimates have shown that roughly 75% of mesotheliomas arise from pleura.[28] Using these estimates, we estimate approximately 31,400 deaths due to pleural mesothelioma were unaccounted for in the data set. Further, we were unable to assess mortality by histologic subtype because this variable is not accounted for within the database. In addition, we were unable to assess mortality in younger age groups due to sample size and unreliability of the data. The database reports the state in which the death occurred, which may not be the same state in which an individual resides. Finally, there is the possibility of miscoding within the database; nevertheless, the CDC WONDER undergoes rigorous quality control checks and has been used in a number of previous studies assessing mortality in the United States.

Conclusion

We used a nationwide database linked with death certificates to assess temporal trends in mesothelioma mortality in the United States, finding a significant decrease in mortality between 1999 and 2020. This decrease in mortality may be related to new developments that have changed the landscape for mesothelioma, including the use of immunotherapy in this patient population. Numerous clinical trials are underway assessing combination therapies with immunotherapy, with promising results. Nevertheless, further work is needed to improve care and limit mortality for vulnerable subgroups in the United States.

CRediT Authorship Contribution Statement

Alexander J. Didier: Data Curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing - original draft.

Mingjia Li: Writing - review & editing.

Jinesh Gheeya: Writing - review & editing.

Asrar Alahmadi: Writing - review & editing.

Jacob Kaufman: Writing - review & editing.

Regan Memmott: Writing - review & editing.

Kai He: Writing - review & editing.

Peter Shields: Writing - review & editing.

David Carbone: Writing - review & editing.

Carolyn Presley: Writing - review & editing.

Dwight Owen: Writing - review & editing.

Logan Roof: Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Validation, Writing - review & editing.

Data Availability Statement

The data that support the findings of this study are available at: https://wonder.cdc.gov.

Disclosure

The authors declare no conflict of interest.

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