Malignant Mesothelioma Mortality in the United States, 1999–2001

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Malignant mesothelioma is strongly associated with asbestos exposure. This paper describes demographic, geographic, and occupational distributions of mesothelioma mortality in the United States, 1999–2001. The data (n = 7,524) were obtained from the National Center for Health Statistics multiple-cause-of-death records. Mortality rates (per million per year) were age-adjusted to the 2000 U.S. standard population, and proportionate mortality ratios (PMRs) were calculated by occupation and industry, and adjusted for age, sex, and race. The overall age-adjusted mortality rate was 11.52, with males (22.34) showing a sixfold higher rate than females (3.94). Geographic distribution of mesothelioma mortality is predominantly coastal. Occupations with significantly elevated PMRs included plumbers/pipefitters and mechanical engineers. Industries with significantly elevated PMRs included ship and boat building and repairing, and industrial and miscellaneous chemicals. These surveillance findings can be useful in generating hypotheses and developing strategies to prevent mesothelioma. *Key words:* mesothelioma; mortality; occupations; industries.

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Malignant mesothelioma is a rare tumor that arises from the mesothelial surfaces of the pleural and peritoneal cavities as well as from the pericardium.[1] The annual incidence of malignant mesothelioma in the United States was reported as 10.2 cases/million/year in the 1998–2002 period.[2] Latency periods from the time of exposure to the development of mesothelioma range from 20 to 60 years.[1,3,4] About 80% of mesotheliomas are pleural in origin.[1] Spirtas et al. reported that about 88% of pleural mesotheliomas have been attributed to asbestos exposure,[5] but other risk factors, such as zeolite, have also been implicated.[1] Epidemiologic studies have shown that, of the different types of asbestos fiber (chrysotile, crocidolite, amosite, actinolite, anthophyllite, and tremolite), crocidolite may be the most potent in terms of carcinogenicity.[6] Some cases of mesothelioma have been associated with exposure to chrysotile.[7]

In the past, asbestos was used for many applications, including building materials (e.g., insulation materials), manufacturing products (e.g., asbestos cement pipe), and automobile industry (e.g., vehicle brake shoes and clutch pads). Asbestos use declined substantially in the 1980s in the United States and is still currently decreasing.[8] However, legacy exposures still occur during remediation and handling of existing asbestos applications. For example, approximately 1.3 million workers were exposed to asbestos in the United States in 2002,[4] including shipbuilders, miners, construction workers (e.g., insulation workers, plumbers, and pipe fitters), electricians, sheet metal workers, and makers of asbestos products. Although asbestos was eliminated in the manufacturing of some products such as electric hair dryers, gas fireplaces, and wallboard patching compounds, the product is still used in the United States.

In 1999, the 10th revision of the International Classification of Diseases (ICD-10) was adopted by the National Center for Health Statistics (NCHS) for coding mortality data in the United States.[9] In this classification, malignant mesothelioma has a discrete code, C45,[9] thereby providing the opportunity to study mesothelioma mortality with respect to the demographic, geographic, and occupational distributions in the United States. The aim of this study was to provide recent (1999–2001) surveillance information using the new data for the 10th ICD revision for research and for developing prevention strategies to reduce industry- and occupation-specific deaths from mesothelioma.

METHODS

For this study, we used the NCHS multiple-cause-of-death data files for the period 1999–2001, for U.S. residents aged ≥ 15 years. Cases with any mention of ICD-10, code C45,[9] specifically C45.0 (mesothelioma of pleura); C45.1 (mesothelioma of peritoneum); C45.2 (mesothelioma of pericardium); C45.7 (mesothelioma of other sites); and C45.9 (unspecified mesothelioma) listed on the entity axis* were included in this study.[9,10] We calculated age-adjusted mortality rates (per million

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*The entity axis preserves diagnostic detail for all listed conditions and their placement on the death certificate.[10]

TABLE 1 Demographic Characteristics of Malignant Mesothelioma Deaths by Site, Sex, Race, and Median Age at Death, 1999–2001

Site (ICD-10 Code)	Deaths No. (%)	Underlying Cause (%)	Sex		Race			Median Age at Death (Years)
			Male No. (%)	Female No. (%)	White No. (%)	Black No. (%)	Other No. (%)	
Pleura (C45.0)	746 (9.9)	89.1	624 (83.6)	122 (16.4)	716 (96.0)	22 (2.9)	8 (1.1)	73
Peritoneum (C45.1)	261 (3.5)	90.0	163 (62.5)	98 (37.5)	246 (94.3)	13 (5.0)	2 (0.7)	68
Pericardium and other sites (C45.2, C45.7)	1,250 (16.6)	90.9	1,000 (80.0)	250 (20.0)	1,200 (96.0)	42 (3.4)	8 (0.6)	74
Unspecified (C45.9)	5,375 (71.4)	94.2	4,361 (81.1)	1,014 (18.9)	5,704 (95.0)	215 (4.0)	56 (1.0)	74
Total (Any site)	7,524 (101.4)	94.3	6,058 (80.5)	1,466 (19.5)	7,161 (95.2)	289 (3.8)	74 (1.0)	74

The sums of individual site deaths and percentages are greater than the total numbers of deaths and percentages because some decedents had more than one site of mesothelioma listed on their death certificates.

per year) based on the 2000 U.S. standard population, and age-specific mortality rates by gender using SAS® software version 8.2 (SAS Institute, Cary, NC). For the geographic mortality distribution, age-adjusted mortality rates were mapped for counties with three or more mesothelioma deaths in each year, using MapInfo Professional version 7.5 (MapInfo Corp., Troy, NY). The proportionate mortality ratio (PMR) adjusted for age, sex, and race was computed by industry and occupation. The data used for the PMR analyses were a subset of the 1999 NCHS multiple-cause-of-death files for which the information on usual occupation and industry was available. Occupation and industry data were available for19 states (Colorado, Georgia, Hawaii, Idaho, Indiana, Kansas, Kentucky, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Rhode Island, South Carolina, Utah, Vermont, West Virginia, and Wisconsin).

The PMR was defined as the observed number of deaths with the condition of interest in a specified the Bureau of Census Industry Code (CIC) or Census Occupation Code (COC),[11] divided by the expected number of deaths with that condition. The expected number of deaths was calculated using the total number of deaths in the industry/occupation of interest multiplied by a proportion defined as the number of cause-specific deaths for the condition of interest in all industries/occupations, divided by the total number of deaths in all industries/occupations. In this report only PMRs for those industries/occupations with five or more decedents with mesothelioma and a lower 95% confidence limit exceeding 1.0 are reported.

The standardized mortality ratio (SMR) was calculated to measure the mesothelioma mortality risk in counties with elevated mortality rates. The numerator of the SMR was obtained by summing the number of mesothelioma deaths in all age groups in each county. The expected numbers of deaths for the denominator were obtained by multiplying the age-specific mesothelioma mortality rates of the 2000 U.S. population by the corresponding population in each county, and then summing all age groups.[12] The 95% confidence intervals (CIs) were computed for PMRs and SMRs, assuming a Poisson distribution of the data.[13]

RESULTS

The demographic characteristics of malignant mesothelioma deaths by sex, race, and median age at death are listed in Table 1. A total of 7,524 mesothelioma deaths were identified for the period 1999–2001. Of these, 6,058 (80.5%) and 7,161 (95.2%) deaths occurred among males and whites, respectively. Malignant mesothelioma was designated as the underlying cause of death in 94.3% of all malignant mesothelioma deaths. Over 71% of cases were classified as unspecified mesothelioma (C45.9).

During the study period, national age-adjusted mesothelioma mortality rates were stable: 11.65, 11.63, and 11.36 per million in 1999, 2000, and 2001, respectively; the overall age-adjusted rate for the three years was 11.52. The number of deaths by age group and the age-specific mortality rates of malignant mesothelioma are presented in Table 2. Mortality rates for males were higher than those for females in all age groups and were nearly six times that of females overall. The age-specific mortality rates of malignant mesothelioma for males increased steadily with age: 0.38 per million for age group 15–44 and 151.72 per million for age group 85 and older (Table 2).

Statistically significant (lower 95% confidence limit exceeding 1.0) PMRs, by usual occupation and industry, are listed in Table 3. By industry, *ship and boat building and repairing* had the highest adjusted PMR of 5.95 (95% CI, 2.39–12.27), followed by *industrial and miscellaneous chemicals*, PMR of 4.81 (95% CI, 2.90–7.51). By occupation, *plumbers, pipefitters, and steamfitters* had the highest adjusted PMR of 4.76 (95% CI, 2.81–7.51), followed by *mechanical engineers*, PMR of 3.04 (95% CI, 1.11–6.62).

Although 55% (4,150) of all malignant mesothelioma deaths were residents of California (n = 757), Florida (n = 520), Pennsylvania (n = 481), New York (n = 453), Illinois (n = 381), Texas (n = 373), Ohio (n =

TABLE 2 Numbers of Malignant Mesothelioma (Any Site) Deaths, Age-specific and Age-adjusted Rates (per Million per Year) by Sex and Age Group, 1999–2001

	Males		Females		Both Sexes	
Age (Years)	No.	Age-specific Rate/Million	No.	Age-specific Rate/Million	No.	Age-specific Rate/Million
15–44	71	0.38	59	0.32	130	0.35
45–54	297	5.3	116	2.01	413	3.64
55–64	905	25.73	216	5.71	1,121	15.35
65–74	1,985	79.72	395	13.15	2,380	43.31
75–84	2,231	151.57	517	23.05	2,748	73.97
≥ 85	569	151.72	163	17.90	732	56.94
Age (Years)	No.	Age-specific Rate/Million	No.	Age-specific Rate/Million	No.	Age-specific Rate/Million
All ages	6,058	22.34	1,466	3.94	7,524	11.52

347), New Jersey (n = 316), Michigan (n = 269), and Massachusetts (n = 253), the states with the greatest age-adjusted mortality rates (per million) were Alaska (24.0), Maine (21.4), Delaware (18.2), Washington (17.7), Oregon (17.1), Montana (16.0), Massachusetts (15.8), New Hampshire (15.7), New Jersey (15.2), and Virginia (14.8). Mortality patterns by county, presented in Figure 1, indicate clustering of elevated mortality rates in coastal counties in California, Florida, and New Jersey. The top 20 counties with the largest age-adjusted malignant mesothelioma mortality rates and SMRs are listed in Table 4. The SMRs in these counties exceeded the national mortality rate by more than six-fold. Somerset County, New Jersey, had the largest SMR (14.5, 95% CI, 10.0–20.4).

DISCUSSION

This report provides recent surveillance information about malignant mesothelioma in the U.S. The major findings are: a high proportion of unspecified mesotheliomas; distribution of high mortality rates in coastal areas; elevated PMRs for the *ship and boat building and repairing* industry and in the *plumbers, pipefitters, and steamfitters* occupation.

Over 71% of malignant mesotheliomas were unspecified, compared with nearly 10% of malignant mesotheliomas of the pleura (Table 1). Other studies based on morbidity or mortality data reported that the pleura is the most frequently specified primary site of malignant mesothelioma, followed by the peritoneum.[6] In Australia, 83% of the incident cases of mesothelioma arose from the pleura, and both pleura and peritoneum accounted for nearly 91%.[14] The large proportion of unspecified sites of malignant mesothelioma coded on death certificates in this study might therefore be due to failure to be precise about the specific site of the tumor on the death certificate, and thus lead to an underestimate of the cases of pleural mesothelioma.

Mortality data coded using ICD-10 have been shown to be a valid source of information for mesothelioma surveillance. Pinheiro et al. reported a high correlation between mesothelioma mortality according to ICD-10 and the disease incidence rate.[15] Previous investigations of mesothelioma mortality data coded using ICD-9 were inadequate because there was no specific code for this

TABLE 3 Malignant Mesothelioma Proportionate Mortality Ratios (PMRs) by Usual Industry and Occupation, 1999 (19 States)*

Census Industry Code (CIC)	Industry	Number of Deaths	PMR	95% CI
360	Ship and boat building and repairing	7	5.95	2.39–12.27
192	Industrial and miscellaneous chemicals	19	4.81	2.90–7.51
200	Petroleum refining	5	3.80	1.23–8.87
460	Electric light and power	10	3.08	1.48–5.66
60	Construction	77	1.55	1.23–1.94
Census Occupation Code (COC)	**Occupation**	**Number of Deaths**	**PMR**	**95% CI**
585	Plumber, pipefitters, and steamfitters	18	4.76	2.81–7.51
57	Mechanical engineers	6	3.04	1.11–6.62
575	Electricians	12	2.42	1.25–4.22
156	Teachers, elementary school	13	2.13	1.13–3.64

*Colorado, Georgia, Hawaii, Idaho, Indiana, Kansas, Kentucky, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Rhode Island, South Carolina, Utah, Vermont, West Virginia, and Wisconsin.

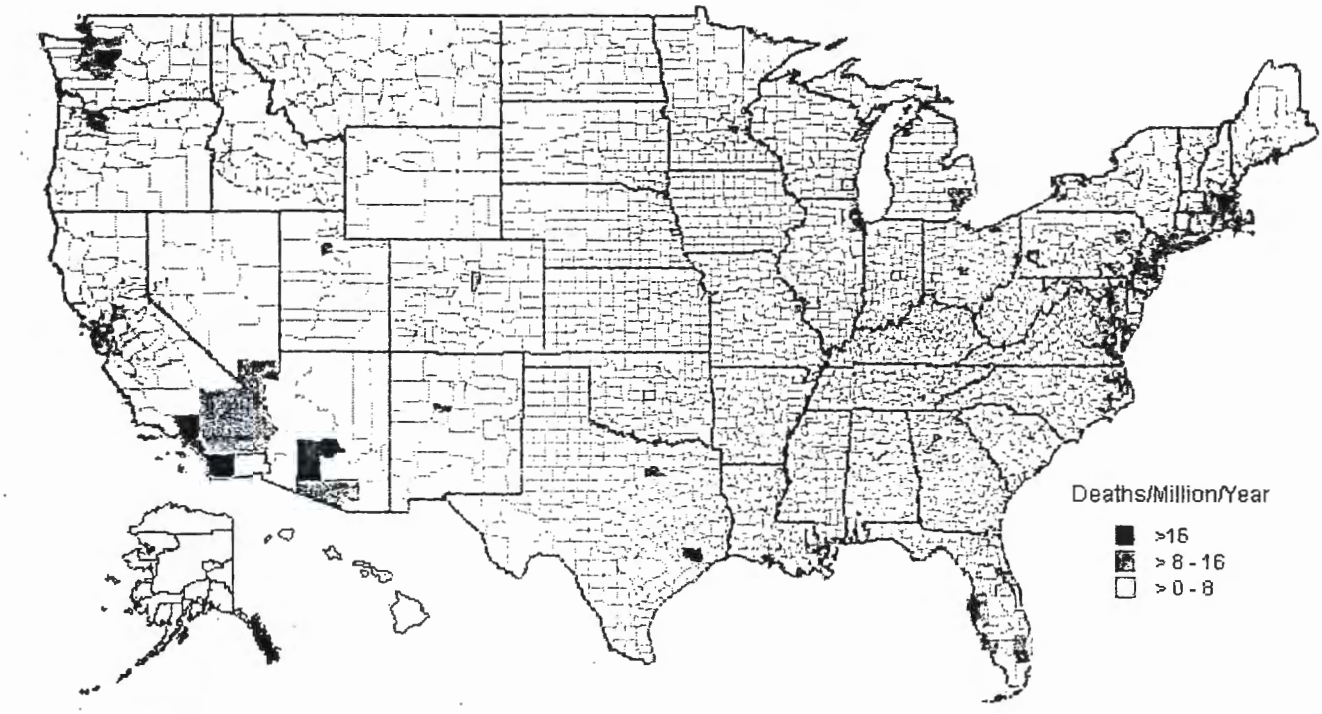

Figure 1—Age adjusted mesothelioma mortality rates (per million) by county, United States 1999–2001. Note: Mortality rates were calculated only for counties with three or more deaths in each year.

disease and pleural mesothelioma was classified with other pleural tumors. This was demonstrated by a study using the Massachusetts Cancer Registry. With ICD-9 codes the registry reported only 12% of cancers of the peritoneum and pleura as the underlying cause of death. The rate increased to 83% when death certificates were reviewed for any mention of mesothelioma.[16] Similarly, the Work-Related Lung Disease Surveillance Report shows about 20% of deaths from pleural cancer compared with mesothelioma in 1999.[17,18]

There was no substantial change in the mesothelioma mortality rate during 1999–2001. In this period, the total number (7,524) of malignant mesothelioma deaths was similar to the number of incident cases (7,500) reported by Price and Ware[19] for the same period. These authors projected mesothelioma incident cases for 2003–2054 based on 1993–2000 mesothelioma incidence data released by the Surveillance, Epidemiology, and End Results (SEER) Program, National Cancer Institute. The SEER data for mesothelioma cover 13 geographic areas, representing 10% of the U.S. population. In addition, the authors reported that the number of incident mesothelioma cases is expected to gradually decline from the peak of approximately 2,500 cases annually during 2000–2004.[19] Authors linked these cases to a high occupational exposure to asbestos in workplaces during 1960–1980. In this period the asbestos consumption ranged from 600,000 tons in 1960 to 803,000 tons in 1973. After that, asbestos consumption decreased, to 13,100 tons in 2001.[20]

Nearly 81% of all mesothelioma deaths in this study occurred among men, suggesting that men were more likely to be exposed to asbestos in the workplace than were women. In the 1930s through the 1960s, most women did not work in industries in which men were usually exposed to high levels of asbestos[19] and were primarily exposed to asbestos in the environment. Some of the mesothelioma deaths in women might have resulted from environmental exposures. Cases of mesothelioma have been observed in families of asbestos workers who brought home asbestos-contaminated clothing.[21] Anderson et al. reported five pleural mesothelioma deaths among the family contacts of the 1,664 workers who were employed in a factory that produced amosite asbestos products from 1941 to 1954.[22] Mesothelioma has also been associated with environmental exposures to zeolite mineral fibers. A study from Turkey reported that high mortality (11 among 18 total deaths) from pleural and peritoneal mesotheliomas in small villages was caused by environmental exposures to domestic soil and rock rich in zeolite minerals.[23]

Among industries with significantly elevated PMRs for malignant mesothelioma, *ship and boat building and repairing* had the highest. This finding is consistent with known exposure to asbestos in this industry, since this material was widely used in insulation in ships in the past.[4] Other studies have also shown that shipbuilding workers had high mortality from mesothelioma.[24]

In this study, where the geographic distribution of mesothelioma mortality rates was examined by county,

Table 4 Top 20 Counties and County Equivalents* with Highest Age-adjusted Malignant Mesothelioma Mortality Rates (per Million per Year) and Standardized Mortality Ratios (SMRs), 1999–2001

County	State	No. of Deaths	Age–adjusted Rate	SMR (95% CI)
Somerset County	New Jersey	33	52.7	14.4 (9.9–20.2)
Portmouth City	Virginia	11	45.0	12.0 (6.0–21.4)
Jefferson Parish	Louisiana	47	44.1	12.0 (8.8–15.9)
Chesapeake City	Virginia	13	36.8	9.7 (5.2–16.6)
Kitsap County	Washington	16	34.3	9.4 (5.4–15.2)
Niagara County	New York	20	32.2	8.9 (5.4–13.8)
Anne Arundel	Maryland	31	32.1	8.8 (6.0–12.5)
Clackamas County	Oregon	22	29.6	8.3 (5.2–12.6)
Delaware County	Pennsylvania	46	29.1	7.8 (5.7–10.4)
York County	Maine	14	29.1	7.7 (4.2–12.9)
Chesterfield	Virginia	12	28.1	8.6 (4.4–15.0)
St. Louis County	Minnesota	17	27.7	7.9 (4.6–12.7)
Rockingham County	New Hampshire	14	26.4	7.1 (3.9–12.0)
St. Tammany Parish	Louisiana	10	26.2	8.5 (4.4–15.6)
Lake County	Illinois	29	26.1	6.9 (4.7–10.0)
Charleston County	South Carolina	17	25.2	6.8 (3.9–10.9)
Rock Island County	Illinois	10	24.2	7.3 (3.5–13.5)
Plymouth County	Massachusetts	25	23.5	6.5 (4.2– 9.5)
Pierce County	Washington	32	23.4	6.1 (4.2– 8.6)
Norfolk County	Massachusetts	40	22.9	6.0 (4.3– 8.2)
Overall United States		7,524	11.5	

*Other primary legal or statistical subdivisions or State geopolitical units, which may include boroughs and census areas (Alaska), parishes (Louisiana), and independent cities (Maryland, Missouri, Nevada and Virginia). Counties and county equivalents with fewer than three deaths in any individual year were not included.

there was considerable variation, but some clustering. In particular, coastal counties in California, Florida, and New Jersey had elevated age-adjusted mesothelioma mortality rates. Previous studies reported a similar mortality distribution and suggested an association between geographic pattern of malignant mesothelioma and the distribution of potential exposures to asbestos used in shipyards[5,25,26] and to asbestos-contaminated vermiculite ore.[27] The highly elevated SMR in Somerset County, NJ, could be related to manufacturing of asbestos products in Manville.[25] The second-highest PMR was found in *industrial and miscellaneous chemicals.* Lilis et al.[28] demonstrated that maintenance workers in this type of industry were exposed to asbestos in various occupations. The *construction* industry had the highest number of deaths (n = 77) and accounted for 14% of 541 decedents with malignant mesothelioma on death certificates in the 19 states in 1999.[18] As suggested in other reports, the elevated PMR might be related to an excess risk of asbestos exposure in the construction industry, leading to the development of mesothelioma.[29] Demolition workers in the construction industry may continue to encounter asbestos from past uses in old buildings.[30]

Exposures to asbestos of workers in occupations with significantly elevated PMRs (*plumbers, pipefitters, and steamfitters, mechanical engineers,* and *electricians)* have been previously described.[20,24,31,32] The PMR of 2.13 for schoolteachers in this study might reflect potential exposures of teachers to asbestos in schools. Schools built between 1945 and 1973 are likely to harbor asbestos-containing materials.[33] In 1982, the U.S. Environmental Protection Agency estimated approximately 8,600 schools contained friable asbestos and 100,000 to 300,000 teachers were potentially exposed to airborne asbestos in these schools.[34] The friable asbestos fibers might enter a school environment as a consequence of disturbance of the material during maintenance or renovation operations, or the resuspension of settled fibers caused by custodial dusting or cleaning.[35] In a case report, a 50-year-old schoolteacher died of pleural mesothelioma after 28 years' teaching in the same high school classroom with an asbestos ceiling and asbestos pipe insulation.[36]

There are some limitations to this study. First, we were not able to evaluate information about exposures specifically to asbestos and other mineral fibers, because such data are not on the death certificates. Second, the "usual" occupation and industry given on the death certificate may not have been the industry and occupation in which the decedent's causative exposure occurred. Third, only three years of data were available for analysis of temporal changes. More data are needed for in-depth meaningful trend analysis of mesothelioma mortality. Fourth, because of potential migration factors, the state of residence at death does not always reflect the state in which the decedents' causative exposures occurred. In some geographic areas elevated mortality rates seemed to have little bearing on past potential asbestos exposures. In these cases, migration may have played a role. For example, high mortality in some counties in Florida might be related

to elderly persons who retired, moved there, and died with mesothelioma.

Unlike some other countries,[37,38] the United States has no national mesothelioma registry collecting information about exposures and pathology data. The National Cancer Institute provides annual mesothelioma incidence data through the Surveillance, Epidemiology, and End Results (SEER) program from 13 participating centers in the United States.[39] For mesothelioma mortality surveillance in the United States, the Division of Respiratory Disease Studies, NIOSH, maintains mesothelioma mortality data under the National Occupational Respiratory Mortality System (NORMS) based on data from the NCHS multiple-cause-of-death records.[40] However, the NORMS relies on the death certificate occupation and industry information for exposures and so has limited potential to clearly identify and describe work exposures in detail. For the purposes of a registry, more and better occupational information could be obtained from the next of kin. Such information would enhance knowledge about potential causative exposures, including information about the proportion of all malignant mesothelioma cases that have an occupational versus an environmental origin.

In conclusion, our data indicate that malignant mesothelioma deaths are closely associated with industries and occupations where exposures to asbestos were likely. These surveillance findings can be useful for generating epidemiologic research hypotheses and developing asbestos-related disease prevention and intervention strategies. The use of ICD-10 codes since 1999 has been shown to provide enhanced capability to identify malignant mesothelioma. Therefore, mortality, as well as morbidity surveillance for mesothelioma should be continued in order to monitor its mortality and incidence both nationally and geographically.

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

References

1. Albelda SM, Sterman DH, Litzky LA. Malignant mesothelioma and other primary pleural tumors. In: Fishman AP (ed). Fishman's Pulmonary Diseases and Disorders. 3rd ed. New York: McGraw-Hill, 1998:1453–66.
2. National Cancer Institute. SEER age-adjusted rates & 95% confidence intervals: Mesothelioma, SEER 13 Registries for 1998–2002. <http://canques.seer.cancer.gov>.
3. Lanphear BP, Buncher CR. Latent period of malignant mesothelioma of occupational origin. J Occup Med. 1992; 342:718–21.
4. Weeks JL, Christiani DC. Asbestos-related diseases. In: Levy BS, Wagner GR, Rest KM, Weeks JL (ed). Preventing Occupational Disease and Injury. Washington, DC: American Public Health Association, 2005: 93–7.
5. Spirtas R, Heineman EF, Bernstein L, et al. Malignant mesothelioma: attributable risk of asbestos exposure. Occup Environ Med. 1994;51:804–11.
6. Lee YCG, Klerk NH, Henderson W, Musk AW. Malignant mesothelioma. In: Hendrick DJ, Burge PS, Beckett WS, Chung A (eds). Occupational Disorders of the Lung: Recognition, Management, and Prevention. New York: W. B. Saunders, 2002: 359–79.
7. Smith AH, Wright CC. Chrysotile asbestos is the main cause of pleural mesothelioma. Am J Ind Med. 1996;30:252–66.
8. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile. U.S. Public Health Service, U.S. Department of Health and Human Services, 1995.
9. World Health Organization. International Statistical Classification of Diseases and Related Health Problems, Tenth Revision. Geneva, Switzerland: WHO, 1992.
10. National Center for Health Statistics, Division of Vital Statistics. Documentation for underlying and multiple cause-of-death public-use data file, 1999. <http:/wonder.cdc.gov/wonder/sci%5Fdata/mort/mcmort/typpe_txt/mcmort99.asp>.
11. U.S. Department of Commerce, Economic and Statistics Administration, Bureau of the Census, 1992. Classified Index of Industries and Occupations. Washington, DC: U.S. Government Printing Office, 1992.
12. Checkoway H, Pearce N, Crawford-Brown DJ. Research Methods in Occupational Epidemiology. New York: Oxford University Press, 1989:125–8.
13. Bailar JC III, Ederer F. Significance factors for the ratio of a Poisson variable to its expectation. Biometrics. 1964;20:639–43.
14. National Occupational Health and Safety Commission (NOHSC). The incidence of mesothelioma in Australia 1993 to 1995. NOHSC, 1998.
15. Pinheiro GA, Antao VCS, Bang KM, Attfield MD. Malignant mesothelioma surveillance: a comparison of ICD 10 mortality data with SEER incidence data in nine areas of the United States. Int J Occup Environ Health. 2004;10:251–5.
16. Davis LK, Martin TR, Kligler B. Use of death certificates for mesothelioma surveillance. Public Health Rep. 1992;107:491–3.
17. National Institute for Occupational Safety and Health (NIOSH). Work-Related Lung Disease Surveillance Report, 1999. DHHS (NIOSH) Number 2000-195, 2000.
18. National Institute for Occupational Safety and Health (NIOSH). Work-Related Lung Disease Surveillance Report, 2002. DHHS (NIOSH) Number 2003-111, 2003.
19. Price B, Ware A. Mesothelioma trends in the United States: an update based on surveillance, epidemiology, and end results program data for 1973 through 2003. Am J Epidemiol. 2004; 159:107–12.
20. Virta R. US Geological survey: mineral commodity summaries, January 2003. <http://www.minerals.usgs.gov/minerals/pubs/commodity/asbestos>.
21. Cane MJ, Chahinina SP, Holland JF. Malignant mesothelioma in young adults. Cancer. 1990;65:1449–55.
22. Anderson HA, Lilis R, Daum SM, Selikoff IJ. Asbestosis among household contacts of asbestos factory workers. Ann NY Acad Sci. 1979;330:387–99.
23. Baris YI, Artvinli M, Sahin LAA. Environmental mesothelioma in Turkey. Ann NY Acad Sci. 1979;330:423–32.
24. Selikoff IJ, Hammond EC, Seidman H. Mortality experience of insulation workers in the United States and Canada, 1943–1976. Ann NY Acad Sci. 1979;330:91–116.
25. Enterline PE, Henderson VL. Geographic patterns for pleural mesothelioma deaths in the United States, 1968–81. J Natl Cancer Inst. 1987;79(1):31–7.
26. Jemal A, Grauman D, Devesa S. Recent geographic patterns of lung cancer and mesothelioma mortality rates in 49 shipyard counties in the United States, 1970–94. Am J Ind Med. 2000; 37:512–21.
27. McDonald JC, McDonald AD, Armstrong B, Sebastien P. Cohort study of mortality of vermiculite miners exposed to tremolite. Br J Ind Med. 1986;43:436–44.
28. Lilis R, Daum S, Anderson H, Sirota M, Andrews G, Selikoff IJ. Asbestos disease in maintenance workers of the chemical industry. Ann NY Acad Sci. 1979;330:127–35.
29. Selikoff IJ, Chung J, Hammond EC. Relation between exposure to asbestos and mesothelioma. N Engl J Med. 1965;272:560–5.
30. Greenberg M. Changing trends in US mesothelioma incidence. Occup Environ Med. 2005;62:134.

31. Robinson CF, Petersen M, Palu S. Mortality patterns among electrical workers employed in the U.S. construction industry, 1982–1987. Am J Ind Med. 1999;36:630–7.
32. McDonald AD. Mesothelioma registries in identifying asbestos hazards. Ann NY Acad Sci. 1979;330:441–54.
33. U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Support document for proposed rule on friable asbestos-containing materials in school buildings. Health effects and magnitude of exposure. 1980.
34. U.S. Environmental Protection Agency. A review of the scientific basis for EPA's school asbestos hazard program with recommendations to state health officials, 1984.
35. U.S. Environmental Protection Agency. Asbestos-containing materials in schools: health effects and magnitude of exposure. EPA-560/12-80-003, Office of Pesticides and Toxic Substances, Washington, DC, October 1980.
36. Huncharek M. Occult asbestos exposure. Am J Ind Med. 1991; 20:713–4.
37. Neumann V, Gunther S, Muller KM, Fischer M. Malignant mesothelioma—German mesothelioma register 1987–1999. Int Arch Occup Environ Health. 2001;74:383–95.
38. Leigh J, Davidson P, Hendrie L, Berry D. Malignant mesothelioma in Australia, 1945–2000. Am J Ind Med. 2002;41:188–201.
39. National Cancer Institute. SEER Program, 2003: <http://seer.cancer.gov>.
40. National Institute for Occupational Safety and Health (NIOSH). National Occupational Respiratory Mortality System (NORMS): <http://webappa.cdc.gov/ords/norms.html>.