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Original Contribution

Silicosis Mortality With Respiratory Tuberculosis in the United States, 1968–2006

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The presence of tuberculosis (TB) in patients with silicosis increases mortality risk. To characterize silicosis-respiratory TB comortality in the United States, the authors used 1968–2006 National Center for Health Statistics multiple cause-of-death data for decedents aged ≥25 years. The authors calculated proportionate mortality ratios (PMRs) using available information on decedents' industries and occupations reported from 26 states from 1985 through 1999. Among 16,648 silicosis deaths, 2,278 (13.7%) had respiratory TB listed on the death certificate. Of silicosis-respiratory TB deaths, 1,666 decedents (73.1%) were aged ≥65 years, 2,255 (99.0%) were male, and 1,893 (83.1%) were white. Silicosis-respiratory TB deaths declined 99.5% during the study period ($P < 0.001$ for time-related trend), from 239.8 per year during 1968–1972 to 1.2 per year during 2002–2006, with no reported deaths in 2006. Silicosis-respiratory TB deaths reported from Pennsylvania ($n = 525$; 1.29 per million population), Ohio ($n = 258$; 0.81 per million), and West Virginia ($n = 146$; 2.35 per million) accounted for 40.8% of all such deaths in the United States. The highest PMR for silicosis-respiratory TB death was associated with the "miscellaneous nonmetallic mineral and stone products" industry (PMR = 73.7, 95% confidence interval: 33.8, 139.8). In the United States, 2006 marked the first year since 1968 with no silicosis-respiratory TB deaths. The substantial decline in silicosis-respiratory TB comortality probably reflects prevention and control measures for both diseases.

industry; mortality; occupational exposure; occupations; silicosis; tuberculosis

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; ICD, *International Classification of Diseases*; PMR, proportionate mortality ratio; TB, tuberculosis.

Silicosis, a preventable occupational lung disease, is associated with various other diseases, including tuberculosis (TB) (1). Silicosis occurs as a consequence of occupational exposure to respirable crystalline silica-containing dust (2), and chronic silicosis may develop or progress even after occupational exposure to silica has been discontinued (3). Even in the absence of clinically apparent silicosis, persons who have been exposed to high levels of silica dust may be at increased risk of developing TB (3). Tuberculin-positive persons with silicosis have a 30 times' higher risk of developing active TB as compared with a control population without regard to tuberculin-test status (4). In 2003, Calvert et al. (5) showed that the odds of dying with TB are 40 times higher among persons with silicosis than among persons without the disease. Similarly, in 1997, Chen et al. (6) reported that persons with silicosis have a 19 times' greater risk of having TB (mentioned on the death certificate) than those without silicosis. Direct impairment of macrophage function by crystalline silica and poor drug penetration into silicotic lung nodules have resulted in high treatment failure and relapse rates (>20%) for patients with silicosis who are receiving chemotherapy for TB (7).

In 1995, in a study using national multiple cause-of-death data, Althouse et al. (8) described the pattern of pulmonary TB comortality with silicosis among men in the United States. They found that decedents with TB represented 4.2% of persons with silicosis. This percentage was substantially higher than that for decedents with mention of asbestosis (0.5%) or coal worker's pneumoconiosis (0.8%) or without mention of silicosis, asbestosis, or coal worker's pneumoconiosis (0.2%) (8). Additionally, among silicosis decedents, TB mortality in black males (9.1%) was over twice that in white males (3.4%) (8). However, the article was deficient in describing the overall trends of TB comortality with silicosis in the

United States. In addition, females and persons of ''other'' races were excluded from the study.

The trends in silicosis mortality and TB morbidity in the United States have previously been documented (9–13). However, the information on TB and silicosis comortality is limited. In this paper, we describe the temporal, demographic, and geographic patterns of respiratory TB and silicosis mortality and comortality in the United States. In addition, we identify US industries and occupations with elevated risk of silicosis-respiratory TB mortality.

MATERIALS AND METHODS

Data source

Multiple cause-of-death data collected annually for 1968–2006 were obtained from the National Center for Health Statistics (Centers for Disease Control and Prevention) under the Data Use Agreement for Vital Statistics Data Files for the purpose of health statistical analysis and reporting. All direct identifiers, as well as any characteristics that might have led to identification of the subjects, were omitted from the data set (14).

Case ascertainment

Decedents with an *International Classification of Diseases* (ICD) code for silicosis and/or respiratory TB listed on the death certificate as either the underlying cause of death (15) or a contributing cause of death were identified from the 1968–2006 mortality data. Decedents with silicosis and/or respiratory TB were identified using codes from the Eighth (US-Adapted), Ninth, and Tenth revisions of the ICD (Table 1) (16–18). In addition, for the years 1999–2006, deaths with an underlying cause coded as J65 (pneumoconiosis associated with tuberculosis) were included in the silicosis underlying cause-of-death tabulation if code J62 (silicosis) was listed as a contributing cause of death or in the respiratory

Table 1. *International Classification of Diseases* (ICD) Codes for Silicosis, Respiratory Tuberculosis, and Human Immunodeficiency Virus

Condition	ICD Revision and Rubric (ICD Code)		
	ICDA-8 (1968–1978)	ICD-9 (1979–1998)	ICD-10 (1999–Present)[a]
Respiratory tuberculosis	Pulmonary tuberculosis (011)	Primary tuberculous infection (010)	Respiratory tuberculosis, not confirmed bacteriologically or histologically (A16)
	Other respiratory tuberculosis (012)	Pulmonary tuberculosis (011)	Miliary tuberculosis (A19)
	Disseminated tuberculosis (018)	Other respiratory tuberculosis (012)	Sequelae of tuberculosis—sequelae of respiratory and unspecified tuberculosis (B90.9)
	Late effects of tuberculosis—respiratory tuberculosis (019.0)	Miliary tuberculosis (018)	
		Late effects of tuberculosis—late effects of respiratory or unspecified tuberculosis (137.0)	
Silicosis	Silicosis (515.0)	Pneumoconiosis due to other silica or silicates (502)	Pneumoconiosis due to dust containing silica (J62)
Silicotuberculosis	Silicotuberculosis (010)	No discrete ICD-9 code	No discrete ICD-10 code
HIV-related conditions[b]	No discrete ICDA-8 code	HIV infection with specified conditions (042)	HIV disease resulting in infectious and parasitic diseases (B20)
		HIV infection causing other specified conditions (043)	HIV disease resulting in malignant neoplasms (B21)
		Other HIV infection (044)	HIV disease resulting in other specified diseases (B22)
		Nonspecific abnormal histologic and immunologic findings—positive serologic or viral culture findings for HIV (7958)	HIV disease resulting in other conditions (B23)
			Unspecified HIV disease (B24)
			Laboratory evidence of HIV (R75)

Abbreviations: HIV, human immunodeficiency virus; ICD, *International Classification of Diseases*; ICDA-8, *International Classification of Diseases, Adapted for Use in the United States,* Eighth Revision; ICD-9, *International Classification of Diseases,* Ninth Revision; ICD-10, *International Classification of Diseases,* Tenth Revision.

[a] Deaths with the underlying cause coded as J65 (pneumoconiosis associated with tuberculosis) were included in the silicosis underlying cause-of-death tabulation if code J62 (silicosis) was listed as a contributing cause of death. Deaths with the underlying cause coded as J65 (pneumoconiosis associated with tuberculosis) were included in the respiratory TB underlying cause-of-death tabulation if code A16, A19, or B90.9 was listed as a contributing cause of death.

[b] Coded in National Center for Health Statistics multiple cause-of-death data files since 1987.

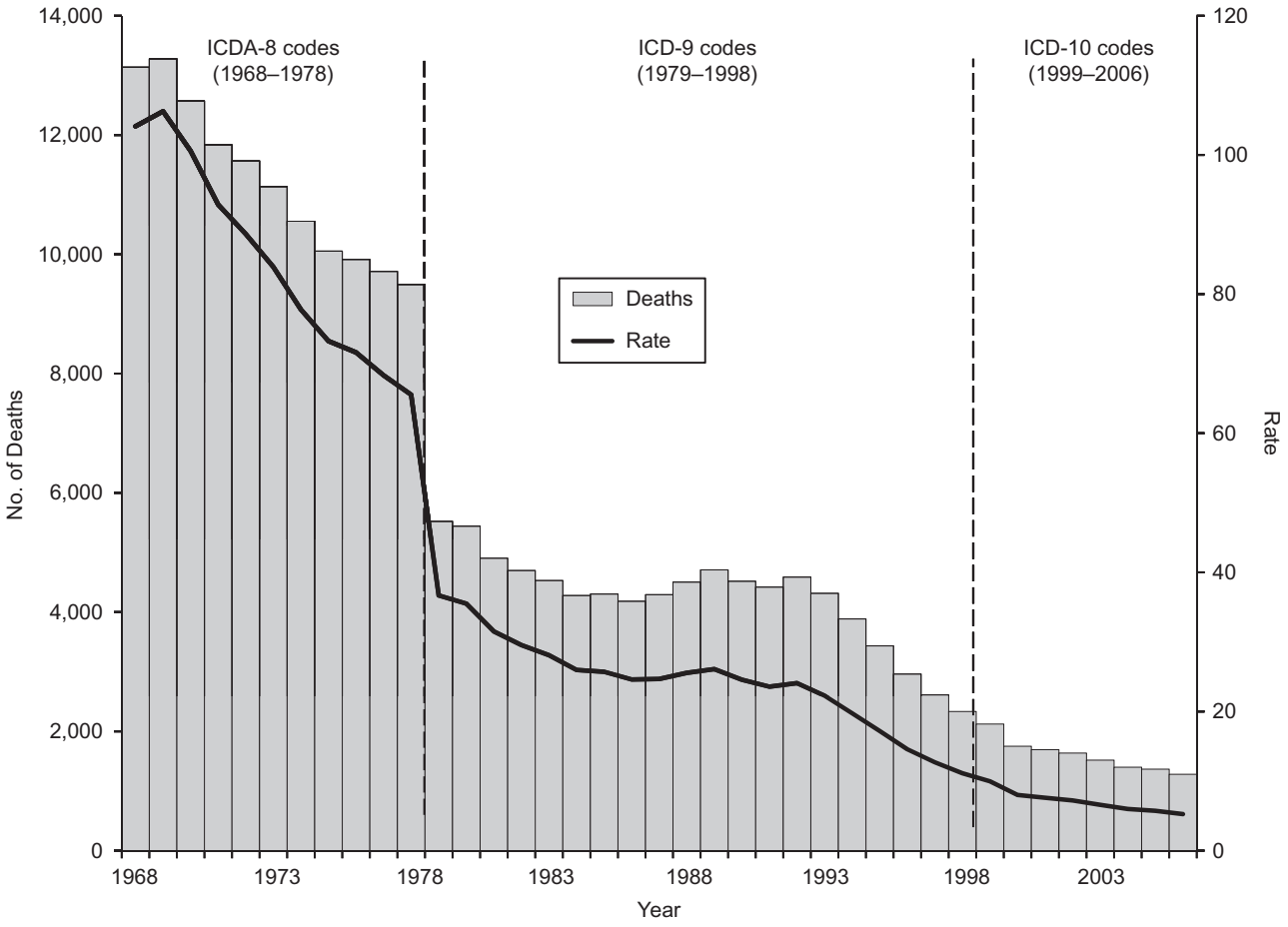

Figure 1. Numbers of deaths with respiratory tuberculosis ($n = 220,444$) and age-adjusted death rates per million population among US residents aged ≥25 years, by year, 1968–2006. Age-adjusted death rates were based on annual underlying or contributing cause-of-death data obtained from the National Center for Health Statistics. ICDA-8, *International Classification of Diseases, Adapted for Use in the United States,* Eighth Revision; ICD-9, *International Classification of Diseases,* Ninth Revision; ICD-10, *International Classification of Diseases,* Tenth Revision.

TB underlying cause-of-death tabulation if the code A16 (respiratory tuberculosis, not confirmed bacteriologically or histologically), A19 (miliary tuberculosis), or B90.9 (sequelae of respiratory and unspecified tuberculosis) was listed as a contributing cause of death.

Information on decedents' ethnicity was available for 1990–2006 and on human immunodeficiency virus (HIV) infection status for 1987–2006 (Table 1). Because of the occupational etiology and typically long latency period of silicosis, only deaths of persons aged ≥25 years were considered (3). Symptoms of accelerated silicosis usually manifest within 5–10 years after first exposure, and acute silicosis can occur within several weeks to 5 years after initial exposure to very high airborne concentrations of silica. Because some participants may have started working at the age of 16 years, we decided to examine decedents aged ≥25 years.

Industry and occupation

Standard industry and occupation information that met Centers for Disease Control and Prevention quality criteria was available for decedents in 26 states for the period 1985–1999 (19). The number of states reporting data in any particular year varied from 16 to 22, and the number of years of data available for any one state varied from 2 to 15. Information on decedents' usual industry and occupation (20) from death certificates was coded in the National Center for Health Statistics multiple cause-of-death data files according to the Census Bureau's 1980 Index of Industries and Occupations (1985–1992) or 1990 classification system (1993–1999) (21). Most codes and titles did not differ between the 1980 and 1990 systems (22).

Data analysis

We used SAS, version 9.2, software (SAS Institute Inc., Cary, North Carolina) for analyses. We age-adjusted death rates (per million per year) to the 2000 US standard population and computed the age-specific death rates (per million per year). To assess time trends for the numbers of deaths and death rates, we calculated the year-to-year difference for both numbers of deaths and death rates. We performed

Table 2. Characteristics of Decedents Aged ≥25 Years With Silicosis, Respiratory Tuberculosis, or Silicosis-Respiratory Tuberculosis Coded as an Underlying or Contributing Cause of Death, United States, 1968–2006

Characteristic	Silicosis		Respiratory TB		Silicosis-Respiratory TB		
	No.	%	No.	%	No.	%	Death Rate[a]
Total	16,648	100.0	220,444	100.0	2,278	100.0	0.32
Age group, years							
25–44	232	1.4	21,158	9.6	34	1.5	<0.01
45–64	3,632	21.8	64,373	29.2	578	25.4	0.08
≥65	12,784	76.8	134,913	61.2	1,666	73.1	0.24
Sex							
Male	16,268	97.7	144,134	65.4	2,255	99.0	0.79
Female	380	2.3	76,310	34.6	23	1.0	0.01
Race							
White	14,579	87.6	159,403	72.3	1,893	83.1	0.30
Black	1,992	12.0	52,702	23.9	373	16.4	0.62
Other	77	0.5	8,339	3.8	12	0.5	0.08
State/area of residence							
Pennsylvania	3,585	21.5	12,676	5.8	525	23.1	1.29
Ohio	1,763	10.6	8,939	4.1	258	11.3	0.81
West Virginia	671	4.0	2,327	1.1	146	6.4	2.35
Michigan	700	4.2	6,984	3.2	131	5.8	0.54
California	832	5.0	22,409	10.2	124	5.4	0.18
New York	788	4.7	25,623	11.6	116	5.1	0.21
Arizona	312	1.9	3,027	1.4	64	2.8	0.60
New Jersey	456	2.7	8,772	4.0	64	2.8	0.26
Illinois	441	2.6	11,177	5.1	59	2.6	0.18
Wisconsin	495	3.0	3,120	1.4	52	2.3	0.36
North Carolina	385	2.3	6,604	3.0	50	2.2	0.27
Alabama	275	1.7	4,806	2.2	47	2.1	0.41
Kentucky	333	2.0	4,410	2.0	42	1.8	0.38

Table continues

a Wilcoxon signed rank test on the year-to-year differences to test for the significance of time trends. Comparisons of proportions between groups were done using chi-square tests. All tests were 2-sided, with P values less than 0.05 being considered significant.

Proportionate mortality ratios (PMRs) for silicosis-respiratory TB cases were calculated by occupation and industry using state- and year-specific death certificate information on industry and occupation (22). The PMR was defined as the observed number of deaths with silicosis-respiratory TB (mentioned as either an underlying or contributing cause) in a specified industry/occupation divided by the expected number of deaths with silicosis-respiratory TB. The expected number of deaths was the total number of deaths in the Census Bureau's industry codes or occupation codes of interest multiplied by a proportion defined as the number of silicosis-respiratory TB deaths in all industries/occupations divided by the total number of deaths in all industries/occupations. The PMRs presented in this report were adjusted for age, sex, and race; 95% confidence intervals were calculated assuming a Poisson distribution of the data. For confidentiality reasons, PMRs were calculated only for industries and occupations with 5 or more silicosis-respiratory TB deaths.

RESULTS

Respiratory TB mortality

During the period 1968–2006, respiratory TB was coded as a cause of death for 220,444 deaths (age-adjusted death rate = 32.71 per million per year); of these, 80,948 decedents (36.7%) had respiratory TB coded as the underlying cause of death. The number of respiratory TB deaths varied annually, from a high of 13,278 (106.26 per million per year) in 1969 to a low of 1,281 (5.25 per million per year) in 2006 (Figure 1). Overall, respiratory TB mortality declined 88.5% from 1968 to 2006, from an average of 12,478 deaths per year during 1968–1972 to an average of 1,440 deaths per year during 2002–2006 ($P < 0.001$ for deaths and $P < 0.001$ for

Table 2. Continued

Characteristic	Silicosis		Respiratory TB		Silicosis-Respiratory TB		
	No.	%	No.	%	No.	%	Death Rate[a]
Virginia	376	2.3	4,708	2.1	42	1.8	0.26
Indiana	281	1.7	4,478	2.0	40	1.8	0.26
Colorado	502	3.0	1,675	0.8	37	1.6	0.46
Vermont	146	0.9	375	0.2	37	1.6	2.40
Texas	368	2.2	12,314	5.6	35	1.5	0.09
Massachusetts	188	1.1	5,075	2.3	32	1.4	0.17
Tennessee	244	1.5	5,626	2.6	29	1.3	0.20
Washington	241	1.4	2,725	1.2	29	1.3	0.24
New Mexico	144	0.9	1,088	0.5	28	1.2	0.80
Connecticut	184	1.1	2,322	1.1	27	1.2	0.28
Missouri	237	1.4	4,894	2.2	27	1.2	0.16
Utah	209	1.3	473	0.2	23	1.0	0.74
Florida	381	2.3	11,615	5.3	22	1.0	0.05
Maryland	160	1.0	4,616	2.1	18	0.8	0.15
Minnesota	256	1.5	2,750	1.2	17	0.8	0.13
Georgia	197	1.2	5,351	2.4	16	0.7	0.10
Idaho	136	0.8	354	0.2	16	0.7	0.56
Kansas	102	0.6	1,472	0.7	16	0.7	0.20
Montana	191	1.1	522	0.2	15	0.7	0.65
Oregon	124	0.7	1,710	0.8	15	0.7	0.18
Oklahoma	97	0.6	2,760	1.3	14	0.6	0.14
Louisiana	123	0.7	4,390	2.0	11	0.5	0.10
Other[b]	725	4.4	18,277	8.3	54	2.4	

Abbreviation: TB, tuberculosis.

[a] Age-specific death rate for age groups and age-adjusted death rate (per million persons) for the other groups shown in the table.

[b] States with ≤10 silicosis-respiratory TB deaths during 1968–2006: Alaska, Arkansas, Delaware, District of Columbia, Hawaii, Iowa, Maine, Mississippi, Nebraska, Nevada, New Hampshire, North Dakota, Rhode Island, South Carolina, South Dakota, and Wyoming.

time-related trend in the death rate). Of all respiratory TB deaths, 21,158 decedents (9.6%; 2.93 per million per year) were aged 25–44 years, 64,373 (29.2%; 9.89 per million per year) were aged 45–64 years, and 134,913 (61.2%; 19.89 per million per year) were aged ≥65 years; 144,134 (65.4%; 51.67 per million per year) were male and 76,310 (34.6%; 19.46 per million per year) were female; and 159,403 (72.3%; 26.44 per million per year) were white and 52,702 (23.9%; 84.69 per million per year) were black (Table 2).

Of 45,829 respiratory TB deaths reported during 1990–2006 for which information on ethnicity was available, 5,020 decedents (11.0%; age-adjusted death rate = 21.24 per million per year) were Hispanic, 39,612 (86.4%; 11.84 per million per year) were non-Hispanic, 801 (1.7%) had unknown ethnicity, and 396 (0.9%) had unreported ethnicity. Over 74% of Hispanic decedents were from 3 states—California ($n = 1{,}564$; 31.2%), Texas ($n = 1{,}176$; 23.4%), and New York ($n = 978$; 19.5%), with corresponding age-adjusted death rates of 24.01, 29.08, and 33.66 per million population.

Silicosis mortality

During 1968–2006, silicosis was coded as a cause of death on 16,648 death certificates (age-adjusted death rate = 2.40 per million per year); of these, 7,851 (47.2%) had silicosis coded as the underlying cause of death. The annual number of silicosis deaths varied from a high of 1,135 (8.74 per million per year) in 1968 to a low of 125 (0.52 per million per year) in 2006 (Figure 2). Overall, silicosis mortality declined 85.0% from 1968 to 2006, from an average of 1,034 deaths per year during 1968–1972 to an average of 156 deaths per year during 2002–2006 ($P = 0.006$ for deaths and $P < 0.001$ for time-related trend in the death rate).

Of the 16,648 silicosis deaths, 232 decedents (1.4%; 0.03 per million per year) were aged 25–44 years, 3,632 (21.8%; 0.52 per million per year) were aged 45–64 years, and 12,784 (76.8%; 1.85 per million per year) were aged ≥65 years; 16,268 (97.7%; 5.96 per million per year) were male and 380 (2.3%; 0.10 per million per year) were female; and 14,579

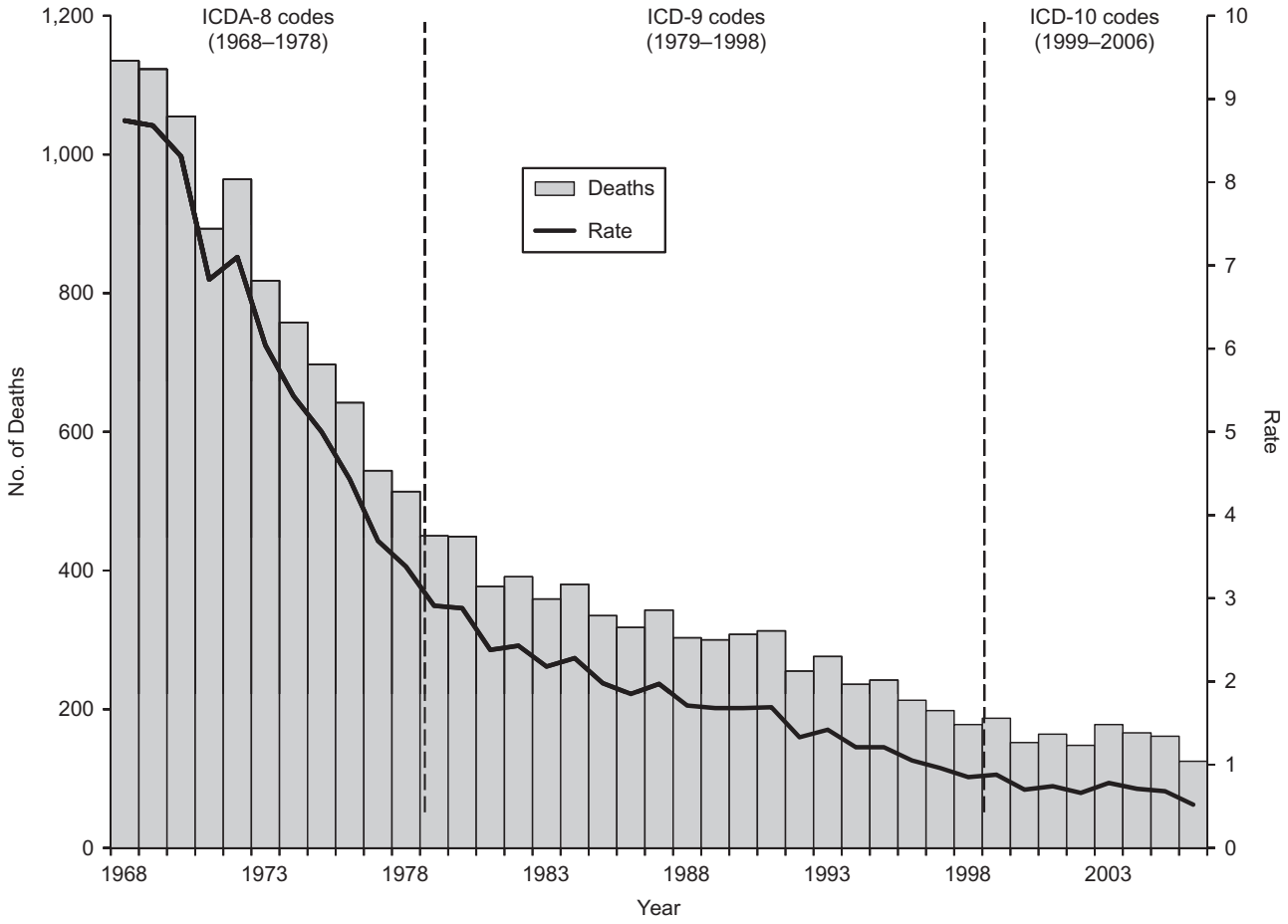

Figure 2. Numbers of deaths with silicosis ($n = 16{,}648$) and age-adjusted death rates per million population among US residents aged ≥25 years, by year, 1968–2006. Age-adjusted death rates were based on annual underlying or contributing cause-of-death data obtained from the National Center for Health Statistics. ICDA-8, *International Classification of Diseases, Adapted for Use in the United States,* Eighth Revision; ICD-9, *International Classification of Diseases,* Ninth Revision; ICD-10, *International Classification of Diseases,* Tenth Revision.

(87.6%; 2.34 per million per year) were white and 1,992 (12.0%; 3.35 per million per year) were black (Table 2).

Of 3,500 silicosis deaths reported during 1990–2006 for which information on ethnicity was available, 182 decedents (5.2%; age-adjusted death rate = 0.94 per million per year) were Hispanic, 3,279 (93.7%; 0.97 per million per year) were non-Hispanic, 12 (0.3%) had unknown ethnicity, and 27 (0.8%) had unreported ethnicity. The majority (70.3%) of Hispanic decedents were from 4 states—California ($n = 37$; 20.3%), Texas ($n = 31$; 17.0%), Colorado ($n = 30$; 16.5%), and New Mexico ($n = 30$; 16.5%), with corresponding age-adjusted death rates of 0.66, 0.76, 8.12, and 5.32 per million population.

Silicosis-respiratory TB mortality

Among all silicosis deaths, respiratory TB was listed on 2,278 (13.7%) death certificates, corresponding to an age-adjusted death rate of 2.4 per million per year. Of silicosis-respiratory TB deaths, 1,666 decedents (73.1%) were aged ≥65 years, 2,255 (99.0%) were male, and 1,893 (83.1%) were white (Table 2). The highest number of silicosis-respiratory TB deaths, 326 (2.5 per million population), was reported in 1968. In each of the years 2001, 2004, and 2005, only 1 silicosis-respiratory TB death was reported, and in 2006, none were reported (Figure 3). The annual average for silicosis-respiratory TB deaths declined 99.5% during the study period, from 239.8 per year during 1968–1972 to 1.2 per year during 2002–2006 ($P = 0.007$ for deaths and $P < 0.001$ for time-related trend in the death rate).

Of all silicosis-respiratory TB deaths, the underlying cause was coded as silicotuberculosis (ICD-8, Adapted, code 010) for 1,320 (57.9%), respiratory TB for 194 (8.5%), and silicosis for 54 (2.4%). Discrete ICD codes for silicosis and respiratory TB were available during the period 1979–2006. Of the 311 silicosis-respiratory TB deaths reported during 1979–2006, the underlying cause was coded as TB for 168 (54.0%) and as silicosis for 30 (9.6%). The most frequently reported underlying causes of death for the remaining 705 decedents were chronic ischemic heart disease ($n = 107$) during

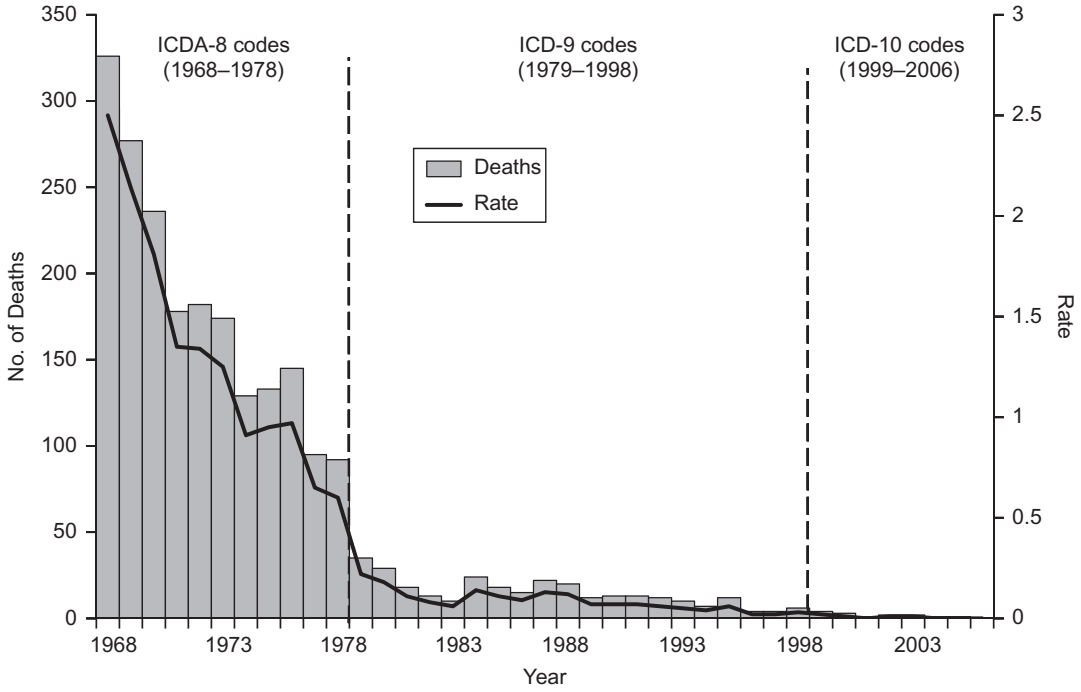

Figure 3. Numbers of deaths with silicosis-respiratory tuberculosis ($n = 2,278$) and age-adjusted death rates per million population among US residents aged ≥25 years, by year, 1968–2006. Age-adjusted death rates were based on annual underlying or contributing cause-of-death data obtained from the National Center for Health Statistics. ICDA-8, *International Classification of Diseases, Adapted for Use in the United States,* Eighth Revision; ICD-9, *International Classification of Diseases,* Ninth Revision; ICD-10, *International Classification of Diseases,* Tenth Revision.

1968–1978, chronic airway obstruction not elsewhere classified ($n = 18$) during 1979–1998, and other chronic obstructive pulmonary disease ($n = 2$) during 1999–2006.

Of 95 silicosis-respiratory TB deaths reported during 1990–2006 for which information on ethnicity was available, 8 decedents (8.4%) were Hispanic. All Hispanic decedents with silicosis-respiratory TB were from 5 states—California ($n = 3$), Texas ($n = 2$), Colorado ($n = 1$), New Mexico ($n = 1$), and Utah ($n = 1$).

Geographic distribution. Nearly 41% of all silicosis-respiratory TB deaths in the United States occurred among residents of 3 states—Pennsylvania ($n = 525$; 23.1%), Ohio ($n = 258$; 11.3%), and West Virginia ($n = 146$; 6.4%) (Table 2). Corresponding age-adjusted death rates for the 3 states were 1.29, 0.81, and 2.35 per million population, more than twice the national average of 0.32 per million population.

HIV infection status. Information on HIV infection status was available for 4,446 silicosis deaths, 59,332 respiratory TB deaths, and 149 silicosis-respiratory TB deaths reported during 1987–2006. No silicosis decedent and no silicosis-respiratory TB decedent had HIV infection listed as the underlying cause of death; 578 (1.5%) of 39,530 decedents with respiratory TB listed as the underlying cause of death had HIV infection listed as a contributing cause of death.

Industry and occupation. During 1985–1999, a total of 32,067,371 deaths, including 172 silicosis-respiratory TB deaths, among persons aged ≥25 years were reported. Of these, information on industry and occupation was available for 8,479,887 (26.4%) deaths, including 67 (39.0%) deaths involving silicosis-respiratory TB (silicosis-respiratory TB deaths vs. non-silicosis-respiratory TB deaths: $P < 0.001$). Of 31 industries reported, significantly elevated PMRs for silicosis-respiratory TB death were associated with miscellaneous nonmetallic mineral and stone products (PMR = 73.7, 95% confidence interval (CI): 33.8, 139.8); iron and steel foundries (PMR = 30.5, 95% CI: 12.2, 62.8); and blast furnaces, steelworks, and rolling and finishing mills (PMR = 4.5, 95% CI: 1.7, 9.8) (Table 3). Of 32 occupations reported, crushing and grinding machine operators (PMR = 142.3, 95% CI: 57.2, 293.5), mining machine operators (PMR = 9.5, 95% CI: 3.8, 19.6), machinists (PMR = 5.7, 95% CI: 2.1, 12.5), and laborers (except construction workers) (PMR = 2.4, 95% CI: 1.2, 4.5) had significantly elevated PMRs (Table 3).

DISCUSSION

This study has shown a significant decline in silicosis-respiratory TB mortality in the United States during 1968–2006. The decline parallels decreases in both silicosis death and TB death resulting from implementation of disease-specific preventive measures (12, 23) and a decrease in employment involving silica exposure in the United States (12). Despite progress towards elimination of silicosis and TB, both diseases still occur. Silicosis persists despite the existence of enforceable limits on workers' exposure to respirable

Table 3. Occupations and Industries Associated With Silicosis-Respiratory Tuberculosis Death in Selected States[a] and Years, United States, 1985–1999

Industry or Occupation	No. of Deaths	Proportionate Mortality Ratio[b]	95% Confidence Interval[c]
Industry (Census Bureau industry code)[d]			
Miscellaneous nonmetallic mineral and stone products (262)	9	73.65	33.79, 139.76
Iron and steel foundries (271)	7	30.45	12.23, 62.78
Blast furnaces, steelworks, rolling and finishing mills (270)	6	4.5	1.65, 9.81
Other[e]	44		
Occupation (Census Bureau occupation code)[d]			
Crushing and grinding machine operators (768)	7	142.34	57.16, 293.48
Mining machine operators (616)	7	9.53	3.83, 19.64
Machinists (637)	6	5.72	2.10, 12.47
Laborers, except construction (889)	10	2.43	1.17, 4.47
Janitors and cleaners (453)	5	1.89	0.61, 4.41
Other[e]	31		

[a] Alaska, Colorado, Georgia, Hawaii, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Vermont, Washington, and West Virginia.
[b] Adjusted for age, sex, and race.
[c] Calculated assuming a Poisson distribution of the data.
[d] Industry and occupation were not reported for 1 death certificate.
[e] Includes occupations and industries with fewer than 5 deaths.

crystalline silica dust. Substantial overexposures continue to occur, particularly in construction, manufacturing, and mining industries, indicating a need for hazard surveillance and the development of workplace-specific interventions (22, 24).

After the resurgence of TB in the mid-1980s (25), federal, state, and local governments increased their TB control measures, including strict recommendations for overall TB control in the United States and instructions for TB screening and treatment among persons applying for immigration benefits (26). TB still persists in the United States, particularly among foreign-born persons and racial/ethnic minorities (10). Crowding, low income, poverty, unemployment, and low educational level have been associated with increased TB risk (27). Approximately half of the increased risk of TB among US-born blacks, Hispanics, and Native Americans is accounted for by socioeconomic status indicators (27). In addition, TB is associated with HIV infection and acquired immunodeficiency syndrome, incarceration, homelessness, and intravenous drug abuse (23). HIV infection has been found to be highly associated with TB morbidity among whites, blacks, males, and persons aged 25–44 years (28).

The greater decline in silicosis-respiratory TB deaths among blacks and persons aged ≥45 years parallels the patterns of decline in silicosis mortality and TB morbidity (9, 23, 29, 30). One of the most important factors responsible for the decrease in TB in the United States is thought to be improvements in TB control and treatment programs in communities serving the populations at greatest risk for TB (31). Similarly, regulatory limits on silica dust exposure by the Mine Safety and Health Administration and the Occupational Safety and Health Administration and silica dust exposure limits recommended by the National Institute for Occupational Safety and Health have probably led to reduced silica dust exposures in the United States since the 1970s (12). The burden of silicosis (32) and TB (33), especially multiple-drug-resistant TB (34) and coinfection with HIV (35), is high in developing countries. Global elimination and control of silicosis and TB has been addressed by the World Health Organization. In 1995, the International Labour Organization/World Health Organization joint committee on occupational health launched a global program on the elimination of silicosis for raising awareness on the magnitude of the silicosis problem, demonstrating the feasibility of silicosis elimination, and training occupational hygienists in developing countries (36). The World Health Organization's Global Plan to Stop TB offers an evidence-based approach for reducing the burden of TB (37). Racial and ethnic minorities have elevated TB morbidity (3), consistent with generally lower socioeconomic status (3).

In our study, although there were few deaths, the highest industry-specific and occupation-specific PMRs for silicosis-respiratory TB death were associated with employment in the "miscellaneous nonmetallic mineral and stone products" industry and with crushing and grinding machine operators. While the mortality data analyzed for this report do not include information on silica exposure, blacks are employed in jobs with potentially higher silica exposures than whites (38). When compared with white men and women, respectively, black men had a 25% greater chance of exposure to at least

1 occupational hazard, and black women had a 93% greater chance of exposure to at least 1 hazard (39). On average, black workers find themselves in substantially more dangerous occupations as compared with whites with the same levels of education and experience (39).

Thirty-four cases of silicosis-respiratory TB occurred among persons aged 25–45 years. This is of particular concern because extremely high exposure to crystalline silica may result in much shorter latency and more rapid progression of silicosis (i.e., acute or accelerated silicosis) (3).

In our study, silicosis-respiratory TB deaths reported from Pennsylvania, Ohio, and West Virginia accounted for 41% of all such deaths. The geographic distribution of silicosis-respiratory TB deaths is similar to the distribution of silicosis deaths associated with mining or construction industries in these states (12).

The findings in this report are subject to some limitations. Death certificates may reflect erroneous or incomplete diagnoses, resulting in misclassification of conditions under study (40). For example, silicosis may be classified as ''other pneumoconiosis.'' Seven decedents with respiratory TB were coded as having ''unspecified pneumoconiosis'' on their death certificates (2 in 1999, 3 in 2000, 1 in 2001, and 1 in 2005); no additional evidence was available to determine the type of pneumoconiosis (i.e., silicosis, asbestosis, coal worker pneumoconiosis). Death certificates do not contain data on the date of onset or diagnosis of any condition; thus, it was impossible to determine the sequence of events—for example, whether silicosis preceded TB. Additionally, codes for industry and occupation were available for only 39.0% of silicosis-respiratory TB decedents for selected states and years. Thus, these data are probably not nationally representative. Industry and occupation are surrogates for exposure, and no exposure data are recorded on death certificates. Moreover, there may be recall bias by next of kin, resulting in erroneous recollections of occupation and industry (41). However, generally good agreement exists between this information on death certificates and that obtained from other sources (42). Because we had no data on the incidence of silicosis-respiratory TB, we could not address whether the decrease in silicosis-respiratory TB mortality we found was solely due to improvement in the treatment of TB, which reduced mortality, or due to an actual decrease in TB among persons with silicosis. Finally, the ICD cause-of-death codes used in this analysis changed twice during the period 1968–2006. Differences exist between the Eighth, Ninth, and Tenth revisions of the ICD in terms of coding for silicosis and respiratory TB. The overall effect of this change may explain the abrupt 42% decrease in the number of respiratory TB deaths between the Eighth and Ninth revisions of the ICD (i.e., between 1978 and 1979).

While comorbidity and comortality with silicosis and TB once represented such a prevalent scourge that ''silicotuberculosis'' had a discrete ICD code, 2006 marks the first year in which no silicosis-respiratory TB deaths were recorded among residents of the United States. This accomplishment in the United States suggests that prevention and control measures for TB and silica exposure should be implemented globally, particularly in areas with endemic TB and industries and occupations involving silica exposure.

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