

Silicosis Mortality Surveillance in the United States, 1968–1990

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The temporal, demographic, geographic, and occupational patterns of silicosis mortality in the United States were examined based on the national multiple-cause-of-death data available since 1968 from the National Center for Health Statistics. Since silicosis is an occupational lung disease, decedents less than 15 years old were excluded. The total number of deaths with silicosis was 13,744 for the period 1968 to 1990, and silicosis was the underlying cause of death in approximately 46 percent of these deaths. Approximately 98 percent of deaths with silicosis occurred in males. The racial distribution of decedents with silicosis was 88.4 percent white, 11.3 percent black, and 0.3 percent other races. An annual maximum of 1157 silicosis deaths occurred in 1968 and a minimum of 301 occurred in 1988. The annual age-adjusted mortality rate per million population declined from a maximum of 5.64 in 1968 to a minimum of 0.96 in 1988 and 1989. In recent years the annual silicosis death counts and rates have not evidenced continued declines. Deaths with silicosis were concentrated in 12 states: California, Colorado, Florida, Illinois, Michigan, New Jersey, New York, Ohio, Pennsylvania, Virginia, West Virginia, and Wisconsin accounted for 68 percent of all silicosis deaths. Based on a subset of the national data for which usual industry and occupation information was available, the construction industry accounted for the highest proportion of silicosis deaths—over 10 percent of the total. By occupation, silicosis proportionate mortality ratios (PMRs) were highest in metal/plastic processing machine operators (PMR = 330, 95% confidence interval = 142 to 650), although all of the ten highest occupation-specific PMRs were statistically significant. These silicosis mortality data can be utilized to develop hypotheses for further research, to target and prioritize interventions to prevent silicosis, and to evaluate the effectiveness of silicosis prevention efforts. BANG, K.M.; ALTHOUSE, R.B.; KIM, J.H.; GAME, S.R.; CASTELLAN, R.M.: SILICOSIS MORTALITY SURVEILLANCE IN THE UNITED STATES, 1968–1990. APPL. OCCUP. ENVIRON. HYG. 10(12):1070–1074; 1995.

The Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH), has developed a silicosis mortality surveillance system using the national multiple-cause-of-death data available since 1968 from the National Center for Health Statistics (NCHS). A subset of these data for the period 1985–1990 includes usual industry and occupation codes for the decedents.

The purpose of this article is to present the temporal trend of silicosis mortality, the demographic and geographic distribution of silicosis deaths, and silicosis proportionate mortality ratios (PMRs) by occupation. The data presented here are

included in the latest edition⁽¹⁾ of the *Work-Related Lung Disease Surveillance Report*, originally published in 1991.⁽²⁾

Materials and Methods

Data were derived from the NCHS multiple-cause-of-death tapes covering the period 1968–1990. These computer tapes list both underlying and contributing causes of death as coded from death certificates, as well as demographic information on all U.S. decedents.⁽³⁾ Deaths with silicosis were identified as those with International Classification of Disease (ICD)-8 code 515.0 ("silicosis") or code 010 ("silituberculosis") in the 1968–1978 period,⁽⁴⁾ and ICD-9 code 502 ("pneumoconiosis due to other silica or silicates") in the 1979–1990 period.⁽⁵⁾ For this analysis, all decedents less than 15 years of age were excluded because of the occupational nature of silicosis.

The descriptive analyses of silicosis mortality data presented in this report include: (1) annual death counts, and distribution of silicosis deaths by age, race, and sex; (2) annual crude silicosis mortality and age-adjusted silicosis mortality rates computed by the direct method, using the 1940 U.S. population, age 15 and over, as the standard. (National population estimates for the period 1970–1990 from the U.S. Bureau of the Census were used for computing annual crude silicosis mortality rate.⁽⁶⁾); (3) geographic distribution of silicosis mortality by state; (4) distribution of silicosis deaths by usual industry; and (5) silicosis PMRs by occupation for the period 1985–1990. Usual occupation and industry were coded using the 1980 Bureau of Census occupation and industry codes.⁽⁷⁾ PMR was defined as the observed number of silicosis deaths (based on underlying cause of death) with the specified usual occupation divided by the expected number of silicosis deaths, standardized for age at death and year of death. Ninety-five percent confidence intervals (CIs) of PMRs were calculated assuming that the observed deaths were distributed as Poisson random variables.⁽⁸⁾ PMRs were not computed for occupations with less than three observed deaths.

Results

The total number of U.S. deaths with mention of silicosis from 1968 through 1990 was 13,744, and 46 percent of these deaths had silicosis listed as the underlying cause of death. Deaths with silicosis are tabulated by age, sex, and race in Table 1. Approximately 98 percent of deaths with silicosis occurred in males. While the mean age at death was 71.5 years, a total of 200 deaths with mention of silicosis occurred in individuals less than 45 years old during the period 1968–1990. The racial distribution of decedents with silicosis was approximately 88 percent white, 11 percent black, and less than 1 percent other races.

TABLE 1. Number of Deaths with Silicosis, U.S. Residents Age 15 and Over, by Sex, Race, and Age, 1968-1990

	Number of Deaths	%
Total	13,744	100.0
Sex/race		
Male	13,486	98.1
White	11,914	(88.3)*
Black	1,530	(11.3)*
Other	42	(0.3)*
Female	258	1.9
White	235	(91.1)*
Black	23	(8.9)*
Other	0	(0.0)
Age group		
15-24	16	0.1
25-34	37	0.3
35-44	137	1.0
45-54	618	4.5
55-64	2569	18.7
65-74	4974	36.2
75-84	4229	30.8
85 and over	1164	8.5

*Percentages in parentheses are the percent of each sex-specific total.

Figure 1 presents the annual number of deaths with silicosis during the period from 1968 to 1990. The annual number of deaths with silicosis decreased from 1157 in 1968 to 308 in 1990, with most of the decline occurring before 1980. Notably, there was no apparent effect on the silicosis death count related to the change in ICD codes which occurred between 1978 and 1979.

Figure 2 shows overall crude and age-adjusted silicosis mortality rates from 1968 to 1990. The annual crude rate (per million population) declined from a maximum of 7.92 in 1968

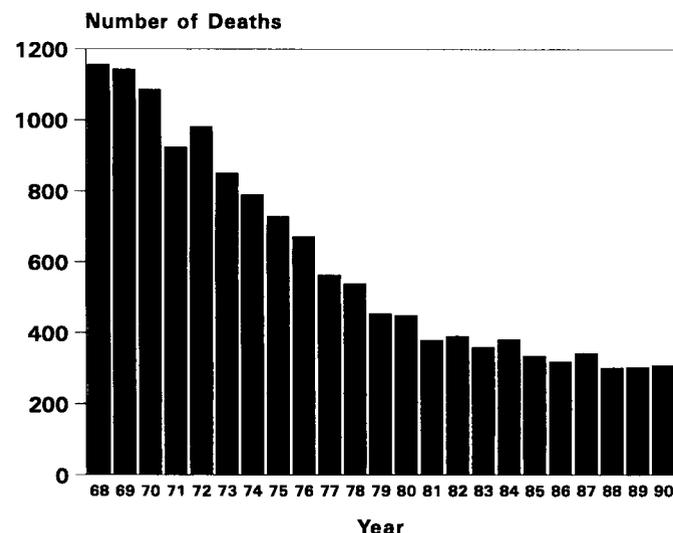


FIGURE 1. Number of deaths from silicosis, U.S. residents age 15 and over, 1968-1990.

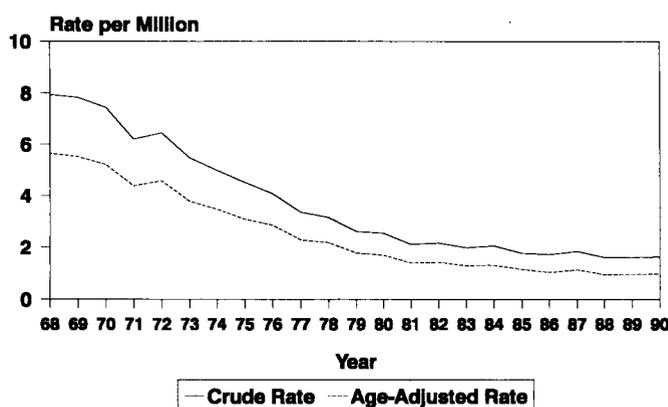


FIGURE 2. Crude and age-adjusted silicosis mortality rates, U.S. residents age 15 and over, 1968-1990.

to 1.63 in 1990. The age-adjusted mortality rate (per million population) declined similarly, from 5.64 in 1968 to 0.98 in 1990. For both crude and age-adjusted rates, declining mortality rates have leveled off in more recent years. Not shown in the figure, the age-adjusted mortality rate among white males has declined by approximately 83 percent, from 12.5 per million in 1968 to 2.1 per million in 1990. Among black males the rate declined by approximately 71 percent, from 14.5 to 4.2 per million during the same period.

Figure 3 presents the geographic distribution of deaths with silicosis by state. Over the period 1968-1990, more than 300 deaths with silicosis occurred in each of 12 states: Pennsylvania (n = 3238), Ohio (n = 1492), California (n = 697), New York (n = 652), West Virginia (n = 619), Michigan (n = 571), New Jersey (n = 396), Colorado (n = 380), Wisconsin (n = 356), Illinois (n = 351), Virginia (n = 328), and Florida (n = 304). Deaths with silicosis in these 12 states accounted for about 68 percent of the national total over this 23-year period.

A total of 683 deaths with silicosis were included in a subset of data for 25 selected states reporting usual occupation and industry codes for one or more selected years (1985-1990) as shown in Table 2. Usual industry data were missing for only 3.4 percent of these deaths. The five industries most frequently recorded on death certificates with mention of silicosis were construction (10.8%), metal mining (7.9%), blast furnaces, steelworks, and finishing mills (6.9%), miscellaneous nonmetallic mineral and stone products (6.1%), and coal mining (5.9%).

The ten highest silicosis PMRs by usual occupation are shown in Table 3. Point estimates of the PMRs ranged from 7 to as high as 330, and all 95 percent CIs excluded 1.

Discussion

Silicosis, a specific type of pneumoconiosis, is an occupational lung disease caused by the inhalation of respirable crystalline silica dust. Although silicosis can occur in an acute form with a relatively short latency following high intensity occupational exposures, it typically presents as chronic disease following 10 or more years of exposure to crystalline silica.^(9,10) Through elimination or control of exposure (e.g., substitution of less toxic abrasive blasting materials for sand, engineering controls,

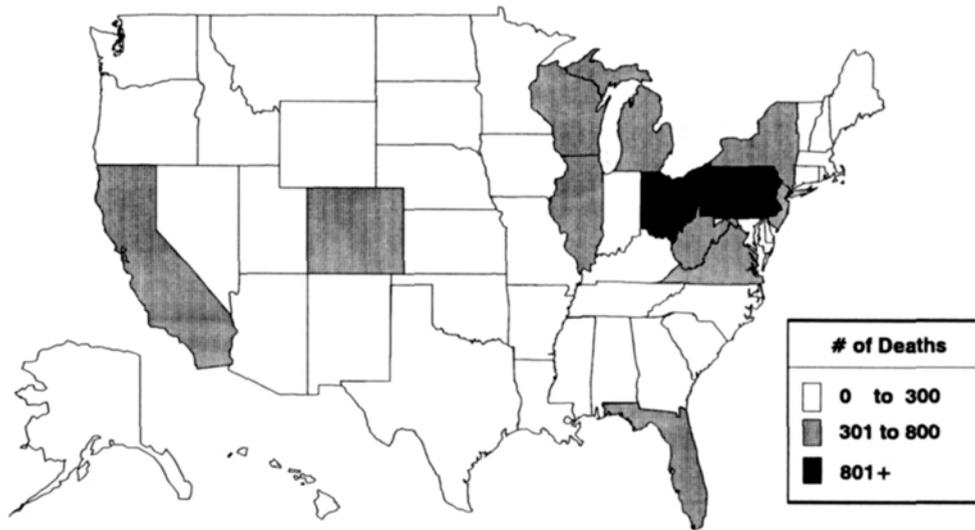


FIGURE 3. Geographic distribution of silicosis deaths, U.S. residents age 15 and over, by state, 1968–1990.

and proper personal respiratory protection), silicosis is preventable. Nevertheless, silicosis continues to account for more than 300 deaths each year in the United States. While many of these deaths occur in elderly individuals first exposed to crystalline silica dust as young adults before 1950, a substantial number result from more recent exposure. For example, among 388 cases of silicosis reported to state health departments in Michigan, New Jersey, and Wisconsin, between 1987 and 1990, 23 (6%) were first exposed after 1969,⁽¹¹⁾ and recent acute and accelerated silicosis deaths continue to occur.^(12,13)

The multiple-cause-of-death data used in this study offer a readily accessible source of national data for silicosis mortality surveillance. Clear secular trends can be observed (e.g., Figure 1) only because annual data tapes have been prepared in

standard format covering the years since 1968. The typical 2-year delay in availability of each year's national data tape is not a major shortcoming with respect to mortality surveillance of silicosis, a noncommunicable disease which typically has a long and variable latency.

A particular strength of mortality surveillance based on multiple cause of death data is that it permits ascertainment of contributing, as well as underlying, causes of death. This is particularly important for chronic conditions like silicosis, which may cause years of impairment and disability in individuals who more often than not die as a result of other underlying causes. In fact, in over half (54%) of the silicosis deaths ascertained from the multiple cause of death data tapes, silicosis was listed as a contributing cause.

Since mild silicosis (by radiographic criteria) infrequently causes clinically significant impairment,^(9,10) silicosis is undoubtedly underascertained through death certificate data, even taking into account contributing causes of death. Consistent with this assertion, the current national annual count of 300 silicosis deaths per year is only one-third to one-fourth of what would reasonably account for the U.S. Department of Labor 1980 estimate that 59,000 cases of silicosis would develop in the total work force of over one million persons then exposed to silica.⁽¹⁴⁾ Despite the overall undercount of silicosis ascertained through death certificate data, the fact that disease listed on the death certificate is more likely to represent more serious disease imparts utility to the use of death certificate data for surveillance purposes.

One limitation of death certificate data is the well-known potential for misclassification of cause of death.⁽¹⁵⁾ In addition to potential missed diagnoses by physicians who care for patients with silicosis, the way in which underlying and contributing causes of death are written on the death certificate influences later coding. With respect to the latter, it is likely that silicosis accounts for a substantial proportion of the 12,180 deaths coded under the ICD-9 rubric of "unspecified pneumoconiosis" during the period 1968–1990.⁽¹⁾

The silicosis mortality data we report here reveal a clear

TABLE 2. Most Frequently Recorded Usual Industries on Death Certificates with Mention of Silicosis, U.S. Residents Age 15 and Over, Selected States, 1985–1990

CIC code*	Industry	Number	%
60	Construction	74	10.8
40	Metal mining	54	7.9
270	Blast furnaces, steelworks, finishing mills	47	6.9
262	Nonmetallic mineral/stone products	42	6.1
41	Coal mining	40	5.9
271	Iron and steel foundries	37	5.4
50	Nonmetallic mining/quarrying, except fuel	35	5.1
392	Not specified manufacturing industries	25	3.7
10	Agricultural production, crops	22	3.2
961	Homemaker, student, volunteer	17	2.5
261	Pottery and related products	15	2.2
	All other industries	252	36.9
	Industry not reported	23	3.4
	Total	683	100.0

*Census Industry Classification.

TABLE 3. Ten Highest Silicosis PMRs by Usual Occupation on Death Certificates, U.S. Residents Age 15 and Over, Selected States, 1985–1990

COC* Code	Occupation	Number of Deaths	PMR	95% CI
725	Miscellaneous metal and plastic processing machine operators	8	330.2	142.3–650.1
675	Hand molders and shapers, except jewelers	8	77.6	33.4–152.7
768	Crushing and grinding machine operators	7	48.1	19.3–99.1
787	Hand molding, casting, and forming operators	3	33.7	6.9–98.4
719	Molding, casting machine operators	8	26.3	11.3–51.7
616	Mining machine operators	37	17.2	11.9–23.9
599	Construction trades, not elsewhere classified	5	15.4	5.0–36.0
709	Grinding, buffing, polishing machine operators	4	11.0	3.0–28.0
878	Machine feeders, offbearers	3	8.1	1.7–23.6
516	Heavy equipment mechanics	3	7.4	1.5–21.7

*Census Occupation Classification.

downward trend between 1968 and the early 1980s. It is notable that the 1978–1979 change in cause of death coding from ICD-8 to ICD-9 codes, which involved a change in the coding categories involving silicosis, seems not to have affected the clear downward trend in mortality at that time. This was so despite the apparently less clear and less specific ICD-9 category of “pneumoconiosis due to other silica or silicates,” suggesting that silicosis represents an overwhelming majority of deaths coded to this category. Since the mid-1980s national silicosis mortality has been essentially stable in terms of both counts and population-based rates. This, along with continuing reports of cases of silicosis resulting from relatively recent exposure^(11,12) and evidence of continuing crystalline silica exposures in excess of permissible exposure limits suggest the need for enhanced intervention.

The silicosis mortality data we report offer some guidance for such intervention. By state, over the period 1968–1990, death counts with silicosis tend to have been concentrated in the nation’s “rust belt” and contiguous states, as well as in California, Colorado, and Florida, a finding which updates a similar pattern based on the national mortality data from 1968 to 1987.⁽¹⁶⁾ While these data cannot provide an answer, one question raised by this geographic distribution is whether a substantial proportion of the silicosis deaths occurring in Florida are the result of migration of individuals with silicosis to that state. In five (Illinois, Michigan, New Jersey, Ohio, and Wisconsin) of the 12 states which had more than 300 deaths with silicosis over the 1968–1990 period, and in two additional states, NIOSH has funded case-based silicosis surveillance and intervention under the Sentinel Event Notification System for Occupational Risks (SENSOR) program.⁽¹⁷⁾ Working with these states, NIOSH has developed reporting guidelines and a surveillance case definition for silicosis.⁽¹⁸⁾ Many state health departments have established silicosis (or pneumoconioses in general) as reportable diseases in their jurisdictions,⁽¹⁹⁾ and can adopt the surveillance and intervention methods developed by SENSOR-funded states to enhance silicosis prevention in their own jurisdictions.

The listing of the most frequently mentioned usual industries on death certificates of decedents with silicosis includes those with well-known silicosis risks, such as mining, quarrying, and metalworks. It is notable, however, that the construc-

tion industry accounted for the most silicosis deaths—over 10 percent of the total. Occupations in construction industry include brickmasons, molders, painters, construction contractors, construction superintendents, and concrete workers. The Occupational Safety and Health Administration Management Information System data for 1979–1982 inspections showed that mean severity levels of silica exposure in construction industry (heavy construction and special trades) were 4.6 times the permissible exposure limit.⁽²⁰⁾

By occupation, the results of the PMR analysis presented in this report showed an elevated risk of silicosis in several occupations known to be exposed to respirable crystalline silica. The extremely high silicosis PMR in metal processing machine operators is consistent with recent SENSOR findings that approximately 60 percent of reported cases of silicosis worked in primary metal industries.⁽¹¹⁾

There are limitations to the industry and occupation coding on national mortality data. First, in providing information only on the usual occupation and industry for each decedent, some degree of misclassification (if one assumes that the usual industry and occupation is the one associated with etiologic exposure) necessarily results.⁽²¹⁾ The second data limitation is that the codes available from the NCHS data tapes are three digit for industry and for occupation, rather than the more detailed four-digit standard industry codes and standard occupation codes.⁽⁷⁾ Thus, while these NCHS codes do permit differentiation by industry and occupation, their lack of precision can be limiting with respect to using them to specifically target preventive interventions. Furthermore, NCHS provides coding for usual industry and occupation only since 1985, and only for deaths occurring in a variable subset of up to only about half of the states. Thus, not only do these data provide a limited number of observations for analysis, but the resulting figures are not necessarily representative of the national situation. Nevertheless, useful leads for further investigation and ultimate preventive intervention arise from these data.

In conclusion, the temporal trends in silicosis mortality (Figures 1 and 2), which demonstrate a leveling off following a prolonged decline, suggest the need for a change in prevention strategies if a downward trend is to be resumed. As illustrated in this article, silicosis mortality surveillance based on NCHS multiple-cause-of-death data can be used to identify

geographic areas, industries, and occupational groups upon which to focus intervention efforts. Currently, in the NIOSH SENSOR program, five of the ten states with the most silicosis deaths during the 1968–1990 period are now basing focused preventive interventions on surveillance of both silicosis mortality and morbidity.⁽¹¹⁾ Public health surveillance of silica exposures, although not the subject of this article, should play a major role in targeting prevention efforts.⁽²²⁾ Nevertheless, disease surveillance will continue to be useful for following trends and guiding decisions regarding silicosis prevention.

This summary report has presented only major highlights from national silicosis mortality surveillance, and the reader is referred to a recent NIOSH publication⁽¹⁾ for additional surveillance findings relevant to silicosis and silica exposure.

References

1. National Institute for Occupational Safety and Health: Work-Related Lung Disease Surveillance Report. DHHS (NIOSH) Pub. No. 94-120. NIOSH, Cincinnati, OH (1994).
2. National Institute for Occupational Safety and Health: Work-Related Lung Disease Surveillance Report. DHHS (NIOSH) Pub. No. 91-113. NIOSH, Cincinnati, OH (1991).
3. U.S. Department of Health and Human Services: Public use data documentation. Multiple cause of death for ICD-9 1990 data, Hyattsville, Maryland (1993).
4. World Health Organization: International Classification of Disease, Adapted Eighth Revision. WHO, Geneva (1967).
5. World Health Organization: International Classification of Disease, Adapted Ninth Revision, WHO, Geneva (1978).
6. Bureau of the Census: Estimates of the Population of the United States, by Age, Sex, and Race: 1970–1990. Census Population Reports, Series P-25. U.S. Government Printing Office, Washington, DC (1990).
7. Bureau of the Census: 1980 Census of Population: Classified Index of Industries and Occupations. Pub. No. PHC80-R4. U.S. Department of Commerce, Washington, DC (1982).
8. Bailar III, J.C.; Ederer, F.: Significant Factors for the Ratio of a Poisson Variable to Its Expectation. *Biometrics* 20:639–643 (1964).
9. Peters, J.: Silicosis. In: *Occupational Respiratory Diseases*, pp. 219–241. J.A. Merchant, Ed. DHHS (NIOSH) Pub. No. 86-102. National Institute for Occupational Safety and Health, Cincinnati, OH (1986).
10. Balaan, M.; Banks, D.E.: Silicosis. In: *Environmental and Occupational Medicine*, 2nd ed., pp. 197–206. W.N. Rom, Ed. Little, Brown and Company, Boston (1983).
11. Centers for Disease Control: Silicosis Surveillance—Michigan, New Jersey, Ohio, and Wisconsin, 1987–1990. *Morb. Mort. Weekly Rep.* 42:23–28 (1993).
12. National Institute for Occupational Safety and Health: NIOSH Alert: Preventing Silicosis and Deaths from Sandblasting. DHHS (NIOSH) Pub. No. 92-102. NIOSH, Cincinnati, OH (1992).
13. National Institute for Occupational Safety and Health: NIOSH Alert: Preventing Silicosis and Deaths in Rock Drillers. DHHS (NIOSH) Pub. No. 92-107. NIOSH, Cincinnati, OH (1992).
14. U.S. Department of Labor: An Interim Report to Congress on Occupational Diseases, p. 20 (June 1980).
15. Percy, C.; Stanek, E.; Gloeckler, L.: Accuracy of Cancer Death Certificates and Its Effect on Cancer Mortality Statistics. *Am. J. Public Health* 71:242–250 (1981).
16. Althouse, R.B.; Castellan, R.M.; Wagner, G.R.: Pneumoconioses in the United States: Highlights of Surveillance Data from NIOSH and Other Federal Sources. *Occup. Med. State Art Rev.* 7:197–208 (1992).
17. Baker, E.L.: Sentinel Event Notification System for Occupational Risks (SENSOR): The Concept. *Am. J. Pub. Health* 79(suppl.):18–20 (1989).
18. Centers for Disease Control: Silicosis: Cluster in Sandblasters—Texas, and Occupational Surveillance for Silicosis. *Morb. Mort. Weekly Rep.* 39:433–437 (1990).
19. Freund, E.; Seligman, P.J.; Chorba, T.L.; et al.: Mandatory Reporting of Occupational Diseases by Clinicians. *J. Am. Med. Assoc.* 262:3041–3044 (1989).
20. Froines, J.R.; Wegman, D.H.; Dellenbaugh, C.A.: An Approach to the Characterization of Silica Exposure in U.S. Industry. *Am. J. Ind. Med.* 10:345–361 (1986).
21. Selikoff, I.J.: Death Certificates in Epidemiologic Studies, Including Occupational Hazards: Inaccuracies in Occupational Categories. *Am. J. Ind. Med.* 22:493–504 (1992).
22. Valiante, D.J.; Richards, T.B.; Kinsley, K.B.: Silicosis Surveillance in New Jersey: Targeting Workplaces Using Occupational Disease and Exposure Surveillance Data. *Am. J. Ind. Med.* 21: 517–526 (1992).



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