

occupational and environmental lung diseases

Silicosis in the 1990s*

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Objective: To describe state-based surveillance for silicosis that estimates prevalence of this condition, describes characteristics of affected individuals, and targets public health interventions.

Design: The data presented are a case series of patients with silicosis reported to a state health department. Patients were interviewed using a standardized questionnaire, chest radiographs interpreted by a "B-reader," pulmonary function tests obtained from medical records, and follow-back investigations conducted at the worksites where the cases had been exposed to silica.

Setting: All individuals with silicosis in the state of Michigan reported to the Michigan Department of Public Health (MDPH).

Subjects: Individuals included in this article were reported from 1987 through 1995. Cases were reported by hospitals, physicians, the state workers' compensation bureau, or from death certificates. Only data on individuals who met the criteria for silicosis developed by the National Institute for Occupational Safety and Health (NIOSH) are included.

Results: Between 1987 and 1995, 577 people were reported to MDPH who met the NIOSH criteria for silicosis. About 60% of the reports came from hospitals. The disease is occurring mainly among men born before 1940 who began working in a Michigan ferrous foundry in the 1930s or 1940s and worked there >20 years. Over 40% of the patients are black. The overall annual average incidence rate of silicosis among black men (14.3 cases per 100,000) is seven times higher than among white men (2.1 cases per 100,000). The individuals identified with silicosis generally have severe disease. Almost 30% have progressive massive fibrosis and another 31.7% have advanced simple silicosis. Only about a third of all patients have normal results of breathing tests. Thirteen percent had been told they had tuberculosis (includes both clinical disease and a positive skin test). They have an increase of over 300% in the likelihood of dying of nonmalignant respiratory disease, both restrictive and obstructive, and an 80% increase in the likelihood of dying of lung cancer. Despite the severity of disease, over 45% of the individuals had not applied for workers' compensation. Although silicosis typically occurs after a long duration of exposure to silica, some individuals developed silicosis after a relatively short time. Three people developed silicosis who began working with silica in the 1980s, 18 in the 1970s, and 66 in the 1960s. Initial industrial hygiene follow-up inspections where the individuals had worked showed ongoing exposure above recommended and/or legal levels. Repeated inspections to these same facilities have subsequently shown reductions in silica exposure.

Conclusion: This state-based surveillance system has proved useful in characterizing individuals with silicosis, estimating its prevalence, increasing the medical community's awareness of the condition, and targeting effective public health interventions.

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Abbreviations: CL=confidence limit; MIOSHA=Michigan Occupational Health and Safety Administration; NIOSH=National Institute for Occupational Safety and Health

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Lung disease secondary to exposure to dusty work conditions from exposure to sand (silica) has been described since antiquity.¹ There has been special concern about the incidence of silicosis in Michigan since the 1930s. Michigan foundries were thought to be at severe economic risk from the large number of workers who might apply for workers'

compensation for silicosis. Initially, a cap was placed on the amount of a workers' compensation award a patient with silicosis could receive. In 1966, the cap was replaced by a special assessment on all insurance companies and self-insured employers who provide workers' compensation. The funds from this special assessment are used to limit the liability of silica-using industries. This article describes a state-based surveillance system for silicosis and presents data derived from it. Preliminary data from Michigan, New Jersey, Ohio, and Wisconsin have been published previously.²

MATERIALS AND METHODS

As part of the Sentinel Event Notification System for Occupational Risks, the Michigan Department of Public Health in 1987, with financial assistance from the National Institute for Occupational Safety and Health (NIOSH), instituted a surveillance/investigation program for silicosis.² Sources used to identify persons with silicosis were as follows: (1) reports from hospitals; (2) reports from physicians; (3) death certificates; and (4) claims awarded by the Michigan Silicosis, Dust Disease and Logging Industry Compensation Fund.

Reports from hospitals were requested once per year. Hospital discharge summaries for individuals with a primary or secondary diagnosis of silicosis (*ICD-502*) or pneumoconiosis not otherwise specified (*ICD-505*) were obtained from all acute-care hospitals in Michigan, including Veteran's Administration hospitals. Reporting by both Michigan practitioners and hospitals was required under part 56 of Public Act 368 of 1978, which requires the reporting of all known or suspected occupational disease.

All 30,000 physicians in the state were required to report. A special effort was made to encourage allergists, pulmonologists, occupational physicians, and selected internists and family practitioners to report occupational disease. In 1988, members of the Michigan Thoracic Society, Michigan Allergy Society, Michigan Occupational Medicine Society, and the full-time and adjunct faculty of the Departments of Medicine and Family Practice at the four medical schools in the state received a letter announcing the program. For seven organizations, the letter was sent from the State Health Department Director, and for four, the letter came from the Chair of their respective department. All three specialty organizations officially supported the program.

There were 3,000 physicians from these seven organizations. All were included to receive the introductory mailings. The lists were updated to reflect retirement, relocation, and new additions, and the number of targeted physicians remained at about 3,000.

Targeted physicians received a four-page quarterly newsletter. The newsletter contained reviews of pertinent diagnostic issues, case reports, and abstracts of selected articles. A display booth was set up at the Annual Michigan State Medical Society Scientific Meeting, the Annual Michigan Thoracic Society Scientific Meeting, and selected continuing medical education meetings throughout the state. Educational material, including newsletters and annual reports, as well as pens, magnets, and rulers with the telephone number to report occupational disease were available at the display booth.

When a report was received, the individual was interviewed by a trained interviewer over the phone. The interviews were typically performed by second-year medical students. A standard questionnaire was used. The interview took approximately 30 to

45 min and consisted of the following: a lifetime work history; cigarette smoking history; onset, frequency, and temporal pattern of respiratory symptoms; medical care history; medication history; and medical and symptom history limited to respiratory conditions. A smoker was defined as anyone who had smoked at least five packs of cigarettes in his or her life, an ex-smoker as anyone who had stopped smoking at least 30 days before his or her interview (or death if an interview was conducted with a next of kin), and a nonsmoker was defined as someone who had smoked less than five packs of cigarettes in his or her life.

Medical records, including pulmonary function testing and a recent chest radiograph on the reported patients, were also collected. All of the above information was reviewed by a physician who was board certified both in internal medicine and occupational medicine. He determined if the individual met the NIOSH criteria for silicosis.² All chest radiographs were reviewed by a physician who was a NIOSH-certified "B reader," and therefore had special training and accreditation to interpret chest radiographs for all pneumoconioses, including silicosis. No attempt was made to determine if the pulmonary function test results met American Thoracic Society criteria for reproducibility or validity. The pulmonary function test results came from a large number of different hospital-based pulmonary laboratories as well as individual physician's offices. These different locations presumably use different reference predictive equations and handle race correction differently.

Because of delays in receiving reports and the availability of databases, the most complete data available were for 1987 to 1993. Only preliminary data were available for 1994 and 1995. Partial data were also available for the years 1985 and 1986.

A person was considered to have silicosis if there was (1) a history of exposure to silica; and (2) a chest radiograph interpretation showing rounded opacities of 1/0 or greater profusion per the International Labor Office classification system for pneumoconiosis, or a biopsy report of lung tissue showing the characteristic silicotic nodule.

RESULTS

Table 1 shows the number of individuals confirmed with silicosis by year and the primary reporting source of the persons confirmed with silicosis for the years 1985 to 1995. Hospital reports are the primary reporting source of the patients with silicosis (61% of reports). Relatively few reports are received from workers' compensation (17%). We do not receive complete reporting from the hospitals until 2½ years and death certificates until half a year after the end of the calendar year. Accordingly, 1994 and 1995 data are incomplete at this time.

Five hundred sixty-seven (98.3%) of the persons with silicosis are men. Two hundred fifty-seven (44.9%) of the persons with silicosis are black, 299 (52.3%) are white, one (0.2%) was listed as Asian, 15 (2.6%) are listed as "other," and race on five individuals was unknown. The average year of birth is 1918 (range, 1888 to 1956). The distribution of the decade of hire is shown in Figure 1. The average year of hire is 1945. The distribution of years worked at a silica-exposed job is shown in Figure 2. The average number of years worked is 27.8. The locations where

Table 1—Number of Confirmed Individuals With Silicosis by Year and Reporting Source*

	<1985	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	All Years
PR	—	—	—	—	—	7	5	5	16	6	6	23	68
HDC	—	—	—	68	57	41	44	36	53	31	23	1	354
DC	—	11	11	12	5	8	0	1	6	0	1	0	55
WC	10	12	13	7	7	4	6	6	2	4	25	0	96
ICFU	—	—	—	—	—	3	1	0	0	0	0	0	4
Total	10	23	24	87	69	63	56	48	77	41	55	24	577

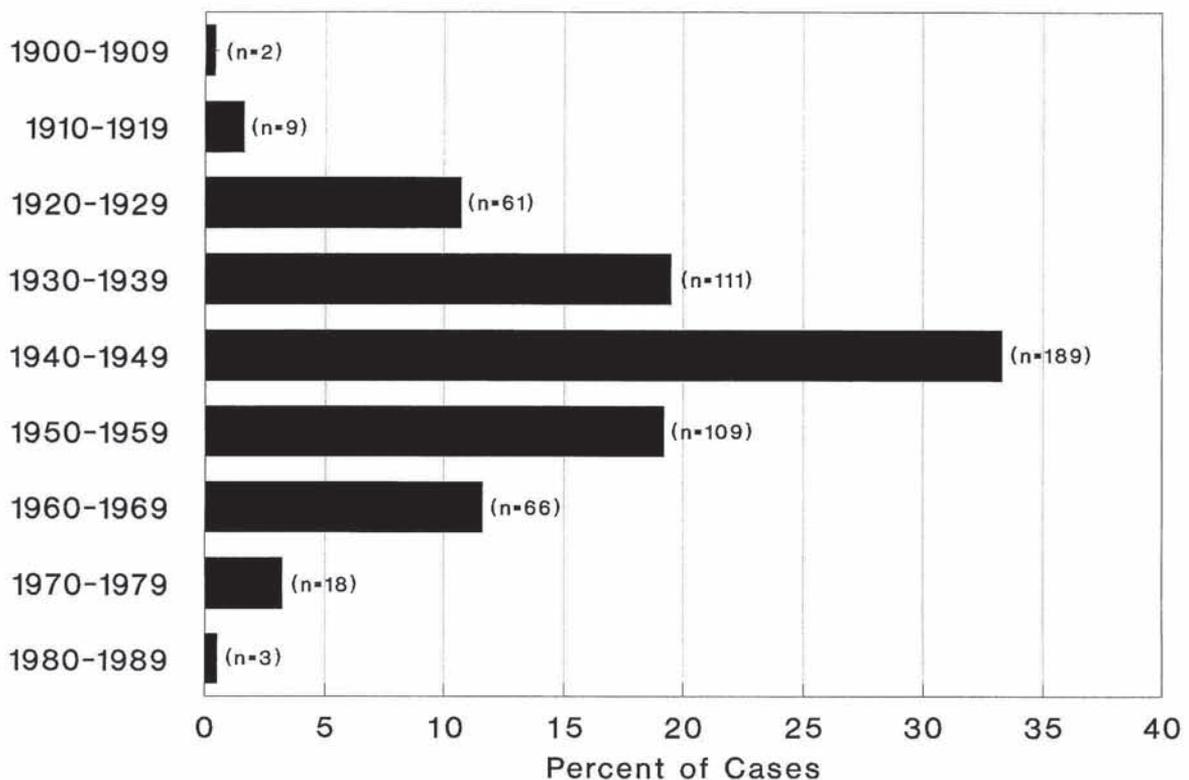
*PR=physician referral; HDC=hospital discharge data; DC=death certificate; WC=workers' compensation; ICFU=index case follow-up.

the individuals were exposed to silica are clustered in three counties: Muskegon (144), Saginaw (72), and Wayne (166). The overall average annual incidence rates for silicosis among black men 40 years or older is 14.3 cases per 100,000, and for white men 40 years or older is 2.1 cases per 100,000.

Overall 377 (65.3%) of the people with silicosis had simple silicosis and 164 (28.4%) had progressive massive fibrosis. Nineteen (3.3%) with silicosis had normal radiographs with biopsy evidence. Seventeen (2.9%) individuals had radiograph reports that were consistent with silicosis but no radiograph was available to classify the film.

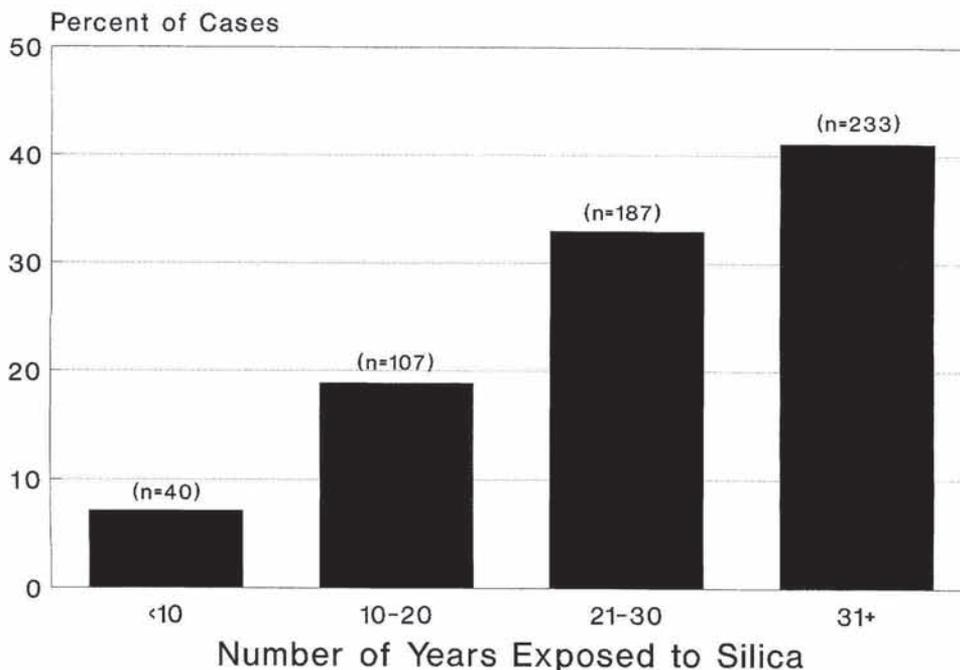
One hundred fifty-four (27.1%) of the people with

silicosis never smoked cigarettes, 331 (58.2%) had quit, 84 (14.8%) were still smoking, and no information was available on eight individuals. Nonsmokers tended to have more severe silicosis. In the nonsmokers, 25.2% had category 1 radiographs, 26.5% had category 2, 9.9% had category 3, and 36.4% had progressive massive fibrosis. This was in comparison to the 37.7% of ever smoked who had category 1 radiographs, 23.1% who had category 2, 8.4% who had category 3, and 26.8% who had progressive massive fibrosis. The greater percentage of nonsmokers with progressive massive fibrosis was statistically significant ($\chi^2=4.45$, $p=0.04$, nonsmokers vs ever smoked; odds ratio, 1.56; 95% confidence limit



*Total cases: 568. Unknown decade for 9 individuals.

FIGURE 1. Distribution of decade when silica exposure began for individuals with confirmed silicosis: 1985 to 1995.



*Total cases: 567. Unknown years for 10 individuals.

FIGURE 2. Distribution of years worked at a silica-exposed job for individuals confirmed with silicosis: 1985 to 1995.

[CL] 1.03 to 2.38). These results were not significantly changed if the analysis was redone controlling for duration of exposure (nonsmokers vs ever smoked; odds ratio 1.64; 95% CL, 1.07 to 2.48) or latency since first hire (nonsmokers vs ever smoked; odds ratio, 1.61; 95% CL, 1.06 to 2.44).

Tables 2 and 3 show the distribution of FVC and the ratio of FEV₁ to FVC by radiograph status. Approximately 60% of people both ever and never cigarette smokers with silicosis had reduced breathing function, either restrictive or obstructive. Never smokers had slightly less obstructive but more re-

strictive disease than ever smokers. The mean percent predicted of FVC among ever smoked was 73.13±21.09 vs 69.89±21.26 among never smoked (p=0.170). The mean percent of FEV₁/FVC among ever smoked was 65.80±16.70 vs 70.84±15.23 among never smoked (p=0.004).

Table 4 shows the primary type of industry where the silica exposure occurred. The predominant industry where people developed silicosis was iron foundries (79.8%). One hundred thirty-five (25.5%) people stated they had done sandblasting as part of their work. The 577 people with silicosis were ex-

Table 2—Percent Predicted FVC by Radiograph Results and Cigarette Smoking Status for Individuals Confirmed With Silicosis for the Years 1985 to 1995*

	Percent Predicted FVC					
	≤60%		60-79%		≥80%	
	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked
Biopsy evidence	6 (33.3) [†]	0 —	8 (44.4)	1 (33.3)	4 (22.2)	2 (66.7)
Unknown severity	7 (35.0)	2 (28.6)	7 (35.0)	4 (57.1)	6 (30.0)	1 (50.0)
Category 1	29 (22.0)	12 (41.4)	48 (36.4)	6 (20.7)	55 (41.7)	11 (37.9)
Category 2	21 (28.4)	12 (40.0)	22 (29.7)	8 (26.7)	31 (41.9)	10 (33.3)
Category 3	6 (25.0)	5 (45.5)	10 (41.7)	3 (27.3)	8 (33.3)	3 (27.3)
PMF	28 (35.0)	11 (30.6)	28 (35.0)	14 (38.9)	24 (30.0)	11 (30.6)
Total	97 (27.9)	42 (36.2)	123 (35.3)	36 (31.0)	128 (36.8)	38 (32.8)

*Total number of cases: 464. Information was missing for 113 individuals. PMF=progressive massive fibrosis.

[†]Number, percentage in parentheses.

Table 3—Ratio of FEV₁ Divided by FVC by Radiograph Results and Cigarette Smoking Status for Individuals Confirmed With Silicosis for the Years 1985 to 1995*

	FEV ₁ /FVC							
	≤40%		41-59%		60-74%		≥75%	
	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked
Biopsy evidence	3 (16.7) [†]	1 (33.3)	4 (22.2)	0 —	5 (27.8)	2 (66.7)	6 (33.3)	0 —
Unknown severity	1 (5.9)	2 (25.0)	2 (11.8)	0 —	3 (17.6)	3 (37.5)	11 (64.7)	3 (37.5)
Category 1	17 (13.0)	1 (3.4)	27 (20.6)	3 (10.3)	45 (34.4)	9 (31.0)	42 (32.1)	16 (55.2)
Category 2	2 (2.9)	2 (6.7)	14 (20.0)	4 (13.3)	31 (44.3)	7 (23.3)	23 (32.9)	17 (56.7)
Category 3	0 —	0 —	3 (12.5)	0 —	5 (20.8)	4 (36.4)	16 (66.7)	7 (63.6)
PMF	13 (16.7)	4 (11.1)	22 (28.2)	8 (22.2)	23 (29.5)	11 (30.6)	20 (25.6)	13 (36.1)
Total	36 (10.7)	10 (8.5)	72 (21.3)	15 (12.8)	112 (33.1)	36 (30.8)	118 (34.9)	56 (47.9)

*Total number of cases: 455. Information was missing for 122 individuals.

[†]Number, percentage in parentheses.

posed to silica in 221 facilities. Inspections were performed at 56 (25.3%) of these facilities. Eighty-nine (40.3%) facilities were no longer in operation, 30 (13.6%) were located out of state, 11 (5.0%) facilities no longer used silica, 14 (6.3%) had worked at multiple construction sites as building trades workers, and 11 (5.0%) were unknown. Another 10 (4.5%) facilities are scheduled for inspections.

Air sampling was conducted in 39 of the 56

Table 4—Primary Industry Where Silica Exposure Occurred for Individuals Confirmed With Silicosis for the Years 1985 to 1995

Industry (SIC Code)*	No. (%) of Cases [†]
Manufacturing	
Primary metal industries (33)	458 (79.8)
Includes iron, steel, gray, and ductile iron foundries	
Stone, clay, glass, and concrete products (32)	28 (4.9)
Transportation equipment (37)	22 (3.8)
Includes auto bodies and boat building	
Fabricated metal products (34)	9 (1.6)
Miscellaneous (25, 26, 28, 30, 35, 38)	14 (2.4)
Includes chemicals and allied products, rubber parts, metalworking machinery, and dental equipment	
Mining	
Metal mining (10)	12 (2.1)
Nonmetallic mineral mining, except fuels (14)	2 (0.3)
Construction (15, 16, 17)	21 (3.7)
Transportation, communication, etc, services (40, 41, 47, 49, 73, 76)	6 (1.0)
Includes transportation, sanitary, and repair services	
Pipeline operations (46)	1 (0.2)
Dental laboratory (80)	1 (0.2)
Total	574 (100.0)

*SIC=standard industrial classification.

[†]For three workers, the industrial classification was not known.

facilities inspected (Table 5). Twenty-four of the 39 (61.5%) facilities were above the NIOSH recommended exposure level of 0.05 mg/m³ for silica. Seventeen of the 24 facilities above the NIOSH recommended level were above the enforceable Michigan Occupational Health and Safety Administration (MIOSHA) standard of 0.1 mg/m³ for silica. Another one (2.7%) company was above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only 4 of the 54 (7.4%) facilities where medical surveillance was established provided medical screening for silicosis for its workers which included a periodic chest radiograph interpreted by a B-certified reader, while one company provided periodic chest radiographs that were not interpreted by a B-certified reader. Sixteen (29.6%) performed only preemployment testing, 15 (27.8%) provided no medical surveil-

Table 5—Results of Industrial Hygiene Inspections of 56 Facilities Where Individuals Confirmed With Silicosis for the Years 1985 to 1995 Were Exposed to Silica

	No. of Companies	(%)
Air sampling performed	39	
Above NIOSH recommended standard of 0.05 mg/m ³ for silica	24	(61.5)
Above MIOSHA enforceable standard of 0.1 mg/m ³ for silica	17	(43.4)
Medical surveillance evaluated	54	
Periodic chest radiographs with B reader	4	(7.4)
Periodic chest radiographs without a B reader	1	(1.9)
Preemployment testing only	16	(29.6)
No medical surveillance	15	(27.8)
Periodic pulmonary function testing	12	(22.2)
Unable to evaluate medical surveillance	6	(11.1)

lance, and 12 (22.2%) performed annual or biannual pulmonary function testing without chest radiographs.

Repeated inspections were conducted at 10 facilities that had been inspected previously because of reports of silicosis and had been found to be in violation of the MIOSHA permissible exposure level for exposure to silica (Table 6). At the follow-up inspections, air sampling for silica showed lower levels. All but 3 of the 10 companies were currently in compliance with the enforceable silica air standard. The workers at the high silica exposure jobs at the facilities not in compliance with the air standard were using air line respirators or positive pressure respirators with HEPA filters.

Only 228 (39.5%) of the persons with silicosis or their next of kin applied for workers' compensation. Two hundred fifty-one (43.5%) had not applied. It was unknown whether the remaining 98 (17.0%) people with silicosis applied for compensation. There was no association between severity of disease and whether a person applied for workers' compensation. Of those known to apply, 194 (85.1%) received compensation, nine (3.9%) had been denied, and 25 (11.0%) were pending.

DISCUSSION

Approximately 50 to 80 new cases of silicosis are reported annually to the Michigan Department of Public Health; hospitals are the major source of the reports (Table 1). Similar type surveillance systems functioning in seven states are also continuing to identify new cases of silicosis.² These new cases are likely an underestimate of the true number of those with silicosis. In fact, we estimate we receive reports on only one third of new patients with silicosis.³ Furthermore, the number of individuals identified in

Michigan is an underestimate because of underdiagnosis of the condition itself. Hospitalized patients are generally the sicker and older patients with silicosis. This is reflected in that the average year of birth is 1918 and that 28.4% have progressive massive fibrosis and 31.7% have advanced simple silicosis. In contrast, surveillance systems in Ohio and Wisconsin receive more reports directly from physicians and consequently have a higher proportion of younger patients with less advanced disease.² In recent years, the Michigan surveillance system has been receiving reports at an earlier stage in the patient's disease. This is reflected in the decrease over time in the number of reports first received through death certificate review and a corresponding increase, though small, in the number of reports received directly from physicians (Table 1).

Because the number of Michigan ferrous foundry workers peaked in the 1970s at around 40,000, dropped to around 20,000 in 1980, and then to 12,000 in the late 1980s, there are fewer Michigan workers currently at risk of developing silicosis. Combined with improved working conditions, this should reduce the number of people who develop silicosis. However, a report from NIOSH highlights that continued reminders and reviews of workplaces are needed as long as silica continues to be used in industry.⁴ New initiatives to encourage the use of silica substitutes are needed. This is particularly true for sandblasting. European countries restricted the use of silica for sandblasting 40 years ago.⁵ Multiple nonsilica abrasives are available as substitutes.

The predominant characteristics of the cases reported are that they are elderly men who mainly worked in foundries in three counties. The age distribution is similar to that reported in the 1950s and does not indicate the disease is disappearing.⁶

Table 6—Comparison of Air Sampling Results at Initial and Follow-up Inspections Among 10 Companies*

Type of Industry	Initial Inspection				Follow-up Inspection			
	Above MIOSHA TWA	No. of Air Samples	Range, mg/m ³	Average, mg/m ³	Above MIOSHA TWA	No. of Air Samples	Range, mg/m ³	Average, mg/m ³
Malleable iron foundry	Y	10	0.34-1.71	0.83	N	2	0.03-0.06	0.05
Gray iron foundry	Y	15	0.13-1.63	0.62	N	2	0.03-0.05	0.04
Pottery	Y	3	0.47-0.97	0.57	N	1	0.03	—
Gray iron foundry	Y	17	0.09-16.64	1.94	N	1	0.03	—
Fabricated metal products	Y	10	ND-0.98	0.21	N	2	ND	0
Gray and ductile iron foundry	Y	6	0.05-3.85	1.04	Y	Requested	Variance	
Ferrous foundry	Y	11	0.20-5.77	1.17	N	3	ND-0.05	0.02
Ferrous foundry	Y	11	ND-3.87	1.00	N	2	0.20-0.60	0.40
Ferrous foundry	Y	5	0.89-6.45	2.76	Y	4	0.50-1.00	0.73
Gray and ductile iron foundry	Y	25	ND-0.12	0.01	N	2	0.01-0.08	0.04

*ND=none detected; TWA=time-weighted average; Y=yes; N=no.

The older age of the patient is secondary to the chronic nature of the disease and the typical long exposure to silica which is required to develop the disease (average 28 years of exposure to silica). However, the surveillance system also received reports of individuals with short-term exposure who began working with silica in the 1970s and 1980s. Forty or 7.1% of the people worked for <10 years. These individuals were less likely to have worked in a foundry (45% vs 80%) and more likely to have performed sandblasting (42% vs 26%). Twenty-one (3.6%) began work in the 1970s or 1980s. Eight of these individuals had worked for <10 years. The people with silicosis who began work in the 1970s or 1980s were more likely to have done sandblasting than the people with silicosis who began work with silica before 1970 (47% vs 31%).

Black men are overrepresented (44.9%). This reflects previous hiring practices in foundries. In fact, among the counties where rates were compared between black and white workers, black workers consistently had higher incidence rates of silicosis than their white counterparts. Overall for the state, the incidence rate of silicosis among black workers was 14.3/100,000 vs 2.1/100,000 for white workers (sevenfold greater incidence).

The individuals described generally have advanced disease: 164 (28.4%) have progressive massive fibrosis; another 183 (31.7%) have advanced simple silicosis (category 2 or 3). Over 60% of the reported patients have reduced breathing function. One of the limitations of our data is the varying quality of the pulmonary function tests. The tests were performed at multiple locations using different equipment and different predictive reference equations.

Individuals with silicosis are at increased risk of pulmonary hypertension, clinically significant bronchitis, and COPD.⁷ Thirteen percent of individuals reported in the Michigan surveillance system have had either tuberculosis or have had a positive skin test indicating infection with the mycobacteria that causes tuberculosis.

Despite the severity of their disease, over 45% had not applied for workers' compensation. Similar results have been reported in New Jersey.⁸ Anecdotally, reasons individuals reported not applying included loyalty to employer, afraid of losing their pension, did not want to go through the hassle, and lack of awareness either of their diagnosis or its association with work.

Over 70% of the patients had ever smoked cigarettes but only 20.3% of the smokers are still smoking cigarettes. Nonsmokers had more severe x-ray findings than current or ex-smokers. This finding was not explained by increased duration or longer latency since first exposure among nonsmokers. Previous studies

have found an increased prevalence of silicosis among cigarette smokers⁹⁻¹¹ but no association between cigarette smoking and progression or degree of profusion on the radiograph.^{9,10} Since we do not know the population of cigarette smokers and nonsmokers at risk, our data cannot address the issue of prevalence of silicosis in smokers vs nonsmokers. The previous studies showing no association with profusion were based on prevalence of current workers and did not include elderly retirees who are the majority of the individuals in our surveillance system. It is possible that the association we found between progressive massive fibrosis and nonsmoking is an artifact of our reporting system, which is mainly based on reports of hospitalized individuals (*ie*, nonsmoking individuals with simple silicosis are less likely to be symptomatic and less likely to be hospitalized and therefore less likely to have been reported to us).

Industrial hygiene inspections reveal violations of the exposure standard for silica in over 40% of the facilities where sampling was done. Another 20% of the companies were above the NIOSH recommended level. However, follow-up inspections of these same companies after the initial inspection have shown a decrease in silica exposures and a reduction in the risk for the development of silicosis among current workers (Table 6). Those companies not in compliance with the silica standard are requiring their workers to use powered air purifying respirators or air line respirators. However, very few facilities provide medical screening of their work force. There was an inadequate or absent medical surveillance program in 92.6% of the facilities. Unlike asbestos, neither the federal government nor Michigan has ever had a comprehensive occupational safety and health standard for silica that would include medical monitoring.

In summary, silicosis remains an ongoing problem in Michigan predominantly among former foundry workers who continue to show development of severe disease. Further, some Michigan workers will continue to be at risk of developing disease because of inadequate controls at foundries currently using silica. Sandblasting also continues to be a high-risk operation.⁴ Given the ready availability of nonsilica abrasives, further educational and regulatory efforts are needed to encourage the replacement of silica in sandblasting operations. Despite the chronic nature of silicosis, the surveillance system for silicosis allows the targeting of current preventive activity for the condition and follow-up inspections of this targeting have documented success in reducing silica exposure.

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