

1997 Annual Report on Silicosis in Michigan

A Joint Report
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Summary:

This is the seventh annual report on silicosis in Michigan. The report is based on complete data for the years 1987 through 1995 and preliminary data for 1996 and 1997. There were 65 new reports confirmed in 1995. The disease continues to occur mainly among men born before 1940 who began working in a Michigan ferrous foundry in the 1930s or 1940s and worked there over 20 years. Forty-five percent of the patients are African American. The overall annual average incidence rate of silicosis among African American males (14.7 cases per 100,000) is seven times higher than white males (2.1 cases per 100,000). The rates within specific counties ranged between 2.1 to 34.1 times higher for African American males than the rates for white males. Exposure to silica occurred mainly in companies in the counties of Calhoun, Muskegon, Saginaw and Wayne.

The patients identified with silicosis generally have severe disease. Over 26 % have progressive massive fibrosis and another 33.0% have advanced simple silicosis. Only about a third of all patients have normal breathing tests. Over 16% had been told they had tuberculosis (includes both clinical disease and a positive skin test). Individuals with silicosis in Michigan have an increase of over 300% in the likelihood of dying from non-malignant respiratory disease, both restrictive and obstructive, and an 80% increase in the likelihood of dying from lung cancer (1).

Despite the severity of disease, 54% of the patients had not applied for workers' compensation.

Although silicosis typically occurs after a long duration of exposure to silica, there continue to be patients who develop silicosis after a relatively short time because of the severity of exposure. Three patients developed silicosis who began working with silica in the 1980s, 27 in the 1970s and 84 in the 1960s. Current exposures to silica are still occurring in foundries, despite the fact that many of Michigan's foundries are now closed. Exposures are also occurring in industries such as pottery making and construction. A survey of the approximately 300 companies in the state doing abrasive blasting shows 62% are continuing to use silica rather than a less hazardous non-silica abrasive. Continued medical and public health vigilance is necessary if we are going to prevent new individuals from developing silicosis.

Background:

Lung disease secondary to dusty work conditions from exposure to sand (silica) has been described since antiquity. There has been special concern about the incidence of silicosis (scarring of the lung caused by exposure to silica) 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 an 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.

In 1987 the Michigan Department of Consumer and Industry Services* (MDCIS) with financial assistance from the National Institute for Occupational Safety and Health (NIOSH) instituted a surveillance/investigation program for silicosis. Sources used to identify persons with silicosis are: (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. Each year, data from the Michigan Health and Hospital Association's (MHA) Michigan inpatient database are obtained to verify the completeness of reporting by the hospitals.

Due to delays in receiving reports and the availability of data bases, the most complete data available are for 1987-1995. Only preliminary data is available for 1996 and 1997. Partial data is also available for the years 1985 and 1986. Given the known inadequacies of occupational disease surveillance systems, even the most complete data for the years 1987-1995 is an underestimate of the true number of persons diagnosed with silicosis. Further, the number of patients identified in Michigan is an underestimate because of under diagnosis of the condition itself.

A person is considered to have silicosis if there is: (1) a history of exposure to silica; and (2) a chest x-ray interpretation showing rounded opacities of 1/0 or greater profusion per the International Labor Office (ILO) classification system for pneumoconiosis, or a biopsy report of lung tissue showing the characteristic silicotic, nodule. All chest x-rays are reviewed by a physician who is a NIOSH certified "B" reader, and therefore has special training and accreditation to interpret chest x-rays for all pneumoconioses, including silicosis.

Results:

Reports

Figure I shows the number of patients confirmed with silicosis by year for 1987 through 1995. To date, we have confirmed an additional 55 persons with silicosis in 1996, and 8 in 1997. Table I shows the primary reporting source of the persons confirmed with silicosis for the years 1985 - 1997. Figure 2 shows the overlap of reporting sources for the most complete reporting years of 1987 through 1996. Hospital reports are the primary reporting source of the patients with silicosis (58% of reports are identified solely through the hospitals). We do not receive complete reporting from the hospitals until two and a half years and death certificates until half a year after the end of the calendar year. Accordingly, 1996 and 1997 data is incomplete at this time.

Gender

Six hundred eighty-three (98.0%) of the persons with silicosis are men.

Race

Three hundred nine (44.7 %) of the persons with silicosis are African American, 360 (52.1 %) are white, one (0.1%) was listed as Asian, 21 (3.0 %) are listed as "other", and race on six individuals was unknown.

*Effective May 14, 1996, the Michigan Department of Public Health Division of Occupational Health became part of the Bureau of Safety and Regulation within the newly created Department of Consumer and Industry Services. This division and its authority to collect occupational disease reports were transferred through Executive orders 1996-1 and 1996-2.

Age

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1919.

Decade of Hire

The distribution of the decade of hire is shown in Figure 4. The average year of hire is 1946.

Duration of Work

The distribution of years worked at a silica exposed job is shown in Figure 5. The average number of years worked is 27.6.

Location in State

Figure 6 shows the counties in which the patients' silica exposure occurred. The locations are clustered in 4 counties: Calhoun, Muskegon, Saginaw and Wayne. Figures 7 and 8 show the average annual incidence rates of silicosis by race and county. The overall average annual incidence rates for silicosis among African American men is 14.7 cases per 100,000, and for white men is 2.1 cases per 100,000. Figure 7 shows the average annual incidence rate of silicosis among African American men age 40 and greater in each county. The rate in Shiawassee was 1,058/100,000, in Muskegon it was 302/100,000, in Monroe it was 62/100,000, in St. Clair it was 27/100,000, in Saginaw it was 79/100,000, in Calhoun it was 36/100,000, and in Macomb it was 24/100,000. Figure 8 shows the annual average incidence rate of silicosis among white men age 40 or greater in each county. The rate in Keewanaw was 23/100,000, in Muskegon it was 27/100,000, in Alpena it was 15/100,000, in Menominee it was 13/100,000, and in Saginaw it was 12/100,000.

Type of Industry

Table 2 shows the primary type of industry where the silica exposure occurred. The predominant industry where individuals developed silicosis is iron foundries (79.7%). One hundred sixty-seven (24.0%) people stated they had done sandblasting as part of their work.

Medical Results

Overall 471 (67.6%) of the people with silicosis had simple silicosis and 184 (26.4%) had progressive massive fibrosis. Twenty-two (3.2%) silicotics had normal x-rays with biopsy evidence. Twenty (2.9%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

One hundred eighty-five (26.9%) of the people with silicosis never smoked cigarettes, 400 (58.2%) had quit, 102 (14.8%) were still smoking and no information was available on 10 individuals. Figure 9 shows the distribution of x-ray results according to the ILO classification and smoking. Non smokers tended to have more severe silicosis. The greater percentage of non smokers with progressive massive fibrosis was statistically significant (32.4% non smokers vs. 20.6% current smokers vs. 25.5% ex smokers) ($\chi^2 = 27.70$, $p = .002$).

Tables 3 and 4 show the distribution of forced vital capacity (FVC) and the ratio of forced expiratory volume in one second (FEV_1) to FVC by x-ray and cigarette smoking status. Approximately 60 % of people with silicosis had reduced breathing function, either restrictive or obstructive. Obstructive changes were found in two thirds of the individuals who had ever smoked cigarettes and half of the individuals who had never smoked cigarettes.

Connective Tissue Disease

Exposure to silica is associated with humoral immunological changes including positive anti-nuclear antibodies (ANA), positive rheumatoid factor (RF), and elevation in immunoglobulins (IgA and IgG). ANA and RF have

been reported to be present in 20-40% of patients with silicosis (2,3). The risk of developing clinical connective tissue disease has been reported to be greater among individuals with both silica exposure and silicosis. The best evidence of this association is for rheumatoid arthritis and scleroderma (4-20). In addition, there are a limited number of reports of systemic lupus erythematosus in individuals with silicosis (10,21-23).

A committee that recently reviewed the adverse effects of crystalline silica concluded there was "persuasive evidence relating scleroderma to occupational silica exposures. . . "; that "a causal association between rheumatoid arthritis and silica exposure is thus plausible but unproved" because of the prevalence of arthritis in the elderly population that develops silicosis and the high prevalence of positive serum tests for rheumatoid factor; and that systemic lupus should only be suspected as being caused by silica in patients with acute or accelerated silicosis (26).

We have reviewed the medical records of individuals reported to the state's surveillance system for silicosis to determine the prevalence of connective tissue disease among individuals with silicosis in Michigan.

We reviewed 583 confirmed cases of silicosis reported to the state from 1985 to 1995. For 120 of the reports there was no discharge summary available for review. Among the 463 silicotics with medical records, there were 24 people with rheumatoid arthritis, 1 person with scleroderma, and 1 person with systemic lupus erythematosus. In the group with medical records, therefore, there is a prevalence of 5.2% for rheumatoid arthritis, .2% for scleroderma, and .2% for systemic lupus erythematosus. All 26 silicotics with connective tissue disease were men. In the general population, however, these conditions are more common in women than men. A summary of the 26 cases is shown in Table 5. The individuals with silicosis who had connective tissue disease did not differ significantly from the individuals with silicosis without connective tissue disease by race, age, type of industry where exposed to silica, whether or not they had done sandblasting, years of exposure to silica, whether they ever had tuberculosis, whether they had applied for workers' compensation, and whether they had progressive massive fibrosis on their chest radiograph (Table 6). The estimated prevalence in the general population which is less than found in this group of individuals with silicosis is shown in Table 7 (24).

Among the 583 silicotics with a completed telephone-administered questionnaire, 124 (21.3%) self-reported they had arthritis. The self-reported prevalence is similar to that reported in the general population (21 %) even though the general population data is from a younger age group (men and women > 18 years of age) compared to the more elderly individuals with silicosis who we have interviewed (25).

Although the literature most commonly cites the association between scleroderma and silicosis than other connective tissue diseases, rheumatoid arthritis was more common in this population of individuals with silicosis; 5.2% had rheumatoid arthritis vs. .2% had scleroderma. (Table 7). There were no demographic, exposure or radiographic characteristics that distinguished the silicotics with connective tissue disease from those without connective tissue disease (Table 6).

The majority of studies reporting an association between connective tissue disease and silicosis or silica exposure have been case reports or case series. Seven studies have been performed which provide risk estimates of approximately 5 fold increase for connective tissue disease among individuals with silicosis or silica exposure: a study in Italy (11); studies among South African (7,18) and U.S. gold miners (20); studies among Finnish (17) and U.S. granite miners (19); and a study of Spanish scouring powder workers (21). Among silicotics in Michigan, rheumatoid arthritis was the most common connective tissue disease among individuals with silicosis (5.2% with a 2.73 fold increased risk, 95% CL. 1.75-4.06). Systemic lupus erythematosus had a prevalence of .2% with a 11.73

fold increased risk, (95 % CL. .15-63.23) and scleroderma had a prevalence of .2 % with a 15.65 fold increased risk, (95% CL. .21-87.03).

Workers' Compensation

Only 270 (45.9%) of the individuals with silicosis or their next of kin applied for workers' compensation. Three hundred eighteen (54.1 %) had not applied. It was unknown whether the remaining 109 people with silicosis applied for compensation. There was no association between severity of disease and whether or not a person applied for workers' compensation. Of those known to apply, 221 (81.8%) received compensation, 17 (6.3%) had been denied, and 32 (11.8%) were pending.

Industrial Hygiene Results

The 697 individuals with silicosis were exposed to silica in 263 facilities (Table 8). Inspections were performed at 62 (23.6%) of these facilities. Another 11 (4.2%) facilities are scheduled for inspections. Ninety-nine (37.6%) facilities were no longer in operation, 40 (15.2%) were located out of state, 11 (4.2%) facilities no longer used silica, 23 (8.7%) had worked at multiple construction sites as building trade workers, 1 (0.4%) was referred to the Mine Safety and Health Administration since the company was out of MIOSHA jurisdiction, and 16 (6.1 %) were unknown.

Air sampling was conducted in 42 of the 62 facilities inspected (Table 9). Twenty-four of 42 (57.1 %) facilities were above the National Institute for Occupational Safety and Health recommended exposure level for silica. Seventeen of the 42 (40.5%) were above the enforceable Michigan Occupational Health and Safety Administration (MIOSHA) standard for silica. Another one (2.4%) company was above the MIOSHA standard for beryllium and another substance and one company was above the MIOSHA standard for silica and silver.

Only 4 of the 55 (7.3%) facilities where the medical surveillance program was evaluated provided medical screening for silicosis for its workers which included a periodic chest x-ray interpreted by a "B" certified reader, while one company provided periodic chest x-rays that were not interpreted by a "B" certified reader. Nineteen (34.5 %) only performed pre-employment testing, 18 (32.7%) provided no medical surveillance, and 13 (23.6%) performed annual or biannual pulmonary function testing without chest x-rays.

Abrasive Blasting Industry

Three hundred six abrasive blasting companies were identified in Michigan, 191 (62.4%) use silica as an abrasive. Of those, 83 agreed to be surveyed and then receive health and safety training. Two survey forms were generated to record conditions before and after the training. The site conditions survey was used to record general site information, work practices, personal protective equipment and hazard control technology. The employer questionnaire was used to examine management commitment to silicosis prevention, employee participation in safety and health programs, silicosis prevention and control methodologies in place, and safety and health training related to silicosis exposure.

Among the first 52 companies surveyed 35 (67.3%) of the companies indicated they have respiratory protection programs (although only 18 (34.6%) had a written program), 8 (15.4%) do not require respiratory protection to be worn during blasting, 19 (36.5%) do not require protective clothing to be worn during blasting, 44 (84.6 %) have no warning signs for silica exposure posted, 50 (96.2 %) have never performed air sampling for silica, 28 (53.8 %) companies use no control technology (containment or ventilation), 38 (73.1 %) have no medical monitoring program, and 42 (80.8%) do not have a safety committee.

Discussion:

For the most recent complete year available (1995) 65 new people were reported to the Michigan Department of Consumer and Industry Services (MDCIS) with silicosis; that was confirmed by x-ray or biopsy evidence and a history of exposure to silica.

The surveillance system in Michigan is mainly based on reports from hospitals (58% of reports are solely received from hospitals). A study in New Jersey of a similar type of surveillance system estimated that the system received reports on only one-third of individuals diagnosed with silicosis (27). Using capture-recapture analyses, we estimate the true number of silicotics in Michigan from 1987-1995 is 2,483 (32). During this same period 577 individuals were reported to the state. This is 23 % of the estimated total number of individuals developing the disease during these 9 years.

Hospitalized patients are generally the sicker and older patients with silicosis. This is reflected in that the average year of birth is 1919 and that 26.4% have progressive massive fibrosis and 33.0 % have advanced simple silicosis. In contrast, surveillance systems in Ohio and Wisconsin received more reports directly from physicians and consequently had a higher proportion of younger individuals with less advanced disease (28). In recent years, the Michigan surveillance system has been receiving reports at an earlier stage in the individual'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 workers today 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 work places are needed as long as silica continues to be used in industry (29). A majority of abrasive blasters in Michigan continue to use silica as the abrasive. A survey of a sample of companies using silica found that most companies of using silica are putting their employees at risk of developing silicosis because the companies are not following recommended and required work practices. New initiatives to encourage the use of silica substitutes are needed. European countries banned the use of silica for sandblasting 40 years ago. Multiple non-silica abrasives are available as substitutes.

The predominant characteristics of the individuals reported are that they are elderly men who mainly worked in foundries in four counties. The age distribution is similar to that reported in the 1950s and does not indicate the disease is disappearing (30). 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, we continue to receive reports of individuals with short term exposure and onset of work in the 1970s and 1980s. Forty-nine or 7.2% worked for less than 10 years. Thirty (4.4%) began work in the 1970s or 1980s. Twelve of these individuals had worked for less than 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 (43 % vs. 25 %).

African American men are over represented (44.7%). This reflects previous hiring practices in foundries. In fact, among the counties where rates were compared between African American and white workers (see Figures 7 and

8), African American workers consistently had higher incidence rates of silicosis than their white counterparts. Overall for the state, the incidence rate of silicosis among African American workers was 14.7 per 100,000 versus 2.1 per 100,000 for white workers (7 fold greater incidence).

The individuals reported generally have advanced disease: 184 (26.4%) have progressive massive fibrosis; another 230 (33.0%) have advanced simple silicosis (category 2 or 3). Over 60% of the reported patients have reduced breathing tests. These include both restrictive and obstructive changes. Obstructive changes although more prevalent among individuals who had smoked cigarettes, were found in half of the individuals who had never smoked cigarettes (Table 4). Individuals with silicosis are developing pulmonary hypertension and clinically significant bronchitis and chronic obstructive pulmonary disease (31). Over 16% 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 54% had not applied for workers' compensation.

Over 70% of the patients had ever smoked cigarettes but only 14.8% of the smokers are still smoking cigarettes. Non-smokers had more severe x-ray findings than current or ex-smokers (Figure 9). This latter finding maybe an artifact of our reporting system which is mainly based on reports of hospitalized individuals. Non-smoking individuals with simple silicosis are less likely to be symptomatic and less likely to be hospitalized and therefore less likely to have been reported.

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease (1,31). The increased risk for death is found both in patients who ever or never smoked cigarettes (1).

Industrial hygiene inspections reveal violations of the exposure standard for silica in 40.5% of the facilities where sampling was done. However, follow-up inspections of these same companies have shown a significant decrease in silica exposures. Those companies not in compliance with the silica standard are requiring their workers to use powered air purifying respirators or air line respirators. However, because of an inadequate or absent medical surveillance program in 93.5% of the facilities there is no way to monitor the adequacy of the controls.

In summary, silicosis remains an ongoing problem in Michigan with former foundry workers continuing to develop severe disease. Further, some Michigan workers will continue to be at risk of developing disease because of inadequate controls at foundries currently in operation. In addition, sandblasting continues to be a high risk operation (29). Given the ready availability of non-silica abrasives, further educational and regulatory efforts are needed to encourage the replacement of silica in blasting operations or at the minimum ensure that silica is used properly.

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Figure 1. Number of Individuals Confirmed with Silicosis by Year Reported

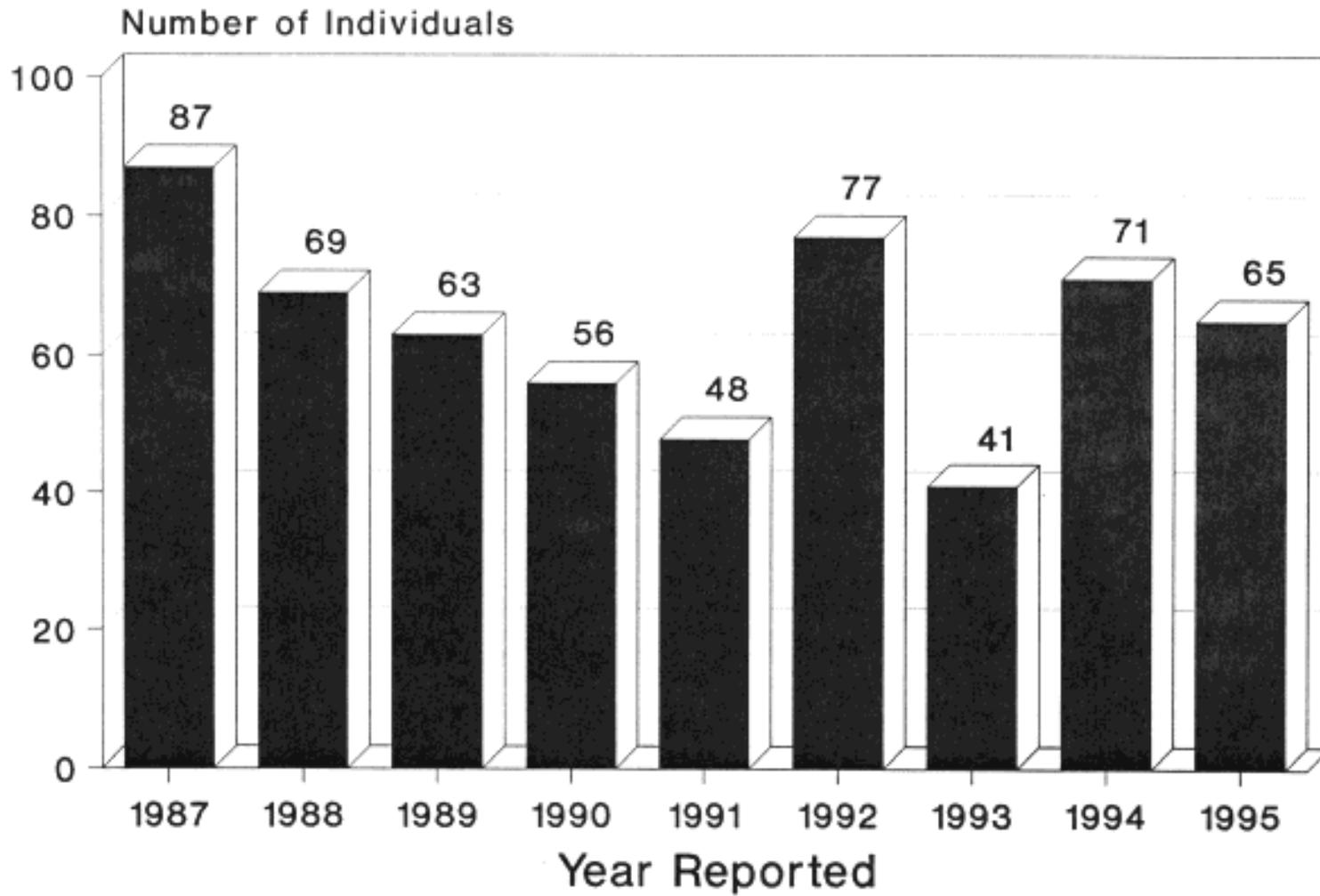
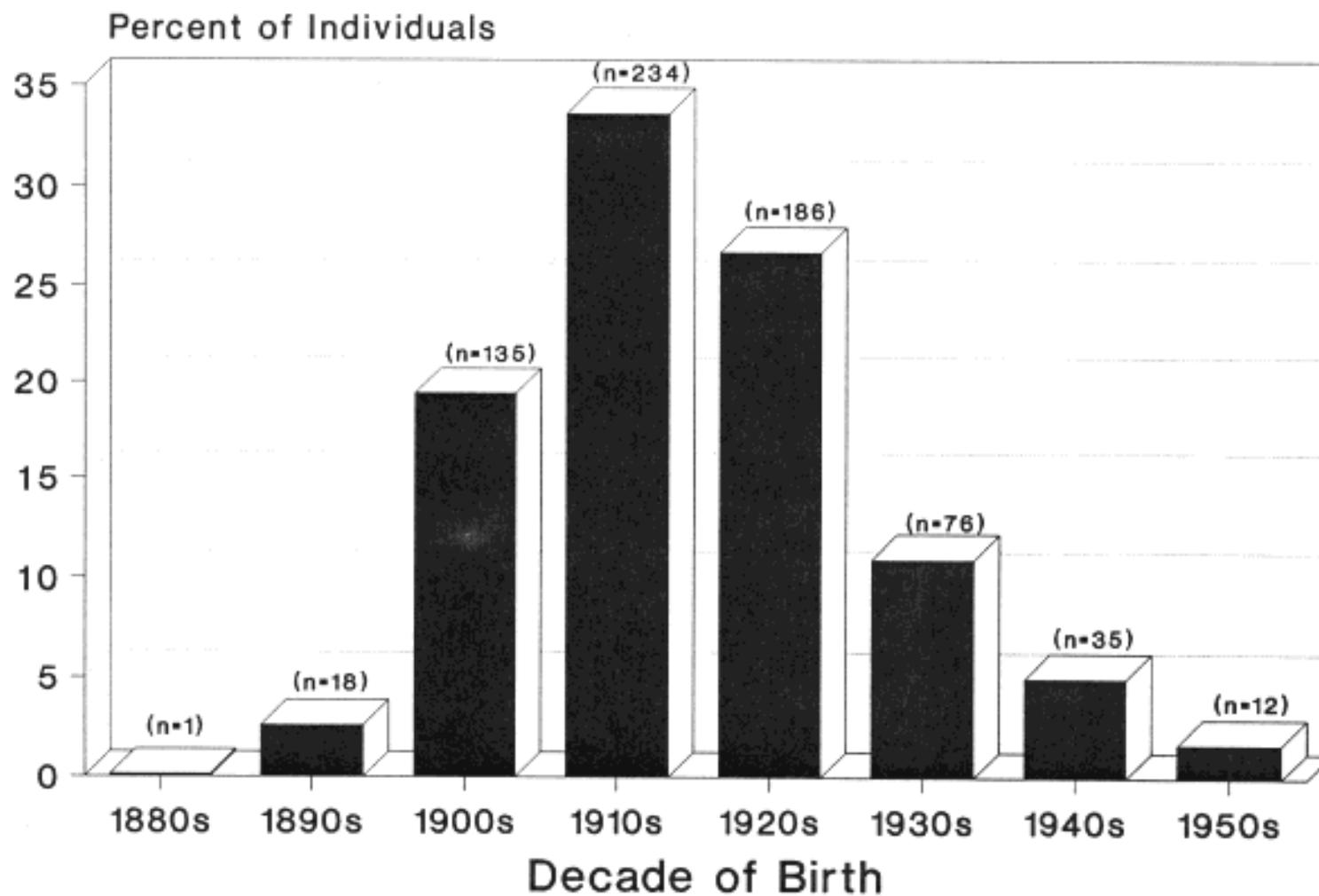
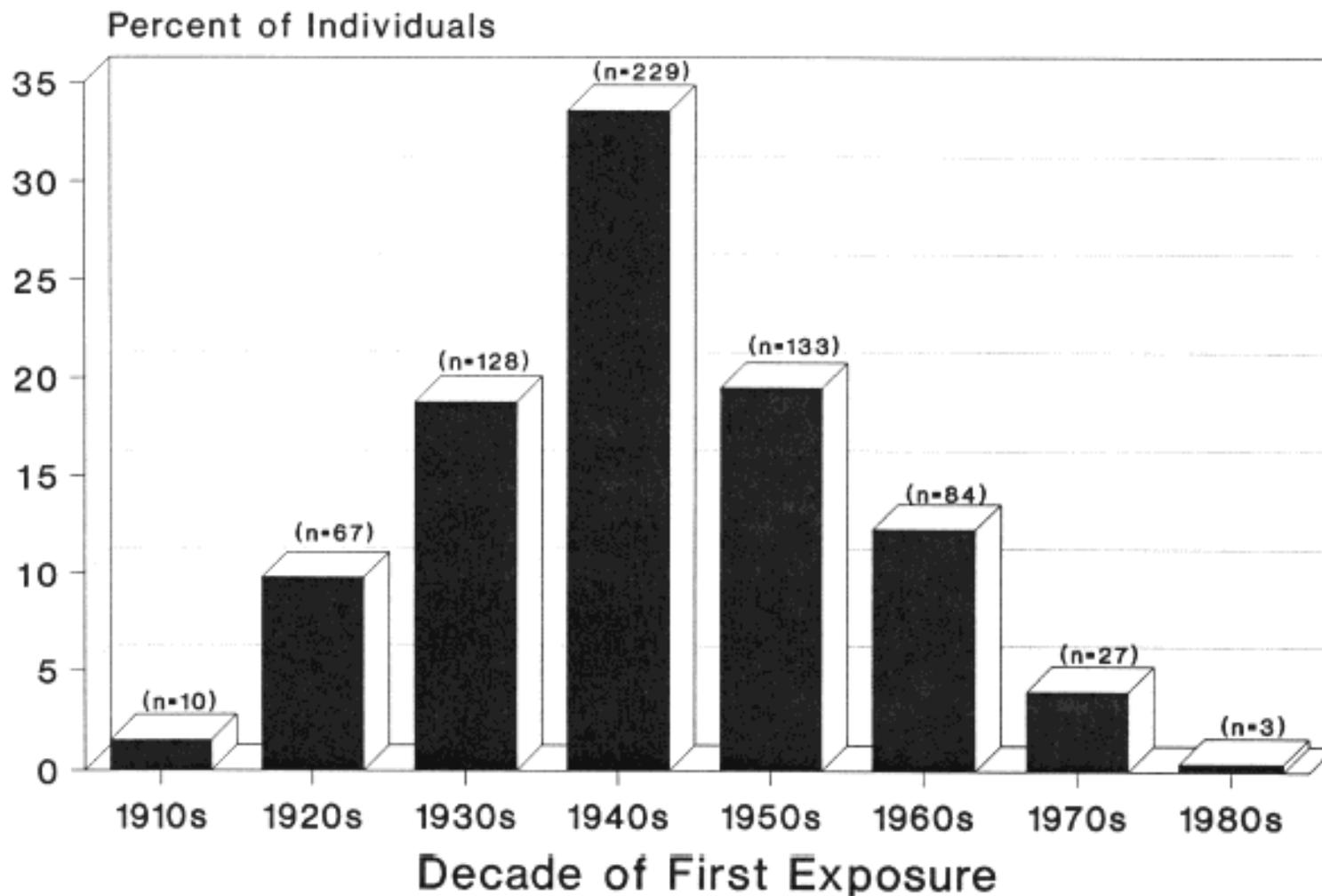


Figure 3. Distribution of Decade of Birth for Individuals Confirmed with Silicosis: 1985-1997*



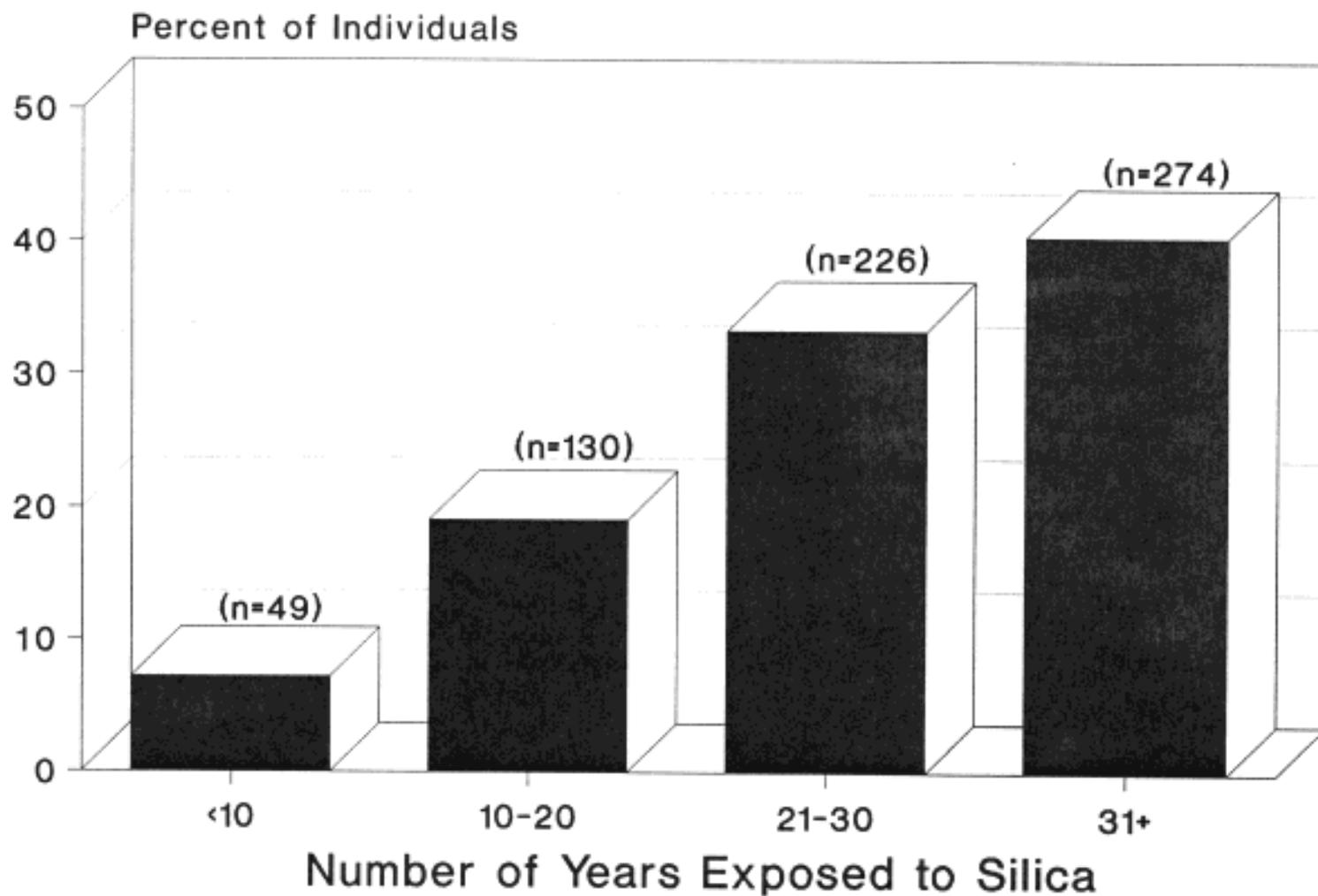
* Total number of individuals: 697.

Figure 4. Distribution of Decade When Silica Exposure Began for Individuals Confirmed with Silicosis: 1985-1997*



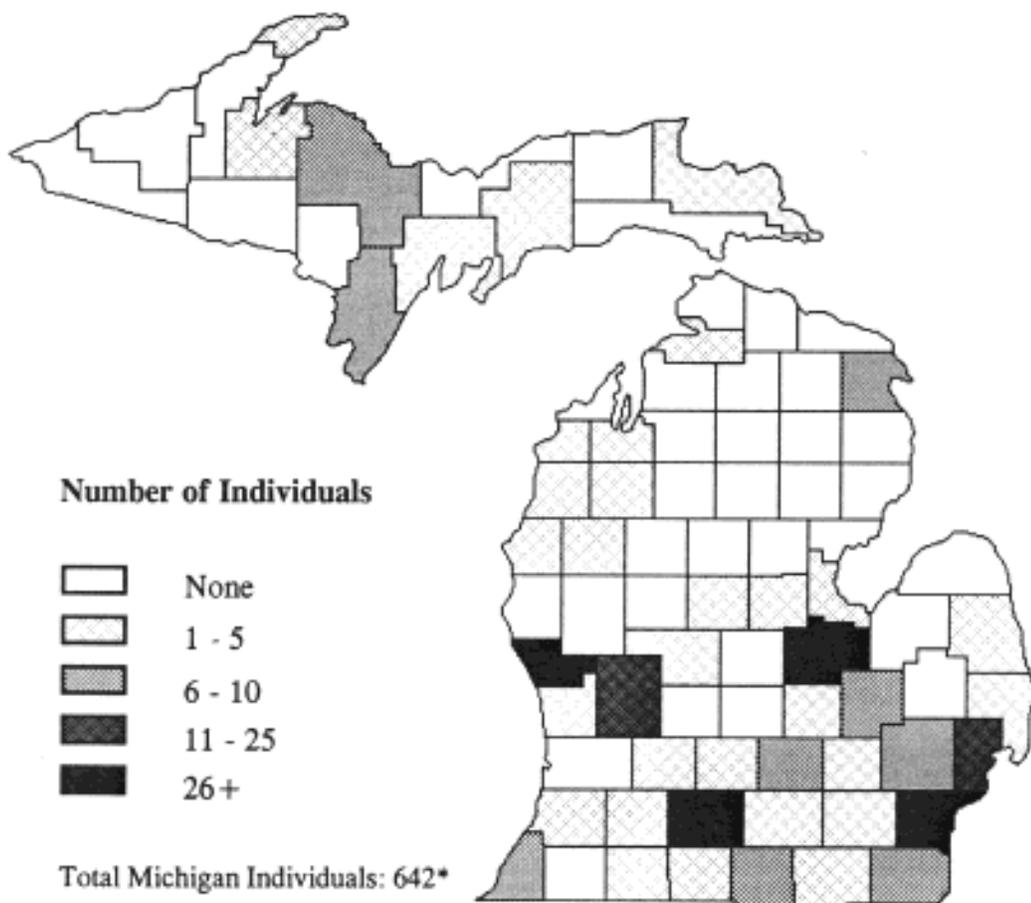
* Total number of individuals: 681. Unknown decade for 16 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Individuals Confirmed with Silicosis: 1985-1997*



* Total number of individuals: 679. Unknown years for 18 individuals.

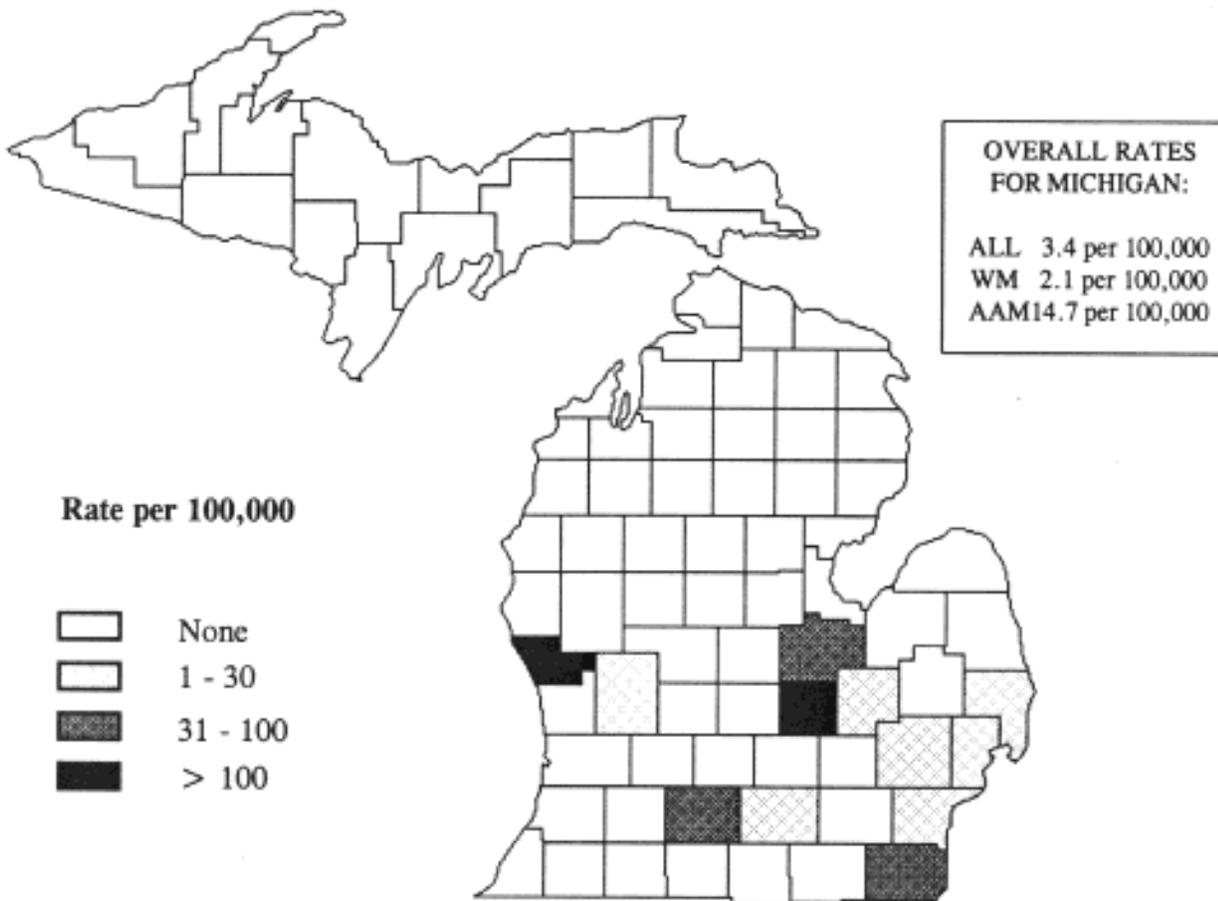
Figure 6. Distribution of Confirmed Silicosis Individuals by County of Exposure: 1985-1997



Calhoun, Muskegon, Saginaw and Wayne counties had the highest number of silicosis individuals, with 29, 168, 106 and 191 individuals, respectively.

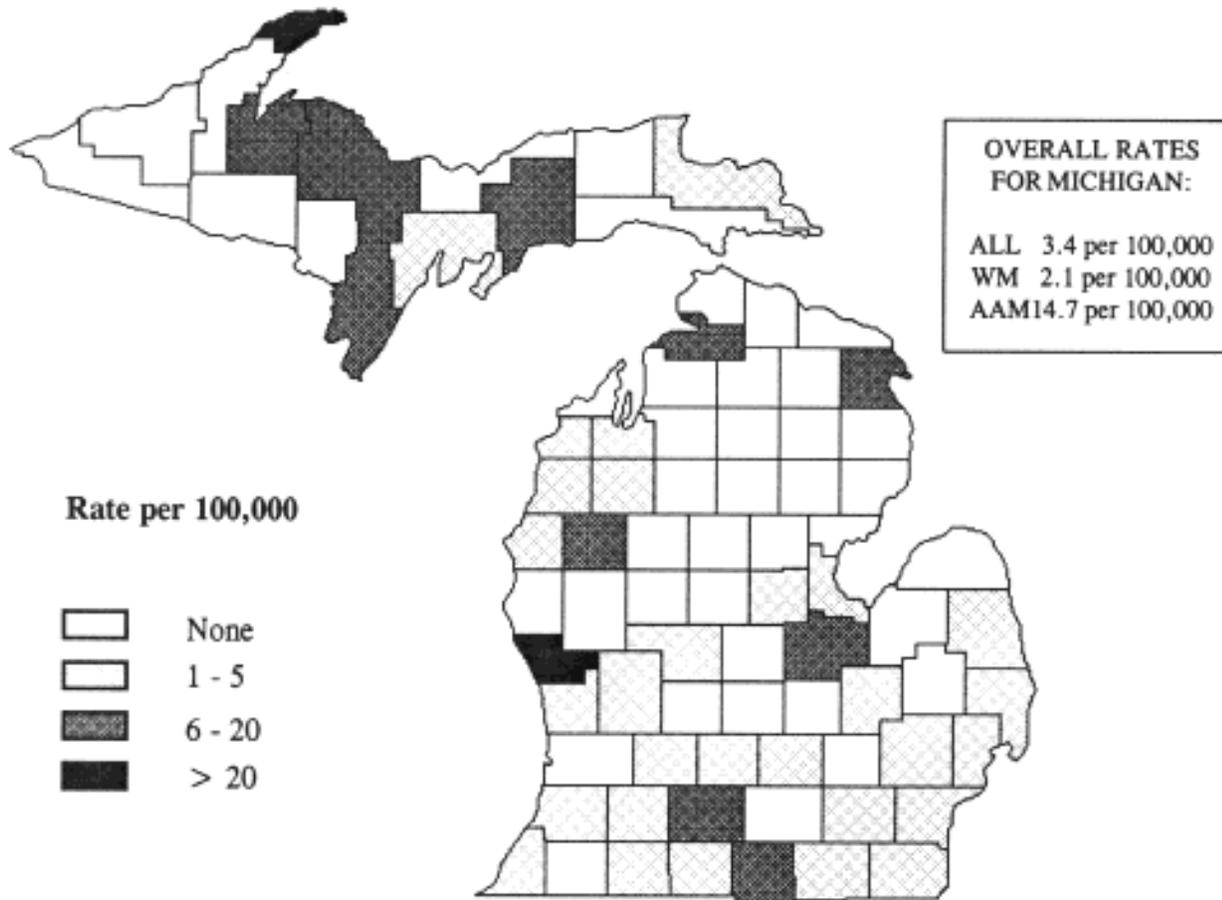
*Fifty-one individuals were exposed to silica out of state, and four individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-1995*



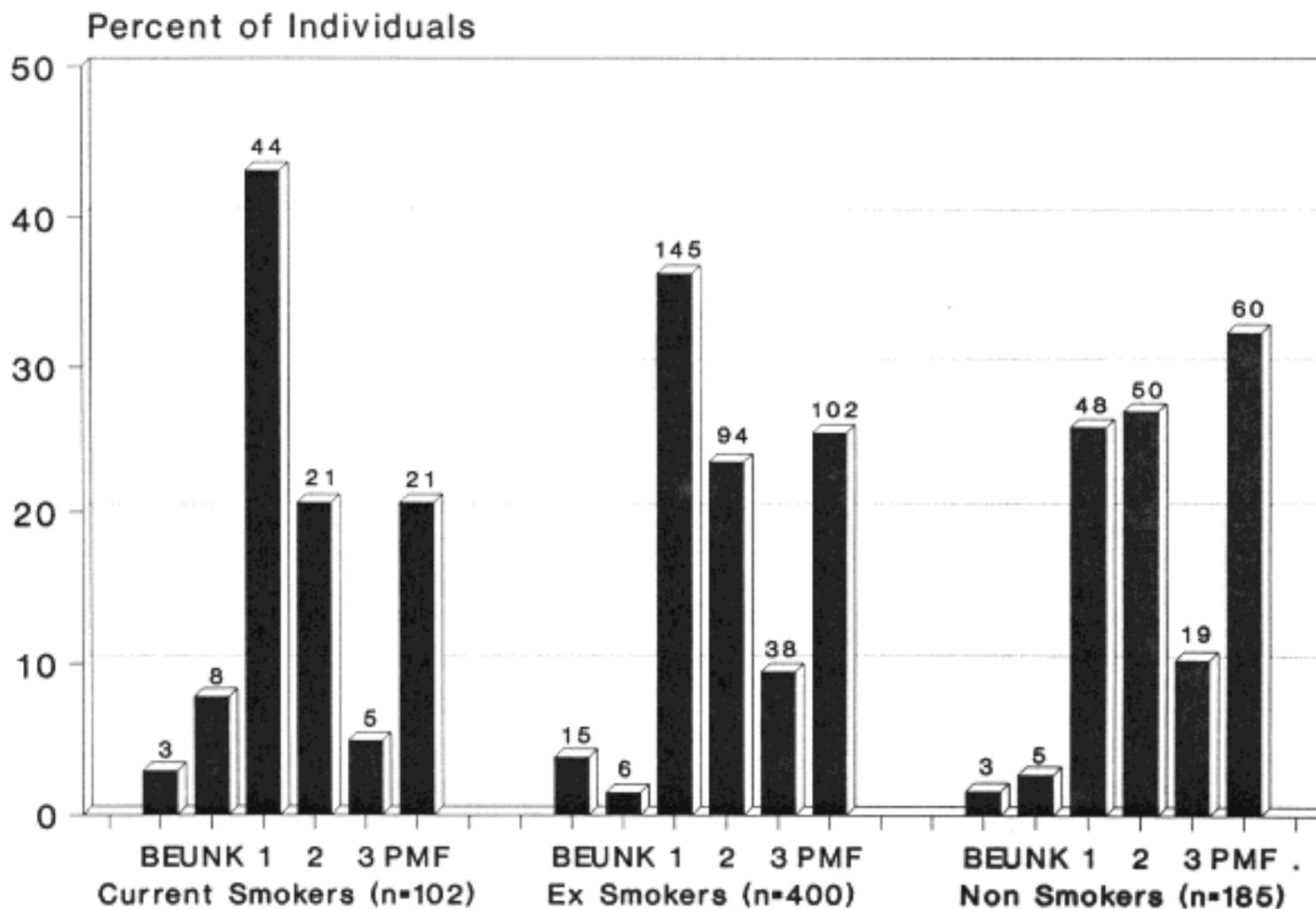
*Rate per 100,000 among African American men age 40+. Numerator is the average number of individuals for the years 1987-1995; denominator is the 1990 U.S. Census population data for African American men age 40 and older, by county. In 1990, there were 174,325 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-1995*



*Rate per 100,000 among white men age 40+. Numerator is the average number of individuals for the years 1987-1995; denominator is the 1990 U.S. Census population data for white men age 40 and older, by county. In 1990, there were 1,410,341 white males 40 years and older living in Michigan.

Figure 9. Severity of X-Ray Results* by Smoking Status for Individuals** Confirmed with Silicosis: 1985-1997



BE = Biopsy Evidence; UNK = Unknown; 1-3 - International Labor Organization categorization system for grading pneumoconioses: Category 1 - 1/0, 1/1, 1/2; Category 2 = 2/1, 2/2, 2/3; Category 3 - 3/2, 3/3, 3/+; PMF = Progressive Massive Fibrosis.

**Total number of individuals: 687. Information was missing for 10 individuals.

Table 1. Number of Confirmed Individuals with Silicosis by Year and Reporting Source*

	<u><1985</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>All Years</u>
PR	--	--	--	--	--	7	5	5	16	6	7	27	29	8	110
HDC	--	--	--	68	57	41	44	36	53	31	36	35	26	0	427
DC	--	11	11	12	5	8	0	1	6	0	1	2	0	0	57
DL	10	12	13	7	7	4	6	6	2	4	27	1	0	0	99
ICFU	--	--	--	--	--	3	1	0	0	0	0	0	0	0	4
Total	10	23	24	87	69	63	56	48	77	41	71	65	55	8	697

*PR=physician referral; HDC=hospital discharge data; DC=death certificate; ICFU=index case follow up.

Table 2. Primary Industry Where Silica Exposure Occurred for Individuals Confirmed with Silicosis for the Years 1985-1997

<u>Industry (SIC code)*</u>	<u>Number of Individuals **</u>	
Manufacturing		
Primary Metal Industries (33) Includes iron, steel, gray & ductile iron foundries.	553	(79.7)
Stone, Clay, Glass and Concrete Products (32)	32	(4.6)
Transportation - Equipment (37) Includes auto bodies and boat building.	24	(3.5)
Fabricated Metal Products (34)	10	(1.4)
Industrial Machinery (35)	7	(1.0)
Miscellaneous (25,26,28,30,36,38) Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment.	10	(1.4)
Mining (10-14)	17	(2.4)
Construction (15-17)	31	(4.5)
Transportation, Communication, etc. Services (40-49)	5	(0.7)
Wholesale Trade (50)	1	(0.1)
Business and Repair Services (73,76)	2	(0.3)
Dental Laboratory (80)	2	(0.3)
<hr/>		
Total	694	(99.9)***

* Standard Industrial Classification

** For three workers, the industrial classification was not known. Percentages are in parentheses.

*** Percent does not add to 100 due to rounding.

Table 3. Percent Predicted Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals* Conrwmmed with Silicosis for the Years 1985-1997

<u>X-Ray Results</u>	Percent FVC**					
	<u><60%</u>		<u>60-79%</u>		<u>>80%</u>	
	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>
Biopsy Evidence	5 (31.3)	0 --	8 (50.0)	1 (33.3)	3 (18.8)	2 (66.7)
Unknown Severity	3 (27.3)	1 (33.3)	4 (36.4)	1 (33.3)	4 (36.4)	1 (33.3)
Category 1	33 (22.9)	13 (38.2)	49 (34.0)	7 (20.6)	62 (43.1)	14 (41.2)
Category 2	28 (31.5)	14 (38.9)	27 (30.3)	11 (30.6)	34 (38.2)	11 (30.6)
Category 3	7 (25.9)	8 (61.5)	11 (40.7)	3 (23.1)	9 (33.3)	2 (15.4)
PMF	31 (35.6)	13 (31.7)	30 (34.5)	15 (36.6)	26 (29.9)	13 (31.7)
Total	107 (28.6)	49(37.7)	129 (34.5)	38(29.2)	138 (36.9)	43 (33.1)

* Total number of individuals: 504. Information was missing for 193 individuals.

**Number, percentage in parentheses. Percentages represent the proportion of individuals in each of the x-ray result categories, within smoking status category (ever or never).

Table 4. Ratio of Forced Expiratory Volume in I Second (FEV₁) Divided by Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals* Confirmed with Silicosis for the Years 1985-1997

<u>X-Ray Results</u>	FEV ₁ /FVC**							
	<u><40%</u>		<u>41-59%</u>		<u>60-74%</u>		<u>>75%</u>	
	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>
Biopsy Evidence	2 (12.5)	1 (33.3)	3 (18.8)	0 (--)	5 (31.3)	2 (66.7)	6 (37.5)	0 (--)
Unknown Severity	0 (--)	0 (--)	0 (--)	0 (--)	1 (12.5)	2 (66.7)	7 (87.5)	1 (33.3)
Category 1	16 (11.2)	1 (2.9)	30 (21.0)	3 (8.8)	53 (37.1)	10 (29.4)	44 (30.8)	20 (58.8)
Category 2	3 (3.6)	2 (5.6)	18 (21.4)	5 (13.9)	36 (42.9)	9 (25.0)	27 (32.1)	20 (55.6)
Category 3	1 (3.8)	0 (--)	4 (15.4)	0 (--)	5 (19.2)	3 (23.1)	16 (61.5)	10 (76.9)
PMF	13 (15.5)	4 (9.8)	24 (28.6)	9 (22.0)	26 (31.0)	13 (31.7)	21 (25.0)	15 (36.6)
Total	35 (9.7)	8 (6.2)	79 (21.9)	17(13.1)	126 (34.9)	39 (30.0)	121 (33.5)	66 (50.8)

* Total number of individuals: 491. Information was missing for 206 individuals. "Number, percentage in parentheses. Percentages represent the proportion of individuals in each of the x-ray result categories, within smoking status category (ever or never).

Table 5. Summary of 26 Individuals with Silicosis Identified With Either Rheumatoid Arthritis, Scleroderma or Systemic Lupus Erythematosus, Michigan 1985-1995

	<u>Gender*</u>	<u>Year of Birth</u>	<u>Race **</u>	<u>Industry where Exposed to Silica</u>	<u>Period Worked</u>	<u>Disease</u>	<u>ILO*** Reading</u>
1.	M	1912	B	Foundry	1935-1973	Rheumatoid Arthritis with Sjogren's Syndrome	2/3, B
2.	M	1915	W	Foundry	1936-1947	Rheumatoid Arthritis	3/3
3.	M	1919	B	Foundry	1944-1979	Rheumatoid Arthritis	1/0
4.	M	1914	B	Foundry	1936-1974	Rheumatoid Arthritis	1/1
5.	M	1924	B	Foundry	1948-1968	Rheumatoid Arthritis	2/2, C
6.	M	1930	W	Shipyard	1966-1980	Scleroderma	3/3, A
7.	M	1908	B	Foundry	1947-1968	Rheumatoid Arthritis	1/1
8.	M	1897	W	Iron Miner	1922-1963	Rheumatoid Arthritis	2/2, B
9.	M	1925	W	Foundry	1953-1959	Rheumatoid Arthritis	1/1, A
10.	M	1911	W	Foundry	1925-1963	Rheumatoid Arthritis	2/3, A
11.	M	1932	B	Foundry	1954-1978	Rheumatoid Arthritis	1/2, A
12.	M	1910	B	Foundry	1925-1940	Rheumatoid Arthritis	2/3
13.	M	1903	W	Foundry	1944-1970	Rheumatoid Arthritis	No x-ray available (Biopsy positive)
14.	M	1923	B	Foundry	1942-1980	Systemic Lupus Erythematosus	2/2

Table 5. Continued

	<u>Gender</u> *	<u>Year of Birth</u>	<u>Race</u> **	<u>Industry where Exposed to Silica</u>	<u>Period Worked</u>	<u>Disease</u>	<u>ILO*** Reading</u>
15.	M	1942	B	Foundry	1969-1989	Rheumatoid Arthritis with Sjogren's Syndrome	2/1
16.	M	1916	W	Foundry	1949-1981	Rheumatoid Arthritis	3/3
17.	M	1918	W	Foundry	1939-1975	Rheumatoid Arthritis with Felty's Syndrome	2/2, A
18.	M	1923	W	Silicon Manufacturer	1952-1970	Rheumatoid Arthritis	1/1
19.	M	1918	B	Foundry	1946-1973	Rheumatoid Arthritis	1/1
20.	M	1892	W	Foundry	1932-1957	Rheumatoid Arthritis	1/2
21.	M	1932	W	Foundry	1952-1994	Rheumatoid Arthritis	3/3, B
22.	M	1916	B	Foundry	1944-1981	Rheumatoid Arthritis	1/1
23.	M	1914	B	Foundry	1940-1960	Rheumatoid Arthritis	1/1
24.	M	1926	W	Foundry	1949-1966	Rheumatoid Arthritis	2/2
25.	M	1949	W	Dental Supply Manufacturing	1967-1986	Rheumatoid Arthritis	1/1, A
26.	M	1923	W	Foundry	1941-1969	Rheumatoid Arthritis	3/2, B

* All 26 cases were males.

** B=Black; W=White;

*** Standardized interpretation using the International Labor Organization Classification system, $\geq 1/0$ is abnormal with larger numbers showing increased paracnyhnal profusion, letters A-C refer to progressive massive fibrosis and the increasing size of the large opacities.

Table 6. Comparison of Silicotics With and Without Connective Tissue Disease, Michigan 1985-1995

	Connective Tissue Disease (26)*		No Connective Tissue Disease (463)*		
	Number	Percent	Number	Percent	O.R. (95% C.L.)
White	14	(53.8)	236	(54.3)	.98 (.39-2.20)
Black	12	(46.2)	188	(43.2)**	
Year of Birth <1930	21	(80.8)	384	(87.9)	.58 (.20-1.84)
Worked in a Foundry	21	(84.0)	329	(75.5)	1.71 (.54-7.17)
Had Done Sandblasting	8	(40.0)	102	(32.6)	1.38 (.50-3.76)
Exposure to Silica >20 years	16	(61.5)	309	(72.4)	.61 (.25-1.49)
Smoked Cigarettes	17	(68.0)	316	(73.0)	.79 (.31-2.05)
Tuberculosis	5	(22.7)	72	(19.6)	1.21 (.37-3.63)
Applied for Workers' Comp.	6	(60.0)	94	(55.6)	1.20 (.29-5.27)
Progressive Massive Fibrosis on Chest X-ray	12	(46.2)	138	(31.6)	1.8 (.77-4.31)

Denominator varies because information is missing on some individuals. Eleven (2.5%) were neither white nor black.

Table 7. Prevalence of Connective Tissue Disease Among Individuals with Silicosis, Michigan, 1985-1995

	Michigan Data		Relative Risk (95% C.L.)	General Population (24,25)
	Number	Prevalence		
Information from Medical Records**				
Rheumatoid Arthritis	24	5.2%	2.73 (1.75-4.06)	2% of White and Black Men ≥ 55 years
Scleroderma	1	.2%	15.65 (.21-87.03)	.014%
Systemic Lupus Erythematosus	1	.2%	11.37 (.15-63.23)	.02% of Men
Self Reports**				
Any Type of Arthritis	124	21.3%		21.0% of White & Black Men & Women ≥ 18 years

*Medical records were available on 463 individuals.

**Questionnaires were completed on 583 individuals.

Table 8. Status of Facilities Where 697 Individuals Confirmed with Silicosis for the Years 1985-1997 were Exposed to Silica

	<u>Number of Individuals Represented</u>	<u>Number of Facilities</u>	<u>Percent of Facilities</u>
Inspections	321	62	(23.6)
Closed	268	99	(37.6)
Out of State	42	40	(15.2)
Scheduled for Inspections	13	11	(4.2)
No Longer Use Silica	13	11	(4.2)
Unknown	16	16	(6.1)
Building Trade	23	23	(8.7)
Referred to MSHA	1	1	(0.4)
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Total	697	263	100.0

Table 9. Results of Industrial Hygiene Inspections of 62 Facilities Where Individuals Confirmed with Silicosis for the Years 1985-1997 were Exposed to Silica

	<u>Number of Companies</u>	<u>Percent</u>
Air Sampling Performed	42	
Above NIOSH Recommended Standard for Silica	24	(57.1)
Above MIOSHA Enforceable Standard for Any Exposure	18	(42.9)
Above MIOSHA Enforceable Standard for Silica	17	(40.5)
Medical Surveillance Evaluated	55	
Periodic Chest Xrays with B Reader	4	(7.3)
Periodic Chest Xrays without a B Reader	1	(1.8)
Pre-employment Testing Only	19	(34.5)
No Medical Surveillance	18	(32.7)
Periodic Pulmonary Function Testing	13	(23.6)