

2004

**Annual Report on
Silicosis in Michigan**



2004 Annual Report on Silicosis in Michigan

A Joint Report
of the
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Summary:

This is the 14th annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 2002 and preliminary data for 2003 and 2004. A total of 953 cases of silicosis have been confirmed from 1985 - 2004: 34 of those reports were confirmed in 2002. To date, another 28 cases have been confirmed for 2003, and two cases in 2004. The number of cases reported from 1998 through 2002 was 20-40 and is decreased from approximately 60-70 reports a year in previous years. We are encouraged by this downward trend and will monitor reports in future years to determine if the smaller number of cases reported from 1998 through 2002 continues in the future.

Based on capture-recapture analysis we would estimate that although we only received 34 reports of newly diagnosed silicosis cases in 2002 there were another 83-170 individuals diagnosed with silicosis in Michigan in 2002 who were not reported¹.

Using data from the Michigan silicosis surveillance system and the number of deaths that occur nationally from silicosis collected by the National Center for Health Statistics, we estimate that there are approximately 3,600 to 7,300 newly diagnosed cases of silicosis occurring each year in the United States¹. This estimate is more reliable than that derived from the existing national system administered by the United States Department of Labor's Bureau of Labor Statistics which in 1999 reported only 2,200 cases for all dust diseases of the lung including diseases such as asbestosis and coal workers' pneumoconiosis in addition to silicosis.

We have analyzed the cost-effectiveness of the Michigan silicosis surveillance system and its usefulness to provide national estimates of silicosis². Using the Michigan silicosis surveillance data from 1989-1995, we identified the costs associated with the collection of data that led to the identification of companies with silica-related violations of the Michigan OSHA standard. Costs were determined for both internal state agency costs (i.e. MIOSHA and Michigan State University) and costs to the entities reporting the cases of silicosis to the state (i.e. physicians, clinics, employers). We then analyzed the costs associated with the identification of silicosis cases by different sources (hospitals, physicians,

workers' compensation and death certificates) to determine the relative effectiveness of each of the sources to lead to the identification of Michigan companies with over-exposures to silica, that is, problem worksites. We calculated that it costs the surveillance system \$11 to identify each silicosis case who works at a problem worksite. That is, a workplace where worker exposures to silica are above permissible limits set by the Michigan Occupational Safety and Health Administration. Identification of these problem worksites is the first step to prevent future cases of silicosis, by improving working conditions. The relatively low cost to identify these problem worksites generates a favorable return for investment of public health dollars.

Silicosis continues to occur mainly among men born before 1940, who began working in a Michigan ferrous foundry in the 1930s, 1940s or 1950s and worked in silica for over 25 years. Forty-three percent of the patients are African American. The overall annual average incidence rate of silicosis among African American males (12.1 cases per 100,000) is almost seven times higher than that of white males (1.8 cases per 100,000). The rates within specific counties ranged between 2.0 to 37.0 times higher for African American males than the rates for white males. Exposure to silica occurred mainly in companies in the counties of Muskegon, Saginaw and Wayne.

The mortality rate for silicosis in the Muskegon area is one of the highest in the country. A recent NIOSH report estimated that the overall age-adjusted silicosis death rate of United States residents age 15 years and older was 1.6 deaths per million individuals³. In comparison, this report showed that the death rate in the Muskegon area was in the highest of the ranges mapped out for the entire nation: >8.0 to 62.5 deaths per million individuals.

The patients identified with silicosis generally have severe disease. Twenty-five percent have progressive massive fibrosis (PMF) and another 34% have advanced simple silicosis. Only about a third of all patients have normal breathing tests. Nineteen percent had been told they had tuberculosis (includes both clinical disease or 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 cancer⁴.

Despite the severity of disease, 59% of the patients with known filing status had

not applied for workers' compensation. The percentage of patients applying has decreased in recent years.

Although silicosis typically occurs after a long duration of exposure to silica, there continue to be patients who develop silicosis after a relatively short period of exposure because of the severity of that exposure. One individual who developed silicosis began working with silica in the 1990s, 10 in the 1980s, 44 in the 1970s and 127 in the 1960s. Exposure to silica is still occurring in foundries, although working conditions have clearly improved from the 1930s and 1940s.

Construction is the other major industry in Michigan where exposure to silica continues to occur. A new report with data from Michigan, New Jersey and Ohio addresses the silica hazard for highway reconstruction workers⁵. Contract language used by the Michigan Department of Transportation (MDOT) prohibits the use of silica for abrasive blasting work on highway bridges and overpasses. Contract language for silica safety and health for highway reconstruction jobs involving the cutting or breaking up of concrete is needed.

Background:

Silicosis is a chronic, progressive lung disease resulting from exposure to respirable particles of silica sand. Irreversible changes in the lung cause increasingly debilitating breathing difficulties among individuals who develop silicosis. Over 2000 years ago, Hippocrates first described lung disease from exposure to dusty working conditions among miners. In the 1860s, the presence of silica in the lungs was first identified, and in 1870, the term silicosis was first used to describe this fibrotic lung condition. Despite the fact that lung disease secondary to dusty work conditions from exposure to silica sand has been described since antiquity, workers continue to be exposed to hazardous levels of silica in industry and suffer from this preventable disease.

Michigan has required the reporting of all known or suspected occupational diseases including silicosis since 1978 under part 56 of Public Act 368 of 1978. Active surveillance of silicosis, however, began in 1988. In that year the State, initially the Michigan Department of Public Health, and now the Michigan Department of Labor and Economic Growth (DLEG), with financial assistance from

the National Institute for Occupational Safety and Health (NIOSH), instituted a surveillance/investigation program for silicosis.

Michigan's surveillance program identifies individuals with known or suspected silicosis, interviews the patients or their next-of-kin about their work and health history using a standardized telephone-administered questionnaire, and obtains medical records including the most recent chest x-ray. A physician who is board-certified in both internal and occupational medicine reviews each patient's information. 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. If the facility where the patient was exposed to silica is still in operation, a Michigan Occupational Safety and Health Administration (MIOSHA) enforcement inspection may be conducted to determine current exposures and conditions.

Michigan uses four sources to identify persons with silicosis: (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.

Results:

Reports

Due to delays in receiving reports and the availability of databases, the most complete data available are for 1987 - 2002. Partial data is also available for the years 1985 and 1986. The system does not receive complete reporting from the hospitals until one and a half years and death certificates until half a year after the end of the calendar year. Accordingly, 2003 and 2004 data is incomplete at this time. Given the known inadequacies of occupational disease surveillance

systems and under-diagnosis of the condition itself, even the most complete data for the years 1987 - 2002 undercounts the true number of persons with silicosis.

Figure 1 shows 866 patients identified and confirmed with silicosis through the surveillance system by year for 1987 through 2002. To date, an additional 28 persons with silicosis in 2003, and two individuals in 2004 have been confirmed with silicosis. Table 1 shows the primary reporting source of the 953 persons confirmed with silicosis from 1985 - 2004. Hospital reports are the primary source of identification of patients, with 58% of silicosis patients identified solely through the hospitals. Often a patient will be reported to the system by more than one source. Figure 2 shows the overlap of reporting sources for the most complete reporting years of 1987 through 2003.

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 silicosis⁶. Using capture-recapture analyses, we estimate that the true number of silicotics in Michigan from 1987 - 1996 is 1,548 - 3,236¹. During this same period 644 individuals were reported to the state; this is 20-42% of the estimated total number of individuals developing the disease during these 10 years.

The following statistics are based on the 953 cases of silicosis confirmed from 1985 - 2004.

Gender

Nine hundred thirty-three (97.9%) of the persons with silicosis are men; the other 20 (2.1%) are women.

Race

Five hundred eighteen (54.5%) of the persons with silicosis are white, 404 (42.5%) are African American, two (0.2%) are of Asian ancestry, one (0.1%) was of American Indian ancestry, and 25 (2.6%) were listed as "other ancestry". The race on three individuals was unknown.

Year of Birth

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1921, ranging from 1888 to 1959.

Decade of Hire

The distribution of the decade of hire is shown in Figure 4. The average year of hire is 1948, ranging from 1910 to 1990.

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 27.9.

Location in State

Figure 6 shows the counties of the companies at which the patients' silica exposure occurred. The locations are clustered in three counties: Muskegon, Saginaw and Wayne. The overall average annual incidence rate for silicosis among African American men is 12.1 cases per 100,000, and for white men is 1.8 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 595/100,000, in Muskegon it was 251/100,000, in Saginaw it was 88/100,000, in Monroe it was 52/100,000, in Calhoun it was 32/100,000, in Macomb it was 27/100,000, and in St. Clair it was 15/100,000. The rate of silicosis among African American men in Shiawassee was based on 2 cases and only 21 African American males age 40 and older in this county, according to Census figures. Figure 8 shows the annual average incidence rate of silicosis among white men age 40 or greater in each county. The rate in Muskegon was 21/100,000, in Alpena it was 17/100,000, in Keweenaw it was 13/100,000, in Saginaw it was 11/100,000, and in Menominee it was 10/100,000.

Type of Industry

Table 2 shows the primary type of industry where silica exposure occurred. The predominant industry where individuals were exposed to silica was iron foundries

(76.2%). Two hundred forty-five of the 718 individuals for whom sandblasting history is known (34.1%) stated they had done sandblasting as part of their work.

Medical Results

Overall 661 (69.4%) of the people with silicosis had simple silicosis and 237 (24.9%) had progressive massive fibrosis. Thirty (3.1%) silicotics had normal x-rays with lung biopsy evidence. Twenty-five (2.6%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred sixty-three (28.0%) of the people with silicosis never smoked cigarettes, 546 (58.1%) had quit, 130 (13.8%) were still smoking and no information was available on 14 individuals. Figure 9 shows the distribution of x-ray results according to the ILO classification and smoking status. Non-smokers tended to have more severe silicosis. The greater percentage of non-smokers with progressive massive fibrosis was statistically significant (28.5% non smokers vs. 20.8% current smokers vs. 24.3% ex smokers) ($X^2 = 27.134$, $p = .007$). This latter finding may be 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 hospitalized and therefore less likely to have been reported to the surveillance system.

Tables 3 and 4 show the distribution of percent predicted 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 (Table 4) were found in two thirds of the individuals who had ever smoked cigarettes and among half of the individuals who had never smoked cigarettes.

In addition to causing silicosis (acute-alveolar proteinosis and chronic-parenchymal fibrosis), silica exposure increases the risk of developing other diseases:

- | | |
|-------------------------|--------------------|
| • <u>Non-Malignant</u> | • <u>Malignant</u> |
| • Tuberculosis | • Lung Cancer |
| • Scleroderma | |
| • Rheumatoid Arthritis | |
| • Chronic Renal Failure | |
| • Emphysema | |

We have previously reported an increase in rheumatoid arthritis, systemic lupus erythematosus and scleroderma among individuals reported to the Michigan silicosis registry⁷. There is recently reported evidence in the medical literature that silica exposure is a risk factor for systemic lupus erythematosus⁸ and Sjogren's syndrome⁹.

We have also previously reported that ten percent of the individuals with silicosis had some mention of chronic kidney disease in their medical record and 33% had a serum creatinine level greater than 1.5 mg/dl. Individuals with silicosis were more likely to have a serum creatinine level of greater than 1.5 mg/dl than age and race matched controls¹⁰. As with the connective tissue disease cases, no association was found between duration of exposure to silica or the amount of scarring on the chest x-ray and the presence of kidney disease or elevated serum creatinine. These results are consistent with the presumed immunological etiology. We are aware of one individual with anti-neutrophil cytoplasmic antibody (ANCA) positive chronic renal failure among the individuals in the Michigan silicosis registry. ANCA positive renal disease has been repeatedly associated with silica exposure¹¹.

Recently, in cooperation with the National Institute for Occupational Safety and Health, the New Jersey Health Department and the Ohio Health Department, we matched individuals in the Michigan, New Jersey and Ohio silicosis registries with the Medicare database for individuals with chronic renal failure. There were nine individuals with end stage renal disease in the three states for a non-significant risk ratio of 1.67 (95% CI 0.76-3.17). For the four glomerular end stage renal cases identified, the risk ratio was 4.19 (95% CI 0.50-15.13)¹².

Workers' Compensation

Since the 1930s, there has been special concern about the incidence and burden of silicosis in Michigan. 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 provided workers' compensation. The funds from this special assessment are used to limit the liability of silica using industries.

Only 324 (41.0%) of the 791 individuals with silicosis or their next of kin for whom

filing status was known had applied for workers' compensation. Four hundred sixty-seven (59.0%) had not applied. It was unknown whether the remaining 162 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, 255 (78.7%) received compensation, 23 (7.1%) had been denied, and 46 (14.2%) were pending.

Industrial Hygiene Results

The 953 individuals with silicosis were exposed to silica in 366 facilities (Table 5). Inspections were performed at 80 (21.9%) of these facilities. Currently three facilities are scheduled for inspections. One hundred twenty-two (33.3%) facilities were no longer in operation, 54 (14.8) were located out of state, 22 (6.0%) facilities no longer used silica, 39 (10.7%) had worked at multiple construction sites as building trade workers, two (0.5%) were inspected by the Mine Safety and Health Administration because the company was out of MIOSHA jurisdiction, and 44 (12.0%) were unknown.

Air sampling was conducted in 57 of the 80 facilities inspected (Table 6). Thirty-four of 57 (59.6%) facilities were above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure level for silica. Twenty-one of the 57 (36.8%) were above the enforceable Michigan Occupational Safety and Health Administration (MIOSHA) standard for silica. Another two (3.5%) companies were above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only seven of the 65 (10.8%) facilities where the medical surveillance program was evaluated provided medical screening for silicosis for its workers that included a periodic chest x-ray interpreted by a "B" certified reader. Three companies provided periodic chest x-rays that were not interpreted by a "B" certified reader. Nineteen (29.2%) only performed pre-employment testing, 24 (36.9%) provided no medical surveillance, and 17 (26.2%) performed annual or biennial pulmonary function testing without chest x-rays.

Discussion:

The predominant characteristics of the individuals reported during Michigan's sixteen years of silicosis surveillance are that they are elderly men who mainly worked in foundries in three counties. The age distribution is similar to that reported in the 1950s¹³. The older age of the patient (average year of birth, 1921) is secondary to the chronic nature of the disease and the typical long exposure to silica that is required to develop the disease (average 28 years of exposure to silica).

We continue to receive reports of individuals with short-term exposure, who began work in the 1970s, 1980s and one in the 1990s. Sixty-five or 7.2% worked for less than 10 years. Fifty-five of the 909 individuals with known decade of hire (6.1%) began work in the 1970s, 1980s or 1990s; 17 of them had worked for less than ten years. The people with silicosis who began work in the 1970s or later were more likely to have done sandblasting than those who began work with silica before 1970 (48% vs. 32%). Of the 11 people who first were exposed to silica in the 1980s or 1990s; three worked in foundries, two were buffing and polishing metal, one worked in auto manufacturing, one worked in minerals processing, one worked in a dental laboratory, one was a heavy equipment operator who did excavating, one did cement work, and one owned an auto repair shop.

African American men are over represented (42.5%). This reflects previous hiring practices in foundries¹⁴. In fact, African American workers consistently had higher incidence rates of silicosis than their white counterparts in the counties where rates were compared between these groups (see Figures 7 and 8). Overall for the state, the incidence rate of silicosis among African American workers was 12.1 per 100,000 versus 1.8 per 100,000 for white workers (an almost 7 fold greater incidence).

The individuals reported generally have an advanced disease: 237 (24.9%) with progressive massive fibrosis; and another 322 (33.8%) with advanced simple silicosis (category 2 or 3). Over 60% of the reported patients have reduced breathing tests, including 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). Nineteen percent have had either tuberculosis or have had a positive skin test

indicating infection with the mycobacterium that causes tuberculosis. Despite the severity of their disease, 59% had not applied for workers' compensation.

The reports of Michigan silicotics having obstructive lung changes is consistent with published reports of increased chronic obstructive pulmonary disease (COPD) among silicotics, as well as among individuals without silicosis who have had silica exposure¹⁵. Individuals with silicosis are at risk of developing pulmonary hypertension, clinically significant bronchitis and chronic obstructive pulmonary disease¹⁶.

Hospitals are the primary reporting source of the patients identified through Michigan's surveillance system. Hospital discharge reporting is a more cost-effective method for identifying silica problem worksites than physician reporting, death certificates or workers' compensation data². A comprehensive surveillance system for silicosis that combines all four reporting sources is as good if not better return for public health dollars invested as most existing public health programs².

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease^{4,17}. The increased risk for death is found both in patients who ever or never smoked cigarettes⁴. Individuals with silicosis also have an increased risk of developing connective tissue disease, particularly rheumatoid arthritis⁷ as well as an increased risk of developing chronic renal disease, especially ANCA positive disease^{10,11,12}.

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 foundry workers who develop silicosis. The number of new cases of silicosis, from 1998 to 2002 (the last five years of complete data), shows a decrease in reports from previous years.

Abrasive blasting companies in Michigan continue to use silica abrasives. A survey performed in the 1990s of companies using silica found that most of them are putting their employees at risk of developing silicosis because they are not following recommended and required work practices. European countries banned the use of silica for sandblasting 50 years ago. In 2005, we will be updating the

survey of abrasive blasters in the state to assess their current use of silica.

In previous years, the risk of silicosis in dental laboratories^{18,19} and among highway reconstruction workers⁵ has been highlighted. Educational material was sent to all the dental laboratories. Further work is needed to protect highway construction workers from silica exposure. Engineering changes in equipment used to do highway repair and contract language to ensure safe work practices are needed to reduce the risk of silicosis among highway repair workers.

Industrial hygiene inspections reveal violations of the exposure standard for silica in 36.8% 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 89.2% of the facilities, there is no way to monitor the adequacy of these controls in terms of health outcomes.

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 silicosis because of inadequate controls at foundries currently in operation. Even without the development of silicosis, silica exposure is a risk factor for the development of lung cancer, connective tissue disease, tuberculosis and COPD^{8,15,17,20}. These risks provide justification for tighter work place controls for silica even if the number of new cases of silicosis continues to decline.

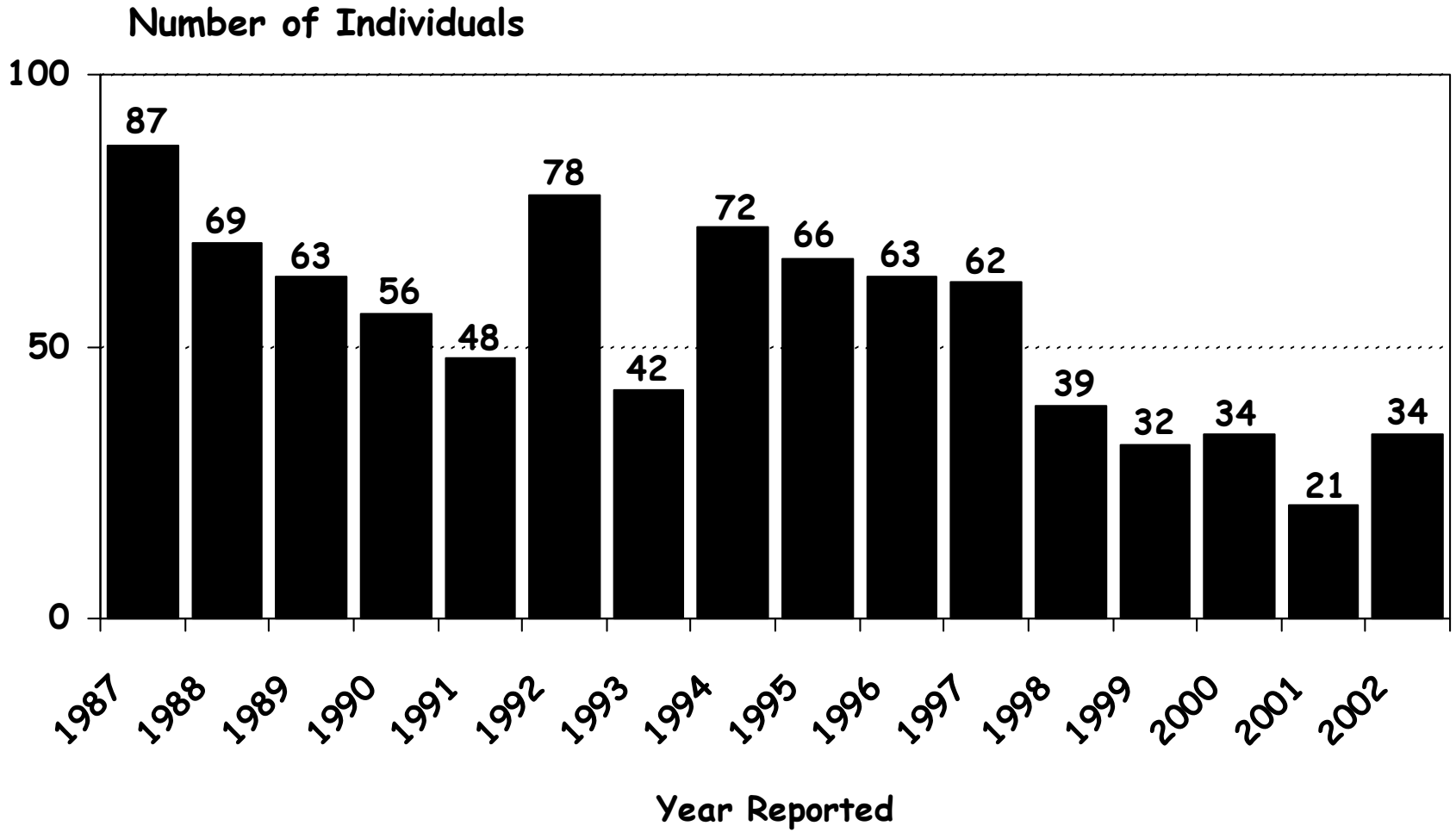
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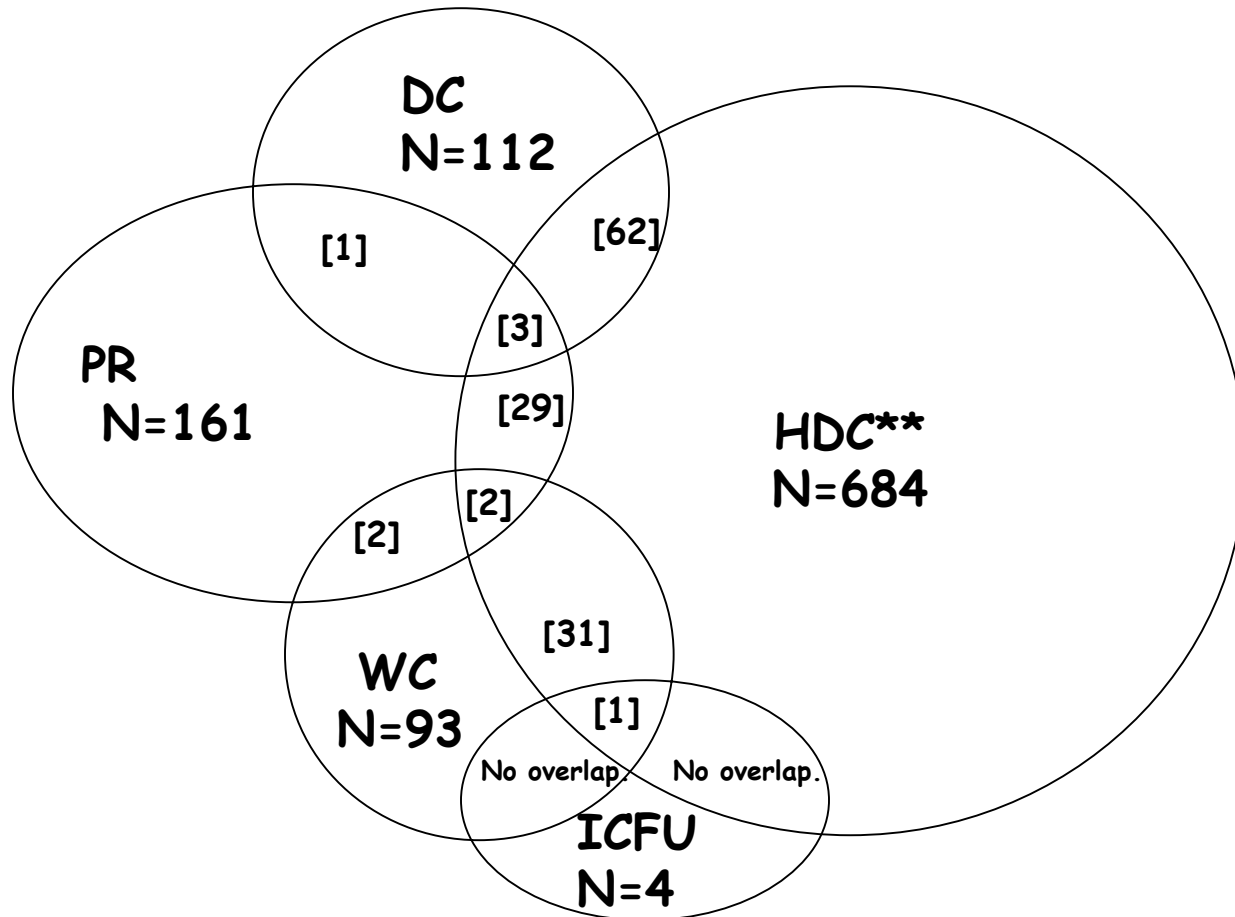
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Figure 1. Number of Individuals Confirmed with Silicosis by Year Reported*



*Total number of individuals: 866.

Figure 2. Overlap of Reporting Sources for Individuals Confirmed with Silicosis: 1987-2003*



*Diagram represents 894 individuals initially reported from 1987 to 2003.

N's represent the total number for that source.

Numbers in [] represent the overlap of reporting sources.

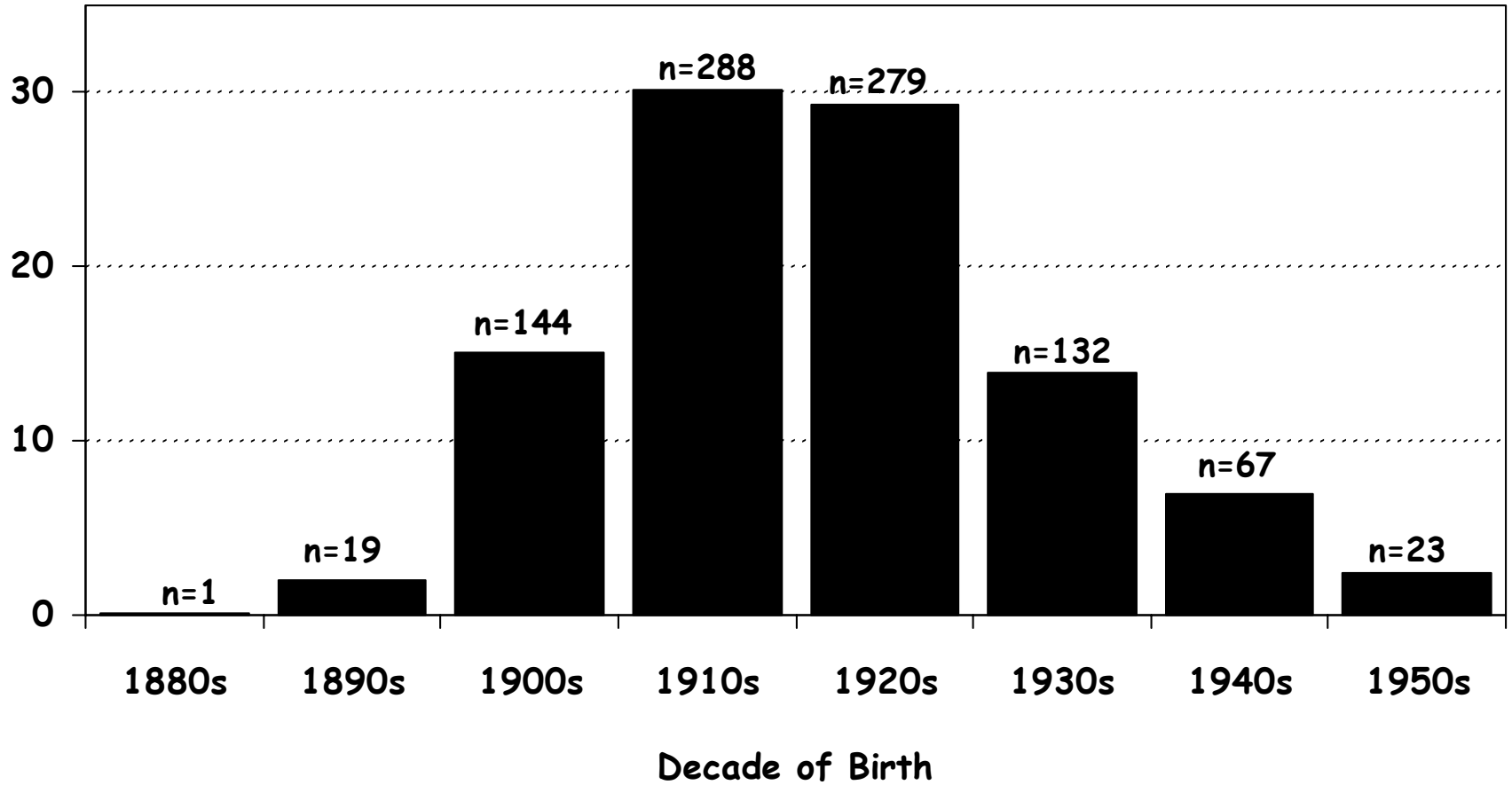
Reporting Source Codes: HDC=Hospital Discharge Data; PR=Physician Referral;

DC=Death Certificate; WC=Workers' Compensation; ICFU=Index Case Follow Up.

**There was also an overlap of HDC-DC-WC for nine individuals; an overlap of HDC-PR-WC-DC for one individual; and an overlap of HDC-DC-ICFU for one individual.

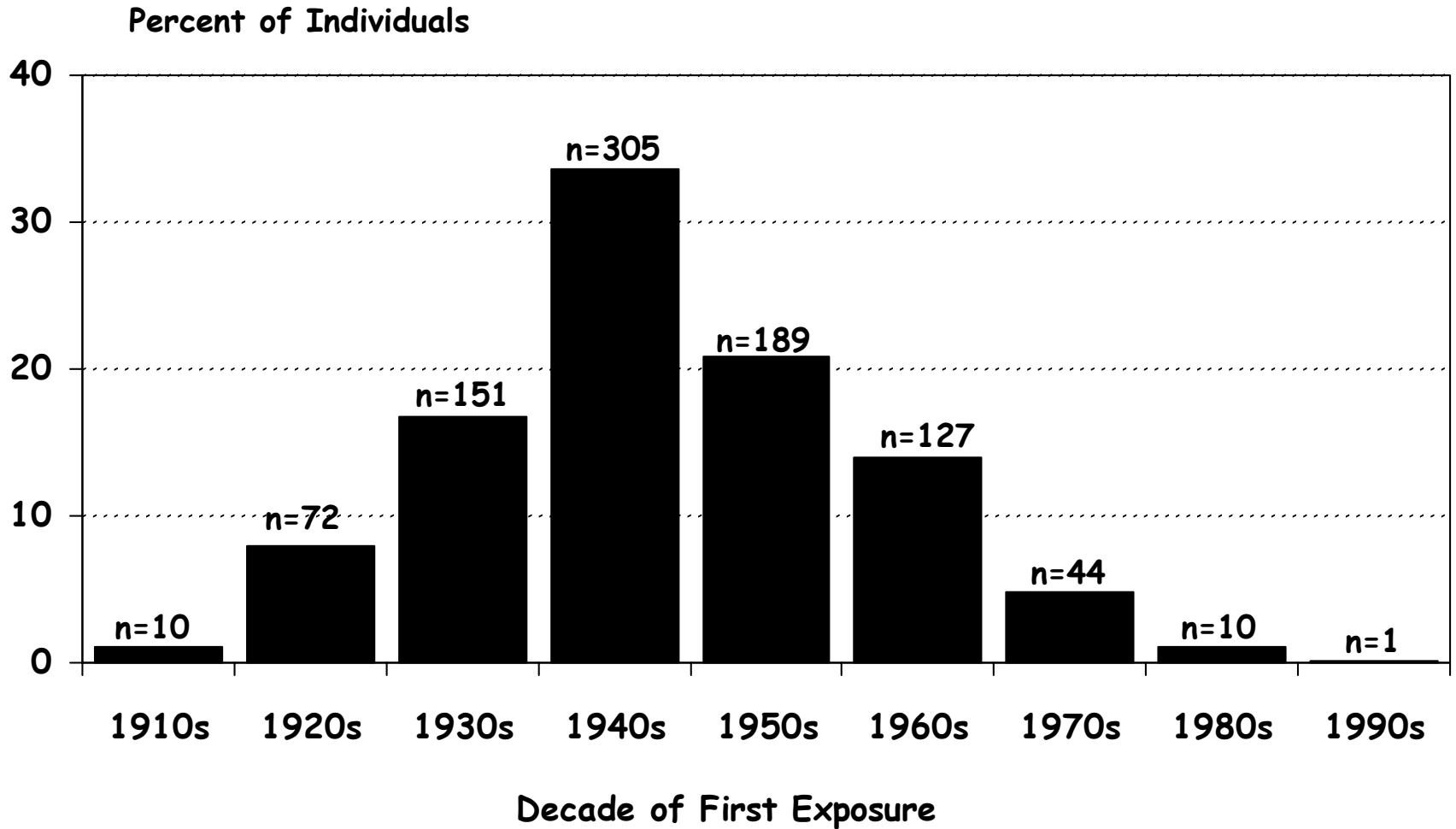
Figure 3. Distribution of Decade of Birth for Individuals Confirmed with Silicosis: 1985-2004*

Percent of Individuals



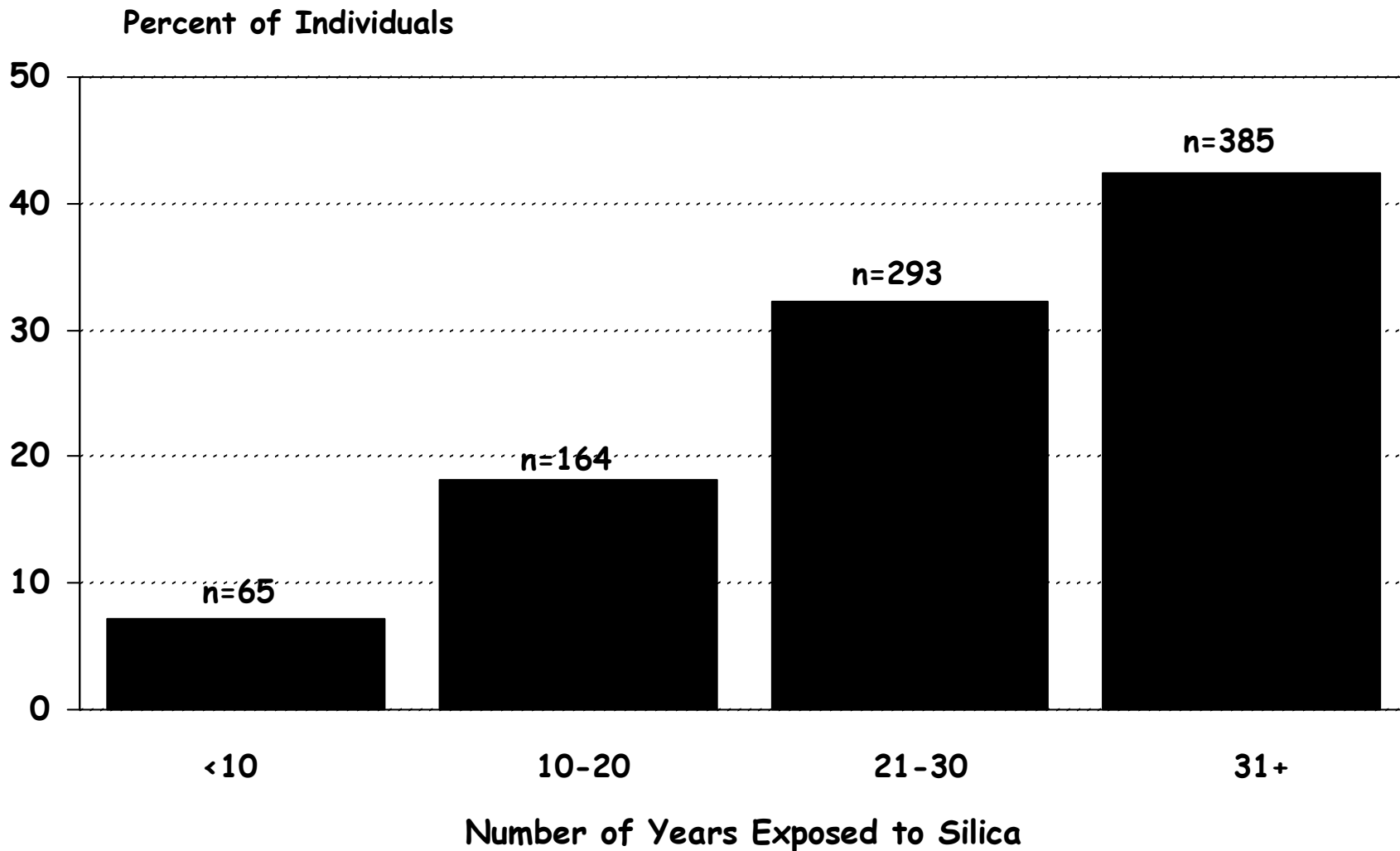
*Total number of individuals: 953.

Figure 4. Distribution of Decade When Silica Exposure Began for Individuals Confirmed with Silicosis: 1985-2004*



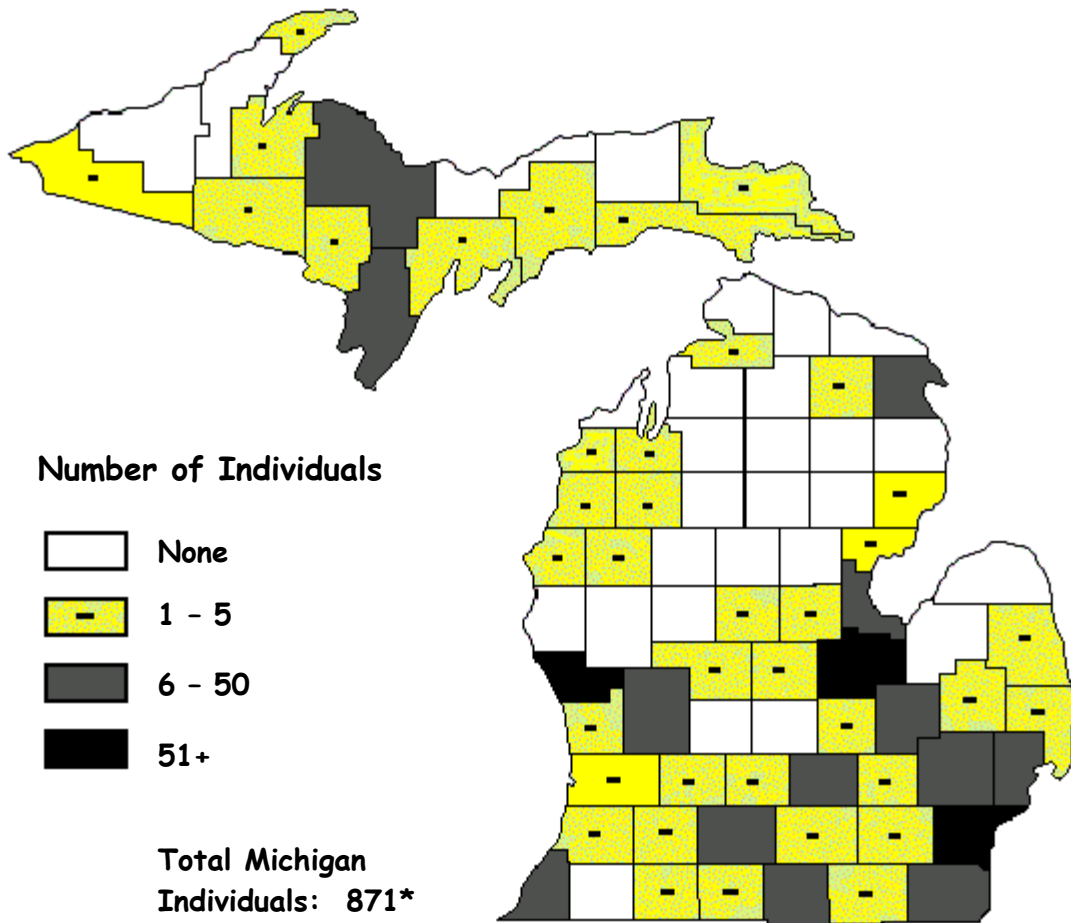
*Total number of individuals: 909. Unknown decade for 44 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Individuals Confirmed with Silicosis: 1985-2004*



*Total number of individuals: 907. Unknown decade for 46 individuals.

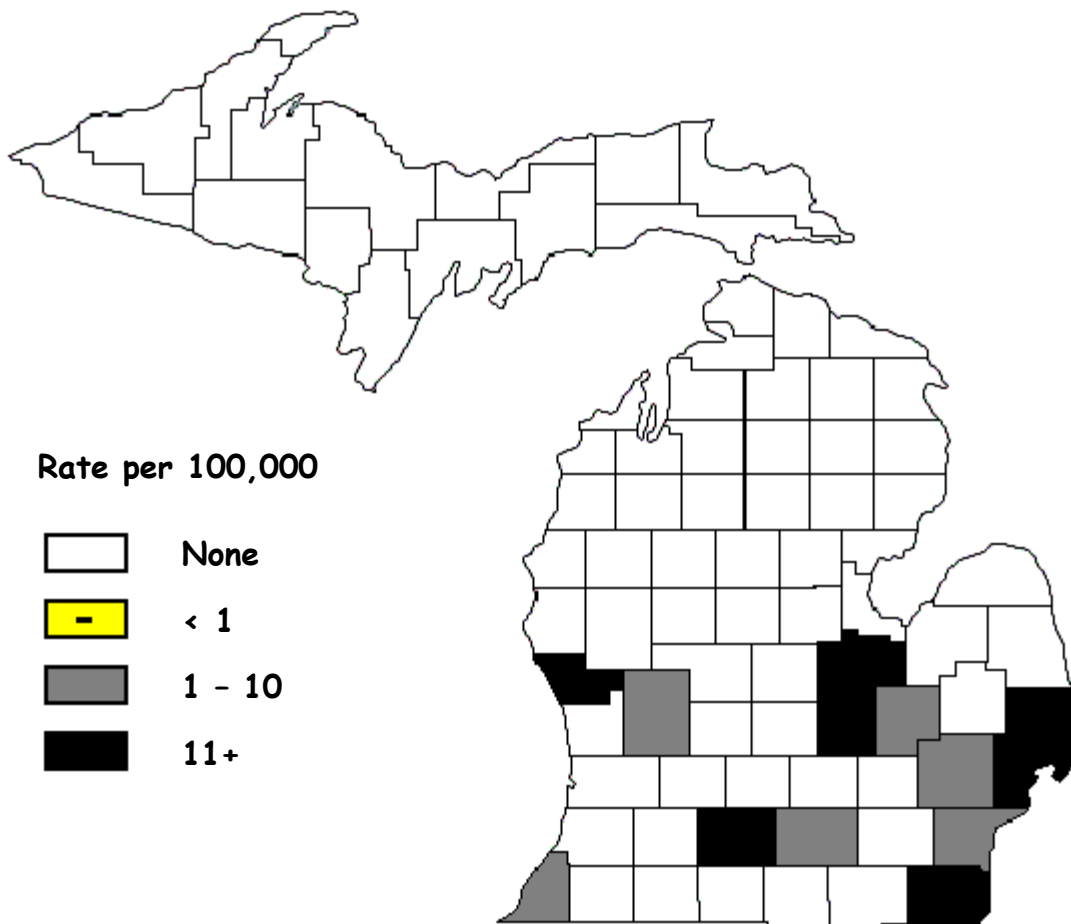
Figure 6. Distribution of Individuals Confirmed with Silicosis by County of Exposure: 1985-2004



Muskegon, Saginaw and Wayne counties had the highest number of individuals with silicosis, with 226, 138 and 247 individuals, respectively.

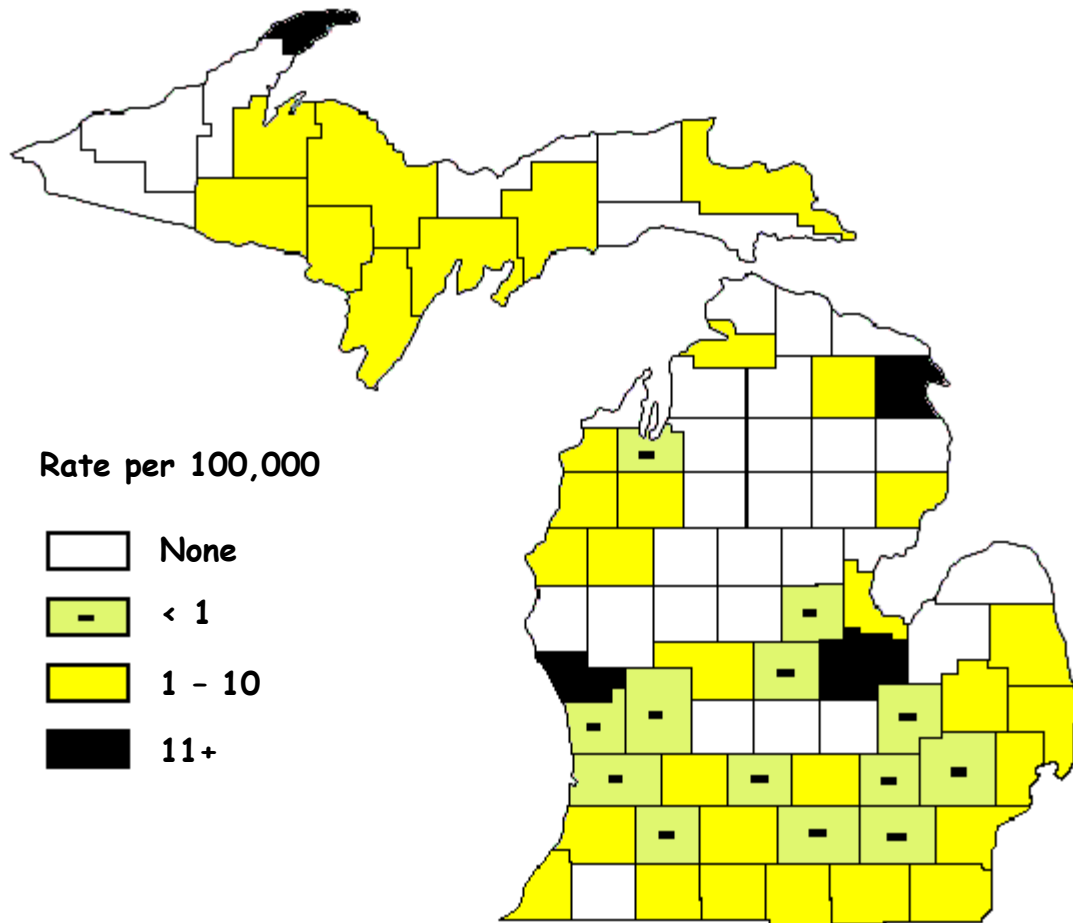
*Sixty-four individuals were exposed to silica out-of-state, and eighteen individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-2002*



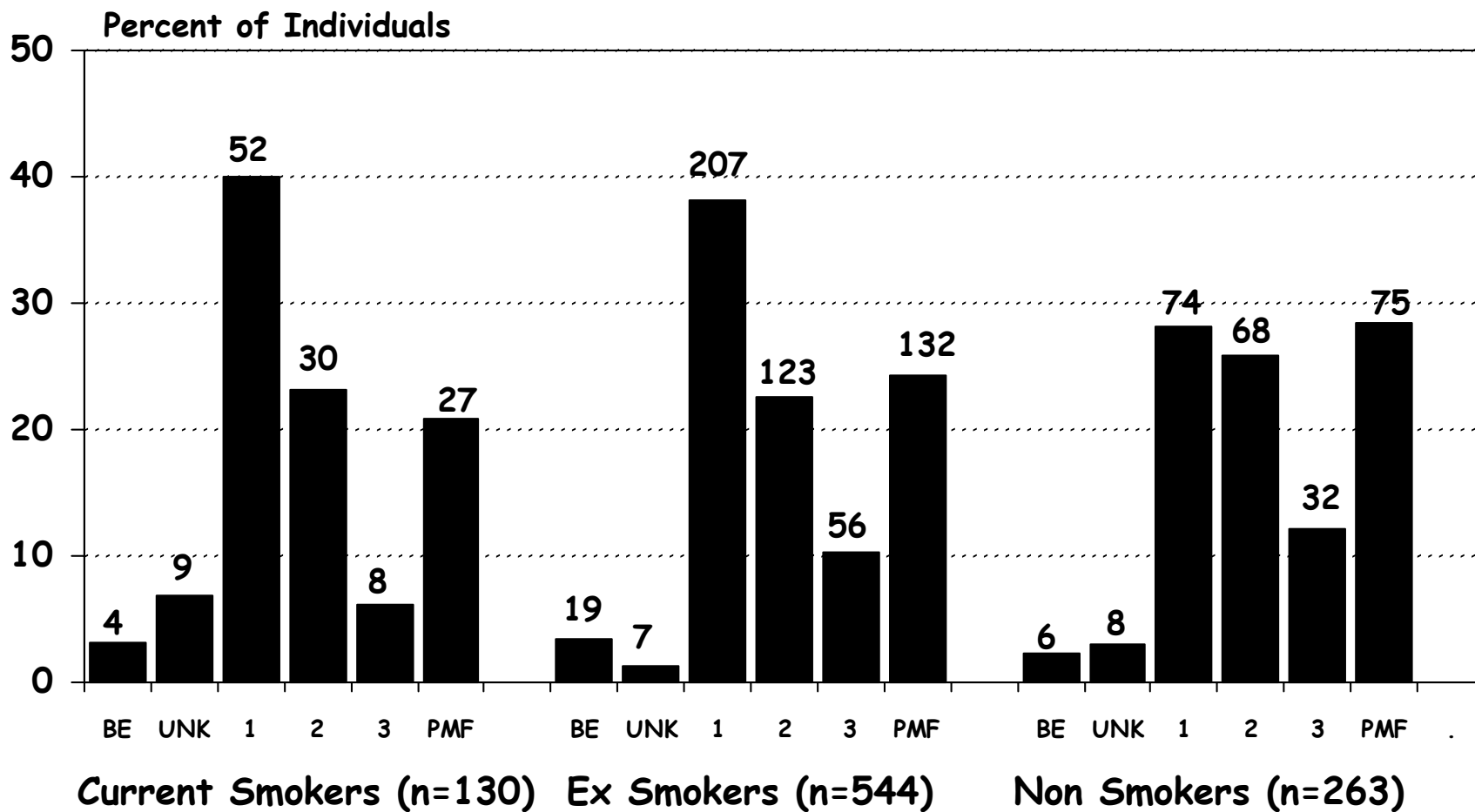
*Rate per 100,000 among African American men age 40+. Numerator is the average number of individuals with silicosis for the years 1987 - 2002; denominator is the 1990 Census population data for African American men age 40 and older, by county. In 1990, there were 174,325 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-2002*



*Rate per 100,000 among white men age 40+. Numerator is the average number of individuals with silicosis for the years 1987 - 2002; denominator is the 1990 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 - 2004**



*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: 937. Unknown smoking status for 16 individuals.

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

	<u>PR</u>	<u>HDC</u>	<u>DC</u>	<u>WC</u>	<u>ICFU</u>	<u>Total</u>
1985-1987	N/A**	67	35	42	N/A	144
1988	N/A	56	6	7	N/A	69
1989	7	40	9	4	3	63
1990	5	44	0	6	1	56
1991	5	36	1	6	0	48
1992	16	54	6	2	0	78
1993	6	31	1	4	0	42
1994	7	36	1	28	0	72
1995	26	35	3	2	0	66
1996	28	35	0	0	0	63
1997	13	48	1	0	0	62
1998	10	28	1	0	0	39
1999	5	25	1	1	0	32
2000	4	30	0	0	0	34
2001	8	12	1	0	0	21
2002	1	32	1	0	0	34
2003	6	22	0	0	0	28
2004	2	0	0	0	0	2
All Years	149	631	67	102	4	953

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

**N/A = not applicable - reporting by this source was not active in this year.

Table 2. Primary Industry Where Silica Exposure Occurred for Individuals Confirmed with Silicosis for the Years 1985-2004

<u>Industry (SIC code)*</u>	<u>Number of Individuals**</u>	
Manufacturing		
Primary Metal Industries (33)	719	(76.2)
Includes iron, steel, gray & ductile iron foundries		
Stone, Clay, Glass and Concrete Products (32)	42	(4.5)
Transportation Equipment (37)	35	(3.7)
Includes auto bodies and boat building		
Fabricated Metal Products (34)	13	(1.4)
Industrial Machinery (35)	10	(1.1)
Miscellaneous (25,26,28,30,36,38,39)	19	(2.0)
Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment		
Mining (10-14)	26	(2.8)
Construction (15-17)	57	(6.0)
Transportation, Communication Services (40-49)	8	(0.8)
Trade (50-59)	2	(0.2)
Business and Repair Services (73,75,76)	4	(0.4)
Dental Laboratory (80)	5	(0.5)
Government (95,96)	2	(0.2)
Farming (01-07)	1	(0.1)
Total	943	(99.9)***

*Standard Industrial Classification

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

***Percentage 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 Confirmed with Silicosis*
for the Years 1985-2004**

<u>X-Ray Results</u>	Percent Predicted FVC**											
	<60%				60-79%				≥80%			
	Ever <u>Smoked</u>		Never <u>Smoked</u>		Ever <u>Smoked</u>		Never <u>Smoked</u>		Ever <u>Smoked</u>		Never <u>Smoked</u>	
	#	%	#	%	#	%	#	%	#	%	#	%
Biopsy Evidence	6	(31.6)	0	--	9	(47.4)	2	(50.0)	4	(21.1)	2	(50.0)
Unknown	3	(27.3)	1	(33.3)	5	(45.4)	1	(33.3)	3	(27.3)	1	(33.3)
Severity												
Category 1	44	(24.3)	15	(29.4)	61	(33.7)	15	(29.4)	76	(42.0)	21	(41.2)
Category 2	33	(30.8)	19	(40.4)	38	(35.5)	15	(31.9)	36	(33.6)	13	(27.7)
Category 3	11	(27.5)	14	(66.7)	17	(42.5)	3	(14.3)	12	(30.0)	4	(19.0)
PMF	41	(38.0)	19	(37.3)	36	(33.3)	16	(31.4)	31	(28.7)	16	(31.4)
Total	138	(29.6)	68	(38.4)	166	(35.6)	52	(29.4)	162	(34.8)	57	(32.2)

*Total number of individuals: 643. Information was missing for 310 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 1 Second (FEV₁) Divided by Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals Confirmed with Silicosis* for the Years 1985-2004

<u>X-Ray Results</u>	FEV ₁ /FVC**								
	<=40 %		41%-59%		60-74%		>=75%		
	Ever	Never	Ever	Never	Ever	Never	Ever	Never	
	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	<u>Smoked</u>	
#	%	#	%	#	%	#	%	#	%
Biopsy Evidence	2 (10.5)	1 (33.3)	3 (15.8)	0 --	8 (42.1)	2 (66.7)	6 (31.6)	0 --	
Unknown Severity	0 --	0 --	0 --	0 --	1 (12.5)	2 (66.7)	7 (87.5)	1 (33.3)	
Category 1	21 (11.7)	2 (3.9)	37 (20.7)	3 (5.9)	64 (35.8)	17 (33.3)	57 (31.8)	29 (56.9)	
Category 2	5 (5.0)	3 (6.7)	21 (21.0)	6 (13.3)	42 (42.0)	12 (26.7)	32 (32.0)	24 (53.3)	
Category 3	1 (2.6)	1 (5.0)	6 (15.8)	0 --	5 (13.2)	6 (30.0)	26 (68.4)	13 (65.0)	
PMF	16 (15.2)	6 (11.8)	34 (32.4)	11 (21.6)	30 (28.6)	16 (31.4)	25 (23.8)	18 (35.3)	
Total	45 (10.0)	13 (7.5)	101 (22.5)	20 (11.6)	150 (33.4)	55 (31.8)	153 (34.1)	85 (49.1)	

*Total number of individuals: 622. Information was missing for 331 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. Status of Facilities Where 953 Individuals
Confirmed with Silicosis for the Years
1985-2004 were Exposed to Silica**

	<u>Number of Individuals Represented</u>	<u>Number of Facilities</u>	<u>Percent of Facilities</u>
Inspections	429	80	(21.9)
Closed	354	122	(33.3)
Out of State	58	54	(14.8)
Scheduled for Inspection	3	3	(0.8)
No Longer Use Silica	24	22	(6.0)
Unknown	44	44	(12.0)
Building Trade	39	39	(10.7)
Inspected by MSHA*	2	2	(0.5)
Total	953	366	(100.0)

*MSHA = Mine Safety and Health Administration.

**Table 6. Results of Industrial Hygiene Inspections
of 80 Facilities Where Individuals Confirmed
with Silicosis for the Years 1985-2004
were Exposed to Silica**

	<u>Number of Companies</u>	<u>Percent</u>
Air Sampling Performed	57	
Above NIOSH* Recommended Standard for Silica	34	(59.6)
Above MIOSHA** Enforceable Standard for Any Exposure	22	(38.6)
Above MIOSHA Enforceable Standard for Silica	21	(36.8)
Medical Surveillance Evaluated	65	
Periodic Chest X-rays with B Reader	7	(10.8)
Periodic Chest X-rays without a B Reader	3	(4.6)
Pre-employment Testing Only	19	(29.2)
No Medical Surveillance	24	(36.9)
Periodic Pulmonary Function Testing	17	(26.2)

*NIOSH = National Institute for Occupational Safety and Health.

**MIOSHA = Michigan Occupational Safety and Health Administration.