2007

Annual Report on Silicosis in Michigan

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A Joint Report
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Summary:

This is the 17th annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 2005 and preliminary data for 2006 and 2007. A total of 1,045 cases of silicosis have been confirmed from 1985 – 2007: 27 of those reports were confirmed in 2005. To date, another 19 cases have been confirmed for 2006, and 15 cases in 2007. The number of cases reported from 1998 through 2005 was 20-40 and has 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 since 1998 continues.

Based on capture-recapture analysis we estimate that although we only received 27 reports of newly diagnosed silicosis cases in 2005 there were another 83-170 individuals diagnosed with silicosis in Michigan in 2005 who were not reported[1].

Silicosis occurs 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-one percent of the patients are African American. The annual average incidence rate of silicosis among African American males (9.2 cases per 100,000) is over six times higher than that of white males (1.5 cases per 100,000). The rates within specific counties ranged between one to 534 times higher for African American males than the rates for white males. Exposure to silica occurred mainly in companies in Muskegon, Saginaw and Wayne counties.

Two Michigan counties are in the top 10 with the highest national mortality rates for silicosis: Alpena was 8th with 15.2 deaths per million individuals and Muskegon was 10th with 13.4 deaths per million individuals. In comparison, the overall age-adjusted silicosis death rate of United States residents 15 years and older from 1995-2004 was 0.8 deaths per million individuals[2].

The patients identified with silicosis generally have severe disease. Twenty-four 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 either 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 cancer [3].

Despite the severity of disease, 60% 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 time because of the severity of that exposure. One individual who developed silicosis began working with silica in the 1990s, 15 in the 1980s, 59 in the 1970s and 147 in the 1960s. Exposure to silica is still occurring in foundries, although working conditions have clearly improved from the 1930s and 1940s.

In 2007, MIOSHA began an initiative to inspect all silica-using foundries in the state. The project is ongoing. To date, 20 foundries have been inspected, and 47% of the 17 where air monitoring was performed were found to have at least one personal air sample for silica above the MIOSHA

permissible exposure limit. The program is expected to be completed within the next two years.

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 Energy, Labor and Economic Growth (DELEG), 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 - 2005. 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, 2006 and 2007 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 - 2005 undercounts the true number of persons with silicosis.

Figure 1 shows 954 patients identified and confirmed with silicosis through the surveillance system by year for 1987 through 2005. To date, an additional 19 persons with silicosis in 2006, and 15 individuals in 2007 have been confirmed with silicosis. Table 1 shows the primary reporting source of the 1,045 persons confirmed with silicosis from 1985 - 2007. Hospital reports are the primary source of identification of patients, with 60% 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 2006.

A study in New Jersey of a similar type of surveillance program estimated that the system received reports on only one-third of individuals diagnosed with silicosis[4]. Using capture-recapture analyses, we estimate that the true number of silicotics in Michigan from 1987 - 1996 is 1,548 - 3,236[1]. 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 1,045 cases of silicosis confirmed from 1985 - 2007.

Gender

One thousand twenty-three (97.9%) of the persons with silicosis are men; the other 22 (2.1%) are women.

Race

Five hundred eighty-one (55.6%) of the persons with silicosis are white, 427 (40.9%) are African American, two (0.2%) are of Asian ancestry, one (0.1%) was of American Indian ancestry, and 28 (2.7%) were listed as "other ancestry". The race on six individuals was unknown.

Year of Birth

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1922, ranging from 1888 to 1962.

Decade of Hire

The distribution of the decade of hire is shown in Figure 4. The average year of hire is 1949, 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 27.7.

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 9.2 cases per 100,000, and for white men is 1.5 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 427/100,000, in Muskegon it was 173/100,000, in Saginaw it was 62/100,000, in Monroe it was 34/100,000, in Calhoun it was 25/100,000, in Macomb it was 12/100,000, and in St. Clair it was 9/100,000. The rate of silicosis among African American men in Shiawassee was based on 2 cases and only 26 African American males age 40 and older residing 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 17/100,000, in Alpena it was 16/100,000, in Keweenaw it was 9/100,000, in Saginaw it was 9/100,000, and in Menominee it was 8/100,000.

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 manufacturing (iron foundries) (87.3%). Two hundred eighty-three of the 790 individuals for whom sandblasting history is known (35.8%) stated they had done sandblasting as part of their work.

Medical Results

Overall 732 (70.0%) of the people with silicosis had simple silicosis and 255 (24.4%) had progressive massive fibrosis. Thirty (2.9%) silicotics had normal x-rays with lung biopsy evidence. Twenty-eight (2.7%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred seventy-seven (26.9%) of the people with silicosis never smoked cigarettes, 609 (59.1%) had quit, 145 (14.1%) 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 (27.8% non smokers vs. 21.4% current smokers vs. 23.6% ex smokers) ($X^2 = 32.430$, $p = .001$). 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:

Non-Malignant	Malignant
• 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 registry[5]. There is more recently reported evidence in the medical literature that silica exposure is a risk factor for systemic lupus erythematosus[6] and Sjogren's syndrome[7]. We recently updated the analysis of Michigan silicosis cases for connective tissue disease. The following reports the results of the updated analysis.

From 1985-2006, 1030 cases of silicosis were reported and confirmed to have silicosis. Medical records were available for 790, 770 males and 20 females, and relevant medical information was abstracted from records obtained through hospitals, physician offices and death certificates. Thirty three individuals had rheumatoid arthritis (RA) for a prevalence of 4.2% (Relative Risk (RR) 4.18, 95% CI 2.07-8.42), two had scleroderma for a prevalence of 0.3% (RR 8.73, 95% CI 2.08-36.52), one had systemic lupus erythematosus (SLE) for a prevalence of 0.1% (RR 2.81, 95% CI 0.38-20.38), two had Sjogrens syndrome for a prevalence of 0.3% (RR 0.18, 95% CI 0.02-1.55) and six had vasculitis (ANCA positive) for a prevalence of 0.8% (Table 5). There was a four-to-eight fold increased risk of developing CTD in individuals with silicosis compared to the estimated prevalence in the general population. There was no difference between those with and without CTD with respect to age, race, industry type, history of TB, application to workers' compensation or severity of fibrotic changes on chest x-ray (Table 6). No cases of Caplan's Syndrome were identified. Although the association between scleroderma and silicosis has been more widely reported in the literature, the most common CTD among silicotics in the Michigan disease registry was rheumatoid arthritis. A manuscript is currently being prepared to report these findings.

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 controls[8]. 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 exposure[9].

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 347 (40.0%) of the 868 individuals with silicosis or their next of kin for whom filing status was known had applied for workers' compensation. Five hundred twenty-one (60.0%) had not applied. It was unknown whether the remaining 177 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, 268 (77.2%) received compensation, 28 (8.1%) had been denied, and 51 (14.7%) were pending at the time of interview.

Industrial Hygiene Results

The 1,045 individuals with silicosis were exposed to silica in 416 facilities (Table 7). Inspections were performed at 85 (20.4%) of these facilities. One hundred forty-five (34.9%) facilities were no longer in operation, 63 (15.1) were located out of state, 24 (5.8%) facilities no longer used silica, 48 (11.5%) 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 49 (11.8%) were unknown.

Air sampling was conducted in 60 of the 85 facilities inspected (Table 8). Thirty-five of 60 (58.3%) facilities were above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit for silica. Twenty-two of the 60 (36.7%) were above the enforceable Michigan Occupational Safety and Health Administration (MIOSHA) permissible exposure limit for silica. Another two (3.3%) companies were above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only eight of the 68 (11.8%) 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. Twenty (29.4%) only performed pre-employment testing, 25 (36.8%) provided no medical surveillance, and 18 (26.5%) performed annual or biennial pulmonary function testing without chest x-rays.

Michigan Foundry Inspection Initiative

In 2007, MIOSHA began an initiative to review silica levels in Michigan foundries. Ninety-four facilities were identified through multiple sources, including federal OSHAs on-line IMIS system, the Michigan Manufacturing Directory published annually by Pick Publications, and on-line searches. To date, 20 facilities have been inspected, 39 are pending, 15 have been identified as out of business, and 20 were confirmed as not using silica. Personal air monitoring was conducted at 17 of those companies inspected where silica is still being used. Eight facilities had silica levels above the MIOSHA permissible exposure limit and nine were within permissible limits for silica. The 39 pending inspections will be completed within the next two years, and a full report of the findings will be shared. Table 9 lists the 59 potential silica-using foundries in

Michigan, by county.

Discussion:

The predominant characteristics of the individuals reported during Michigan's 20 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 1950s[10]. The older age of the patient (average year of birth, 1922) 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. Overall, seventy-four (7.5%) silicosis cases worked for less than 10 years (Figure 5). Seventy-five (7.5%) of the 996 individuals with known decade of hire began work in the 1970s, 1980s or 1990s; 22 of them had worked for less than ten years. Individuals working since the 1970s were more likely to have done sandblasting than those who began working with silica before 1970 (51% vs. 34%). Of the 16 people who first were exposed to silica in the 1980s or 1990s; four worked in foundries, two were buffing and polishing metal, two 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, one was a painter, one worked as a miner in gold fields in the Southwest, one did welding, and one owned an auto repair shop.

African American men are over represented (40.9%). This reflects previous hiring practices in foundries[11]. 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 9.2 per 100,000 versus 1.5 per 100,000 for white workers (an over six-fold greater incidence).

The individuals reported generally have advanced disease: 255 (24.4%) with progressive massive fibrosis; and another 356 (34.1%) 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 a positive skin test indicating infection with the mycobacterium that causes tuberculosis. Despite the severity of their disease, 60% 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 exposure[12]. Individuals with silicosis are at risk of developing pulmonary hypertension, clinically significant bronchitis and chronic obstructive pulmonary disease[13].

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 data[14]. 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 programs[14].

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease[3,15]. The increased risk for death is found both in patients who ever or never smoked cigarettes[3]. Individuals with silicosis also have an increased risk of developing connective tissue disease, particularly rheumatoid arthritis[5] as well as an increased risk of developing chronic renal disease, especially ANCA positive disease[8,9,16].

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. There has been a decrease in the number of new silicosis cases since 1998.

The national surveillance system was not designed to count chronic diseases such as silicosis. We have previously estimated that there were 3,600 to 7,300 newly diagnosed cases of silicosis each year in the United States from 1987 – 1996[1]. Using the same methodology for the time period 1997 – 2003 we estimate there were 5,586 – 11,674 newly diagnosed cases of silicosis per year in the United States. Using an alternative approach with hospital discharge data we estimate there were 1,372 – 2,867 newly diagnosed cases of silicosis per year in the United States. Although the estimate based on death certificates is approximately fourfold greater than the one based on hospital discharge data, we believe that the true number of new cases of silicosis is closer to these larger estimates than using the actual number of death certificates that mention silicosis (~150 per year) or the Bureau of Labor Statistics estimate based on employer reporting, which in 1999 reported only 2,200 cases for <u>all</u> dust diseases of the lung, including asbestosis and coal worker's pneumoconiosis in addition to silicosis.

Industrial hygiene inspections reveal violations of the exposure standard for silica in 36.7% 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 88.2% of the facilities, there is no way to monitor the adequacy of these controls in terms of health outcomes.

In 2007, MIOSHA began an initiative to review silica levels in Michigan foundries. Ninety-four facilities were identified through multiple sources. To date, of the 20 facilities inspected, eight had silica levels above the MIOSHA permissible exposure limit, nine were within permissible limits for silica, and three were not sampled for silica. The 39 pending inspections will be completed within the next two years, and a full report of the findings will be shared.

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 continued use of silica among abrasive blasters and inadequate controls in the construction industry and 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[6,12,15,17]. These risks justify tighter work place controls for silica even if the number of new cases of silicosis continues to decline.

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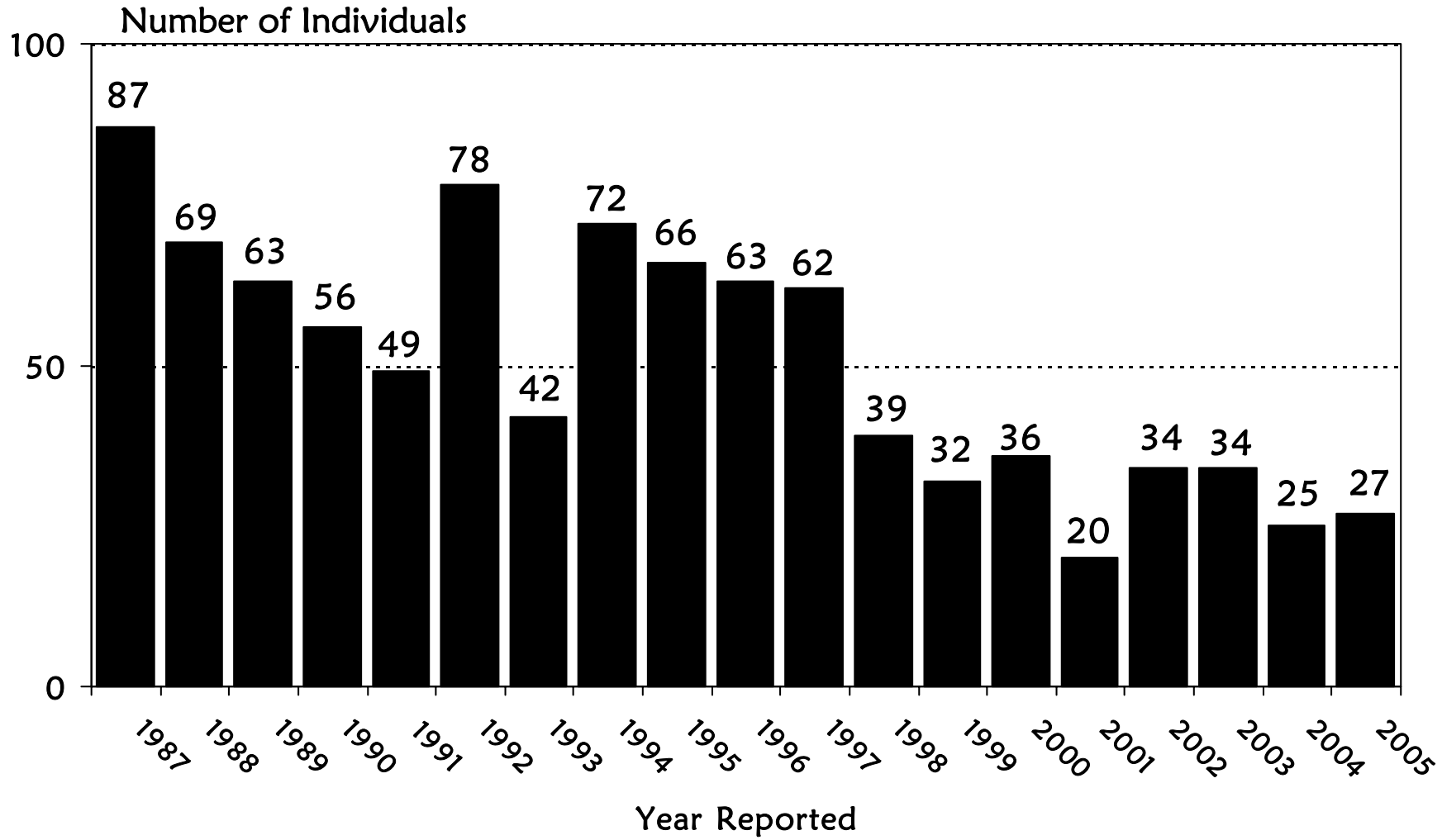
Figure 1. Confirmed Silicosis Cases
by Year Reported*



*Total number of individuals: 954.

Figure 2. Overlap of Reporting Sources for Confirmed Silicosis Cases: 1987-2006*

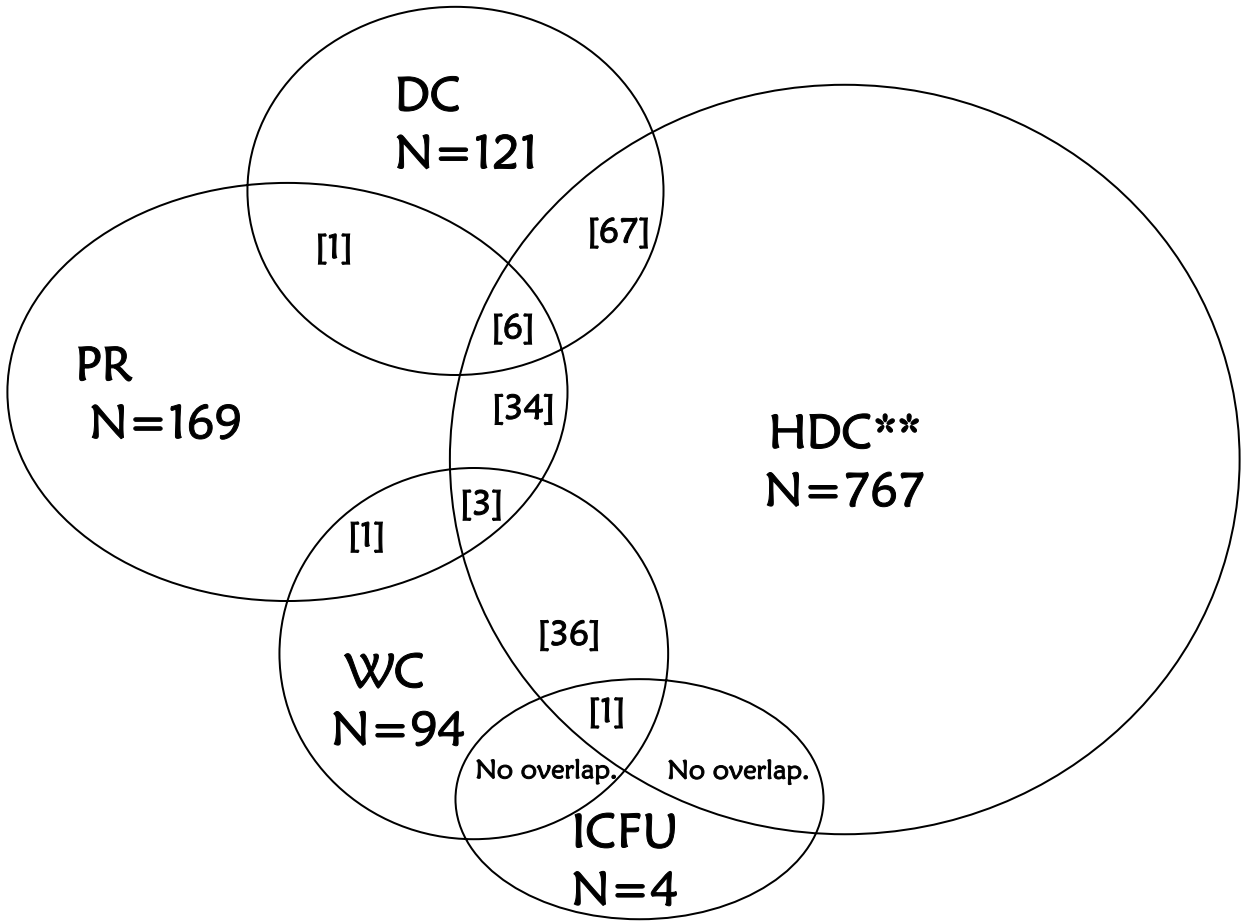
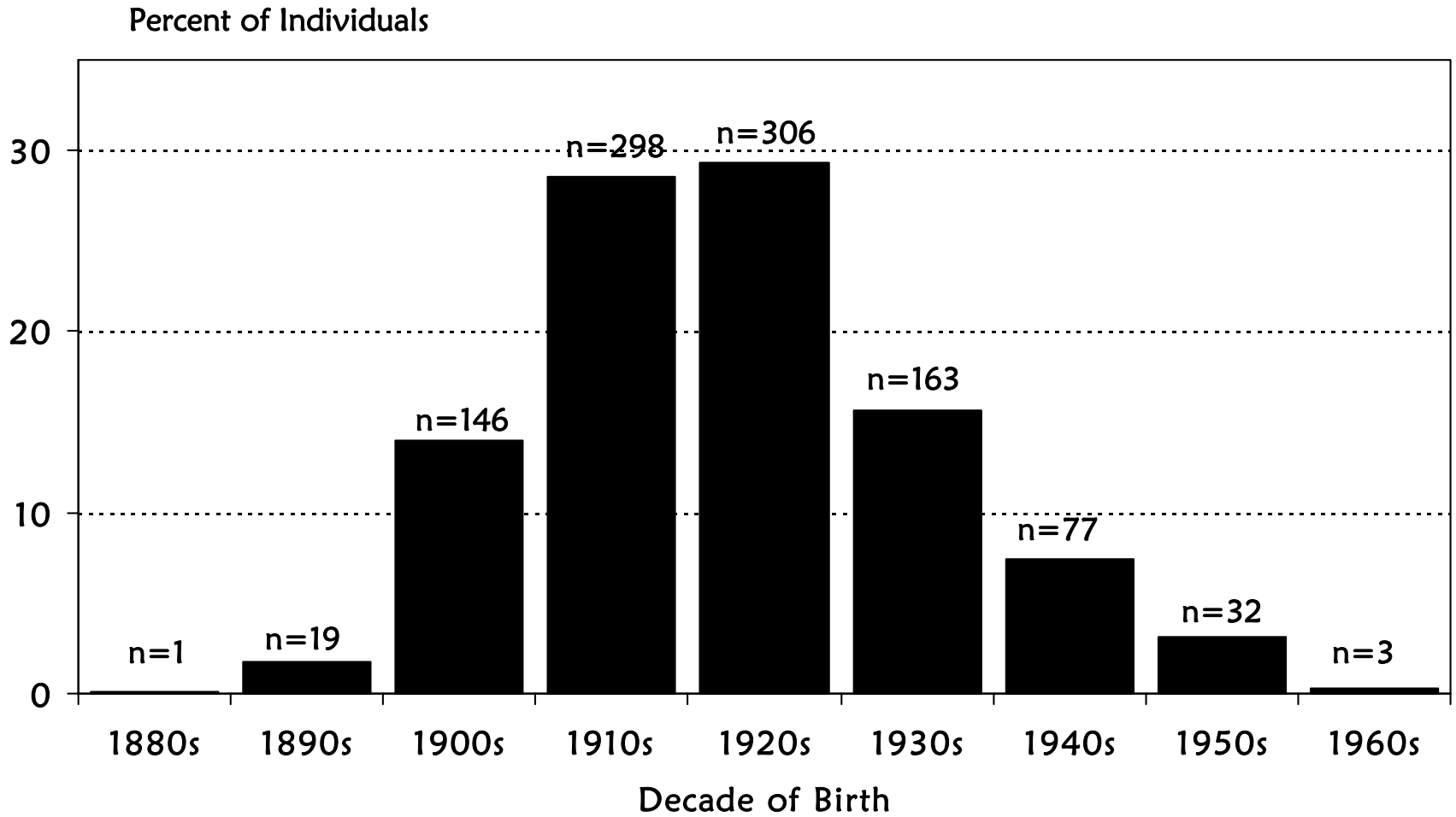


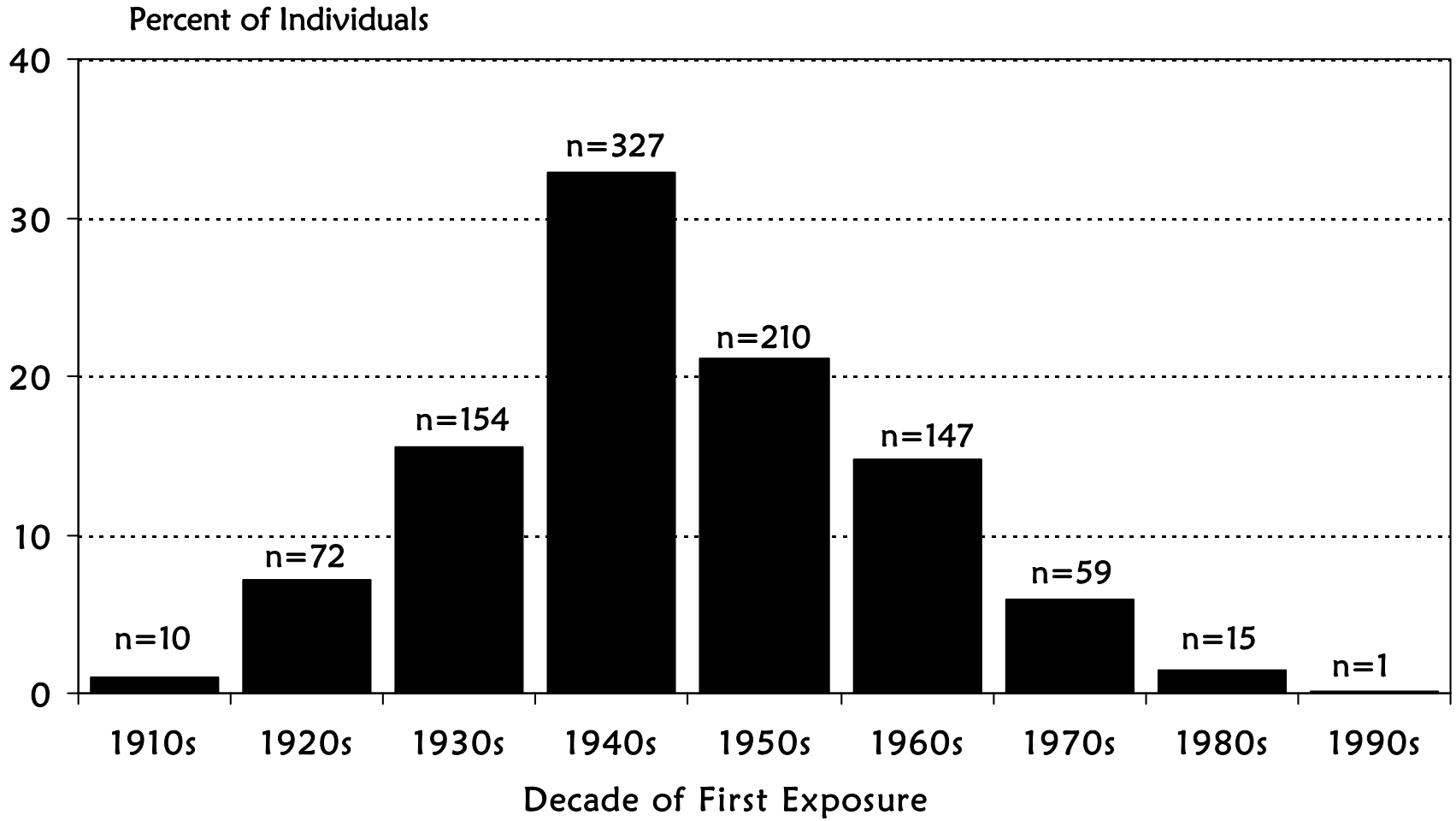
*Diagram represents 973 individuals initially reported from 1987 to 2006.
N's represent the total number for that source.
Numbers in [ ] represent the overlap of reporting sources.
Reporting Source Codes: HDC=Hospital Discharge Data; PR=Physician Referral;
DC=Death Certificate; WC=Workers' Compensation; 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 Confirmed Silicosis Cases: 1985-2007*



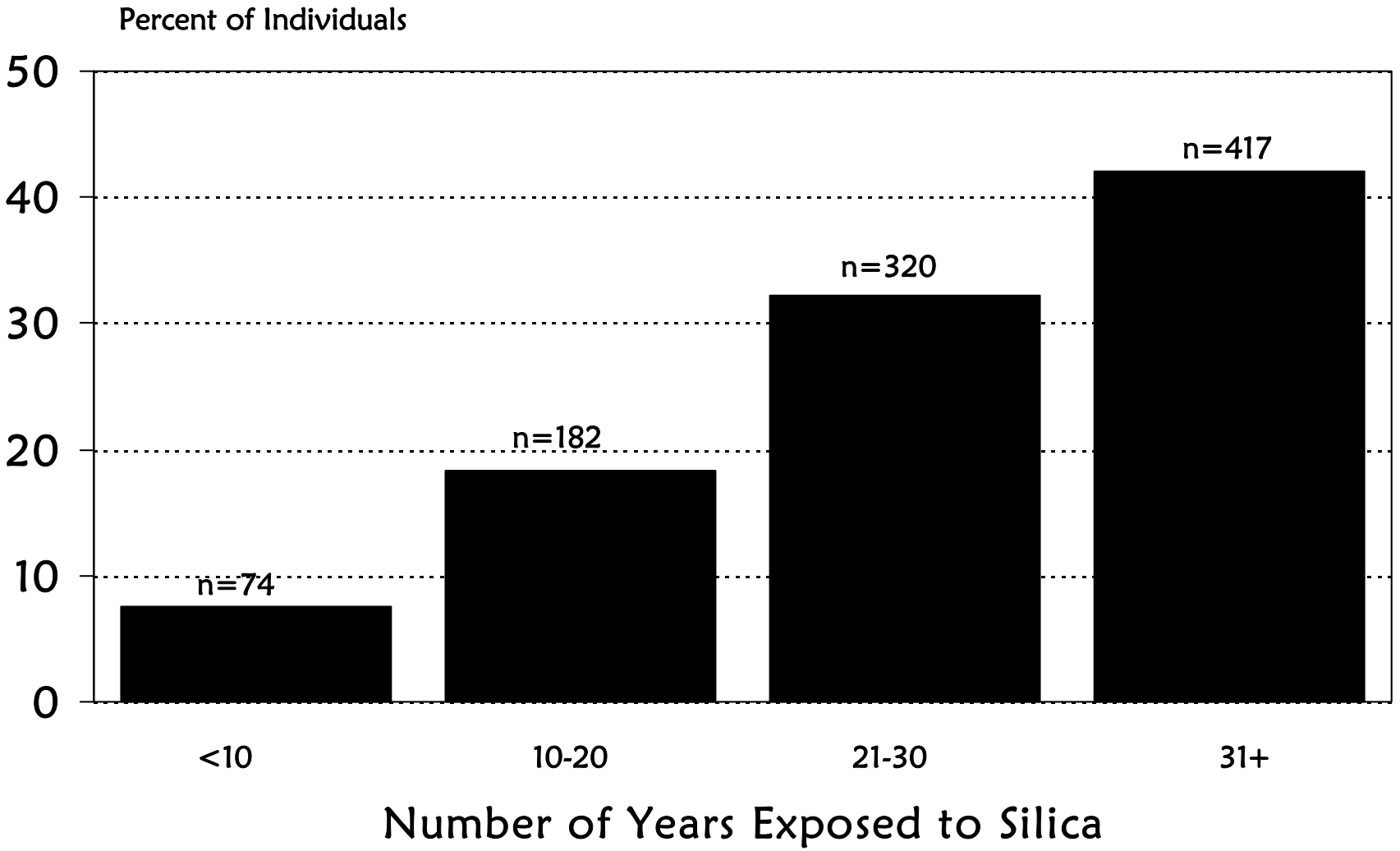
*Total number of individuals: 1,045.

Figure 4. Distribution of Decade When Silica Exposure Began for Confirmed Silicosis Cases: 1985-2007*



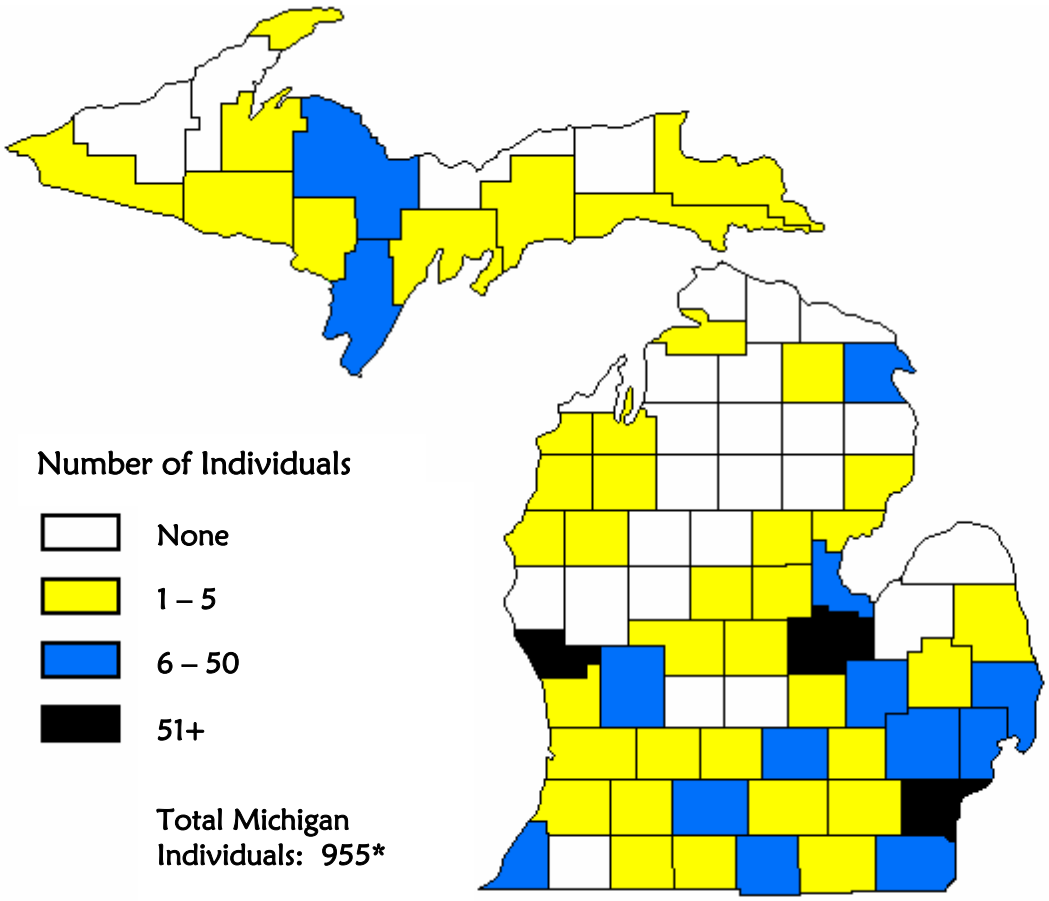
*Total number of individuals: 995. Unknown decade for 50 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Confirmed Silicosis Cases: 1985-2007*



*Total number of individuals: 993. Unknown duration for 52 individuals.

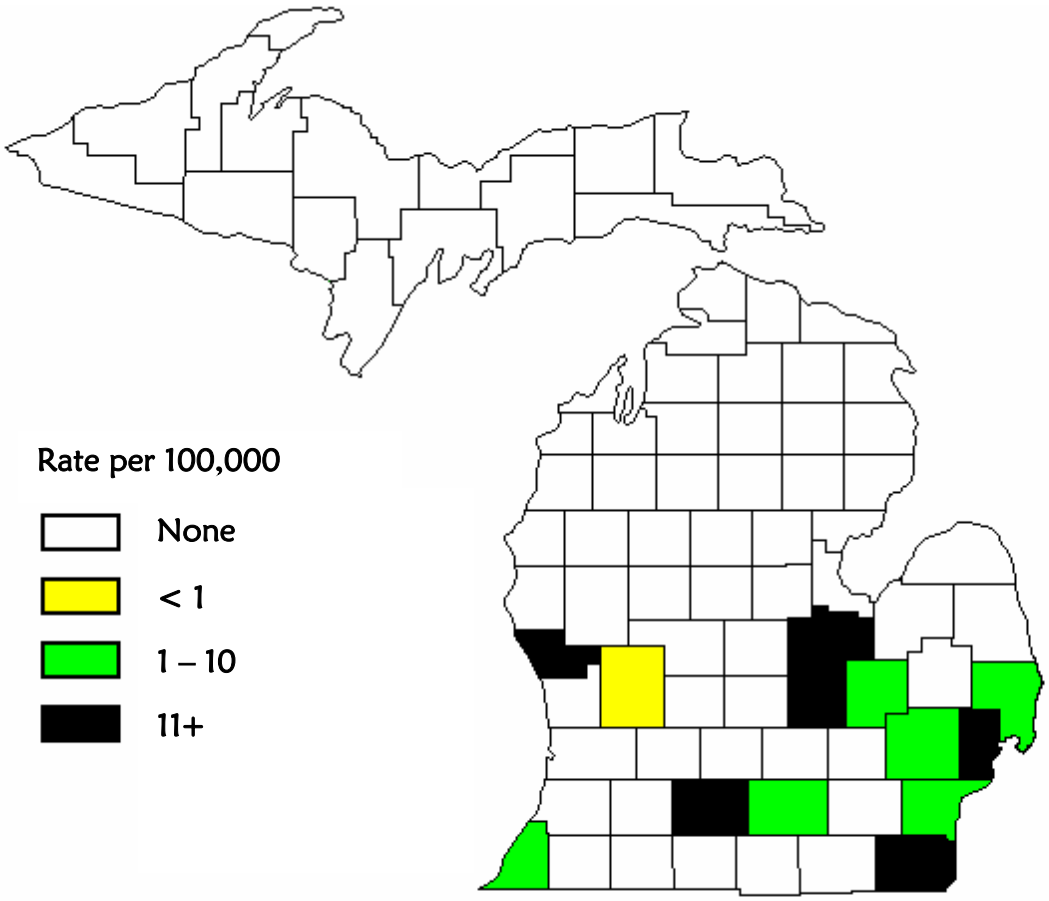
Figure 6. Distribution of Confirmed Silicosis Cases by County of Exposure: 1985-2007



Muskegon, Saginaw and Wayne counties had the highest number of individuals with silicosis, with 246, 140 and 274 individuals, respectively.

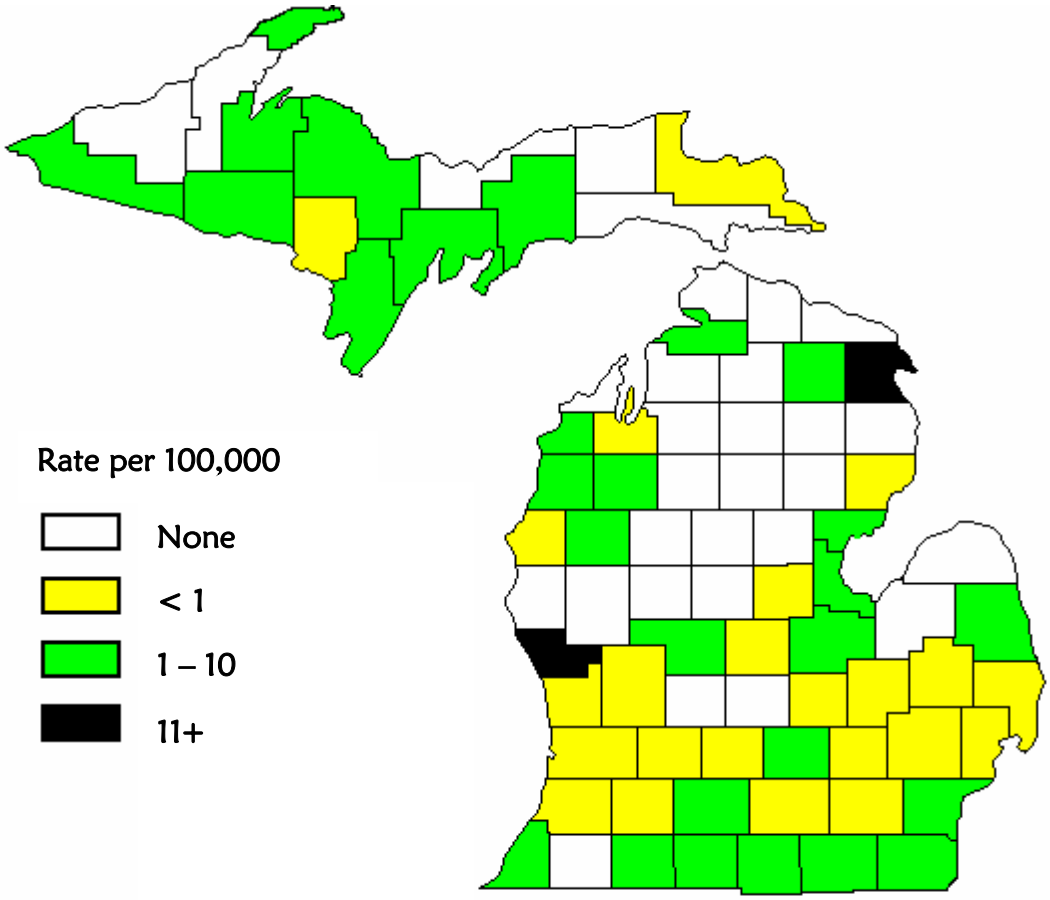
*Sixty-nine individuals were exposed to silica out-of-state, and 21 individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-2005*



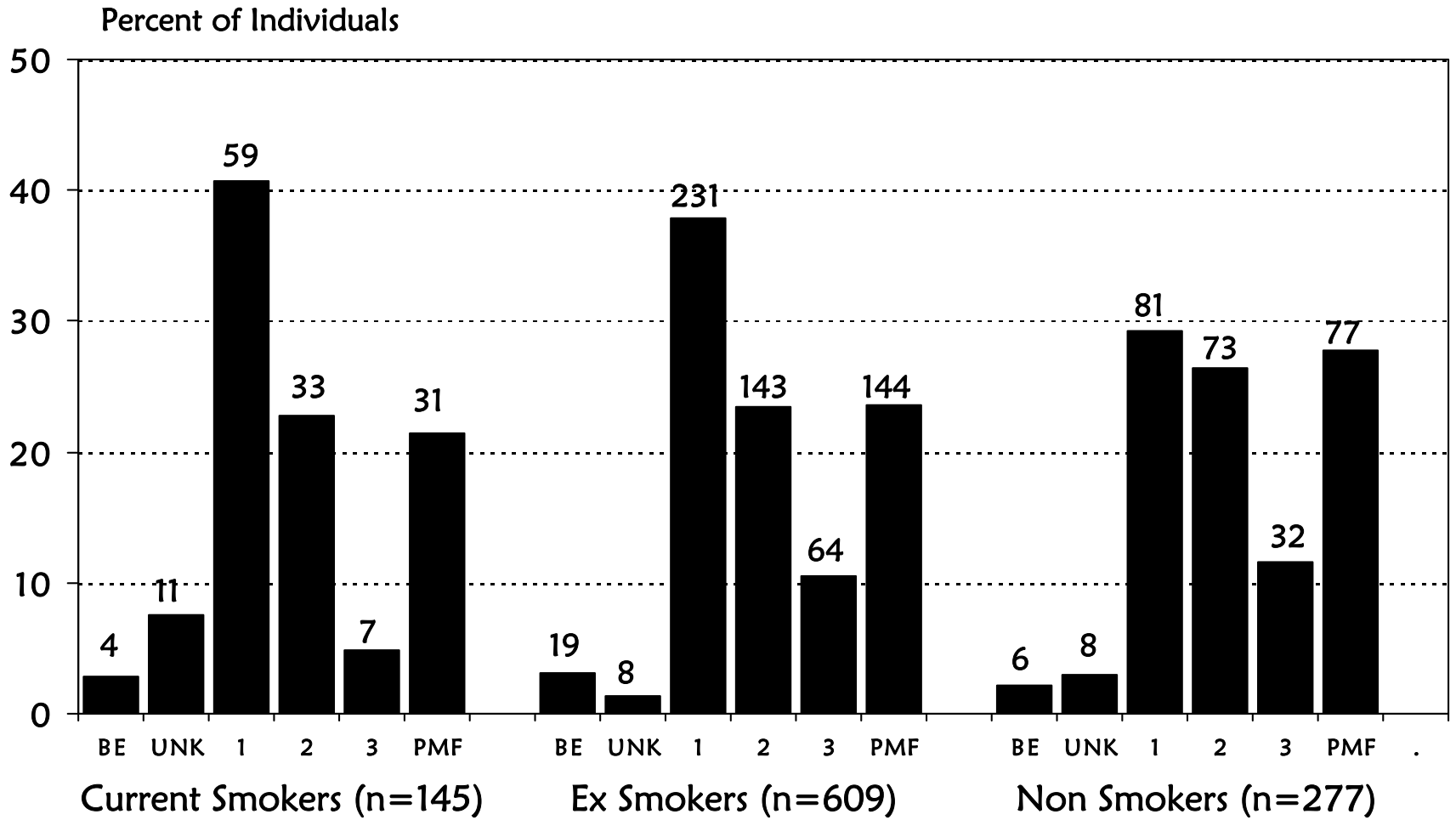
*Rate per 100,000 among African American men age 40+. Numerator is the average number of African American males with silicosis for the years 1987 – 2005; denominator is the 2000 Census population data for African American men age 40 and older, by county. In 2000, there were 219,076 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-2005*



*Rate per 100,000 among white men age 40+. Numerator is the average number of white males with silicosis for the years 1987 – 2005; denominator is the 2000 Census population data for white men age 40 and older, by county. In 2000, there were 1,730,017 white males 40 years and older living in Michigan.

Figure 9. Severity of X-Ray Results* by Smoking Status for Confirmed Silicosis Cases: 1985–2007**



*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: 1,031. Unknown smoking status for 14 individuals.

Table 1. Year and Reporting Source for Confirmed Silicosis Cases: 1985-2007						
	Reporting Source					
Year Reported	Physician Referral	Hospital Discharge	Death Certificate	Workers' Compensation	Index Case Follow-Up	Total
1985-1987	*	67	35	42	N/A	144
1988	*	56	6	7	N/A	69
1989	7	40	9	4	3	63
1990	5	44	0	6	1	56
1991	5	37	1	6	0	49
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	32	0	0	0	36
2001	8	11	1	0	0	20
2002	1	32	1	0	0	34
2003	8	26	0	0	0	34
2004	2	23	0	0	0	25
2005	2	24	1	0	0	27
2006	2	16	1	0	0	19
2007	2	13	0	0	0	15
All Years	157	713	69	102	4	1,045
*Reporting by physicians was not active in this year.						

Table 2. Primary Industrial Silica Exposure for Confirmed Silicosis Cases: 1985-2007			
2002 North American Industry Classification System		# Individuals	%
11	Agriculture, Forestry, Fishing & Hunting	2	0.2
21	Mining	34	3.3
22	Utilities	1	0.1
23	Construction	71	6.8
31-33	Manufacturing	912	87.3
42	Wholesale Trade	2	0.2
44-45	Retail Trade	1	0.1
48-49	Transportation & Warehousing	6	0.6
56	Administrative & Support & Waste Management & Remediation Services	2	0.2
81	Other Services (except Public Administration)	4	0.4
92	Public Administration	4	0.4
00	Unknown	6	0.6
Total		1,045	

Table 3. Percent Predicted Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Confirmed Silicosis Cases: 1985-2007

	Percent Predicted FVC***											
	<60%				60-79%				>=80%			
X-Ray Results*	Ever Smoked		Never Smoked		Ever Smoked		Never Smoked		Ever Smoked		Never Smoked	
	#	%	#	%	#	%	#	%	#	%	#	%
Biopsy Evidence	6	31.6	0	--	9	47.4	2	50.0	4	21.1	2	50.0
Unknown Severity	4	30.8	1	33.3	5	38.5	1	33.3	4	30.8	1	33.3
Category 1	48	24.4	17	31.5	69	35.0	15	27.8	80	40.6	22	40.7
Category 2	37	30.8	19	38.0	42	35.0	16	32.0	41	34.2	15	30.0
Category 3	11	26.8	14	66.7	17	41.5	3	14.3	13	31.7	4	19.0
PMF	44	38.3	19	37.3	38	33.0	16	31.4	33	28.7	16	31.4
Total**	150	29.7	70	38.3	180	35.6	53	29.0	175	34.7	60	32.8

*Biopsy Evidence if no x-ray available; International Labor Organization categorization system for grading pneumoconioses: Category 1= 1/0, 1/1, ½; Category 2= 2/1, 2/2, 2/3; Category 3= 3/2, 3/3, 3+; PMF= Progressive Massive Fibrosis.

**Total number of individuals: 688. Information was missing for 357 individuals.

***Percentages represent the proportion of individuals in each x-ray result category, within smoking status category.

Table 4. Ratio of Forced Expiratory Volume in 1 Second (FEV_1) to Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Confirmed Silicosis Cases: 1985-2007

	FEV_1/FVC**															
	<=40%				41-59%				60-74%				>=75%			
X-Ray Results	Ever Smoked		Never Smoked		Ever Smoked		Never Smoked		Ever Smoked		Never Smoked		Ever Smoked		Never Smoked	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
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	--	2	22.2	2	66.7	7	77.8	1	33.3
Category 1	23	11.7	1	1.9	42	21.4	3	5.6	71	36.2	17	31.5	60	30.6	33	61.1
Category 2	5	4.5	3	6.3	23	20.5	7	14.6	46	41.1	14	29.2	38	33.9	24	50.0
Category 3	2	5.1	1	5.0	6	15.4	0	--	5	12.8	6	30.0	26	66.7	13	65.0
PMF	18	16.1	6	11.8	38	33.9	11	21.6	31	27.7	16	31.4	25	22.3	18	35.3
Total	50	10.3	12	6.7	112	23.0	21	11.7	163	33.5	57	31.8	162	33.3	89	49.7

*Biopsy Evidence if no x-ray available; International Labor Organization categorization system for grading pneumoconioses: Category 1= 1/0, 1/1, ½; Category 2= 2/1, 2/2, 2/3; Category 3= 3/2, 3/3, 3+; PMF= Progressive Massive Fibrosis.

**Total number of individuals: 666. Information was missing for 379 individuals.

***Percentages represent the proportion of individuals in each x-ray result category, within smoking status category.

Table 5. Prevalence of Connective Tissue Disease Among 790 Individuals with Silicosis, Michigan: 1985-2006

		Case Ascertainment Years								
		1985-1995			1996-2006			1985-2006		
Connective Tissue Disease		Prevalence in Silicosis			Prevalence in Silicosis			Prevalence in Silicosis		
	Population Prevalence	%	#	Relative Risk (95% CI)	%	#	Relative Risk (95% CI)	%	#	Relative Risk (95% CI)
Rheumatoid Arthritis	1.0%*	5.2	24	4.59 (2.21-9.54)	3.36	9	3.36 (1.38-8.18)	4.2	33	4.18 (2.07-8.42)
SLE	0.045%*	0.2	1	4.26 (0.59-30.82)	--	0	--	0.1	1	2.81 (0.38-20.38)
Scleroderma	0.0029%*	0.2	1	6.6 (0.93-46.97)	0.37	1	12.86 (1.76-94.11)	0.3	2	8.73 (2.08-36.52)
Sjogrens Syndrome	1.4%**	--	0	--	0.74	2	0.53 (0.06-4.56)	0.3	2	0.18 (0.02-1.55)
Vasculitis	Unknown	--	0	--	2.23	6	--	0.8	6	--

* Lawrence RC, Helmick CG, Arnett FC, Deyo RA, Felson DT, Giannini EH et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. Arthritis Rheum 1998; 41(5):778-799.

**Haugen AJ, Peen E, Hulten B, Johannessen AC, Brun JG, Halse AK et al. Estimation of the prevalence of primary Sjogren's syndrome in two age-different community-based populations using two sets of classification criteria: the Hordaland health study. Scand J Rheumatol 2008; 37(1):30-34.

Table 6. Comparison of Confirmed Silicosis Cases with and without Connective Tissue Disease (CTD): 1985-2006					
	CTD (n=44*)		No CTD (n=746*)		Odds Ratio (95% CI)
Factor	Ratio	%	Ratio	%	
Caucasian	23/44	52.3	424/742	57.1	0.77 (0.40-1.48)
African American	21/44	47.7	299/742	40.3	
Year of Birth <1930	32/44	72.7	586/746	78.6	0.73 (0.35-1.53)
Worked in a Foundry	31/42	73.8	552/743	74.3	0.98 (0.46-2.11)
Did Sandblasting	12/33	36.4	185/546	33.9	1.12 (0.50-2.44)
Exposure to Silica >20 Years	27/44	61.4	513/698	73.5	0.57 (0.29-1.13)
Ever Smoked Cigarettes	30/43	69.8	548/738	74.3	0.80 (0.39-1.65)
History of Tuberculosis	7/36	19.4	125/626	20.0	0.97 (0.38-2.38)
Applied for Workers' Compensation	17/37	45.9	234/604	38.7	1.34 (0.66-2.74)
PMF on Chest X-Ray	12/44	27.3	207/746	27.7	0.98 (0.47-2.01)
*Denominator varies based on availability of information.					

Table 7. Status of Facilities Where 1,045 Confirmed Silicosis Cases were Exposed to Silica: 1985-2007			
	Silicosis Cases	Facilities	
Inspection Status	#	#	%
Inspection Completed	457	85	20.4
Scheduled for Inspection	0	0	--
Inspected by MSHA*	3	2	0.5
Facility Out of Business	395	145	34.9
Facility Out of State	67	63	15.1
Facility No Longer Uses Silica	26	24	5.8
Building Trade: No Inspection	48	48	11.5
Unknown	49	49	11.8
Total	1,045	416**	100.0
*MSHA= Mine Safety and Health Administration.			
**Four facilities are related to one silicosis case's work history.			

Table 8. MIOSHA Inspection Results of 85 Facilities Where Confirmed Silicosis Cases were Exposed to Silica: 1985-2007		
	Companies	
	#	%
Air Sampling Performed	60	
Above NIOSH Recommended Standard for Silica	35	58.3
Above MIOSHA Enforceable Standard for Any Exposure	22	36.7
Above MIOSHA Enforceable Standard for Silica	22	36.7
Medical Surveillance Evaluated	68	
Periodic Chest X-Rays with a B Reader	8	11.8
Periodic Chest X-Rays without a B Reader	3	4.4
Pre-employment Testing Only	20	29.4
No Medical Surveillance	25	36.8
Periodic Pulmonary Function Testing	18	26.5
*NIOSH = National Institute for Occupational Safety and Health.		
**MIOSHA = Michigan Occupational Safety and Health Administration.		

Table 9. 59 Potential Silica-Using Foundries by County: Michigan, 2008			
County	Foundry Name	County	Foundry Name
Alpena	Thunder Bay Manufacturing	Muskegon	Dana Corp Perfect Circle Div.
Arenac	Arenac Castings Inc.		Eagle Alloy Inc.
Bay	Bay Cast Inc.		Harbor Castings
Berrien	Ancast Inc.		Northland Castings Corp.
Calhoun	Calhoun Foundry Co. Inc.		Ravenna Casting Center
	Omega Castings Inc.		West MI Steel Foundry
Cass	Marcellus Metalcasters Inc.	Oakland	General Bearing Corp.
Charlevoix	East Jordan Iron Works Inc.		Lasalle Foundry & Machine Co.
Dickinson	Grede Foundries Inc.		Temperform Corp.
	Smith Castings Inc.		Urgent Plastics Services
Huron	Berne Enterprises Inc.	Ogemaw	Associate Patterns & Castings
	Huron Castings Inc.	Ottawa	Dameron Alloy Foundries
	Village Castings Co.		EPS Industries Inc.
Jackson	Pioneer Foundry Co. Inc.		Steel Forming Systems Inc.
	Specialty Castings Inc.	Saginaw	Bernier Cast Metals Inc.
Kent	Betz Industries Inc.		GM Corp., Malleable Iron Plant
	Cedar Springs Castings	Saint Joseph	Dock Foundry
	Federal-Mogul Power Train Systems		Robert Bosch, Automotive Group, Chassis Div.
	Steeltech Ltd.	Shiawassee	GKN Sinter Metals
Macomb	International Casting Co.	Tuscola	Grede Foundries Inc.
	Invecast Corp.	Washtenaw	RHE Tech Inc.
	Threaded Products Co.	Wayne	April Steel Processing
	Warren Alloy Foundry		Delray Steel Castings Inc.
Menominee	L E Jones Co.		Diversified Diemakers Inc.
Midland	Midland Iron Works Inc.		Northfield Mfg. Inc.
Muskegon	Akzo Manufacturing		Process Prototype Co. Inc.
	Burgess-Norton Foundries		Rouge Steel
	Cannon Muskegon Corp.		Thomas Industrial Rolls Inc.
	Casting Specialties, Specialty Metal Mfg.	Wexford	Hayes Lemmerz Cadillac Operations
	CWC Casting Div of Trextron Inc.		