2010
Annual Report on
Silicosis in Michigan

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A Joint Report
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Summary:

This is the 19th annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 2008 and preliminary data for 2009 and 2010. A total of 1,107 cases of silicosis have been confirmed from 1985 – 2010: 22 of those reports were confirmed in 2008. To date, another 13 cases have been confirmed for 2009, and 16 cases in 2010. The average number of cases reported from 1998 through 2008 was 29 and has decreased from an average of 62 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 22 reports of newly diagnosed silicosis cases in 2008 there were another 67-139 individuals diagnosed with silicosis in Michigan in 2008 who were not reported.[1]

Silicosis occurs mainly among men born before 1940, who began working in a Michigan ferrous foundry in the 1930s through the 1960s and worked in silica for over 25 years. Forty percent of the patients are African American. The annual average incidence rate of silicosis among African American males (8.8 cases per 100,000) is 5.5 times higher than that of white males (1.6 cases per 100,000). The rates within specific counties ranged between two to 366 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.

In the most recent year that national data is available, two Michigan counties were 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-five percent have progressive massive fibrosis (PMF) and another 36% have advanced simple silicosis. Only about a third of all patients have normal breathing tests. [3] Twenty-two 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.[4]

Despite the severity of disease, 61% 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, some patients develop silicosis after a relatively short period of time because of the severity of that exposure. One individual began working in the 2000s, two began working with silica in the 1990s, 17 in the 1980s, 70 in the 1970s and 164 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 identify and inspect all silica-using foundries in the state. Forty-seven foundries were inspected. Personal air monitoring for silica was conducted in 43 of the 47 facilities; 28 companies had silica levels below the MIOSHA PEL and 15 were above the PEL.

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 Licensing and Regulatory Affairs (LARA), 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 - 2008. 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, 2009 and 2000 data are incomplete at this time. We are currently in the process of reviewing the medical records and chest radiographs of additional individuals who were reported with silicosis. 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 - 2008 undercounts the true number of persons with silicosis.

Figure 1 shows patients confirmed with silicosis through the surveillance system from 1987 through 2010. Table 1 shows the primary reporting source of the 1,107 persons confirmed with silicosis from 1985 - 2010. Hospital reports are the primary source of identification of patients, with 59% 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 2009.

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.[5] 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 1,107 cases of silicosis confirmed from 1985 - 2010.

Gender

One thousand eighty-three (97.8%) of the persons with silicosis are men; the other 24 (2.2%) are women.

Race

Six hundred twenty-eight (57.1%) of the persons with silicosis are white, 440 (40.0%) are African American, two (0.2%) are of Asian ancestry, one (0.1%) was of American Indian ancestry, and 28 (2.5%) were listed as "other ancestry". The race on eight individuals was unknown.

Year of Birth

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1923, ranging from 1888 to 1971.

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 2000.

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 27.5.

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 8.8 cases per 100,000, and for white men is 1.6 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 366/100,000, in Muskegon it was 158/100,000, in Saginaw it was 53/100,000, in Monroe it was

29/100,000, in Calhoun it was 22/100,000, in St. Joseph it was 19/100,000 and in Macomb it was 10/100,000. 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 14/100,000, and in Menominee, Keweenaw and Saginaw 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) (86.0%). Two hundred ninety-six of the 834 individuals for whom sandblasting history is known (35.5%) stated they had done sandblasting as part of their work.

Medical Results

Overall 778 (70.3%) of the people with silicosis had simple silicosis and 267 (24.1%) had progressive massive fibrosis. Twenty-four (2.2%) silicotics had normal x-rays with lung biopsy evidence. Thirty-eight (3.4%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred ninety-two (26.8%) of the people with silicosis never smoked cigarettes, 645 (59.1%) had quit, 154 (14.1%) were still smoking and no information was available on 16 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. 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 64% 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. A more comprehensive analysis of spirometry results was published this past year.[3]

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 initially reported an increase in rheumatoid arthritis, systemic lupus erythematosus and scleroderma among individuals reported to the Michigan silicosis registry in 1999.[6] We recently updated the analysis of Michigan silicosis cases for connective tissue disease.[7] We continued to

find an increased prevalence of rheumatoid arthritis, systemic lupus erythematosus (SLE), and scleroderma. In this new analysis, we examined the risk for anti-neutrophil cytoplasmic antibody positive (ANCA) vasculitis, which was markedly elevated (RR 25.3 95% CI 6.34-101.04).[7]

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. ANCA positive renal disease has been repeatedly associated with silica exposure.[9] We are currently updating the analysis of chronic kidney disease.

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 359 (39.3%) of the 914 individuals with silicosis or their next of kin for whom filing status was known had applied for workers' compensation; 555 (60.7%) had not applied. It was unknown whether the remaining 193 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, 274 (76.3%) received compensation, 28 (7.8%) had been denied, and 57 (15.9%) were pending at the time of interview.

Industrial Hygiene Results

The 1,107 individuals with silicosis were exposed to silica in 444 facilities (Table 5). Inspections were performed at 86 (19.4%) of these facilities. One hundred forty-eight (33.3%) facilities were no longer in operation, 66 (14.9%) were located out of state, 25 (5.6%) facilities no longer used silica, 58 (13.1%) 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 58 (13.1%) were unknown. There is one facility scheduled for inspection.

Air sampling was conducted in 61 of the 86 facilities inspected (Table 6). Thirty-six of 61 (59.0%) facilities were above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit for silica. Twenty-two of the 61 (36.1%) 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 69 (11.6%) 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 (4.3%) companies provided periodic chest x-rays that were not interpreted by a "B" certified reader. Twenty (29.0%) only performed pre-employment testing, 26 (37.7%) provided no medical surveillance, and 18 (26.1%) 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-three 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. Table 7 shows the types of facilities originally identified and their inspection status. Forty-seven foundries were inspected. Nineteen no longer used silica and 27 facilities were out of business. Personal air monitoring for silica was conducted in 43 of the 47 facilities; 15 (34.9%) companies were above the PEL and 24 (55.8%) were above the REL (Table 8). Fourteen of the 15 inspections at foundries where a SENSOR case had previously been identified performed air sampling; six (42.9%) had silica levels above the PEL and 10 (71.4%) facilities had silica samples above the REL. Twenty-nine of the 32 inspections with silica air monitoring where no silicosis index case was associated found nine (31.0%) facilities had silica levels above the PEL and 14 (48.3%) were above the REL.

Almost half of the companies that were unionized had at least one silica measure above the PEL, and 63.6% had at least one silica measure above the REL. Thirty-one percent of the 32 non-unionized foundries had at least one respirable silica measurement above the PEL and 50.0% had at least one measure above the REL. About one third of the companies with fewer than 250 employees had at least one respirable silica measurement above the PEL and about half were above the REL. Among companies with 250 or more employees, half had at least one respirable silica measurement above the PEL and 75.0% were above the REL. Table 9 lists the 47 silica-using foundries in Michigan, by county.

Abrasive Blasting Survey in Michigan

In July of 2011, letters were sent to 404 companies in Michigan that potentially did abrasive blasting; 283 of these companies were from a previous survey conducted in 2005 and 121 companies had been newly identified through internet search engines and were considered very likely to perform abrasive blasting. The letter asked these companies to complete a brief survey about their abrasive blasting activities even if they did not use silica. The survey asked whether abrasive blasting was done by their company, what media were used, and how many individuals were employed by and performed these activities. A postage paid envelope was included. Follow-up telephone calls were made to any companies that did not return the survey.

Of the 404 companies identified, 149 were excluded due to: undeliverable address (66), unlisted or disconnected telephone number (73), and being out of business (10). Of the remaining 255 companies, 13 refused to participate, 148 completed the survey, and the remaining 94 are still in the process of being contacted with multiple calls and repeat mailings.

Of the 148 companies that have completed the survey to date, 88 performed abrasive blasting, while 60 indicated they did not perform blasting. Of the 88 companies that perform abrasive blasting, 36 used silica. One of the companies that used silica reported that they did not use silica; rather, they indicated the use of “other abrasives” and described it as “play sand.” Table 10 shows the abrasive material that was being used. Using similar methodology, we have identified

the number of companies using silica as an abrasive in 1995, 1999, and 2005. Figure 10 shows the number of companies using silica as an abrasive for these four surveys.

Follow up calls are being made to non-respondents. In addition, plans are underway to distribute literature to the facilities that perform abrasive blasting using silica, with information on the hazards associated with the use of silica as well as information on alternative media.

Discussion:

The main 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, 1923) 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, 1990s and one in the 2000s. Overall, 86 (8.2%) silicosis cases worked for less than 10 years (Figure 5). Ninety (8.6%) of the 1,049 individuals with known decade of hire began work in the 1970s, 1980s, 1990s or 2000s; 26 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 (49% vs. 34%). Of the 20 people who first were exposed to silica since the 1980s, four worked in foundries, two were buffing and polishing metal, two worked in auto manufacturing, two did cement work, one worked in mineral processing, one worked in a dental laboratory, one was a heavy equipment operator who did excavating, one was a painter, one worked as a miner in gold fields in the Southwest, one did welding, one owned an auto repair shop, one was in construction, one worked in a boiler fabrication shop, and one worked for a small sandpaper manufacturing operation.

African American men are over represented (40.0%). This reflects previous hiring practices in foundries.[11] 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 8.8 per 100,000 versus 1.6 per 100,000 for white workers (a 5.5-fold greater incidence).

The individuals reported generally have advanced disease: 267 (25.0%) with progressive massive fibrosis and another 383 (35.8%) with advanced simple silicosis (category 2 or 3). Approximately 64% 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). Twenty-two percent have had either tuberculosis or a positive skin test indicating infection with the mycobacterium that causes tuberculosis. Despite the severity of their disease, 61% 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.[4,15] The increased risk for death is found both in patients who ever or never smoked cigarettes.[4] Individuals with silicosis also have an increased risk of developing connective tissue disease, particularly rheumatoid arthritis[6,7] as well as an increased risk of developing chronic renal disease, especially ANCA positive disease.[8,9,16]

The number of Michigan ferrous foundry workers peaked in the 1970s at around 40,000, dropped to around 20,000 in the early 1980s, to 10,000 in the 1990s, and to approximately 4,000 in 2010 (Figure 11). 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 employer-based 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 36.1% of the facilities where sampling was done. However, follow-up inspections of these same companies have shown a significant decrease in silica exposures. 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 88.4% 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-three facilities were identified through multiple sources. Forty-seven foundries still in business were inspected; 15 had silica levels above the MIOSHA permissible exposure limit, 28 were within permissible limits for silica, and four were not sampled for silica. These foundry evaluations indicate ongoing silica exposure in this industry above permissible limits.

Although our most recent survey of the abrasive blasting industry in Michigan is still ongoing, the use of silica is down to about one-third of abrasive companies in 2011 compared to 90% of abrasive-using companies in 1995 (Figure 11). The survey also revealed the availability of a large

variety of abrasive media being used in Michigan as alternatives to silica. Efforts to continue to encourage the selection of non-silica abrasives are planned.

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.[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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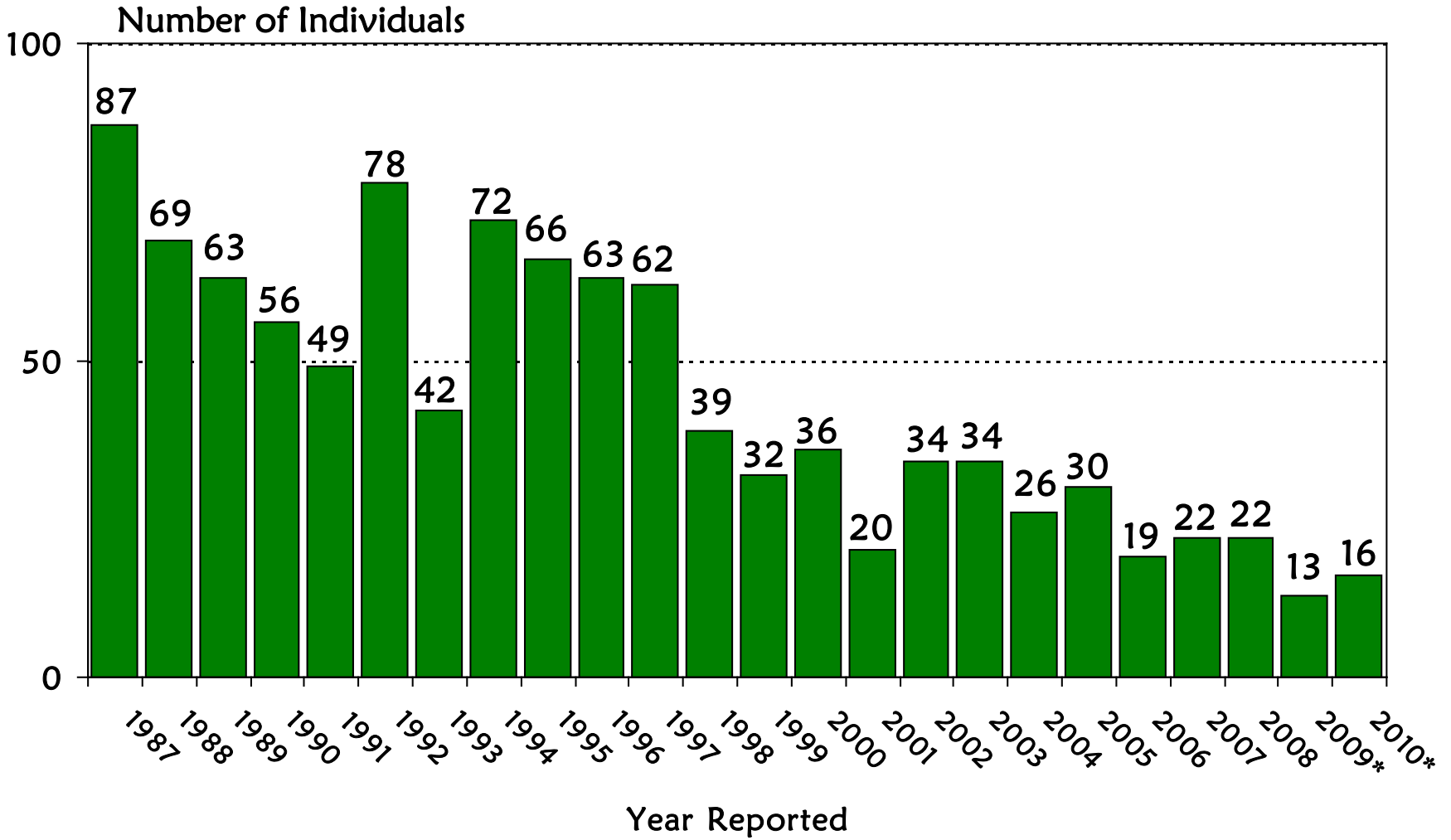
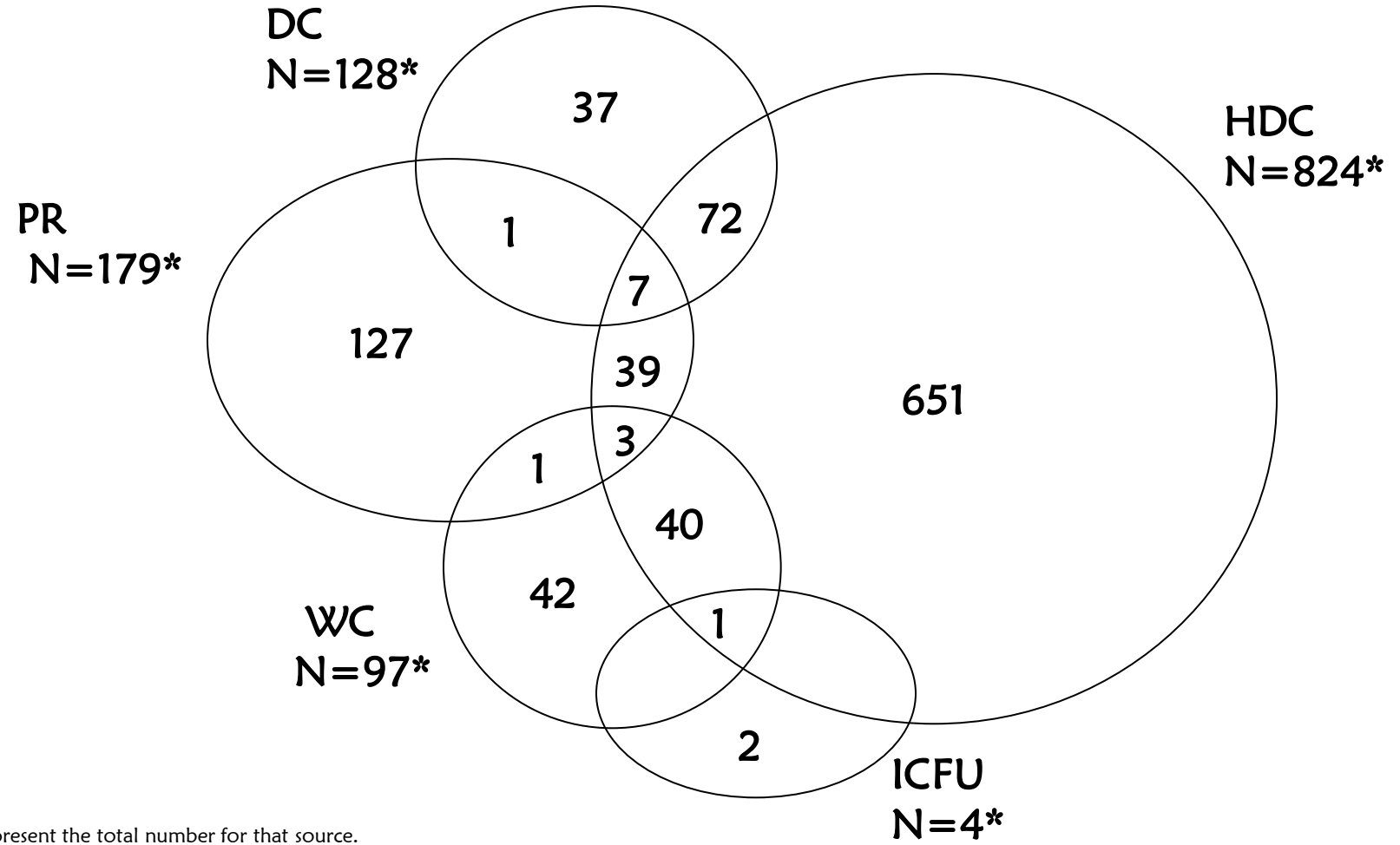
Figure 1. Confirmed Silicosis Cases
by Year Reported



*Provisional data.

Figure 2. Overlap of Reporting Sources for 1,034 Confirmed Silicosis Cases: 1987-2009



*N's represent the total number for that source.
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
1,107 Confirmed Silicosis Cases: 1985-2010

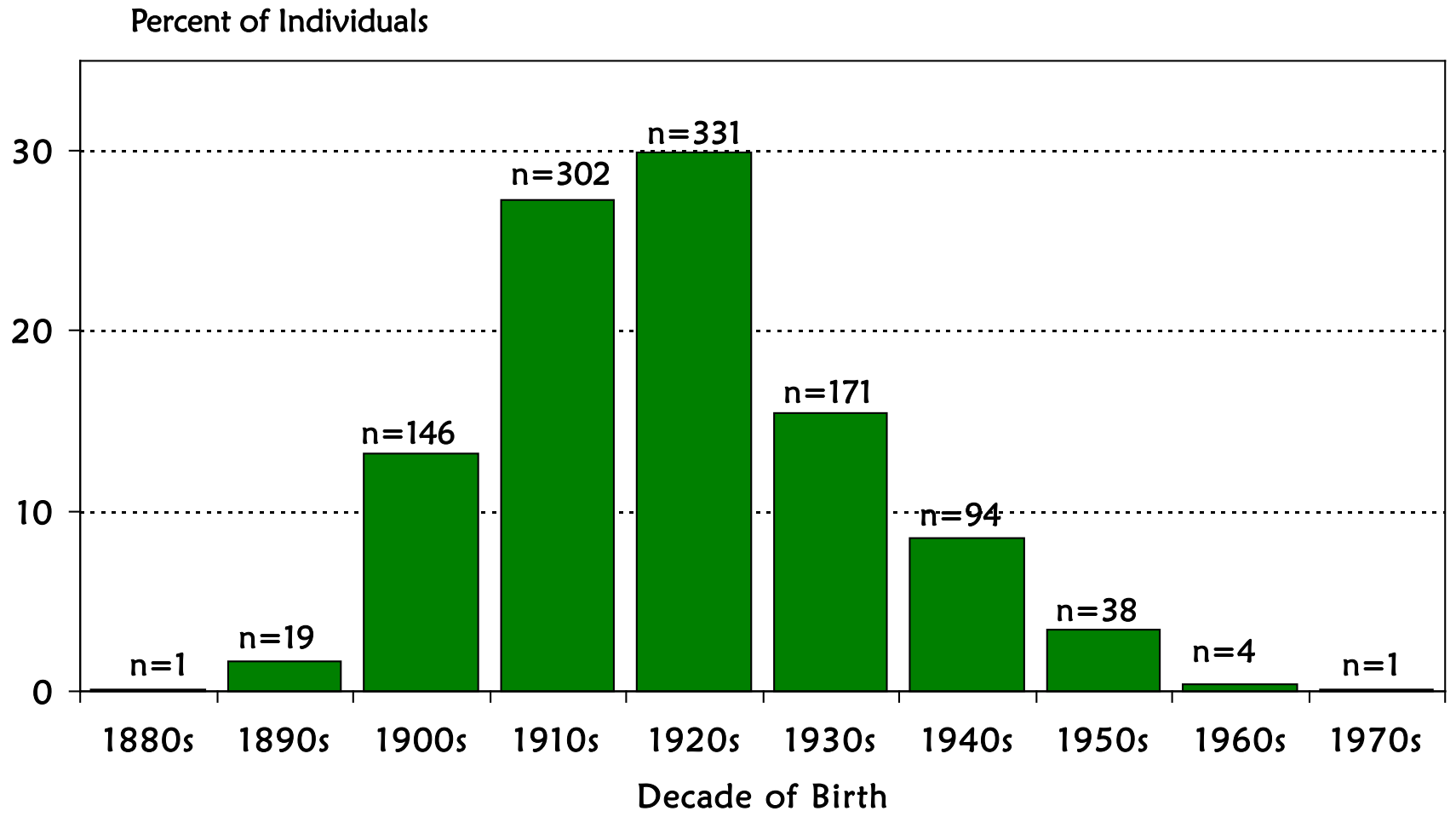
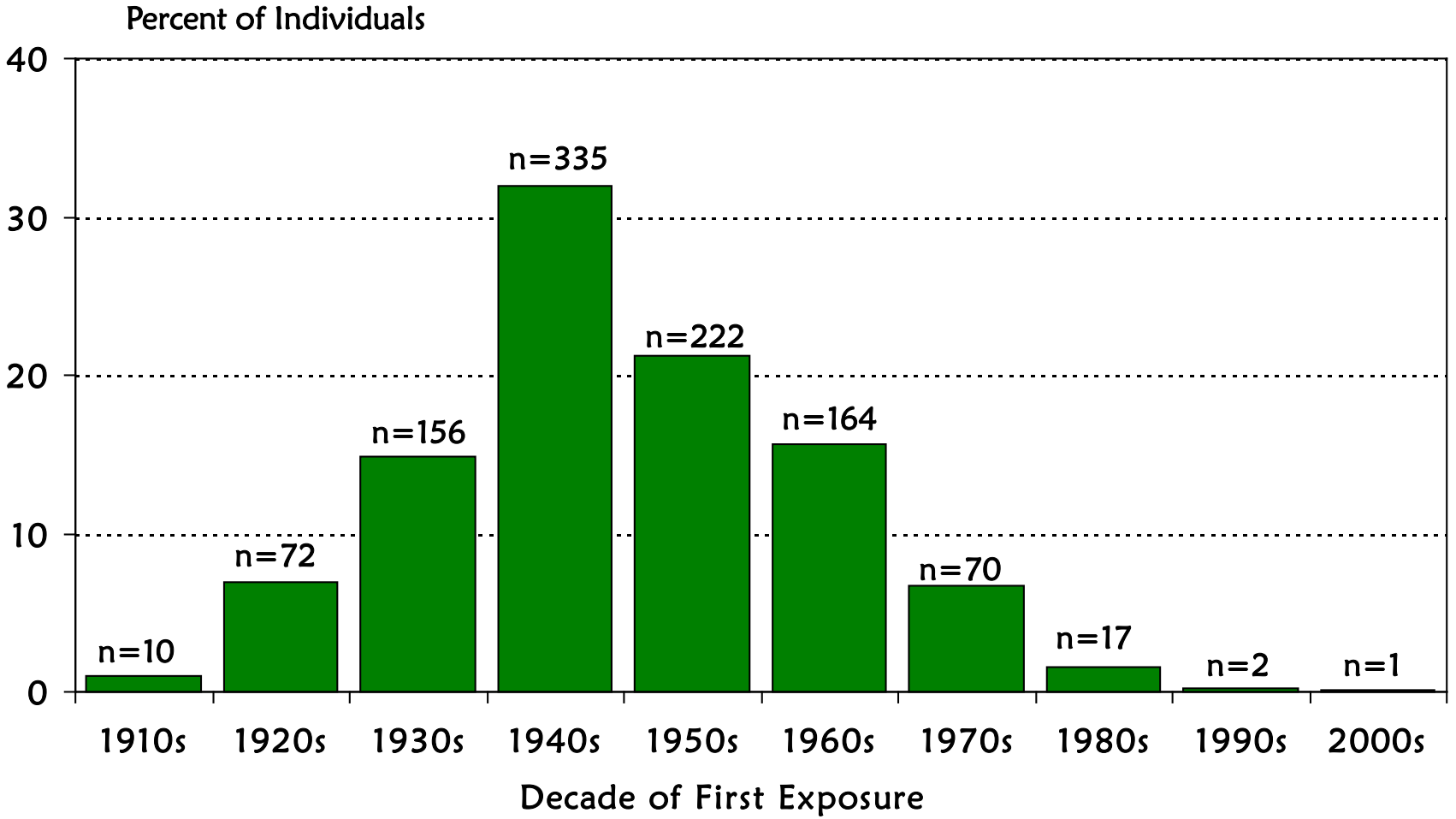
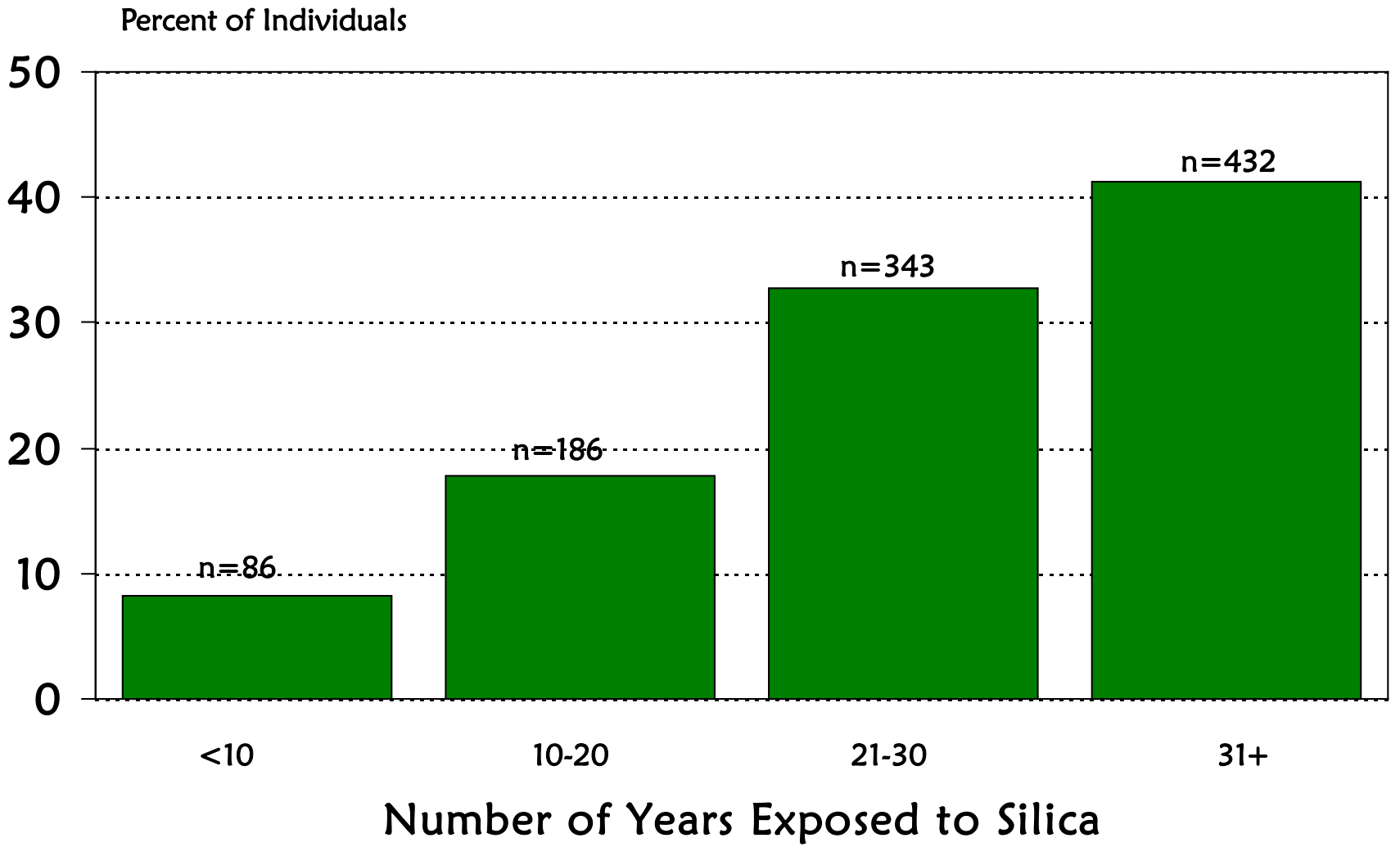


Figure 4. Distribution of Decade When Silica Exposure Began for Confirmed Silicosis Cases: 1985-2010*



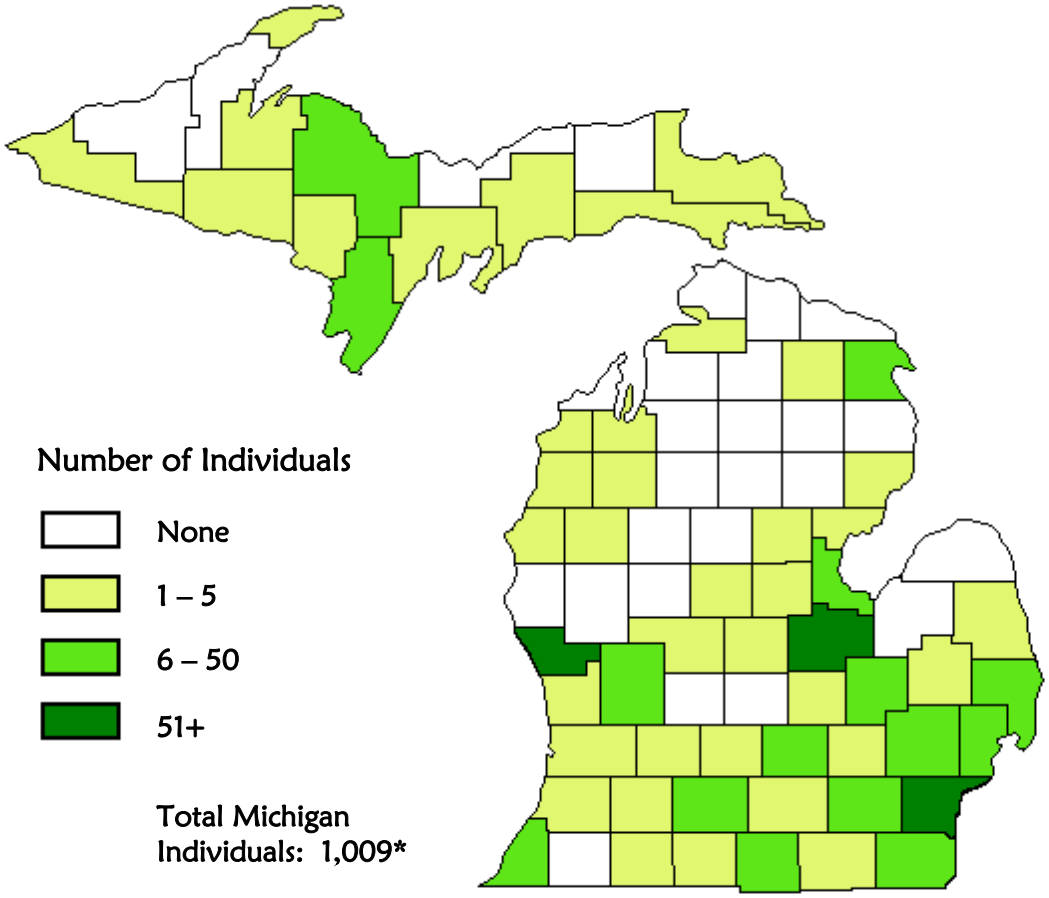
*Total number of individuals: 1,049. Unknown decade for 58 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Confirmed Silicosis Cases: 1985-2010*



*Total number of individuals: 1,047. Unknown duration for 60 individuals.

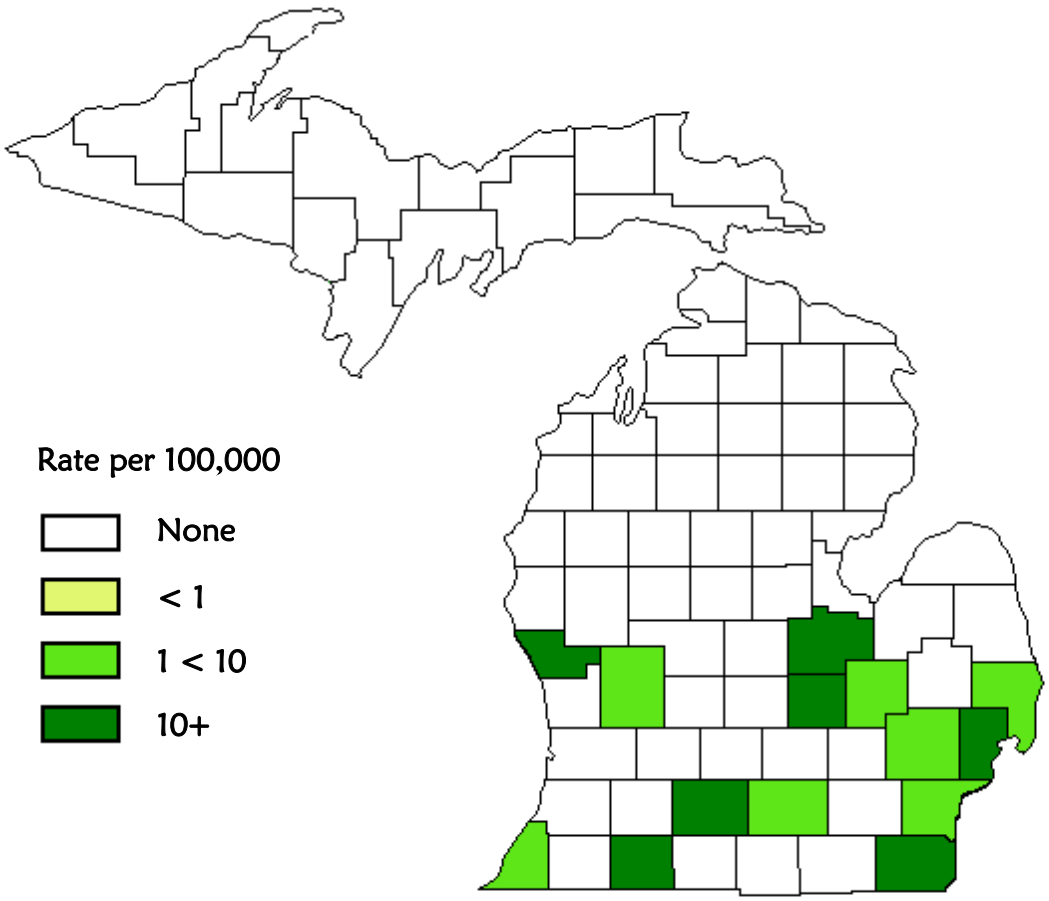
Figure 6. Distribution of Confirmed Silicosis Cases by County of Exposure: 1985-2010



Muskegon, Saginaw and Wayne counties had the highest number of individuals with silicosis, with 258, 143 and 298 individuals, respectively.

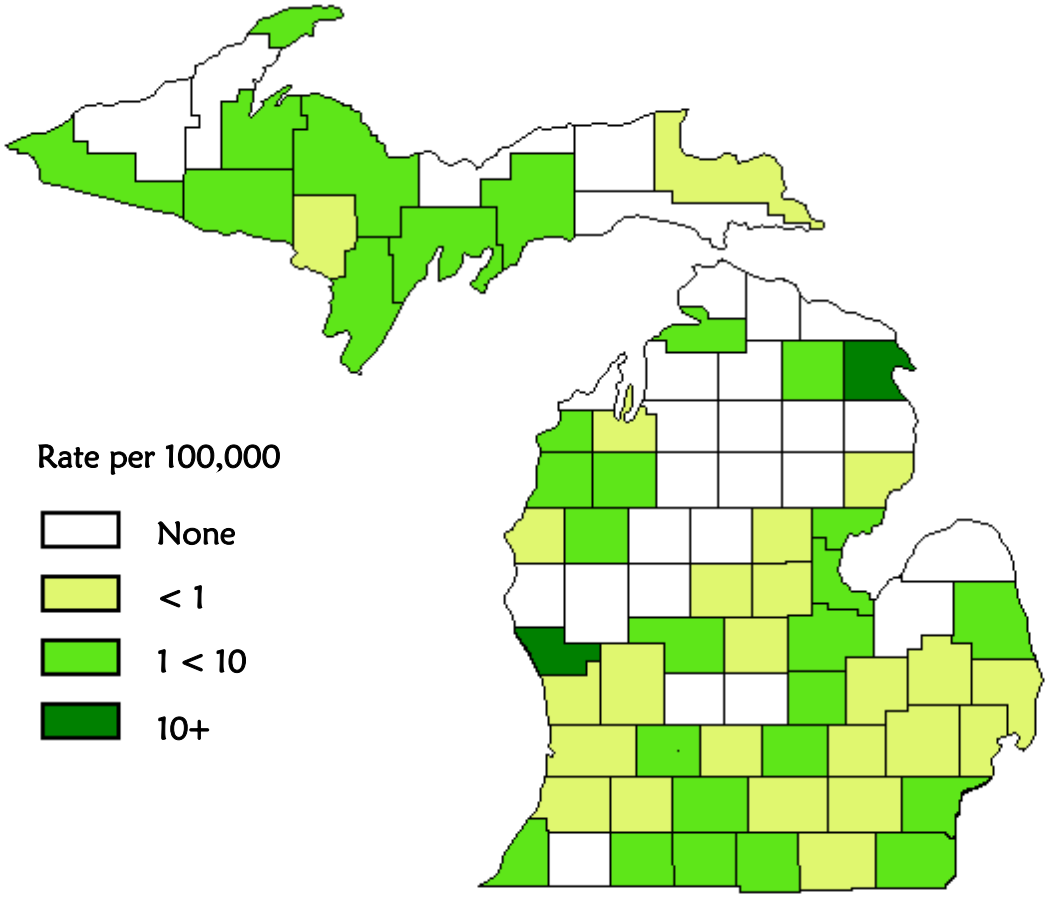
*Seventy-five individuals were exposed to silica out-of-state, and 23 individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-2008*



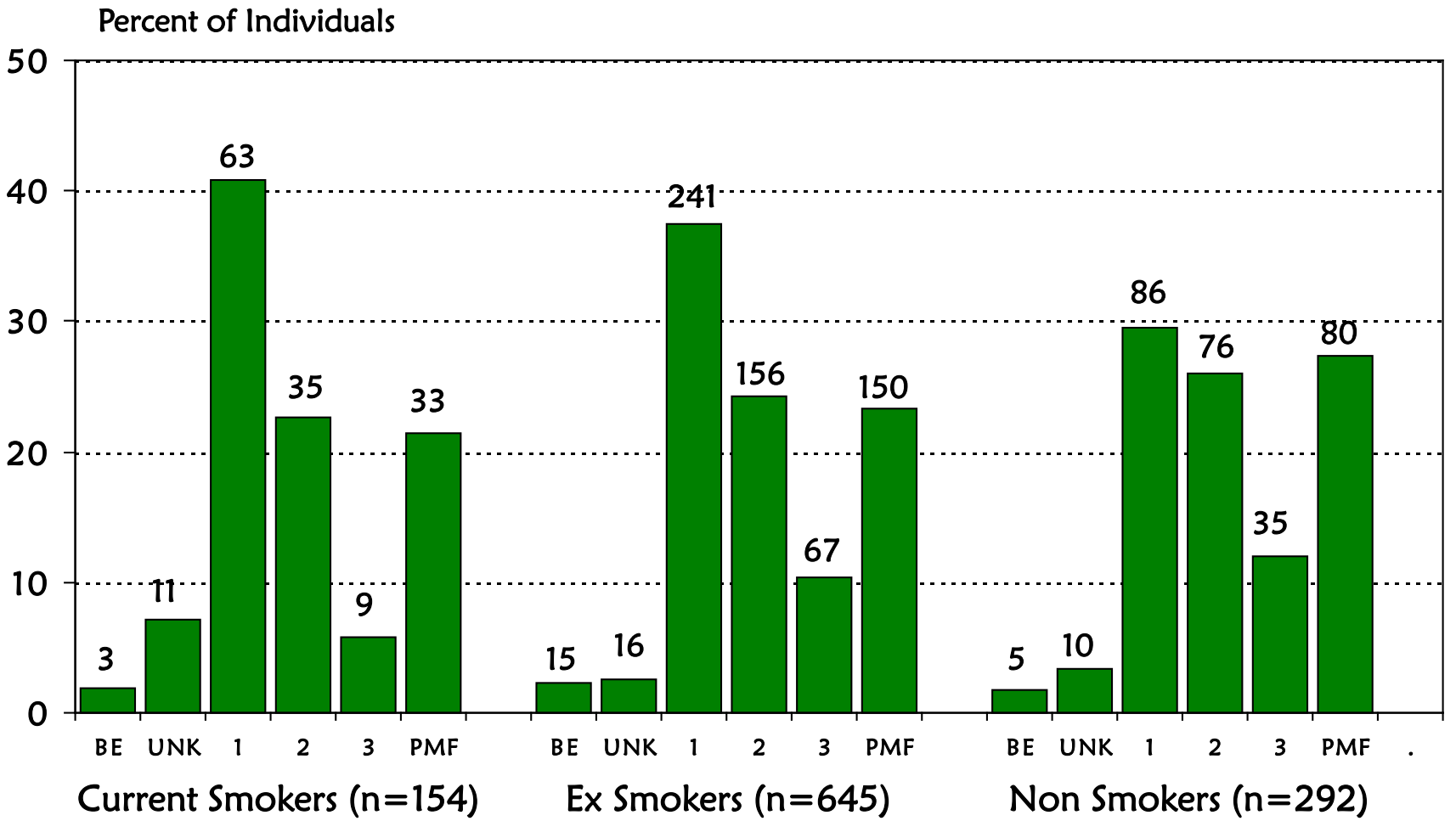
*Rate per 100,000 among African American men age 40+. Numerator is the average number of African American males with silicosis for the years 1987 – 2008; denominator is the 2000 Census population data for African American men age 40 and older, by county. In 2000, there were 219,076 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-2008*



*Rate per 100,000 among white men age 40+. Numerator is the average number of white males with silicosis for the years 1987 – 2008; 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: 1985–2010**



*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: 1,091. Unknown smoking status for 16 individuals.

Figure 10. Abrasive Blasting Survey of Michigan Companies, By Year of Survey and Use of Silica

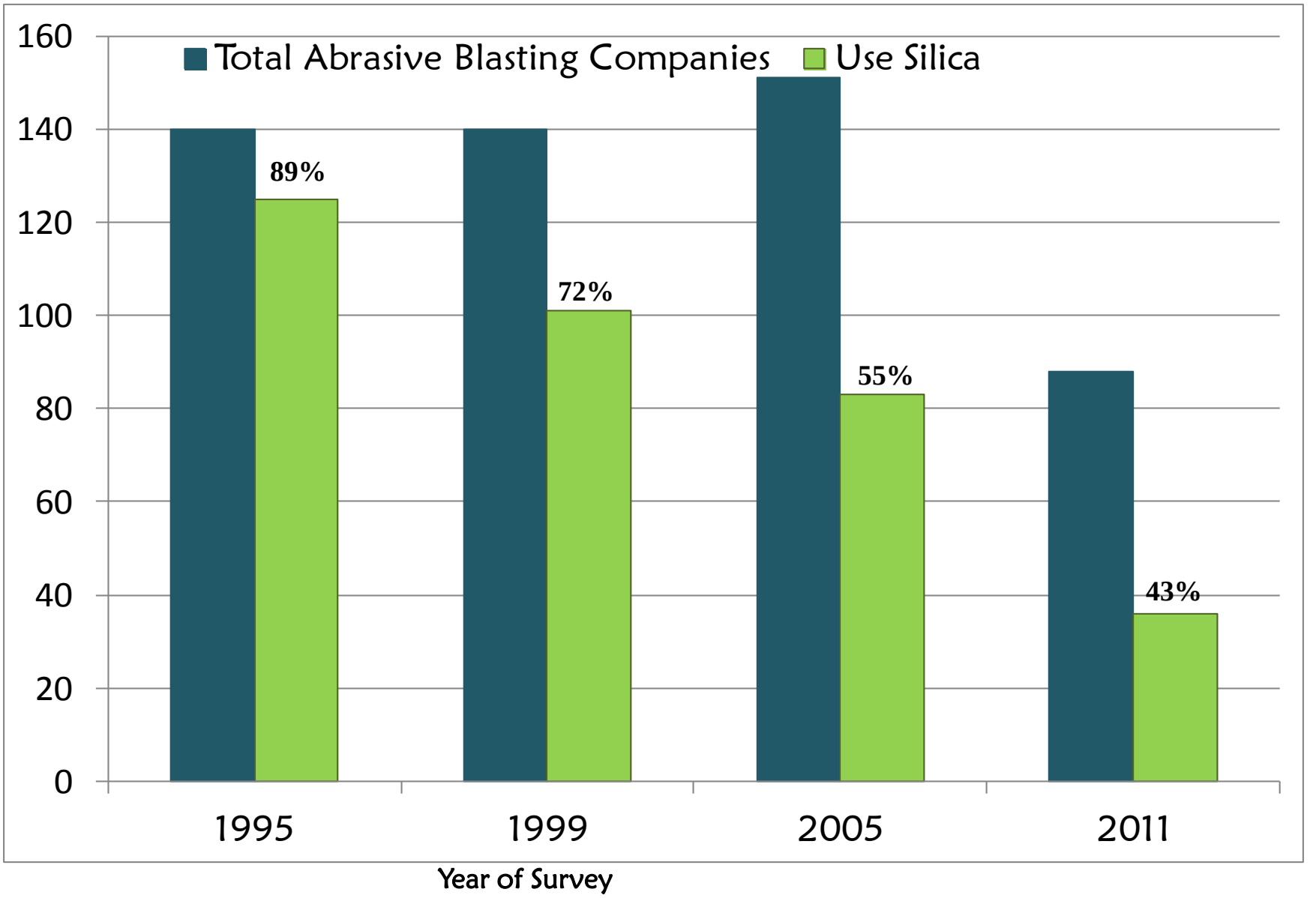


Figure 11. Michigan Ferrous Foundries 1960-2010

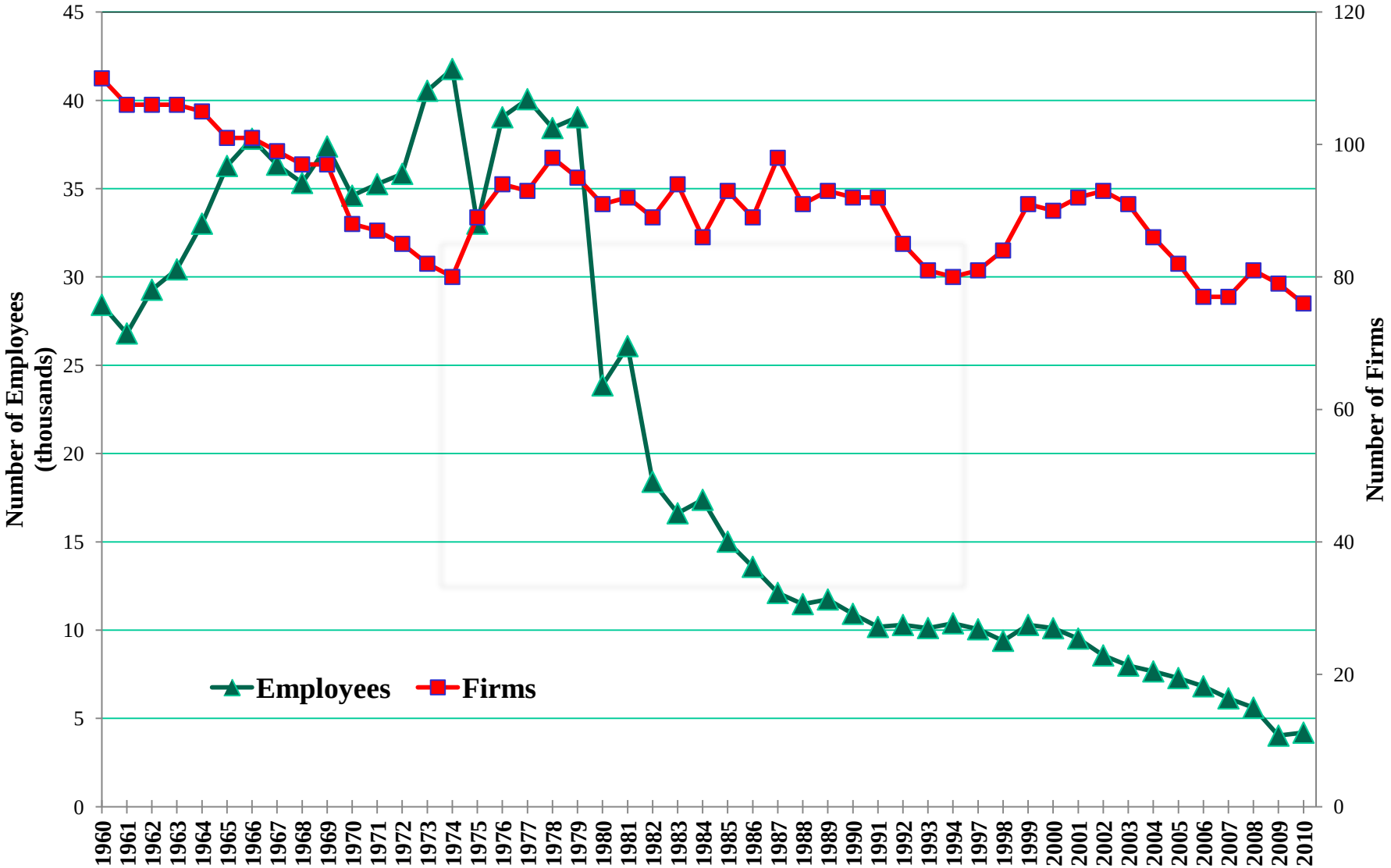


Table 1. Year and Reporting Source for Confirmed Silicosis Cases: 1985-2010

	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	24	0	0	0	26
2005	4	26	0	0	0	30
2006	1	17	1	0	0	19
2007	2	19	0	1	0	22
2008	4	17	0	1	0	22
2009**	1	11	1	0	0	13
2010**	2	14	0	0	0	16
All Years	165	765	69	104	4	1,107

*Reporting by physicians was not active in this year.

**Provisional data.

Table 2. Primary Industrial Silica Exposure for Confirmed Silicosis Cases: 1985-2010			
2002 North American Industry Classification System		# Individuals	%
11	Agriculture, Forestry, Fishing & Hunting	2	0.2
21	Mining	39	3.5
22	Utilities	1	0.1
23	Construction	85	7.7
31-33	Manufacturing	952	86.0
42	Wholesale Trade	2	0.2
44-45	Retail Trade	2	0.2
48-49	Transportation & Warehousing	7	0.6
56	Administrative & Support & Waste Management & Remediation Services	2	0.2
62,81	Other Services (except Public Administration)	6	0.5
92	Public Administration	4	0.4
00	Unknown	5	0.5
Total		1,107	

Table 3. Percent Predicted Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Confirmed Silicosis Cases: 1985-2010

	Percent Predicted FVC***											
	<60%				60-79%				>=80%			
X-Ray Results*	Ever Smoked		Never Smoked		Ever Smoked		Never Smoked		Ever Smoked		Never Smoked	
	#	%	#	%	#	%	#	%	#	%	#	%
Biopsy Evidence	1	8.3	0	--	6	50.0	2	66.7	5	41.7	1	33.3
Unknown Severity	9	40.9	2	40.0	8	36.4	1	20.0	5	22.7	2	40.0
Category 1	48	23.8	17	30.9	72	35.6	16	29.1	82	40.6	22	40.0
Category 2	38	30.4	20	38.5	45	36.0	17	32.7	42	33.6	15	28.8
Category 3	11	26.2	14	66.7	18	42.9	3	14.3	13	31.0	4	19.0
PMF	45	38.1	19	36.5	39	33.1	17	32.7	34	28.8	16	30.8
Total**	152	29.2	72	38.3	188	36.1	56	29.8	181	34.7	60	31.9

*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: 711. Information was missing for 396 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: 1985-2010

	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	0	--	1	50.0	2	15.4	0	--	7	53.8	1	50.0	4	30.8	0	--
Unknown Severity	2	11.1	0	--	2	11.1	0	--	4	22.2	4	80.0	10	55.6	1	20.0
Category 1	20	10.1	1	1.9	42	21.1	2	3.7	72	36.2	19	35.2	65	32.7	32	59.3
Category 2	5	4.3	2	4.1	25	21.4	7	14.3	47	40.2	14	28.6	40	34.2	26	53.1
Category 3	1	2.6	1	5.0	7	17.9	0	--	5	12.8	6	30.0	26	66.7	13	65.0
PMF	18	15.7	3	6.0	37	32.2	11	22.0	35	30.4	18	36.0	25	21.7	18	36.0
Total	46	9.2	8	4.4	115	23.0	20	11.1	170	33.9	62	34.4	170	33.9	90	50.0

*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: 681. Information was missing for 426 individuals.

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

Table 5. Status of Facilities Where 1,107 Confirmed Silicosis Cases were Exposed to Silica: 1985-2010			
	Silicosis Cases	Facilities	
Inspection Status	#	#	%
Inspection Completed	477	86	19.4
Scheduled for Inspection	1	1	0.2
Inspected by MSHA*	4	2	0.5
Facility Out of Business	412	148	33.3
Facility Out of State	70	66	14.9
Facility No Longer Uses Silica	27	25	5.6
Building Trade: No Inspection	58	58	13.1
Unknown	58	58	13.1
Total	1,107	444**	100.1
*MSHA= Mine Safety and Health Administration.			
**Four facilities are related to one silicosis case's work history.			

Table 6. MIOSHA Inspection Results of 86 Facilities Where Confirmed Silicosis Cases were Exposed to Silica: 1985-2010		
	Companies	
	#	%
Air Sampling Performed	61	
Above NIOSH* Recommended Standard for Silica	36	59.0
Above MIOSHA** Enforceable Standard for Any Exposure	22	36.1
Above MIOSHA Enforceable Standard for Silica	22	36.1
Medical Surveillance Evaluated	69	
Periodic Chest X-Rays with a B Reader	8	11.6
Periodic Chest X-Rays without a B Reader	3	4.3
Pre-employment Testing Only	20	29.0
No Medical Surveillance	26	37.7
Periodic Pulmonary Function Testing	18	26.1
*NIOSH = National Institute for Occupational Safety and Health.		
**MIOSHA = Michigan Occupational Safety and Health Administration.		

Table 7. Michigan Foundries Identified in 2007				
Foundry Type - SIC Code	Total #	Inspection		Closed
		Silica	No Silica	
Gray & Ductile Iron - 3321	40	25	6	9
Malleable – 3322	1	--	--	1
Steel, NEC – 3325	50	21	12	17
Conveyors – 3535	1	1	--	--
Motor Vehicles – 3714	1	--	1	--
Total	93	47 (50.5%)	19 (20.4%)	27 (29.0%)

Table 8. Respirable Silica Air Sampling Results at 47 Michigan Foundry Inspections from 2007 – 2010, by Select Indicators						
		> PEL (0.1 mg/m³)			> REL (0.05 mg/m³)	
	Total #	#	%		#	%
Case Reports of Silicosis	14*	6	42.9		10	71.4
No Case Reports of Silicosis	29**	9	31.0		14	48.3
Total	43***	15	34.9		24	55.8
Union	11	5	45.5		7	63.6
Non-Union	32***	10	31.3		16	50.0
<250 Employees	35***	11	31.4		17	48.6
>=250 Employees	8	4	50.0		6	75.0
*1 company had no silica sampling performed.						
**3 companies had no silica sampling performed.						
***4 companies total had no silica sampling performed.						

Table 9. 47 Silica-Using Foundries by County: Michigan, 2010			
County	Foundry Name	County	Foundry Name
Arenac	Arenac Castings Inc.	Muskegon	Akzo Manufacturing
Bay	Bay Cast Inc.		Cannon Muskegon Corp.
Berrien	Ancast Inc.		CWC Casting Div of Trextron Inc.
Calhoun	Calhoun Foundry Co. Inc.		Eagle Alloy Inc.
	Omega Castings Inc.		Harbor Castings
Cass	Marcellus Metalcasters Inc.		Northland Castings Corp.
Charlevoix	East Jordan Iron Works Inc.		Ravenna Casting Center
Dickinson	Grede Foundries Inc.		West MI Steel Foundry
	Smith Castings Inc.	Oakland	General Bearing Corp.
Huron	Berne Enterprises Inc.		Lasalle Foundry & Machine Co.
	Huron Castings Inc.		Temperform Corp.
	Village Castings Co.		Urgent Plastics Services
Jackson	Pioneer Foundry Co. Inc.	Oceana	Great Lakes Casting Corp.
	Specialty Castings Inc.	Ottawa	EPS Industries Inc.
Kent	Betz Industries Inc.	Saginaw	Bernier Cast Metals Inc.
	Federal-Mogul Power Train Systems	Saint Joseph	Metal Technologies (Dock Foundry)
	Kent Foundry Co, Inc.	Tuscola	Grede Foundries Inc.
	Steeltech Ltd.	Washtenaw	RHE Tech Inc.
Macomb	International Casting Co.	Wayne	Delray Steel Castings Inc.
	Invecast Corp.		Northfield Mfg. Inc.
	Threaded Products Co.		Process Prototype Co. Inc.
	Warren Alloy Foundry		Severstal (Rouge Steel)
Menominee	L E Jones Co.	Wexford	Cadillac Castings
Midland	Midland Iron Works Inc.		

Table 10. Type of Abrasive Blasting Media Used by 88 Companies that Reported Performing Abrasive Blasting: Michigan 2011		
	Companies	
Media Type Used (Companies can report the use of multiple types of blasting media.)	#	%
Silica*	36	40.9
Steel Shot	35	39.8
Aluminum Oxide	21	23.9
Coal Slag	21	23.9
Glass Beads	21	23.9
Corn Cobs	16	18.2
Crushed Glass	10	11.4
Garnet	6	6.8
Iron Oxide	3	3.4
Other Media**	30	34.1
*12 of the 36 companies indicated that silica is the only media used.		
**Other media includes: plastic (6), silicon carbide (2), melon seed (1), baking soda (10), walnut shells (14), nickel slag (1), water (1), DuPont Starblast (1), imported from Canada (1), mineral fine (1), dry ice (1), synthetic olivine (2), black slag (1), ground slag shells (1).		