2006

Annual Report on
Silicosis in Michigan

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Summary:

This is the 16th annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 2004 and preliminary data for 2005 and 2006. A total of 1,009 cases of silicosis have been confirmed from 1985 – 2006: 27 of those reports were confirmed in 2004. To date, another 19 cases have been confirmed for 2005, and six cases in 2006. The number of cases reported from 1998 through 2004 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 since 1998 continues.

Based on capture-recapture analysis we estimate that although we only received 27 reports of newly diagnosed silicosis cases in 2004 there were another 83-170 individuals diagnosed with silicosis in Michigan in 2004 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-two percent of the patients are African American. The annual average incidence rate of silicosis among African American males (11.4 cases per 100,000) is almost seven times higher than that of white males (1.7 cases per 100,000). The rates within specific counties ranged between two to 588 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.

The mortality rate for silicosis in the Muskegon area is one of the highest in the country. A NIOSH report estimated that the overall age-adjusted silicosis death rate of United States residents 15 years and older was 1.6 deaths per million individuals[2]. In comparison, this report showed that the death rate in the Muskegon area was in the highest of the ranges mapped 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. 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 [3].

Despite the severity of disease, 60% of the patients with known filing status had <u>not</u> 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, 14 in the 1980s, 51 in the 1970s and 139 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 report with data from Michigan, New Jersey and Ohio addresses the silica hazard for highway

reconstruction workers[4]. 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.

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 were putting their employees at risk of developing silicosis because they were not following recommended and required work practices. In 2005, we updated the survey of abrasive blasters in the state to assess their current use of silica. The updated survey revealed that half of the companies performing abrasive blasting continue to use silica. In 2007, we provided these companies with information on alternatives to silica and the health effects of exposure to silica.

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 - 2004. 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, 2005 and 2006 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 - 2004 undercounts the true number of persons with silicosis.

Figure 1 shows 927 patients identified and confirmed with silicosis through the surveillance system by year for 1987 through 2004. To date, an additional 19 persons with silicosis in 2005, and six individuals in 2006 have been confirmed with silicosis. Table 1 shows the primary reporting source of the 1,009 persons confirmed with silicosis from 1985 - 2006. 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 2005.

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 1,009 cases of silicosis confirmed from 1985 - 2006.

Gender

Nine hundred eighty-seven (97.8%) of the persons with silicosis are men; the other 22 (2.2%) are women.

Race

Five hundred fifty-four (55.2%) of the persons with silicosis are white, 419 (41.8%) are African American, two (0.2%) are of Asian ancestry, one (0.1%) was of American Indian ancestry, and 27 (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 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 27.7.

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 11.4 cases per 100,000, and for white men is 1.7 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 529/100,000, in Muskegon it was 232/100,000, in Saginaw it was 79/100,000, in Monroe it was 47/100,000, in Calhoun it was 31/100,000, in Macomb it was 24/100,000, and in St. Clair it was 14/100,000. 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 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 20/100,000, in Alpena it was 18/100,000, in Keweenaw it was 11/100,000, in Saginaw it was 10/100,000, and in Menominee it was 9/100,000.

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 (74.7%). Two hundred sixty-four of the 759 individuals for whom sandblasting history is known (34.8%) stated they had done sandblasting as part of their work.

Medical Results

Overall 702 (69.6%) of the people with silicosis had simple silicosis and 250 (24.8%) had progressive massive fibrosis. Thirty (3.0%) silicotics had normal x-rays with lung biopsy evidence. Twenty-seven (2.7%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred seventy-two (27.4%) of the people with silicosis never smoked cigarettes, 589 (59.3%) had quit, 133 (13.4%) were still smoking and no information was available on 15 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 (28.3% non smokers vs. 21.8% current smokers vs. 23.9% ex smokers) ($X^2 = 25.195$, $p = .014$). 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[6]. There is more recently reported evidence in the medical literature that silica exposure is a risk factor for systemic lupus erythematosus[7] and Sjogren's syndrome[8].

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[9]. 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[10].

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 336 (40.2%) of the 835 individuals with silicosis or their next of kin for whom filing status

was known had applied for workers' compensation. Four hundred ninety-nine (59.8%) had not applied. It was unknown whether the remaining 174 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, 263 (78.3%) received compensation, 26 (7.7%) had been denied, and 47 (14.0%) were pending at the time of interview.

Industrial Hygiene Results

The 1,009 individuals with silicosis were exposed to silica in 397 facilities (Table 5). Inspections were performed at 82 (20.7%) of these facilities. Currently three facilities are scheduled for inspections. One hundred thirty-four (33.8%) facilities were no longer in operation, 60 (15.1) were located out of state, 24 (6.0%) facilities no longer used silica, 43 (10.8%) 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 (12.3%) were unknown.

Air sampling was conducted in 59 of the 82 facilities inspected (Table 6). Thirty-five of 59 (59.3%) facilities were above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit for silica. Twenty-two of the 59 (37.3%) were above the enforceable Michigan Occupational Safety and Health Administration (MIOSHA) permissible exposure limit for silica. Another two (3.4%) companies were above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only eight of the 67 (11.9%) 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 (29.9%) only performed pre-employment testing, 24 (35.8%) provided no medical surveillance, and 18 (26.9%) performed annual or biennial pulmonary function testing without chest x-rays.

Abrasive Blasting Survey

In October of 2005, letters were sent to 354 companies in Michigan that potentially did abrasive blasting; 308 of these companies were from the original 1990 Michigan survey or had since been identified through internet search engines and were very likely to perform abrasive blasting. Another 46 companies were part of a 10% sample of companies that had originally been surveyed in 1990 and stated they did not perform abrasive blasting activities. 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 354 companies identified, 92 were excluded due to: duplicate company (9), undeliverable address (52), unlisted telephone number (11), and being out of business (20). Of the remaining 262 companies, seven refused to participate, 223 completed the survey, and the remaining 32 did not respond despite multiple calls and repeat mailings.

Of the 223 companies that completed the survey, 72 indicated they did not perform any blasting activities and 151 did perform abrasive blasting. Of the 151 companies that perform abrasive blasting, 83 used silica; 75 of the 83 reported the use of silica, and eight of those 83 companies reported that they did not use silica; rather, they indicated the use of "other abrasives" and described them as "washed beach sand," "Michigan sand," "quartz sand," "beach sand," or "baby sand." In addition, 10 of the 46 companies that originally indicated no blasting activities during the 1990 survey responded to the 2005 survey as performing blasting activities. Two of those 10 companies indicated the use of silica.

In 2007, literature was distributed 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. In addition, the manual "Abrasive Blasting: Preventing Silicosis," was updated and re-posted on www.oem.msu.edu.

Using Hospital Discharge Data to Provide a National Estimate of Newly Diagnosed Cases of Silicosis

Current estimates of the number of individuals diagnosed with silicosis each year are inadequate. The number of death certificates where silicosis is mentioned on the death certificate is approximately 150 per year and the number of hospital discharges (not people) is approximately 1,000. The Bureau of Labor Statistics, which does not separate out silicosis from the other types of pneumoconioses, estimates approximately 2,000 cases per year for all types of pneumoconiosis. We have previously used the national count of death certificates which mention silicosis on them to estimate the total number of individuals with silicosis. In our previous analyses based on data from 1987 through 1996 we estimated there were 6.44 times as many individuals with newly diagnosed silicosis as there were individuals identified by death certificates. Updating the calculations for the time period 1997 through 2003 we estimate the number of individuals alive with silicosis is 15.2 times the number identified via death certificates. Multiplying 150 deaths identified nationwide by 15.2 equals 2,280 cases of silicosis.

Similar analysis can be performed using hospital discharge data. The work sheet to perform the calculations is shown. Hospital discharge data count hospitalizations not individuals, and people can have multiple hospital admissions and discharges. Using our Michigan data we estimate that if multiple admissions in a single calendar year are eliminated for people with the diagnosis of silicosis, then each hospital discharge is equivalent to .69 individuals and if multiple admissions are eliminated both within the year and across a 5-year period then each hospital discharge is equivalent to .56 individuals with silicosis. This would mean that the approximately 1,000 hospital discharges for silicosis would be equivalent to 560 newly diagnosed cases of silicosis per year in the United States.

Our previous publication using capture-recapture analysis estimated our surveillance system missed 2.45-5.12 times the number of cases identified[1]. Multiplying the 560 estimate based on hospital discharge data by 2.45-5.12 equals 1,372 – 2,867 new cases of silicosis per year in the United States. Similarly multiplying 2.45- 5.12 times 2,280, our estimate based on death certificates would increase the estimate to 5,586 – 11,674 new cases of silicosis per year in the United States.

Work Sheet to Evaluate Hospital Discharge Reporting for Silicosis

Steps 1-3 listed below, calculations B, C and D in Step 5, and calculations 6a and 6b can be completed by states with access to hospital discharge data. The additional steps and calculations require a comprehensive silicosis surveillance system in order to complete.

1. Select Time Period: _____

2. Create a database out of your state's Health and Hospital Association hospital discharge records for patients where ICD-9 502 (silicosis) is coded as the primary or one of the initial six secondary discharge diagnoses for the time period specified above. Hospital Discharge Data typically includes: hospital, date of admit, date of discharge, date of birth, race and ethnicity codes, sex, patient zip code, primary discharge diagnosis, up to 6 secondary discharge diagnoses, disposition at discharge, and type of insurance.

   Combine all the years of the selected time period into one database. In this combined database, create fields for the following new variables to be used once patients reported to your surveillance system are identified, to help track each patient: patient name, patient final diagnosis, and two fields to flag duplicates. The first duplicate flag field is used to count hospitalizations of patients reported over multiple years (count the patient in the earliest year covered by the time period selected and flag subsequent years as the duplicates), and the second duplicate flag field is used to count patients hospitalized more than once within a given calendar year.

3. Determine duplicates of patients in the hospitalization database, based on matching of: DOB, SEX and patient Zip Code (note-zip code for a given individual MAY change if the patient is moved to a relative's home, or to a health care facility, etc., so this particular matching criterion should only be loosely applied).

   Accept as a match if: DOB and Sex match and Zip Code matches or is close.

   Mark the duplicates separately for hospitalizations across years and then within each calendar year using the two fields created in Step 2. For across years duplicates, leave field blank for the earliest report of a hospitalization for that individual, and code as "1" for any subsequent hospitalization(s) for that individual. For within years, leave field blank for the first hospitalization within that year, and code as "1" for any subsequent hospitalization(s) for that individual within that calendar year.

4. Through review of your state follow-up of each reported case, add the patient name and final diagnosis code (for example, S for silicosis, CP for coal workers' pneumoconiosis, AB for asbestosis, etc.) for each record in the multi-year hospital discharge database.

5. Tally the records as follows:

A	B	C	D	E	F
Year of Discharge	Number of Confirmed + Non Confirmed Hospitalizations for ICD 502 as a Primary or Second through Seventh Hospital Discharge Diagnosis	Number of **Confirmed + Non Confirmed** Cases With Duplicates Removed Within Each Year (ROWS)	Number of **Confirmed + Non Confirmed** Cases With Duplicates Removed both within (ROWS) and across (COLUMNS) years—count the case in the year they **first** show up in the hospital records	Number of **Confirmed Silicosis** Cases With Duplicates Removed Within Each Year	Number of **Confirmed Silicosis** Cases With Duplicates Removed both within and across years—count the case in the year they **first** show up in the hospital records
Year 1					
Year 2					
Year X					
Total					

6. Calculate the percentages of confirmed cases:

   a) Divide column C by column B within each year to calculate the percentage of hospital discharges that represent unique cases within each year.

   b) Divide column D by column B combined over all years for the time period selected, to calculate the percentage of hospital discharges that represent unique cases over a multiple years.

   c) Divide column E by column B within each year, to calculate the percentage of hospital discharges that are true silicosis cases within each year.

   d) Divide column F by column B combined over all years for the time period selected, to calculate the percentage of hospital discharges that are true incident silicosis cases identified through a multi-year period of time.

7. Calculate the percentage of additional silicosis cases reported by hospitals that are not in the computerized hospital discharge data, by dividing the number of extra cases reported by the hospitals, but that were not reported in the hospital discharge data file, by the total number of cases in that data file.

Discussion:

The predominant characteristics of the individuals reported during Michigan's seventeen 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[11]. 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. Seventy-one or 7.4% worked for less than 10 years. Sixty-six (6.9%) of the 960 individuals with known decade of hire began work in the 1970s, 1980s or 1990s; 21 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 (50% vs. 33%). Of the 15 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 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 (41.8%). This reflects previous hiring practices in foundries[12]. 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 11.4 per 100,000 versus 1.7 per 100,000 for white workers (an almost 7 fold greater incidence).

The individuals reported generally have advanced disease: 250 (24.8%) with progressive massive fibrosis; and another 346 (34.3%) 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). 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, 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[13]. Individuals with silicosis are at risk of developing pulmonary hypertension, clinically significant bronchitis and chronic obstructive pulmonary disease[14].

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[15]. 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[15].

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease[3,16]. 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[6] as well as an increased risk of developing chronic renal disease, especially ANCA positive disease[9,10,17].

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 all dust diseases of the lung, including asbestosis and coal worker's pneumoconiosis in addition to silicosis.

A survey performed in the 1990s of Michigan companies using silica found that most of them were putting their employees at risk of developing silicosis because they were not following recommended and required work practices. European countries banned the use of silica for sandblasting 50 years ago. In 2005, we updated the survey of abrasive blasters in the state to assess their current use of silica, and found that 55% of the companies in Michigan that perform abrasive blasting continue to use silica abrasives. An alarming finding of the 2005 survey was that eight companies using "sand" indicated they did not use silica. A mailing to educate abrasive blasting companies on the hazards of using silica was completed in 2007.

In previous years, the risk of silicosis in dental laboratories[18,19] and among highway reconstruction workers[4] 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 37.3% 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 88.1% of the facilities, there is no way to monitor the adequacy of these controls in terms of health outcomes.

This year MIOSHA has begun an initiative to review silica levels in Michigan foundries. We will report these results in future years.

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[7,13,16,20]. 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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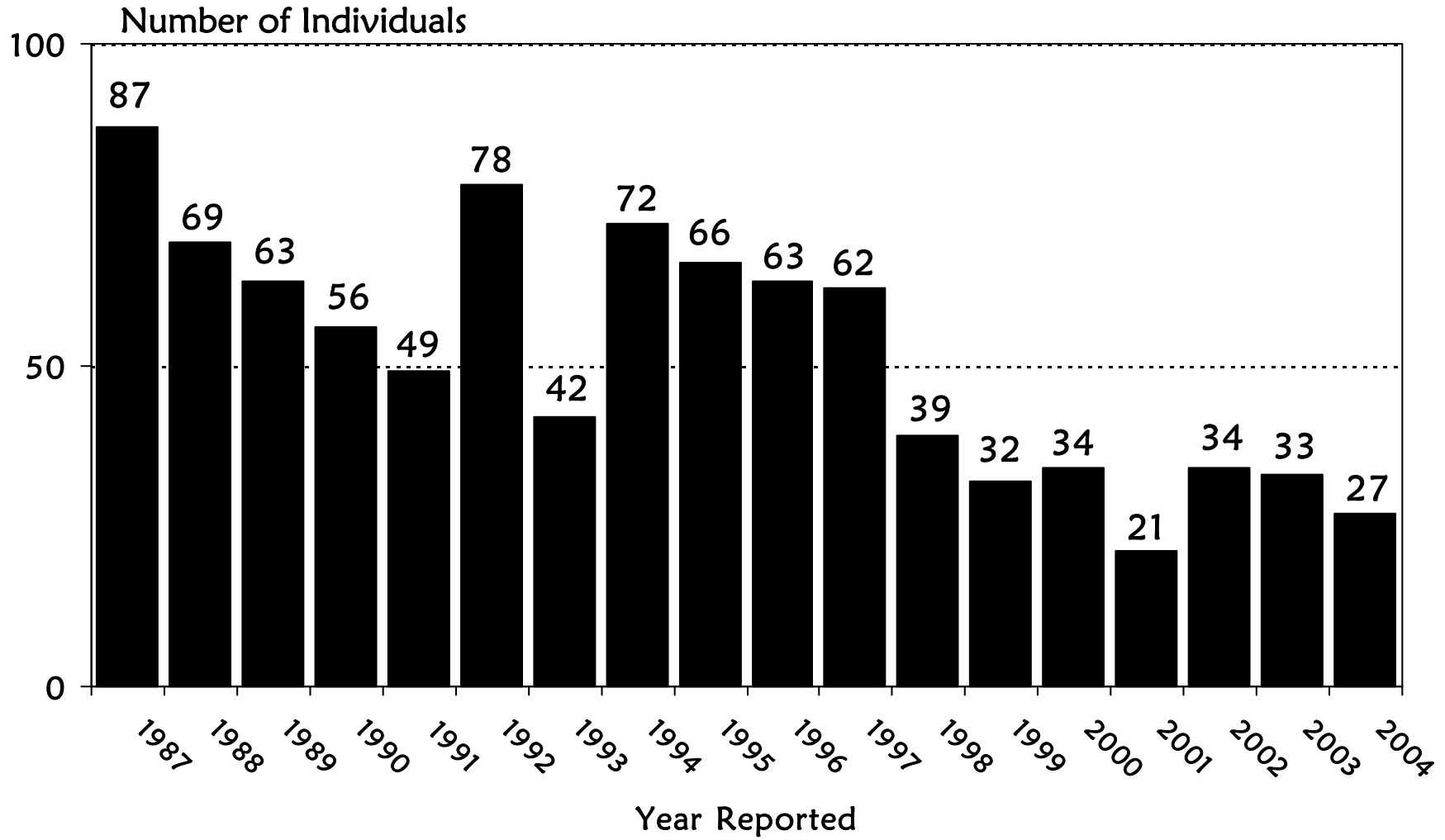
Figure 1. Number of Individuals Confirmed with Silicosis by Year Reported*



*Total number of individuals: 927.

Figure 2. Overlap of Reporting Sources for Individuals Confirmed with Silicosis: 1987-2005*

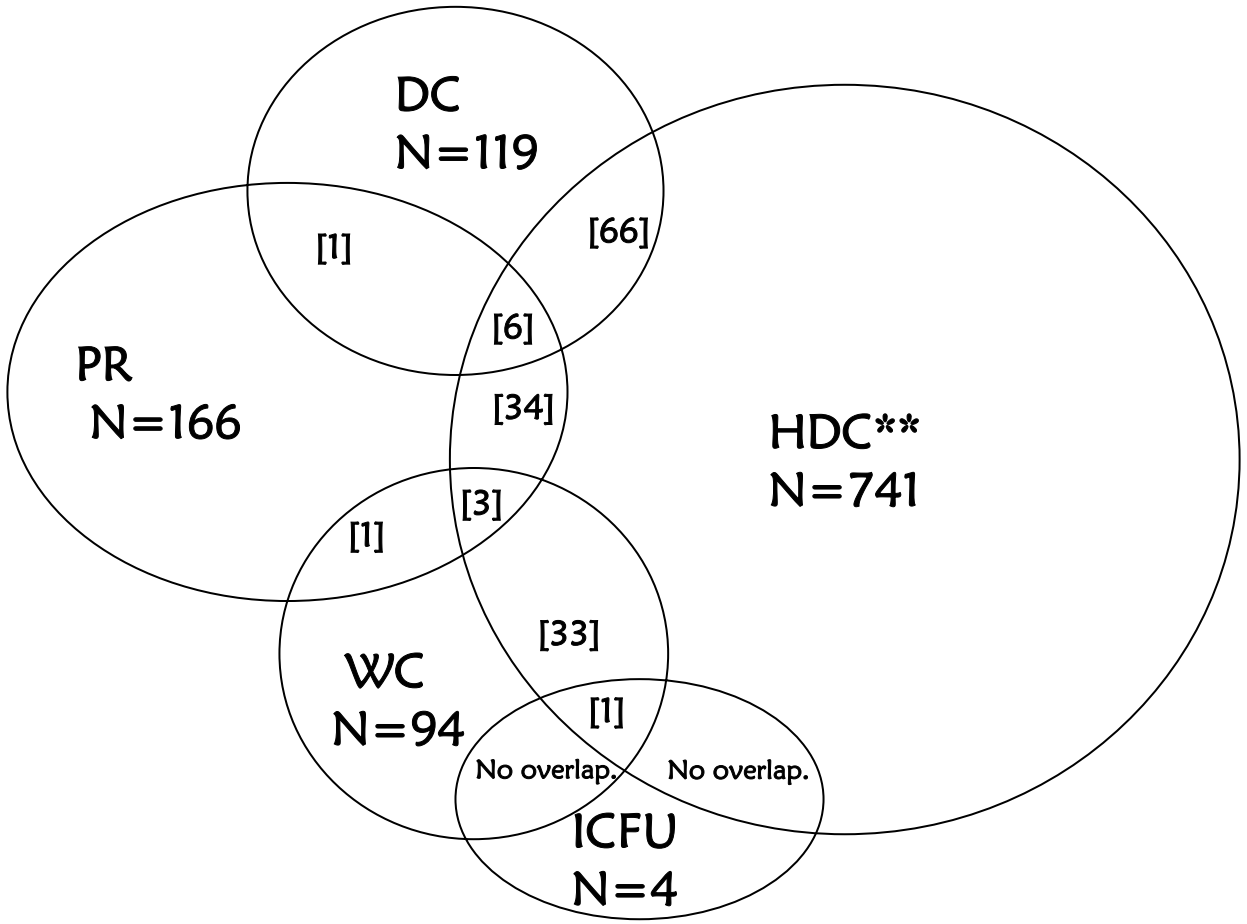
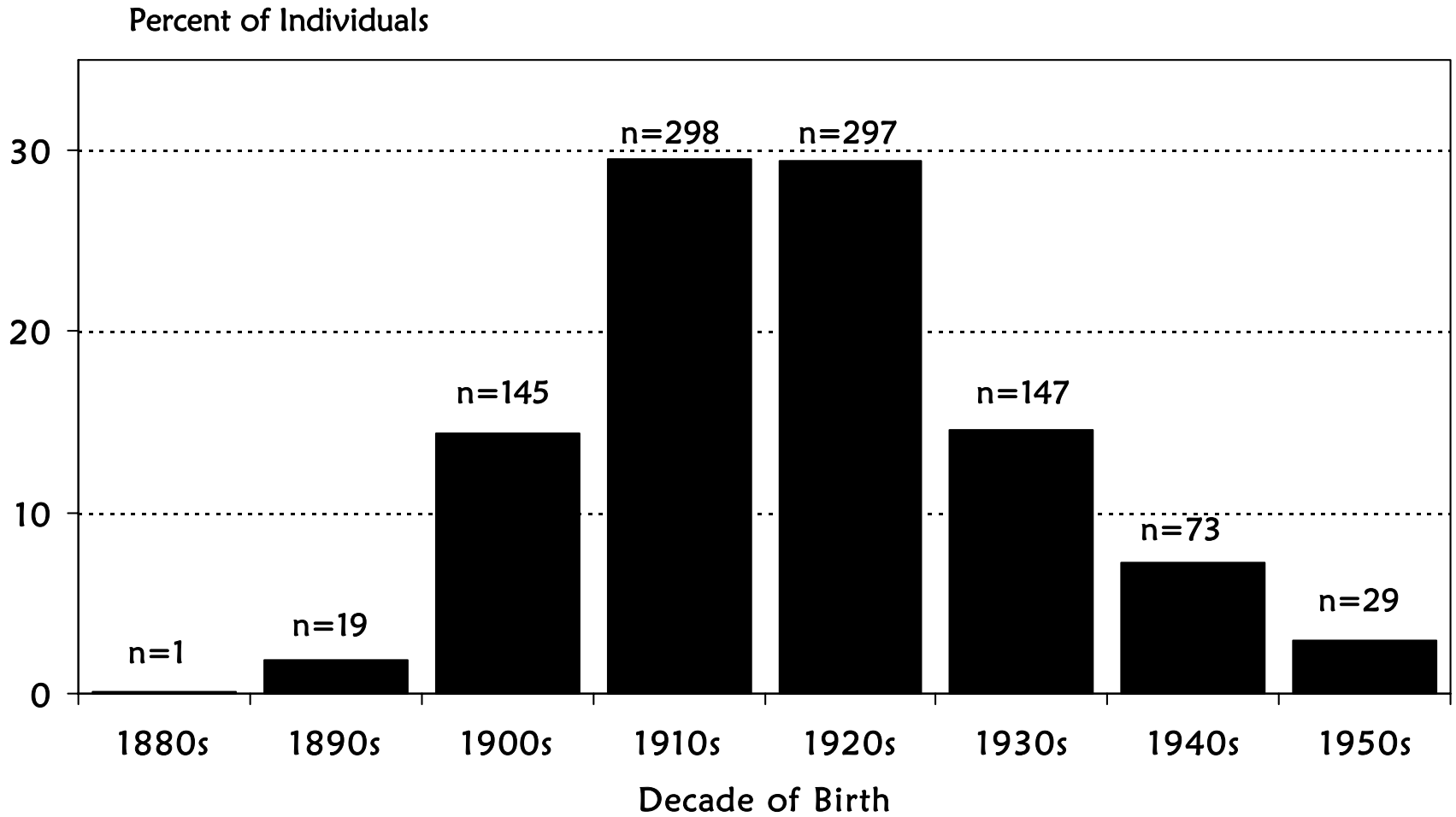


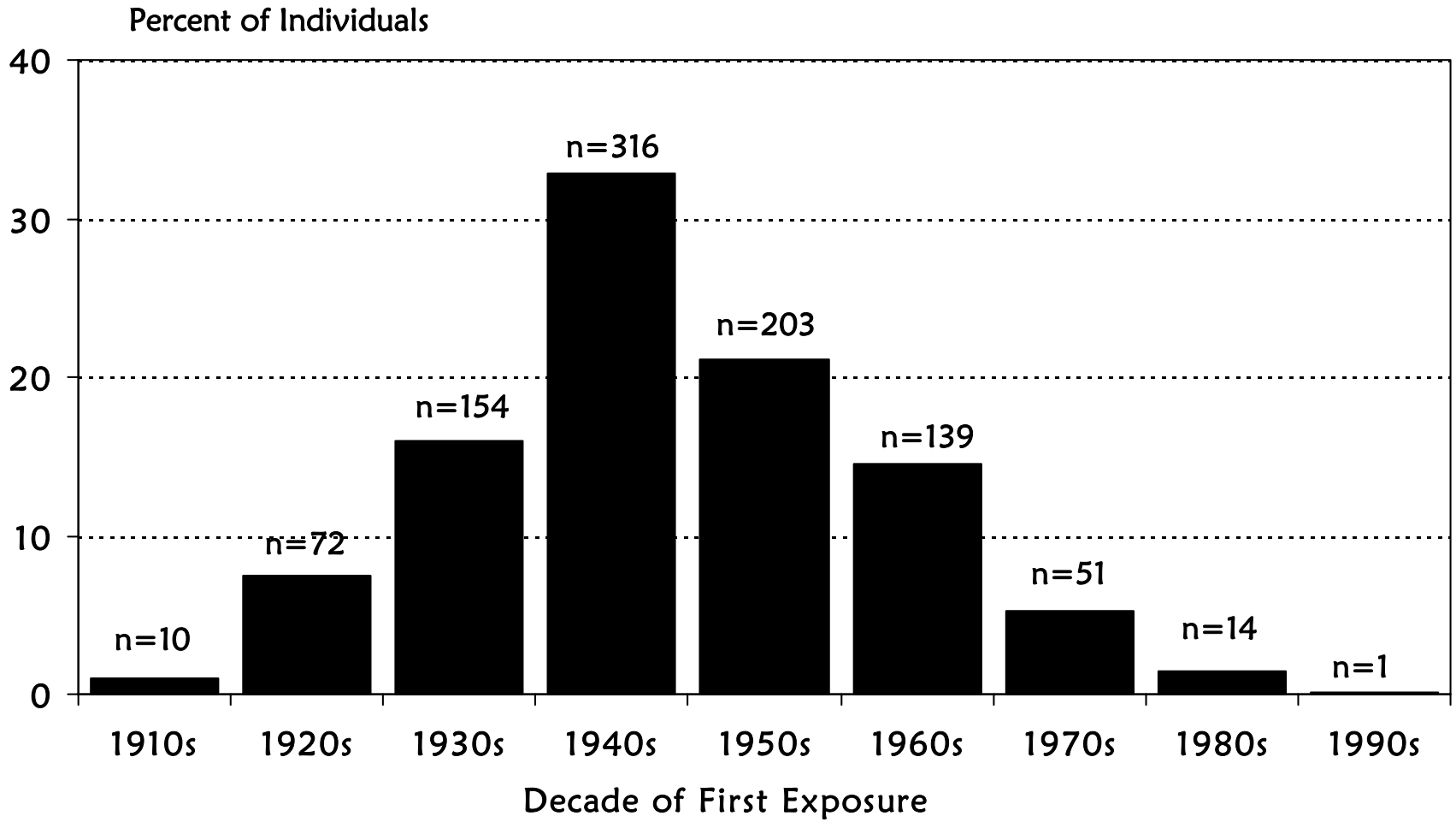
*Diagram represents 946 individuals initially reported from 1987 to 2005.
N's represent the total number for that source.
Numbers in [ ] represent the overlap of reporting sources.
Reporting Source Codes: HDC=Hospital Discharge Data; PR=Physician Referral;
DC=Death Certificate;WC=Workers' Compensation; 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: 1985-2006*



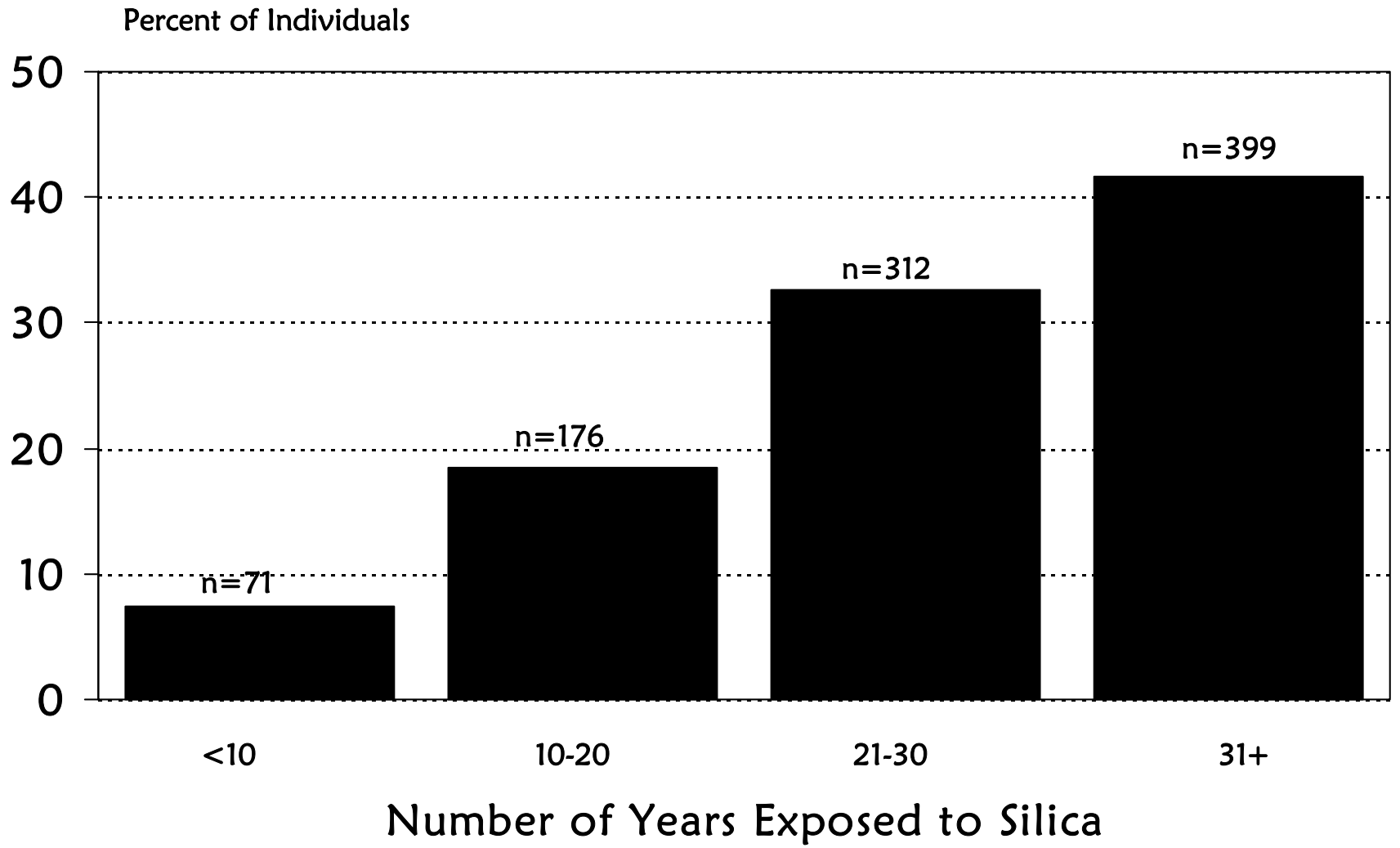
*Total number of individuals: 1,009.

Figure 4. Distribution of Decade When Silica Exposure Began for Individuals Confirmed with Silicosis: 1985-2006*



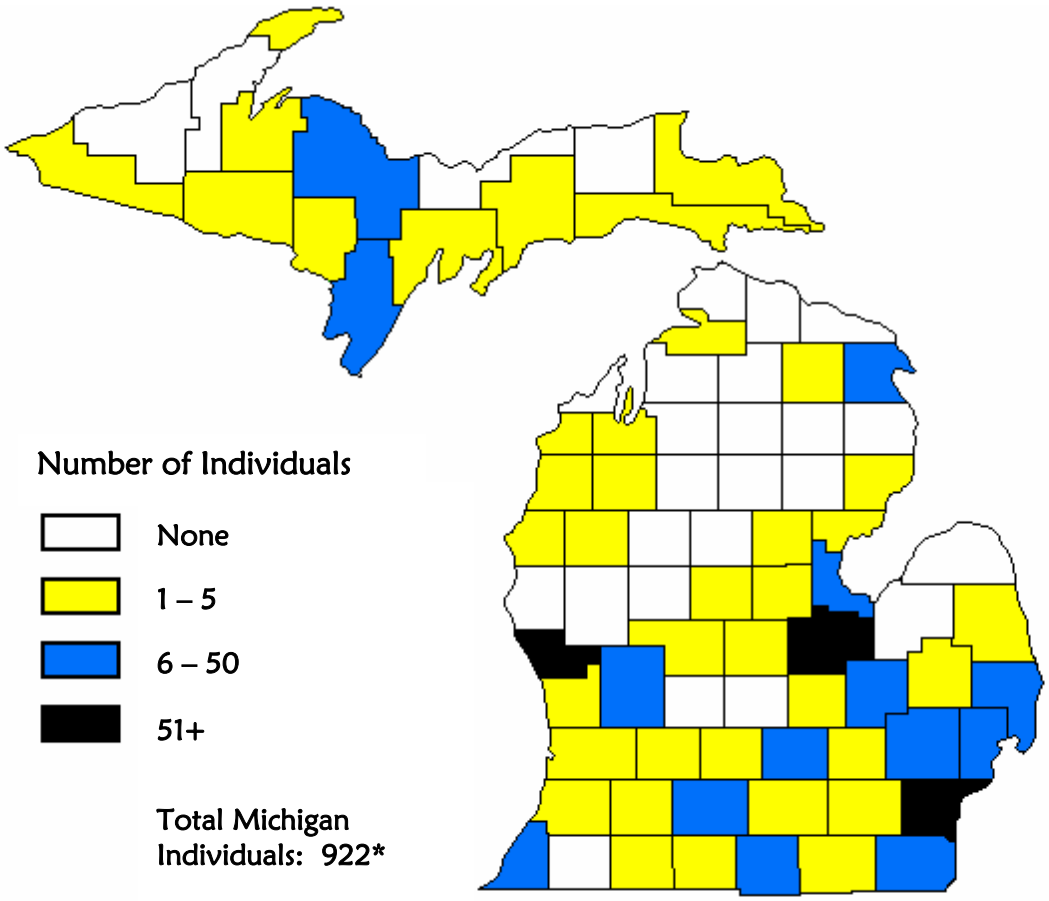
*Total number of individuals: 960. Unknown decade for 49 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Individuals Confirmed with Silicosis: 1985-2006*



*Total number of individuals: 958. Unknown duration for 51 individuals.

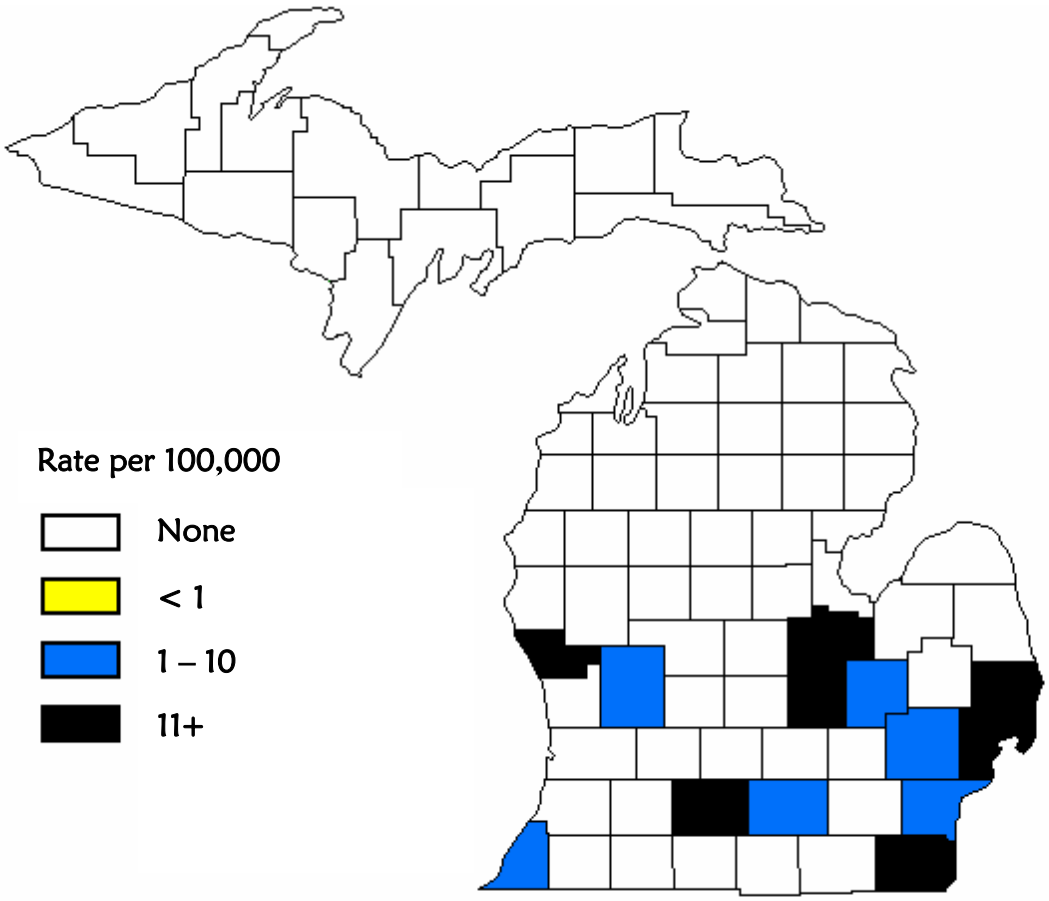
Figure 6. Distribution of Individuals Confirmed with Silicosis by County of Exposure: 1985-2006



Muskegon, Saginaw and Wayne counties had the highest number of individuals with silicosis, with 236, 140 and 265 individuals, respectively.

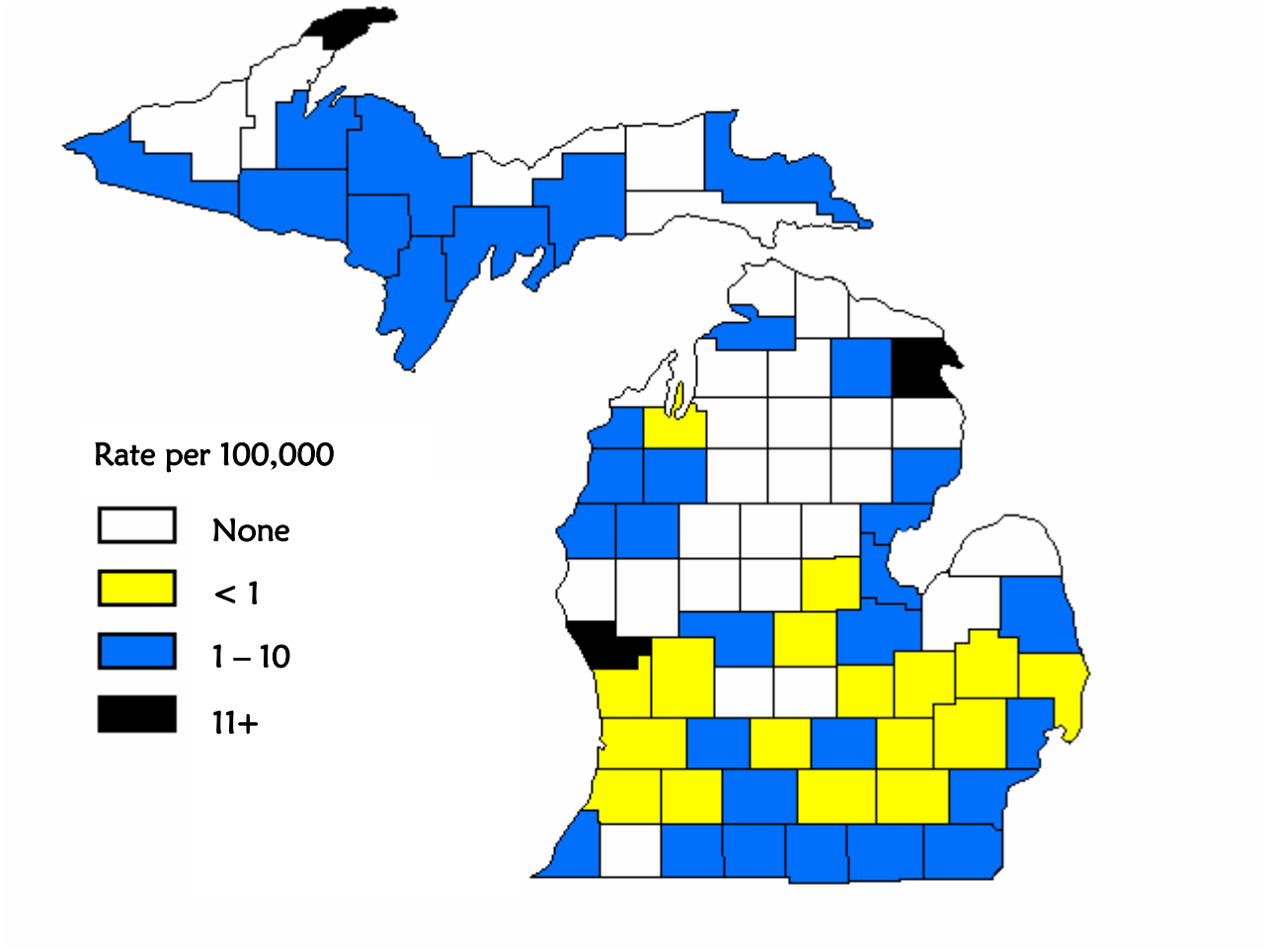
*Sixty-eight individuals were exposed to silica out-of-state, and 19 individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-2004*



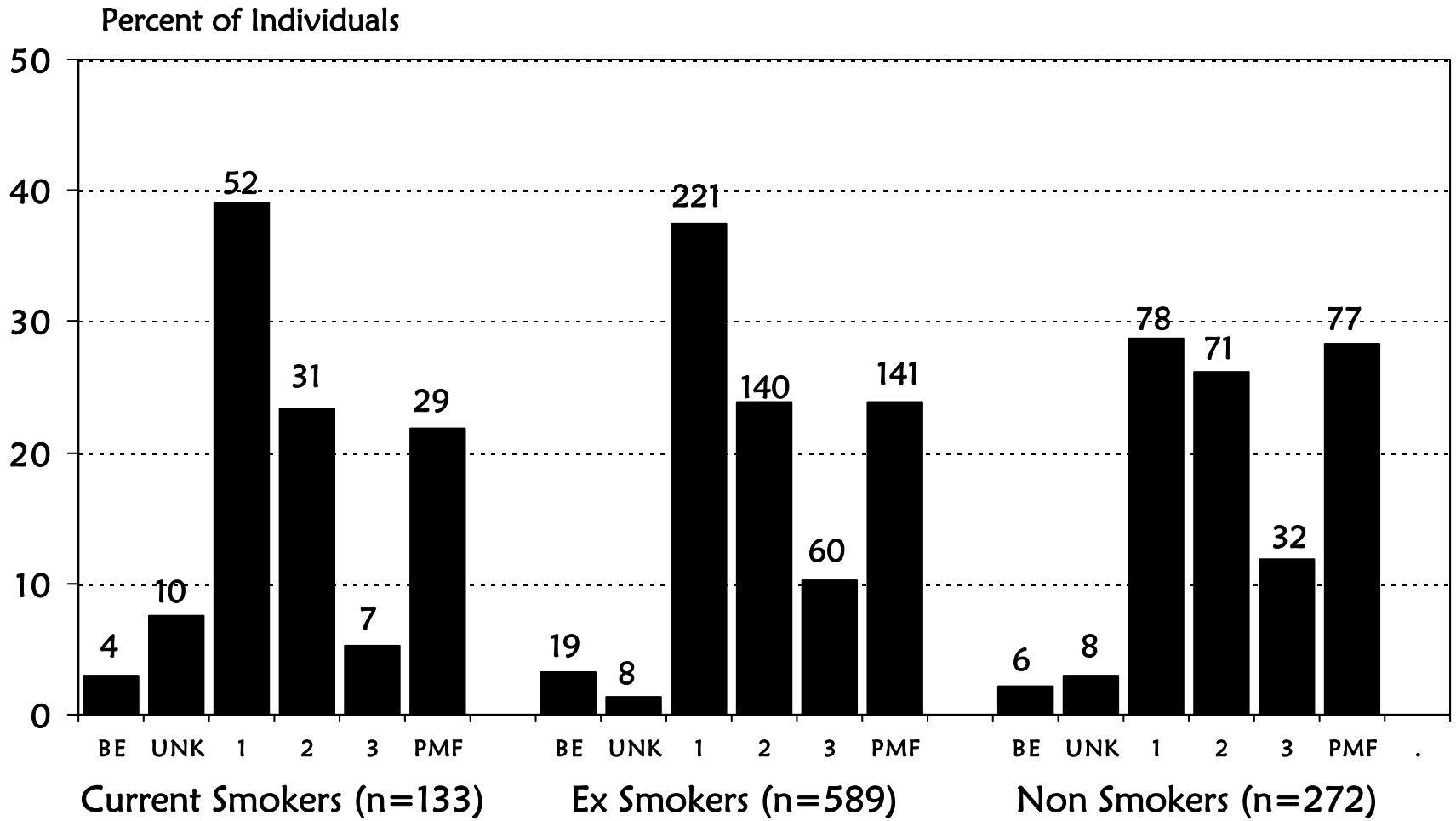
*Rate per 100,000 among African American men age 40+. Numerator is the average number of African American males with silicosis for the years 1987 – 2004; denominator is the 1990 Census population data for African American men age 40 and older, by county. In 1990, there were 174,325 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-2004*



*Rate per 100,000 among white men age 40+. Numerator is the average number of white males with silicosis for the years 1987 – 2004; 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 – 2006**



*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: 994. Unknown smoking status for 15 individuals.

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

	PR	HDC	DC	WC	ICFU	Total
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	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	30	0	0	0	34
2001	8	12	1	0	0	21
2002	1	32	1	0	0	34
2003	7	26	0	0	0	33
2004	2	25	0	0	0	27
2005	2	17	0	0	0	19
2006	2	4	0	0	0	6
All Years	154	682	67	102	4	1,009

*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 1985-2006

Industry (SIC code)*	Number of Individuals**	
Manufacturing		
Primary Metal Industries (33)	749	(74.7)
Includes iron, steel, gray & ductile iron foundries		
Stone, Clay, Glass and Concrete Products (32)	45	(4.5)
Transportation Equipment (37)	39	(3.9)
Includes auto bodies and boat building		
Fabricated Metal Products (34)	14	(1.4)
Industrial Machinery (35)	10	(1.0)
Miscellaneous (25,26,28,30,36,38,39)	21	(2.1)
Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment		
Mining (10-14)	31	(3.1)
Construction (15-17)	67	(6.7)
Transportation, Communication Services (40-49)	8	(0.8)
Trade (50-59)	3	(0.3)
Business and Repair Services (73,75,76)	4	(0.4)
Dental Laboratory (80)	6	(0.6)
Government (92,95,96,97)	4	(0.4)
Farming (01-07)	2	(0.2)
Total	1,003	(100.1)***

*Standard Industrial Classification
**For six 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 1985-2006

Percent Predicted FVC**

X-Ray Results	<60%				60-79%				>=80%			
	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	(21.0)	2	(50.0)
Unknown Severity	3	(25.0)	1	(33.3)	5	(41.7)	1	(33.3)	4	(33.3)	1	(33.3)
Category 1	46	(24.5)	16	(30.8)	65	(34.6)	14	(26.9)	77	(41.0)	22	(42.3)
Category 2	36	(30.5)	19	(38.8)	41	(34.7)	16	(32.7)	41	(34.7)	14	(28.6)
Category 3	11	(27.5)	14	(66.7)	17	(42.5)	3	(14.3)	12	(30.0)	4	(19.0)
PMF	43	(38.1)	19	(37.3)	37	(32.7)	16	(31.4)	33	(29.2)	16	(31.4)
Total	145	(29.6)	69	(38.3)	174	(35.5)	52	(28.9)	171	(34.9)	59	(32.8)

*Total number of individuals: 670. Information was missing for 339 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 (FEV_1) to Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals Confirmed with Silicosis* for the Years 1985-2006

	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	(12.4)	1	(1.9)	37	(19.9)	3	(5.8)	68	(36.6)	17	(32.7)	58	(31.2)	31	(59.6)
Category 2	5	(4.5)	3	(6.4)	23	(20.9)	6	(12.8)	46	(41.8)	14	(29.8)	36	(32.7)	24	(51.1)
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	18	(16.4)	6	(11.8)	36	(32.7)	11	(21.6)	31	(28.2)	16	(31.4)	25	(22.7)	18	(35.3)
Total	49	(10.4)	12	(6.8)	105	(22.2)	20	(11.4)	160	(33.9)	57	(32.4)	158	(33.5)	87	(49.4)

*Total number of individuals: 648. Information was missing for 361 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 1,009 Individuals Confirmed with Silicosis for the Years 1985-2006 were Exposed to Silica

	Number of Individuals Represented	Number of Facilities	Percent of Facilities
Inspections	448	82	(20.7)
Closed	375	134	(33.8)
Out of State	64	60	(15.1)
Scheduled for Inspection	1	3**	(0.8)
No Longer Use Silica	26	24	(6.0)
Unknown	49	49	(12.3)
Building Trade	43	43	(10.8)
Inspected by MSHA*	3	2	(0.5)
Total	1,009	397	(100.0)

*MSHA = Mine Safety and Health Administration.
**Three facilities are related to one silicosis case's work history.

Table 6. Results of Industrial Hygiene Inspections of 82 Facilities Where Individuals Confirmed with Silicosis for the Years 1985-2006 were Exposed to Silica

	Number of Companies	Percent
Air Sampling Performed	59	
Above NIOSH* Recommended Standard for Silica	35	(59.3)
Above MIOSHA** Enforceable Standard for Any Exposure	22	(37.3)
Above MIOSHA Enforceable Standard for Silica	22	(37.3)
Medical Surveillance Evaluated	67	
Periodic Chest X-rays with B Reader	8	(11.9)
Periodic Chest X-rays without a B Reader	3	(4.5)
Pre-employment Testing Only	20	(29.9)
No Medical Surveillance	24	(35.8)
Periodic Pulmonary Function Testing	18	(26.9)

*NIOSH = National Institute for Occupational Safety and Health.
**MIOSHA = Michigan Occupational Safety and Health Administration.