2001

Annual Report on Silicosis in Michigan

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A Joint Report
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Summary:

This is the eleventh annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 1999 and preliminary data for 2000 and 2001. A total of 857 cases of silicosis have been confirmed from 1985 - 2001; 32 of those reports were newly confirmed in 1999. The number of reports in 1998 and 1999 are decreased from approximately 60-70 reports a year in previous years. We will continue to monitor reports in future years to determine if the smaller number of cases in 1998 and 1999 reflect a trend.

Based on capture-recapture analysis we would estimate that although we only received 32 reports of newly diagnosed silicosis cases in 1999 there were another 63-126 individuals diagnosed with silicosis in Michigan in 1999 who were not reported[1] .

We have analyzed the cost-effectiveness of the Michigan silicosis surveillance system and its usefulness to provide national estimates of silicosis[2]. We calculated that it costs the surveillance system $11 to identify each silicosis case who works at a problem work site. That is, a workplace where worker exposures to silica are above permissible limits set by Michigan OSHA. Identification of these problem worksites is the first step in improving working conditions to prevent future cases of silicosis. The relatively low cost to identify these problems generates a favorable return for investment of public health dollars.

Using data from the Michigan silicosis surveillance system and the number of deaths that occur nationally from silicosis collected by the National Center for Health Statistics we estimated that there are approximately 3,600 to 7,300 newly-diagnosed cases of silicosis occurring each year in the United States[1]. This estimate is more reliable than those derived from the existing national system administered by the United States Department of Labor's Bureau of Labor Statistics which in 1999 reported only 2,200 cases for <u>all</u> dust diseases of the lung including diseases such as asbestosis and coal workers' pneumoconiosis in addition to silicosis.

Silicosis continues to occur mainly among men born before 1940 who began working in a Michigan ferrous foundry in the 1930s, 1940s or 1950s who worked in silica for over 25 years. Forty-three percent of the patients are African American. The overall annual average incidence rate of silicosis among African American males (13.5 cases per 100,000) is almost seven times higher than that of white males (2.0 cases per 100,000). The rates within specific counties ranged between 2.0 to 25.3 times higher for African American males than the rates for white males. Exposure to silica occurred mainly in companies in the counties of Muskegon, Saginaw and Wayne.

The mortality rate for silicosis in the Muskegon area is one of the highest in the country. A recent NIOSH report estimated that the overall age-adjusted silicosis death rate of United States residents age 15 years and older was 1.6 deaths per million individuals[3]. In comparison, this report showed that the death rate in the Muskegon area was in the highest of the ranges mapped out for the entire nation: >8.0 to 62.5 deaths per million individuals.

The patients identified with silicosis generally have severe disease. Twenty-five percent have progressive massive fibrosis (PMF) and another 34.0% have advanced simple silicosis. Only

about a third of all patients have normal breathing tests. Nineteen percent had been told they had tuberculosis (includes both clinical disease or a positive skin test). Individuals with silicosis in Michigan have an increase of over 300% in the likelihood of dying from non-malignant respiratory disease, both restrictive and obstructive, and an 80% increase in the likelihood of dying from lung cancer [4].

Despite the severity of disease, 57% of the patients with known filing status had not applied for workers' compensation. The percentage of patients applying has decreased in recent years.

Although silicosis typically occurs after a long duration of exposure to silica, there continue to be patients who develop silicosis after a relatively short period of exposure because of the severity of that exposure. One individual developed silicosis who began working with silica in the 1990s, seven in the 1980's, 38 in the 1970s and 110 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. Further effort is needed to improve the work practices at companies that do abrasive blasting with silica and to encourage them to switch to a non-silica abrasive.

A non-silica abrasive is often a more effective abrasive than silica sand, and can provide excellent profile results, if the proper non-silica media is selected for the application. Another benefit of non-silica abrasives is their ability to be recycled and reused several times. Some examples of non-silica abrasives are coal slag, steel grit and shot, plastic beads, dry ice or baking soda. The cost per ton of non-silica abrasives can be misleading when compared to the cost per ton of silica sand. Because many substitute materials can be recycled and reused, a more useful index of actual cost is price per square foot, which can vary depending on the particular application and factors associated with each job. As with any substitute material, it is important to evaluate the potential of the substitute material for new or different health hazards.

Improving work practices can also significantly affect an individual's exposure to airborne respirable silica. Work practices, such as correctly wearing, maintaining and using a Type CE abrasive blasting respirator, separate change and eating areas, changing into disposable or washable work clothes at the worksite, good personal hygiene and housekeeping procedures can reduce an individual's exposure to silica. An effective engineering control is to construct an abrasive blasting enclosure with sufficient and effective ventilation, adequate lighting, and proper placarding.

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. 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 Michigan Department of Consumer and Industry Services (formerly the Michigan Department of Public Health) 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. The information on each patient is reviewed by a physician who is board-certified in both internal and occupational medicine. 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 Act (MIOSHA) enforcement inspection may be conducted to determine current exposures and conditions.

Michigan uses numerous 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 data bases, the most complete data available are for 1987 - 1999. 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, 2000 and 2001 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 - 1999 undercounts the true number of persons with silicosis.

Figure 1 shows 777 patients identified and confirmed with silicosis through the surveillance system by year for 1987 through 1999. To date, an additional 15 persons with silicosis in 2000, and 8 in 2001 have been confirmed with silicosis. Table 1 shows the primary reporting source of the 857 persons confirmed with silicosis for the years 1985 - 2001. 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 2000.

A study in New Jersey of a similar type of surveillance system estimated that the system received reports on only one-third of individuals diagnosed with silicosis[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 23% of the estimated total number of individuals developing the disease during these 9 years.

The following statistics are based on the 857 cases of silicosis confirmed from 1985 - 2001.

Gender

Eight hundred thirty-seven (97.7%) of the persons with silicosis are men; the other 20 (2.3%) are women.

Race

Three hundred seventy (43.3%) of the persons with silicosis are African American, 458 (53.6%) are white, two (0.2%) are of Asian ancestry, one (0.1%) was of American Indian ancestry, and 23 (2.7%) were listed as "other ancestry". The race on three individuals was unknown.

Age

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1920, 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 1947, ranging from 1910 to 1996.

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 3 counties: Muskegon, Saginaw and Wayne. The overall average annual incidence rate for silicosis among African American men is 13.5 cases per 100,000, and for white men is 2.0 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 733/100,000, in Muskegon it was 268/100,000, in Saginaw it was 100/100,000, in Monroe it was 43/100,000, in Calhoun it was 39/100,000, in Macomb it was 33/100,000, and

in St. Clair it was 19/100,000. Figure 8 shows the annual average incidence rate of silicosis among white men age 40 or greater in each county. The rate in Muskegon was 23/100,000, in Alpena it was 17/100,000, in Keewanaw it was 16/100,000, in Menominee it was 12/100,000, and in Saginaw it was 12/100,000.

Type of Industry

Table 2 shows the primary type of industry where the silica exposure occurred. The predominant industry where individuals developed silicosis is iron foundries (77.3%). Two hundred twenty of the 645 individuals for whom sandblasting history is known (34.1%) stated they had done sandblasting as part of their work.

Medical Results

Overall 591 (69.0%) of the people with silicosis had simple silicosis and 217 (25.3%) had progressive massive fibrosis. Twenty-five (2.9%) silicotics had normal x-rays with lung biopsy evidence. Twenty-four (2.8%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred thirty-three (27.6%) of the people with silicosis never smoked cigarettes, 492 (58.3%) had quit, 119 (14.1%) were still smoking and no information was available on 13 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 (29.2% non smokers vs. 21.0% current smokers vs. 24.6% ex smokers) ($X^2 = 26.887$, $p = .008$). 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 less likely to be 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 were found in two thirds of the individuals who had ever smoked cigarettes and 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 a number of other diseases:

- <u>Non-Malignant</u>
- Tuberculosis
- Scleroderma
- Rheumatoid Arthritis
- Chronic Renal Failure
- Emphysema

- <u>Malignant</u>
- Lung Cancer

We have previously reported an increase in rheumatoid arthritis, systemic lupus erythematosis and scleroderma among individuals reported to the Michigan silicosis registry [6]. 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 serum creatinines greater than 1.5mg/dl. Individuals with silicosis were more likely to have a serum creatinine >1.5 mg/dl than age and race matched controls[7]. As with the connective tissue disease cases, no association was found between duration of exposure 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[8].

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 provide workers' compensation. The funds from this special assessment are used to limit the liability of silica using industries.

Only 309 (43.0%) of the 719 individuals with silicosis or their next of kin for whom filing status was known had applied for workers' compensation. Four hundred ten (57.0%) had not applied. It was unknown whether the remaining 138 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, 246 (79.6%) received compensation, 23 (7.4%) had been denied, and 40 (12.9%) were pending.

Industrial Hygiene Results

The 857 individuals with silicosis were exposed to silica in 322 facilities (Table 5). Inspections were performed at 76 (23.6%) of these facilities. Currently four (1.2%) facilities are scheduled for an inspection. One hundred nine (33.9%) facilities were no longer in operation, 49 (15.2%) were located out of state, 21 (6.5%) facilities no longer used silica, 32 (9.9%) had worked at multiple construction sites as building trade workers, 1 (0.3%) was referred to and inspected by the Mine Safety and Health Administration since the company was out of MIOSHA jurisdiction, and 30 (9.3%) were unknown.

Air sampling was conducted in 54 of the 76 facilities inspected (Table 6). Thirty-three of 54 (61.1%) facilities were above the National Institute for Occupational Safety and Health (NIOSH) recommended exposure level for silica. Twenty-one of the 54 (38.9%) were above the enforceable Michigan Occupational Safety and Health Act (MIOSHA) standard for silica. Another one (1.9%) company was above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only 6 of the 64 (9.4%) facilities where the medical surveillance program was evaluated provided medical screening for silicosis for its workers which included a periodic chest x-ray interpreted by a "B" certified reader, while three companies provided periodic chest x-rays that

were not interpreted by a "B" certified reader. Nineteen (29.7%) only performed pre-employment testing, 24 (37.5%) provided no medical surveillance, and 16 (25.0%) performed annual or biannual pulmonary function testing without chest x-rays.

National Estimates of Silicosis

The only national statistic on silicosis is the count of the number of individuals who die each year from silicosis. We have used United States national mortality data for silicosis, data from the Michigan state-based surveillance system for silicosis and capture-recapture analysis to calculate national estimates of silicosis[1].

From 1987 to 1996, 2787 deaths occurred in the United States where silicosis was mentioned on the death certificate. During the same period in Michigan, 77% of death certificates with a mention of silicosis were confirmed as silicosis-related deaths. The ratio of the total number of confirmed silicosis cases in Michigan from 1987 - 1996 to the number of confirmed deceased silicosis cases was 6.44. Using the proportion of confirmed deaths and the ratio of the total number of confirmed Michigan cases to confirmed deceased cases, we estimated there would have been 1,387 confirmed cases of silicosis identified per year in the United States if there had been a national surveillance system. Table 7 summarizes the calculations. Using capture-recapture analysis which estimated that the Michigan surveillance system missed 59-80% of newly diagnosed cases of silicosis, we estimated there are 3,600 to 7,300 newly diagnosed cases of silicosis per year in the United States.

Cost-Effectiveness Analysis

We conducted an analysis to determine the most cost-effective way to identify problem silica-using worksites[2]. Using the Michigan silicosis surveillance data from 1989-1995, we identified the costs associated with the collection of data that led to the identification of companies with silica-related violations of the Michigan OSHA standard. Costs were determined for both internal state agency costs (i.e. MIOSHA and Michigan State University) and costs to the entities reporting the cases of silicosis to the state (i.e. physicians, clinics, employers). We then analyzed the costs associated with the identification of silicosis cases by the different sources (hospitals, physicians, workers' compensation and death certificates) to determine the relative effectiveness of each of the sources to lead to the identification of Michigan companies with over exposures to silica, that is, problem worksites.

A problem worksite was defined as a workplace where silica exposures were above the MIOSHA permissible limit. The initial reporting source of all 470 confirmed cases of silicosis reported to the Michigan surveillance system from 1989 to 1995 was identified. The cost of identifying confirmed silicosis cases, silica-using worksites, problem worksites (i.e. worksites in violation of a MIOSHA standard other than for silica over-exposures), silica over-exposure problem worksites, and the number of current silica-exposed workers was determined for the four reporting sources: hospitals; physicians; workers' compensation; and death certificates. Hospital reports were the first reporting source to identify 67% of the confirmed cases, 74% of the silica-using worksites, and 58% of the problem worksites. Physician reports initially identified 17% of confirmed cases, 15% of silica-using worksites, and 26% of problem worksites. Workers' compensation records initially identified 11% of confirmed cases, 4% of silica-using worksites, and 8% of problem worksites (Table 8). Hospital reports were the most cost-effective way to identify silicosis cases (US$ 143), silica-using worksites (US$ 313),

problem worksites (US$454) and yielded the lowest cost to identify a case per exposed worker (US$ 6) (Table 9).

Discussion:

The predominant characteristics of the individuals reported during Michigan's thirteen 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 and does not indicate the disease is disappearing[9]. However, the number of reports in 1998 and 1999, the last two years of complete data, do show a decrease in reports from previous years. The older age of the patient (average year of birth, 1920) is secondary to the chronic nature of the disease and the typical long exposure to silica which is required to develop the disease (average 28 years of exposure to silica). However, we continue to receive reports of individuals with short-term exposure and onset of work in the 1970s, 1980s and one in the 1990's. Fifty-eight or 7.0% worked for less than 10 years. Forty-six (5.5%) began work in the 1970s, 1980s or 1990's; fourteen of these individuals had worked for less than 10 years. The people with silicosis who began work in the 1970s or 1980s were more likely to have done sandblasting than those who began work with silica before 1970 (46% vs. 33%). Of the eight people who first were exposed to silica in the 1980's or 1990's; two worked in foundries, two were buffing and polishing metal, one worked in minerals processing, one worked in a dental laboratory, one was a heavy equipment operator who did excavating and one did cement work.

African American men are over represented (43.3%). This reflects previous hiring practices in foundries[10]. In fact, among the counties where rates were compared between African American and white workers (see Figures 7 and 8), African American workers consistently had higher incidence rates of silicosis than their white counterparts. Overall for the state, the incidence rate of silicosis among African American workers was 13.5 per 100,000 versus 2.0 per 100,000 for white workers (a 6.8 fold greater incidence).

The individuals reported generally have advanced disease: 217 (25.3%) have progressive massive fibrosis; another 291 (34.0%) have advanced simple silicosis (category 2 or 3). Over 60% of the reported patients have reduced breathing tests. These include both restrictive and obstructive changes. Obstructive changes although more prevalent among individuals who had smoked cigarettes, were found in half of the individuals who had never smoked cigarettes (Table 4). Individuals with silicosis are developing pulmonary hypertension, clinically significant bronchitis and chronic obstructive pulmonary disease[11]. Nineteen percent have had either tuberculosis or have had a positive skin test indicating infection with the mycobacteria that causes tuberculosis. Despite the severity of their disease, 57% had not applied for workers' compensation.

Hospitals are the primary reporting source of the patients identified through this 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[2]. 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[2].

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease[4,11]. 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] as well as an increased risk of developing chronic renal disease, especially ANCA positive disease[7, 8].

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.

Abrasive blasting companies in Michigan continue to use silica abrasives. A survey of a sample of companies using silica found that most of them are putting their employees at risk of developing silicosis because they are not following recommended and required work practices. European countries banned the use of silica for sandblasting 50 years ago[12]. Further initiatives to encourage the use of silica substitutes are needed.

Industrial hygiene inspections reveal violations of the exposure standard for silica in 38.9% 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 90.6% of the facilities, there is no way to monitor the adequacy of the controls in terms of health outcomes.

The United States relies on an employer-based surveillance system for counting occupational injuries and illnesses, which is administered by the United States Department of Labor's Bureau of Labor Statistics (BLS). This system is known to markedly undercount chronic diseases[13]. An example that highlights the problem was shown for the pneumoconioses, where four states (California, New Jersey, New York and Wisconsin) identified 2,910 individuals with pneumoconioses in 1985 while only 1,700 individuals were officially reported for the entire country in the same year in the official BLS statistics[14].

We estimated there are 76-159 and 3,600 - 7,300 newly diagnosed cases of silicosis each year in Michigan and the United States, respectively[1]. This number is significantly larger than the estimates from the employer based reporting system currently used for counting occupational disease in the United States. The approach used in our analysis which combined a readily available and relatively inexpensive national administrative data base (death certificates) with the more costly Michigan-based active surveillance system is a cost-effective model that could be used to provide better estimates of a number of different occupational diseases. Accurate estimates of occupational illnesses are essential to both direct and evaluate intervention efforts to prevent the occurrence of disease.

Silicosis remains an ongoing problem in Michigan with former foundry workers continuing to develop severe disease. Further, some Michigan workers will continue to be at risk of developing silicosis because of inadequate controls at foundries currently in operation. The Federal Occupational Safety and Health Administration is in the process of proposing a new silica standard. In addition, sandblasting continues to be a high risk operation[15]. Given the ready availability of non-silica abrasives, further educational and regulatory efforts are needed to encourage the replacement of silica in blasting operations or at the minimum ensure that silica is used properly.

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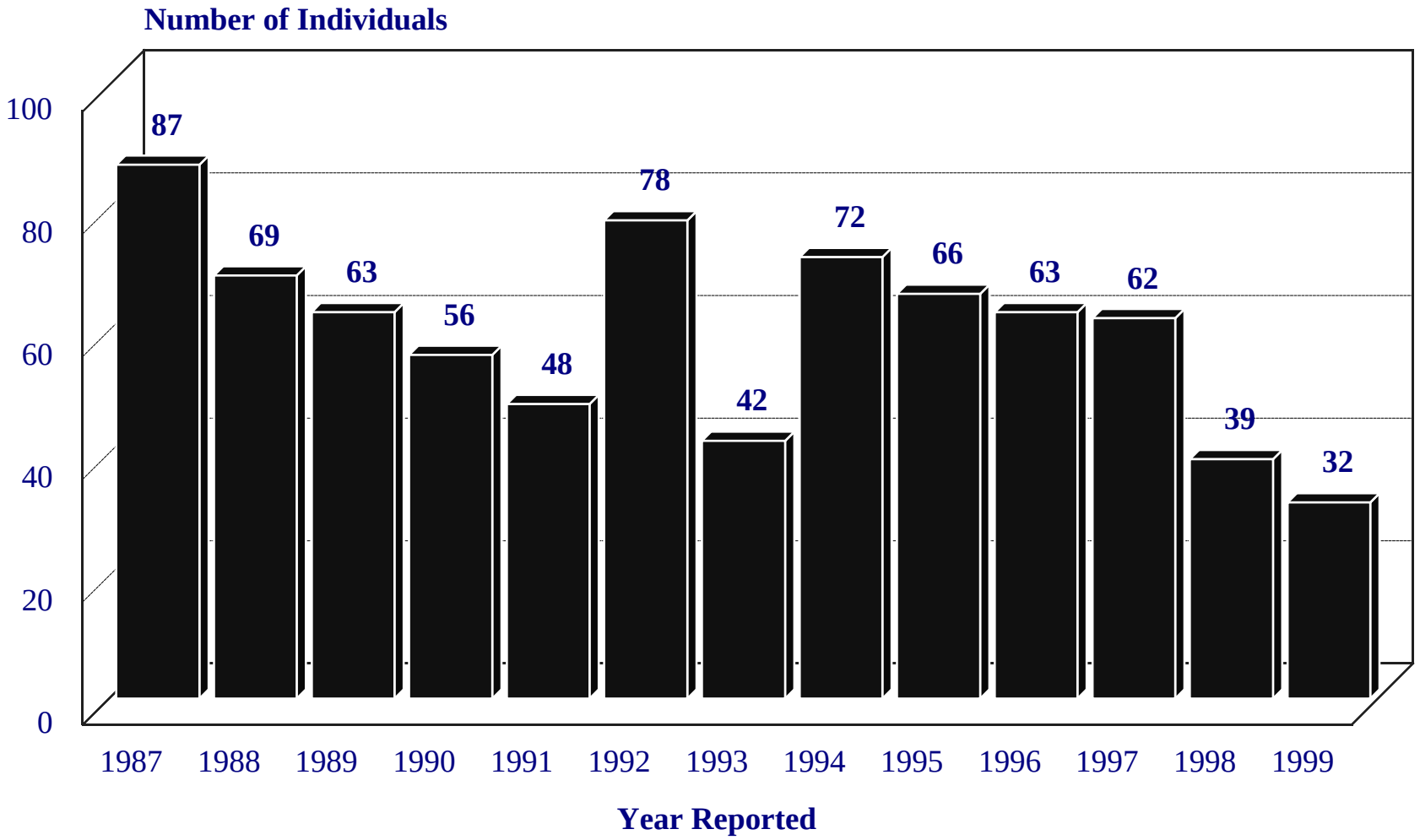
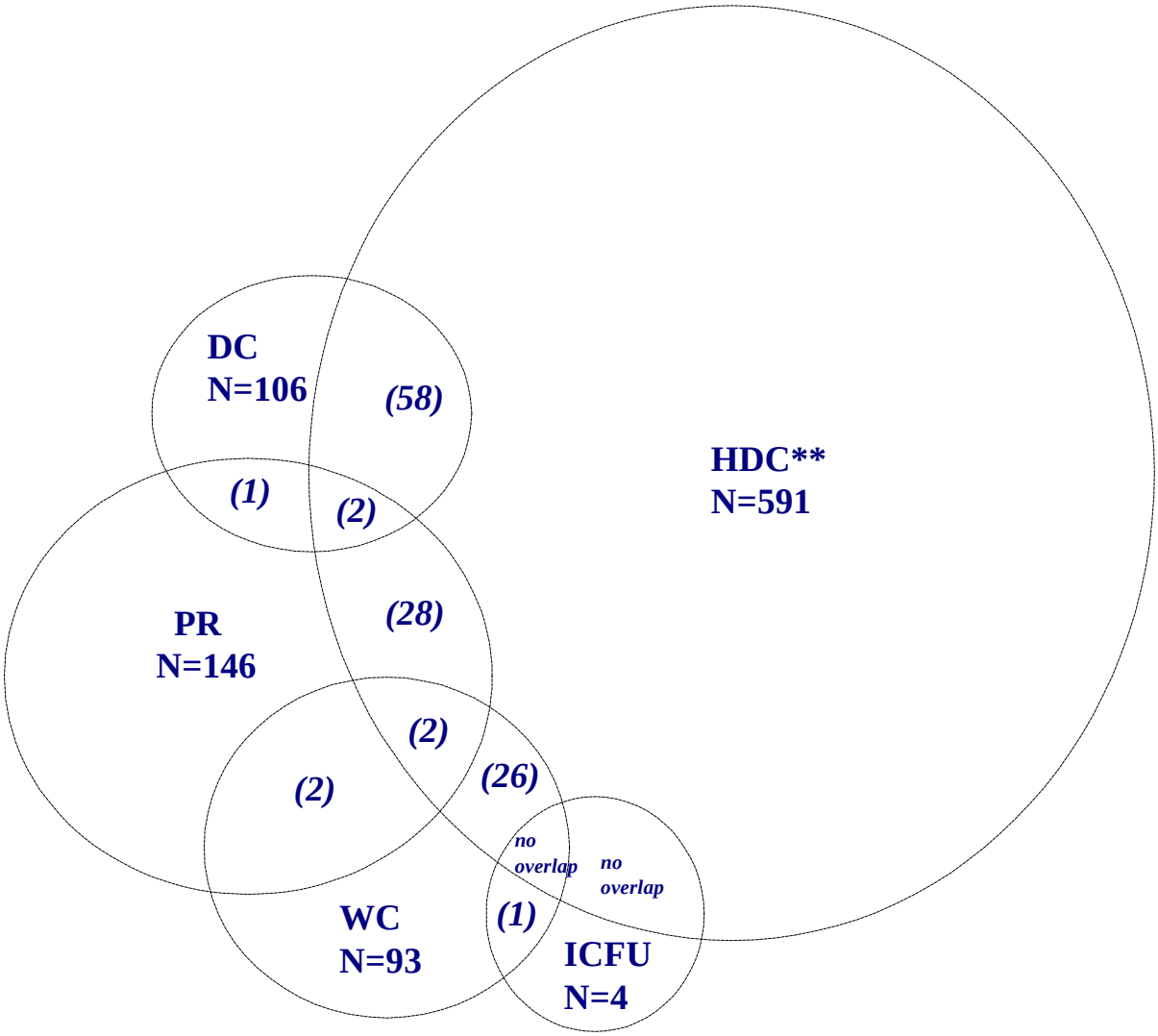
Figure 1. Number of Individuals Confirmed with Silicosis by Year Reported*



*** Total number of individuals: 777.**

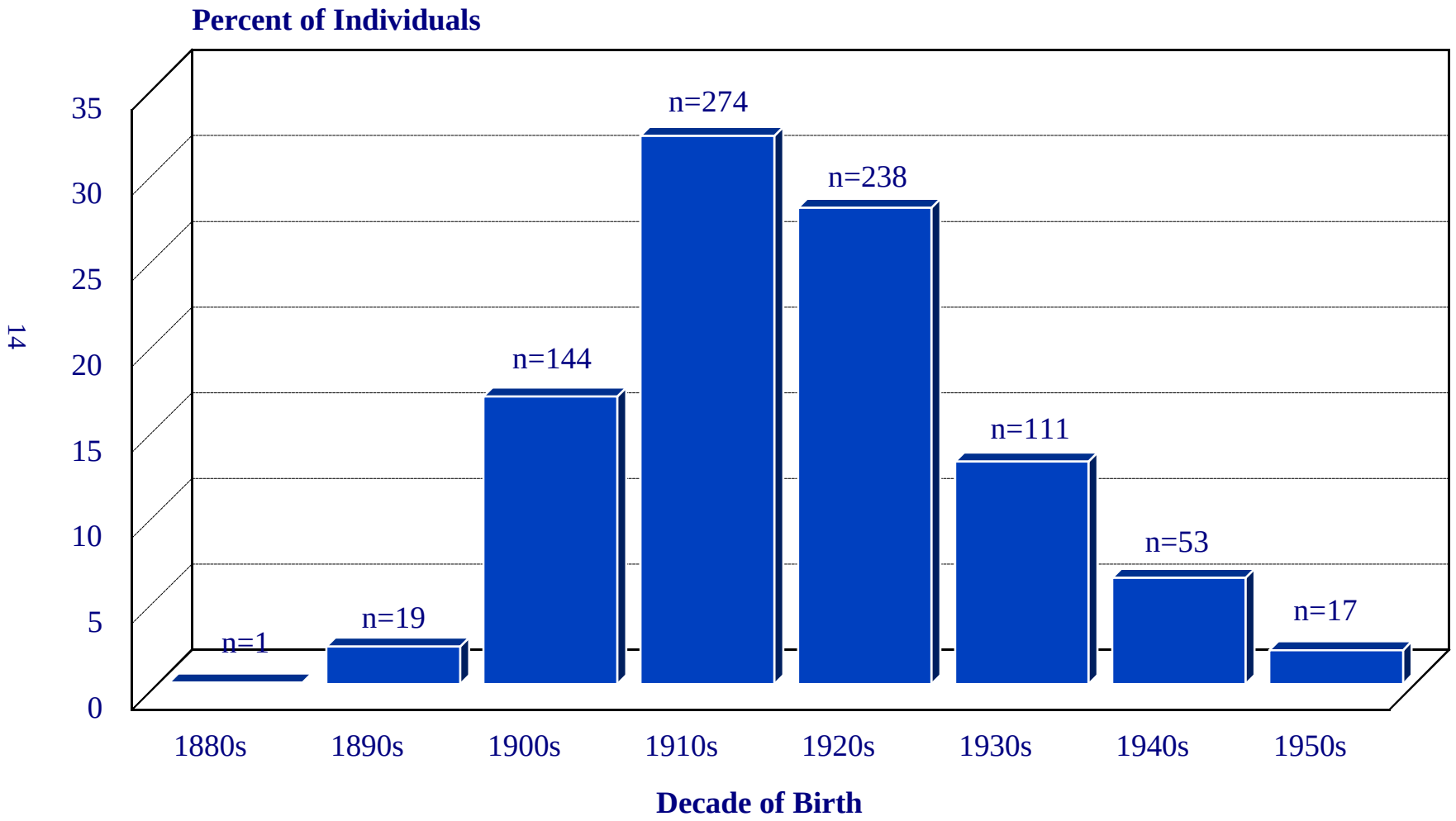
Figure 2. Overlap of Reporting Sources for Confirmed Individuals with Silicosis: 1987-2000*



* Diagram represents 792 individuals initially reported from 1987-2000.
Numbers in parentheses represent the overlap of reporting sources.
HDC=Hospital Discharge Data; DC=Death Certificate; PR=Physician Referral;
WC=Workers' Compensation; ICFU=Index Case Follow-Up.
N's represent the total number for that source.

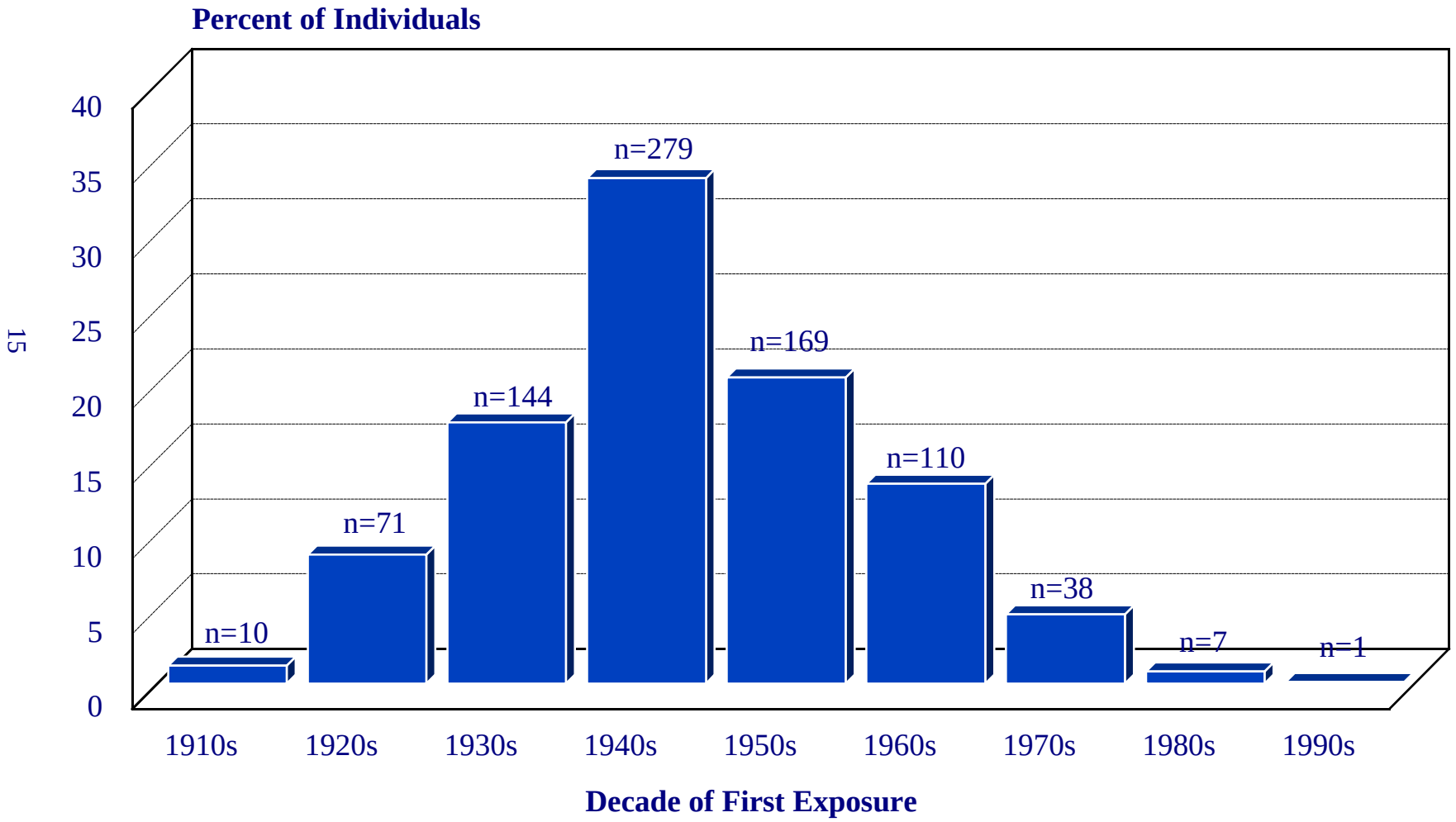
**There was also an overlap of HDC-DC-WC for nine individuals, an overlap of HDC-PR-WC-DC for one individual, and an overlap of HDC-DC-ICFU for one individual.

Figure 3. Distribution of Decade of Birth for Individuals Confirmed with Silicosis: 1985-2001*



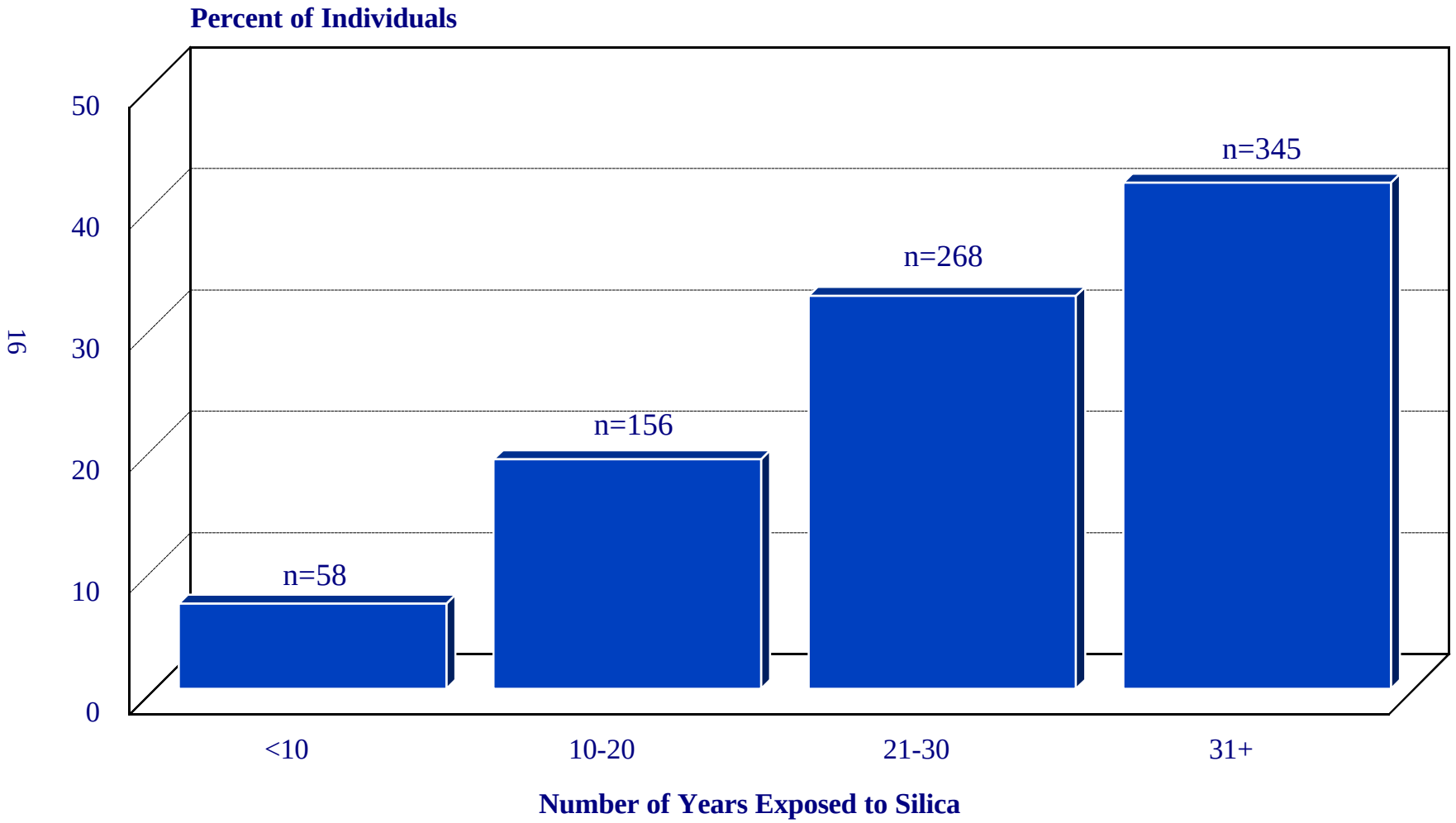
* Total number of individuals: 857.

Figure 4. Distribution of Decade When Silica Exposure Began for Individuals Confirmed with Silicosis: 1985-2001*



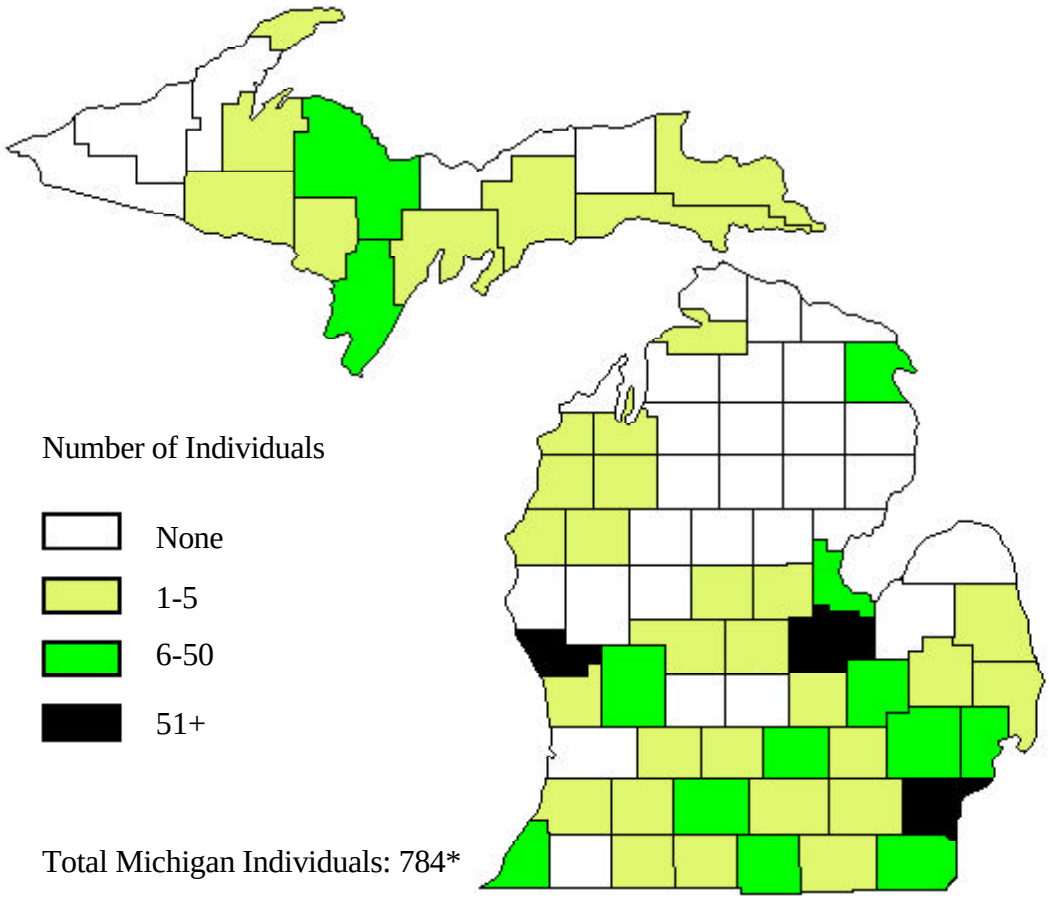
* Total number of individuals: 829. Unknown decade for 28 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Individuals Confirmed with Silicosis: 1985-2001*



* Total number of individuals: 827. Unknown decade for 30 individuals.

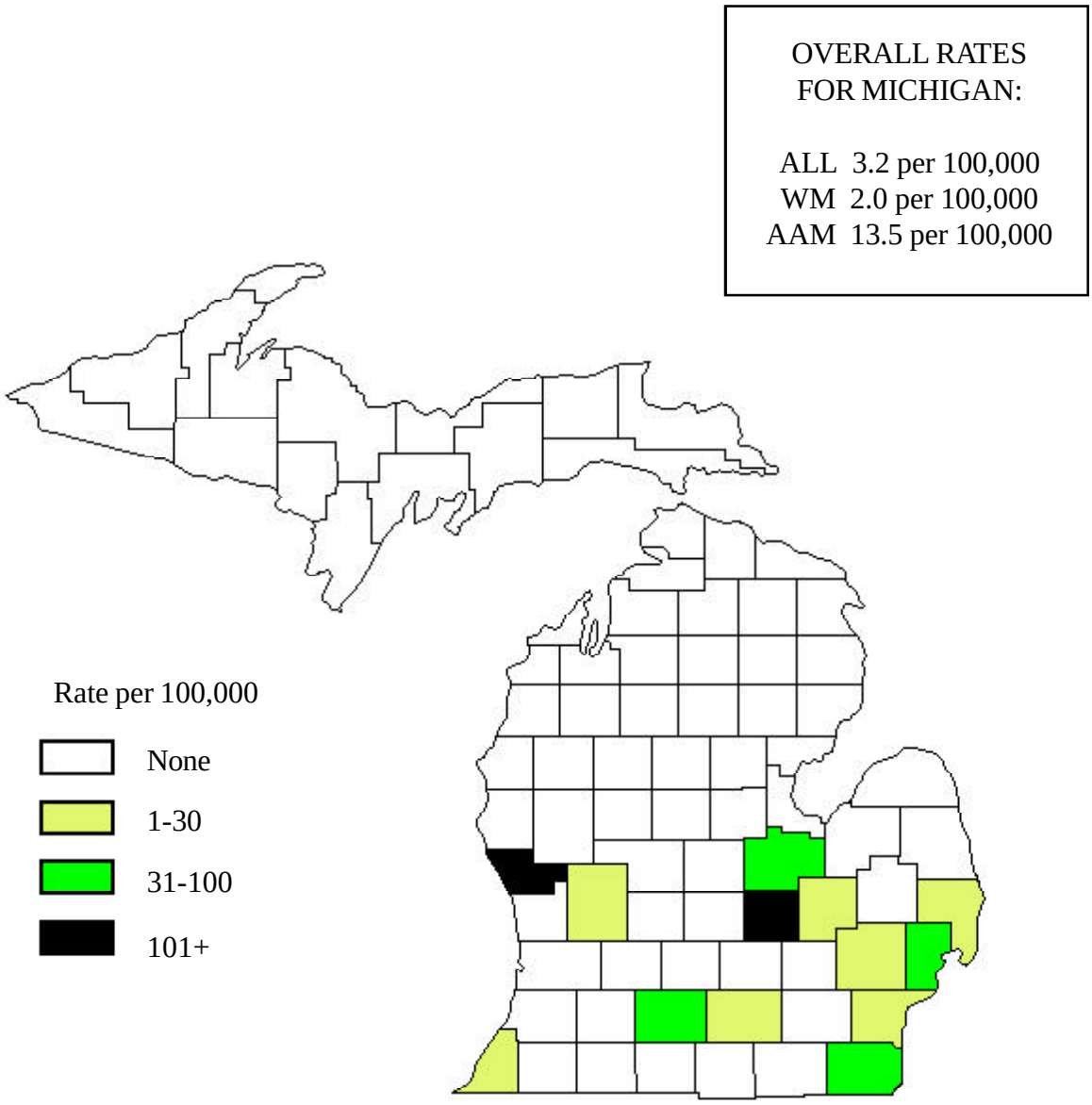
Figure 6. Distribution of Individuals Confirmed with Silicosis by County of Exposure: 1985-2001



Muskegon, Saginaw and **Wayne** counties had the highest number of individuals with silicosis, with 205, 132 and 211 individuals, respectively.

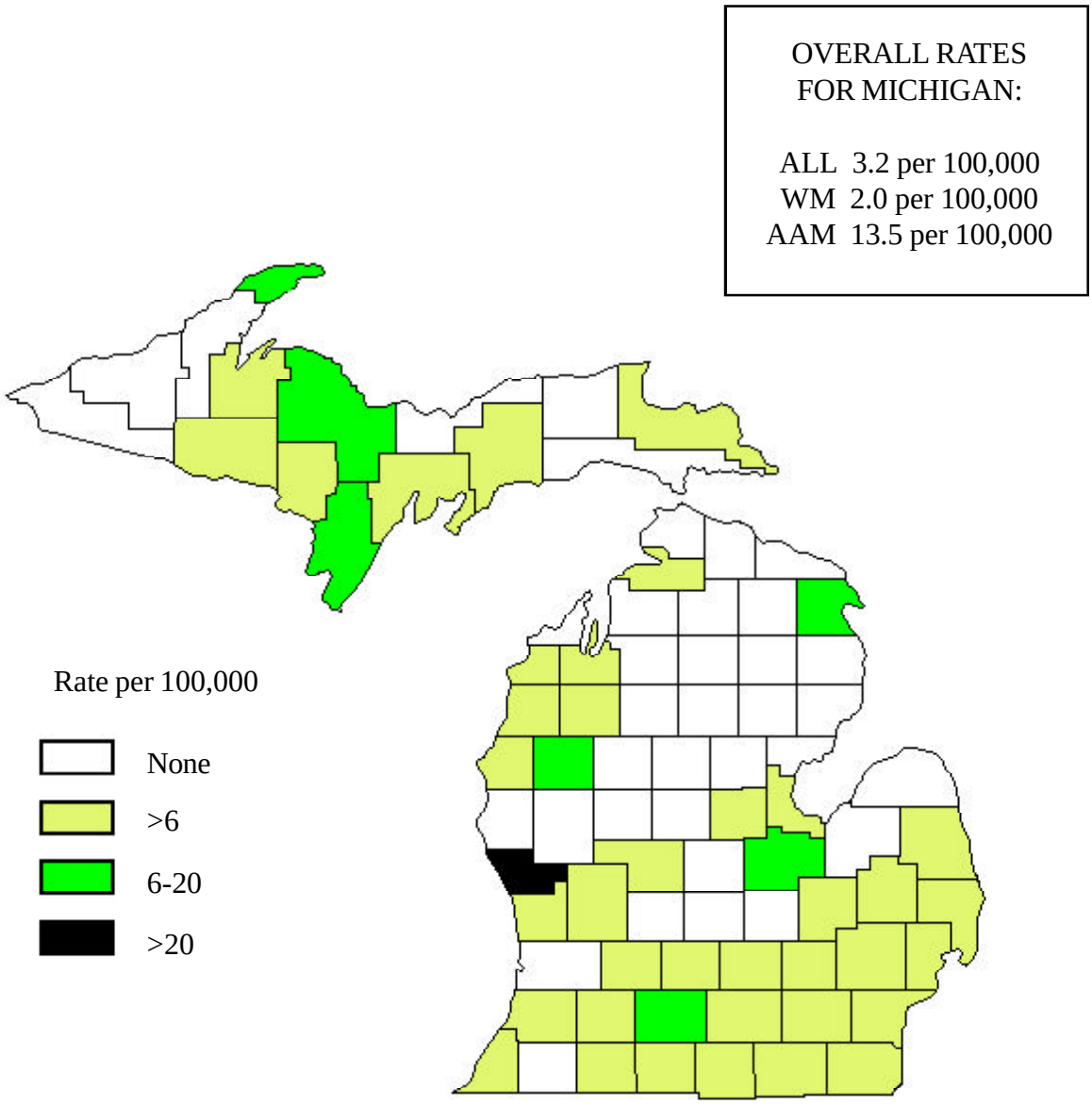
*Fifty-nine individuals were exposed to silica out-of-state, and fourteen individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-1999*



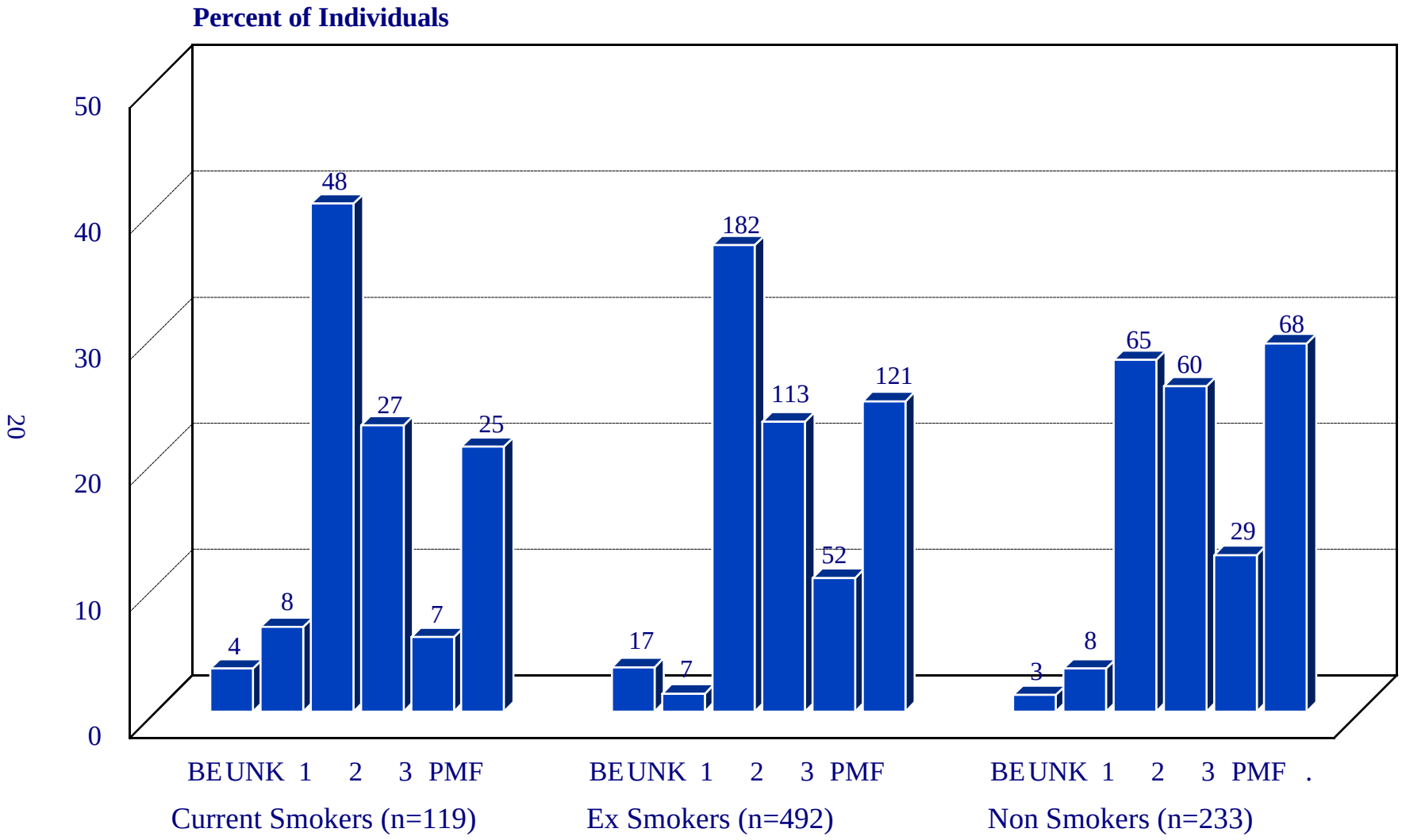
*Rate per 100,000 among African American men age 40+. Numerator is the average number of individuals with silicosis for the years 1987-1999; denominator is the 1990 U.S. Census population data for African American men age 40 and older, by county. In 1990, there were 174,325 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-1999*



*Rate per 100,000 among white men age 40+. Numerator is the average number of individuals with silicosis for the years 1987-1999; denominator is the 1990 U.S. Census population data for white men age 40 and older, by county. In 1990, there were 1,410,341 white males 40 years and older living in Michigan.

Figure 9. Severity of X-Ray Results* by Smoking Status for Individuals Confirmed with Silicosis** 1985 - 2001



* 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: 844. Unknown smoking status for 13 individuals.

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

	PR	HDC	DC	WC	ICFU	Total
<1988	N/A**	67	35	42	N/A	144
1988	N/A	56	6	7	N/A	69
1989	7	40	9	4	3	63
1990	5	44	0	6	1	56
1991	5	36	1	6	0	48
1992	16	54	6	2	0	78
1993	6	31	1	4	0	42
1994	7	36	1	28	0	72
1995	26	35	3	2	0	66
1996	28	35	0	0	0	63
1997	13	48	1	0	0	62
1998	10	28	1	0	0	39
1999	5	25	1	1	0	32
2000	4	11	0	0	0	15
2001	6	1	1	0	0	8
All Years	138	547	66	102	4	857

*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 1985-2001

Industry (SIC code)*	Number of Individuals**	
Manufacturing		
Primary Metal Industries (33) Includes iron, steel, gray & ductile iron foundries	657	(77.3)
Stone, Clay, Glass and Concrete Products (32)	40	(4.7)
Transportation Equipment (37) Includes auto bodies and boat building	32	(3.8)
Fabricated Metal Products (34)	11	(1.3)
Industrial Machinery (35)	9	(1.1)
Miscellaneous (25,26,28,30,36,38,39) Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment	17	(2.0)
Mining (10-14)	22	(2.6)
Construction (15-17)	46	(5.4)
Transportation, Communication, etc. Services (40-49)	7	(0.8)
Wholesale Trade (50)	1	(0.1)
Business and Repair Services (73,76)	2	(0.2)
Dental Laboratory (80)	4	(0.5)
Government (95,96)	2	(0.2)
Total	850	(100.0)

*Standard Industrial Classification
**For seven workers, the industrial classification was not known. Percentages are in parentheses.

Table 3. Percent Predicted Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals Confirmed with Silicosis* for the Years 1985-2001

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	(35.3)	0	--	8	(47.1)	1	(33.3)	3	(17.6)	2	(66.7)
Unknown Severity	3	(30.0)	1	(33.3)	4	(40.0)	1	(33.3)	3	(30.0)	1	(33.3)
Category 1	42	(24.7)	15	(31.3)	58	(34.1)	13	(27.1)	70	(41.2)	20	(41.7)
Category 2	29	(30.2)	18	(41.9)	32	(33.3)	13	(30.2)	35	(36.5)	12	(27.9)
Category 3	10	(27.8)	12	(63.2)	15	(41.7)	3	(15.8)	11	(30.6)	4	(21.1)
PMF	35	(35.4)	16	(34.8)	35	(35.4)	15	(32.6)	29	(29.3)	15	(32.6)
Total	125	(29.2)	62	(38.3)	152	(35.5)	46	(28.4)	151	(35.3)	54	(33.3)

*Total number of individuals: 590. Information was missing for 267 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) Divided by Forced Vital Capacity (FVC) by X-Ray Results and Cigarette Smoking Status for Individuals Confirmed with Silicosis* for the Years 1985-2001

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 (11.8)	1 (33.3)	3 (17.6)	0 (–)	6 (35.3)	2 (66.7)	6 (35.3)	0 (–)
Unknown Severity	0 (–)	0 (–)	0 (–)	0 (–)	1 (14.3)	2 (66.7)	6 (85.7)	1 (33.3)
Category 1	18 (10.7)	2 (4.2)	36 (21.3)	3 (6.3)	60 (35.5)	16 (33.3)	55 (32.5)	27 (56.3)
Category 2	4 (4.4)	2 (4.7)	18 (19.8)	6 (14.0)	39 (42.9)	12 (27.9)	30 (33.3)	23 (53.5)
Category 3	1 (2.9)	1 (5.3)	6 (17.1)	0 (–)	5 (14.3)	6 (31.6)	23 (65.7)	12 (63.2)
PMF	15 (15.6)	4 (8.7)	29 (30.2)	11 (23.9)	29 (30.2)	13 (28.3)	23 (24.0)	18 (39.1)
Total	40 (9.6)	10 (6.2)	92 (22.2)	20 (12.3)	140 (33.7)	51 (31.5)	143 (33.7)	81 (50.0)

*Total number of individuals: 577. Information was missing for 280 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 857 Individuals Confirmed with Silicosis for the Years 1985-2001 were Exposed to Silica

	Number of Individuals Represented	Number of Facilities	Percent of Facilities
Inspections	397	76	(23.6)
Closed	317	109	(33.9)
Out of State	53	49	(15.2)
Scheduled for Inspection	4	4	(1.2)
No Longer Use Silica	23	21	(6.5)
Unknown	30	30	(9.3)
Building Trade	32	32	(9.9)
Inspected by MSHA*	1	1	(0.3)
Total	857	322	99.9* *

*MSHA = Mine Safety and Health Administration.
**Percent does not add to 100 due to rounding.

Table 6. Results of Industrial Hygiene Inspections of 76 Facilities Where Individuals Confirmed with Silicosis for the Years 1985-2001 were Exposed to Silica

	Number of Companies	Percent
Air Sampling Performed	54	
Above NIOSH* Recommended Standard for Silica	33	(61.1)
Above MIOSHA** Enforceable Standard for Any Exposure	21	(38.9)
Above MIOSHA Enforceable Standard for Silica	21	(38.9)
Medical Surveillance Evaluated	64	
Periodic Chest X-rays with B Reader	6	(9.4)
Periodic Chest X-rays without a B Reader	3	(4.7)
Pre-employment Testing Only	19	(29.7)
No Medical Surveillance	24	(37.5)
Periodic Pulmonary Function Testing	16	(25.0)

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

Table 7. Summary of Calculations Used to Estimate the Total Number of Newly Diagnosed Cases of Silicosis in the United States, 1987-1996

Number of Death Certificates which Mentioned Silicosis in the United States, 1987-1996		2787
Multiply by Proportion of Confirmed Silicosis-Related Deaths in Michigan, 1987-1996	X	0.7727
Estimated Number of Confirmed Silicosis-Related Deaths in the United States, 1987-1996		2154
Multiply by Ratio of Number of Living and Deceased Silicosis Cases to Those Deceased in Michigan, 1987-1996	X	7.46
Estimate of Number of Silicosis Cases in the United States That Would Have Been Reported in 1987-1996 if There had Been National Surveillance		16,069
Multiply by the Ratio of Estimated Total Number of Silicosis Cases to Those Actually Reported to the Surveillance System in Michigan, 1987-1996	X	3.89
Estimate of the Total Number of Newly Diagnosed Cases of Silicosis in the United States, 1987-1996		62,508

Table 8. Results by Initial Report Source for Number of Reports, Confirmed Cases, Worksites Identified, Worksites Inspected, Problem Worksites and Silica Problem Worksites, Michigan 1989-1995

	Hospital		Physician Report		Workers' Comp		Death Certificate		Total
	#	%	#	%	#	%	#	%	
Total Case Reports	492	(65)	129	(17)	92	(12)	44	(6)	757
Confirmed Cases	317	(67)	78	(17)	52	(11)	23	(5)	470
Worksites Identified	103	(74)	21	(15)	6	(4)	10	(7)	140
Worksites Inspected	32	(64)	12	(24)	3	(6)	3	(6)	50
Problem Worksites	22	(58)	10	(26)	3	(8)	3	(8)	38
Silica Problem Worksites	17	(59)	8	(28)	1	(3)	3	(10)	29

Table 9. Reporting Source and Public Costs By Initial Source of Report, Michigan 1989-1995

	Hospital Reports	Physician Reports	Workers' Comp	Death Certificates	All Sources
Case Collection Costs					
Reporting Source Cost per Case	$14	$8	$8	$8	$11
Public Cost per Case	$93	$286	$79	$90	$124
Worksite Identification Costs					
Reporting Source					
Cost per Worksite	$29	$12	$35	$16	$25
Cost per Problem Worksite	$43	$14	$35	$16	$32
Cost per Silica Worksite	$56	$18	$104	$16	$42
Public					
Cost per Worksite	$301	$495	$532	$269	$359
Cost per Problem Worksite	$437	$594	$532	$269	$473
Cost per Silica Worksite	$566	$742	$1,597	$269	$620
Total Costs					
Reporting Source					
Cost per Case	$22	$20	$22	$17	$20
Cost per Worksite	$47	$30	$53	$34	$43
Cost per Problem Worksite	$69	$37	$53	$34	$57
Cost per Silica Worksite	$91	$45	$159	$34	$74
Cost per Affected Workers	$1	$4	$5	$1	$1
Cost per Silica Affected Worker	$1	$4	$5	$1	$1
Public					
Cost per Case	$143	$358	$133	$156	$179
Cost per Worksite	$313	$537	$574	$311	$382
Cost per Problem Worksite	$454	$644	$574	$311	$503
Cost per Silica Worksite	$588	$806	$1,723	$311	$659
Cost per Affected Worker	$6	$69	$54	$10	$10
Cost per Silica Affected Worker	$6	$76	$54	$16	$11