

1998

Annual Report on Silicosis in Michigan



1998 Annual Report on Silicosis in Michigan

A Joint Report
of the
Michigan State University
Department of Medicine
117 West Fee Hall
East Lansing, Michigan 48824-1316
(517) 353-1846

Kenneth D. Rosenman, M.D., Professor of Medicine
Mary Jo Reilly, M.S., Epidemiologist

and

the Michigan Department
of Consumer and Industry Services
Bureau of Environmental and
Occupational Health
P. O. Box 30649
Lansing, Michigan 48909-8149
(517) 335-8259

Douglas J. Kalinowski, C.I.H., Deputy Director,
Bureau of Safety and Regulation

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Summary:

This is the eighth annual report on silicosis in Michigan. The report is based on partial data for 1985 and 1986, complete data for the years 1987 through 1996* and preliminary data for 1997 and 1998. A total of 746 cases of silicosis have been confirmed from 1985-1998; 64 of those reports were newly confirmed in 1996.

The disease continues to occur mainly among men born before 1940 who began working in a Michigan ferrous foundry in the 1930s or 1940s and worked there over 25 years. Forty-four percent of the patients are African American. The overall annual average incidence rate of silicosis among African American males (14.8 cases per 100,000) is seven times higher than white males (2.1 cases per 100,000). The rates within specific counties ranged between 2.2 to 25.4 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.

The patients identified with silicosis generally have severe disease. Twenty-five percent have progressive massive fibrosis (PMF) and another 33.4% have advanced simple silicosis. Only about a third of all patients have normal breathing tests. Twenty-three percent had been told they had tuberculosis (includes both clinical disease and 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 (1).

Despite the severity of disease, 56% 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 time because of the severity of exposure. Three patients developed silicosis who began working with silica in the 1980s, 29 in the 1970s and 89 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 survey of the 140 companies in the state doing abrasive blasting shows 89% are continuing to use silica rather than less hazardous non-silica abrasives.

Comparison of the first five years of surveillance data with the second five years suggests a possible decrease in the severity of silicosis among Michigan's workers. However, continued medical and public health vigilance is necessary to prevent more individuals from developing silicosis.

*There is one hospital report of a potential new silicosis patient for 1996 for whom we are still in the process of obtaining medical records to confirm the diagnosis.

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 1987. In that year, the Michigan Department of Consumer and Industry Services (MDCIS) 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 Administration (OSHA) 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 1987-1996. Partial data is also available for the years 1985 and 1986. We do 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, 1997 and 1998 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 1987-1996 is an underestimate of the true number of persons diagnosed with silicosis.

Figure 1 shows 642 patients identified and confirmed with silicosis through the surveillance system by year for 1987 through 1996. To date, we have confirmed an additional 38 persons with silicosis in 1997, and 9 in 1998. Table 1 shows the primary reporting source of the 746 persons confirmed with silicosis for the years 1985 - 1998. Hospital reports are the primary source of identification of patients, with 58% of silicosis patients identified solely through the hospitals. Often a patient will be reported to the system by more than one source. Figure 2 shows the overlap of reporting sources for the most complete reporting years of 1987 through 1997.

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 (2). Using capture-recapture analyses, we estimate the true number of silicotics in Michigan from 1987-1995 is 2,483 (3). During this same period 577 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 746 cases of silicosis confirmed from 1985-1998.

Gender

Seven hundred twenty-nine (97.7%) of the persons with silicosis are men.

Race

Three hundred twenty-five(43.9%) of the persons with silicosis are African American, 392 (53.0%) are white, one (0.1%) was of Asian ancestry, and 22 (3.0%) were listed as "other ancestry". The race on six individuals was unknown.

Age

The distribution of the decade of birth is shown in Figure 3. The average year of birth is 1919,

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 1946, ranging from 1910 to 1985.

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 27.6.

Location in State

Figure 6 shows the counties in which the patients' silica exposure occurred. The locations are clustered in 3 counties: Muskegon, Saginaw and Wayne. The overall average annual incidence rates for silicosis among African American men is 14.8 cases per 100,000, and for white men is 2.1 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 952/100,000, in Muskegon it was 283/100,000, in Saginaw it was 99/100,000, in Monroe it was 56/100,000, in Calhoun it was 42/100,000, in St. Clair it was 25/100,000, and in Macomb it was 22/100,000. 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 25/100,000, in Keewanaw it was 21/100,000, in Alpena it was 13/100,000, in Saginaw it was 13/100,000, and in Menominee 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 (78.9%). One hundred seventy-nine (25.6%) people stated they had done sandblasting as part of their work.

Medical Results

Overall 516 (69.2%) of the people with silicosis had simple silicosis and 188 (25.2%) had progressive massive fibrosis. Twenty-two (2.9%) silicotics had normal x-rays with biopsy evidence. Twenty (2.7%) individuals had x-ray reports which were consistent with silicosis but which could not be classified.

Two hundred three (27.6%) of the people with silicosis never smoked cigarettes, 428 (58.2%) had quit, 105 (14.3%) were still smoking and no information was available on 10 individuals. Figure 9 shows the distribution of x-ray results according to the ILO classification and smoking. Non smokers tended to have more severe silicosis. The greater percentage of non smokers with progressive

massive fibrosis was statistically significant (29.6% non smokers vs. 20.0% current smokers vs. 24.8% ex smokers) ($X^2 = 26.45$, $p = .003$). 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.

Tables 3 and 4 show the distribution of 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.

Figure 10 shows the age-adjusted mortality rate for silicosis from 1982-1993 for men and women 15 years of age and older in the United States from 1982-1993. The Muskegon area is in the top 10 percent in the country (9).

Workers' Compensation

Since the 1930s, there has been special concern about the incidence 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 278 (44.3%) of the individuals with known filing status with silicosis or their next of kin applied for workers' compensation. Three hundred fifty (55.7%) had not applied. It was unknown whether the remaining 118 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, 227 (81.7%) received compensation, 17 (6.1%) had been denied, and 34 (12.2%) were pending.

Industrial Hygiene Results

The 746 individuals with silicosis were exposed to silica in 278 facilities (Table 5). Inspections were performed at 68 (24.5%) of these facilities. Currently one (0.4%) facility is scheduled for an inspection. One hundred five (37.8%) facilities were no longer in operation, 43 (15.5%) were located out of state, 19 (6.8%) facilities no longer used silica, 26 (9.4%) had worked at multiple construction sites as building trade workers, 1 (0.4%) was referred to the Mine Safety and Health Administration since the company was out of MIOSHA jurisdiction, and 15 (5.4%) were unknown.

Air sampling was conducted in 48 of the 68 facilities inspected (Table 6). Thirty of 48 (62.5%)

facilities were above the National Institute for Occupational Safety and Health recommended exposure level for silica. Twenty of the 48 (41.7%) were above the enforceable Michigan Occupational Health and Safety Administration (MIOSHA) standard for silica. Another one (2.1%) company was above the MIOSHA standard for beryllium and one company was above the MIOSHA standard for silica and silver.

Only 5 of the 59 (8.5%) 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 two companies provided periodic chest x-rays that were not interpreted by a "B" certified reader. Nineteen (32.2%) only performed pre-employment testing, 22 (37.3%) provided no medical surveillance, and 15 (25.4%) performed annual or biannual pulmonary function testing without chest x-rays.

Abrasive Blasting

Of the 140 Michigan companies that currently perform abrasive blasting, almost all (89.3%) use silica despite the availability of non-silica abrasives. However, non-silica abrasives are used on many of the larger blasting projects in Michigan because the Michigan Department of Transportation requires the use of non-silica abrasives for blasting bridges, overpasses and other steel structures on the roadways.

Comparison of the First Five Years of Reporting (1987-1991) with the Second Five Years of Reporting (1992-1996)

We compared individuals with silicosis reported during the 1st five years of the surveillance system (1987-1991) with those reported in the next five years (1992-1996) to determine if there were any trends. The average year of birth of patients reported during the first five years was 1917, and 1921 during the second five years. Figure 11 shows the distribution of decade of birth by reporting period. The percentage of silicotics who were white decreased from 55.6 to 49.7%.

The average year of hire during the first five years of reporting was 1944 and was 1948 for the second five years. Figure 12 shows the distribution of decade of hire by reporting period. The average duration of exposure during the first five reporting years was 27 years and was 28 years for individuals reported during the second five years of surveillance. Figure 13 shows the distribution of years worked during the two reporting periods. The percentage with duration of exposure to silica less than 10 years decreased from 9.5 to 4.5%.

The percentages of individuals with exposures by silica-using industry was similar for the two reporting periods (Table 7). However, there was a greater percentage of individuals with a primary exposure to silica in the construction industry who were reported during the second five years. The percentage of individuals who had performed sandblasting decreased from 34.0% to 31.8%. There was no significant difference in the distribution of the location by county of companies where silica exposure occurred between the first and second five years.

The percentage of workers who applied for workers' compensation decreased from 46.2% during the first five years to 41.2% during the second five years of reporting. Of those who applied for workers' compensation, a greater percentage were awarded their claim during the first five years (88.1%) compared to the second five years of surveillance (73.7%).

The percentage of silicotics with clinical tuberculosis or a positive skin test dropped from 23% to 15%; the percentage who have ever smoked decreased from 74.0 to 70.3%; and the percentage with progressive massive fibrosis decreased from 33.4 to 18.5% (Figure 14).

The percentage of silicotics who had never smoked with a markedly abnormal FEV₁/FVC ratio decreased from 26.3% to 11.7% (Table 8). There was no change among silicotics who had ever smoked (32.5% to 31.9%) (Table 8). The percentage of silicotics with a markedly abnormal Percent FVC remained unchanged in smokers (29.3% to 28.8%) and was slightly increased among nonsmokers (34.4% to 40%) (Table 9).

The trend in decreasing severity of disease (fewer people with short duration of exposure, fewer people with progressive massive fibrosis, and fewer people with a markedly abnormal FEV₁/FVC ratio) suggests a decrease in the impact of silicosis from 1987-1991 to 1992-1996. The percentage of reports directly from physicians increased from 5.3% to 26.3% of all reports. Data from other states indicates that individuals reported directly by physicians have less severe disease than individuals reported by hospitals (4). The trend in decreasing severity of disease in Michigan remains while the analysis is limited to just reports received from hospitals.

Discussion:

The predominant characteristics of the individuals reported during Michigan's ten 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 (6). The older age of the patient (average year of birth, 1919) 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 and 1980s. Fifty-one or 7.0% worked for less than 10 years. Thirty-two (4.4%) began work in the 1970s or 1980s. Thirteen 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 (43% vs. 31%).

African American men are over represented (43.9%). This reflects previous hiring practices in foundries. 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 14.8 per 100,000 versus 2.1 per 100,000 for white workers (7 fold greater incidence).

The individuals reported generally have advanced disease: 188 (25.2%) have progressive massive fibrosis; another 249 (33.4%) 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 and clinically significant bronchitis and chronic obstructive pulmonary disease (7). Twenty-three 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 56% had not applied for workers' compensation.

Hospitals are the primary reporting source of the patients through this surveillance system. These hospitalized patients are generally the sicker and older patients with silicosis. In contrast, surveillance systems in Ohio and Wisconsin received more reports directly from physicians and consequently had a higher proportion of younger individuals with less advanced disease (4). In recent years, the

Michigan surveillance system has been receiving reports at an earlier stage in the individual's disease. This is reflected in the decrease over time in the number of reports first received through death certificate review and a corresponding increase, though small, in the number of reports received directly from physicians (Table 1).

Individuals with silicosis have an increased morbidity and mortality for both malignant and non-malignant respiratory disease (1,7). The increased risk for death is found both in patients who ever or never smoked cigarettes (1). Individuals with silicosis also have an increased risk of developing connective tissue disease, particularly Rheumatoid Arthritis (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.

Eighty-nine percent of 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 40 years ago. Initiatives to encourage the use of silica substitutes are needed, based on the European model.

Industrial hygiene inspections reveal violations of the exposure standard for silica in 41.7% of the facilities where sampling was done. However, follow-up inspections of these same companies have shown a significant decrease in silica exposures. Those companies not in compliance with the silica standard are requiring their workers to use powered air purifying respirators or air line respirators. However, because of an inadequate or absent medical surveillance program in 92.6% of the facilities there is no way to monitor the adequacy of the controls.

The overall trend comparing the last five years of surveillance data with the first five years suggests that although the numbers of individuals with silicosis is not changing, the disease is becoming less severe and is less likely to occur after a short working period. The drop among individuals with silicosis who had a history of tuberculosis, the drop in individuals with progressive massive fibrosis and the drop in the percent who had developed silicosis after less than 10 years of exposure are the only changes of any magnitude, and in the direction desirable for seeing a reduction in the impact of silicosis.

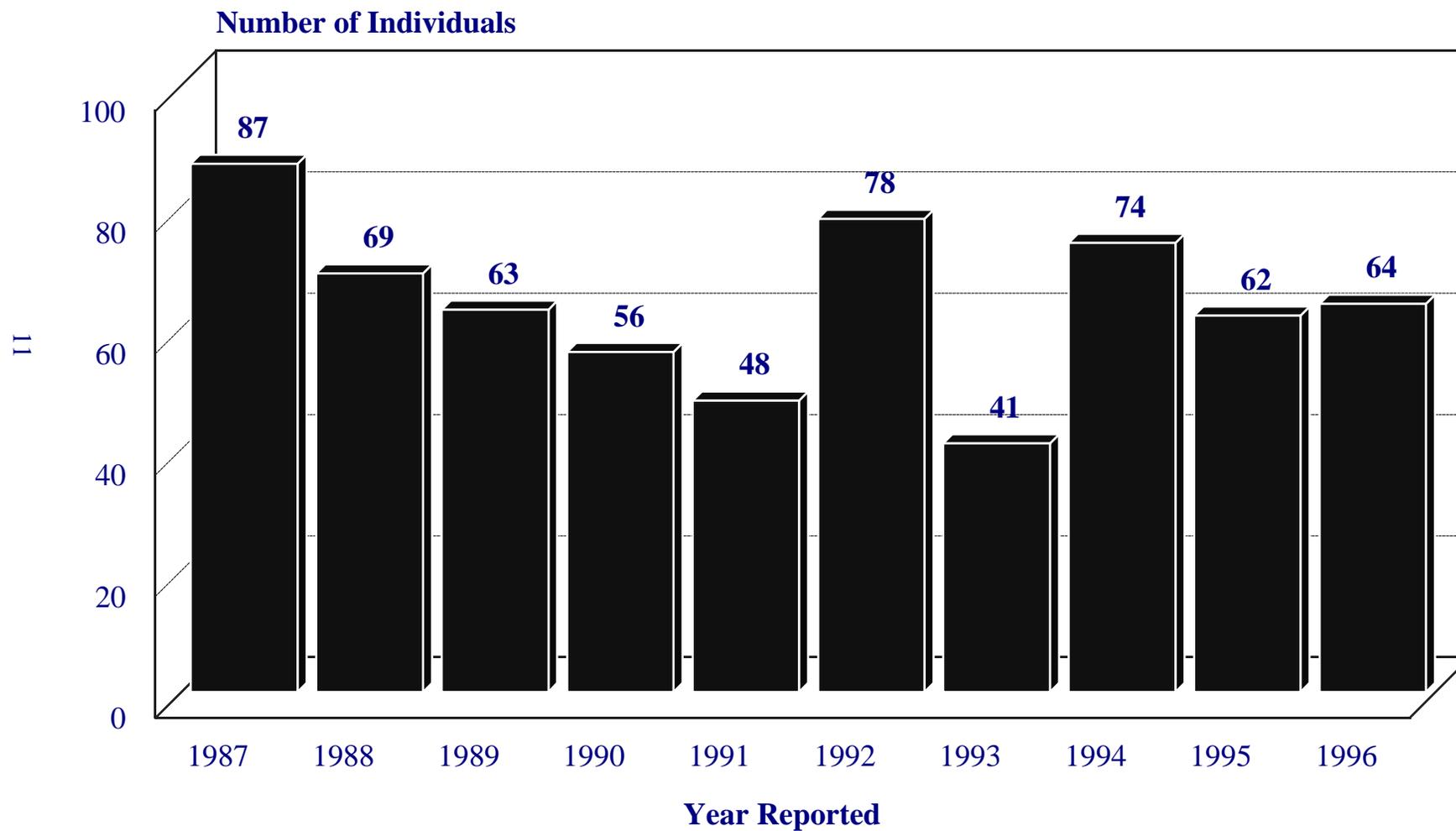
Silicosis remains an ongoing problem in Michigan with former foundry workers continuing to develop severe disease. Further, some Michigan workers will continue to be at risk of developing silicosis because of inadequate controls at foundries currently in operation. In addition, sandblasting continues to be a high risk operation (5). 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. A report from NIOSH highlights that continued reminders and reviews of work places are needed as long as silica continues to be used in industry

(5).

References

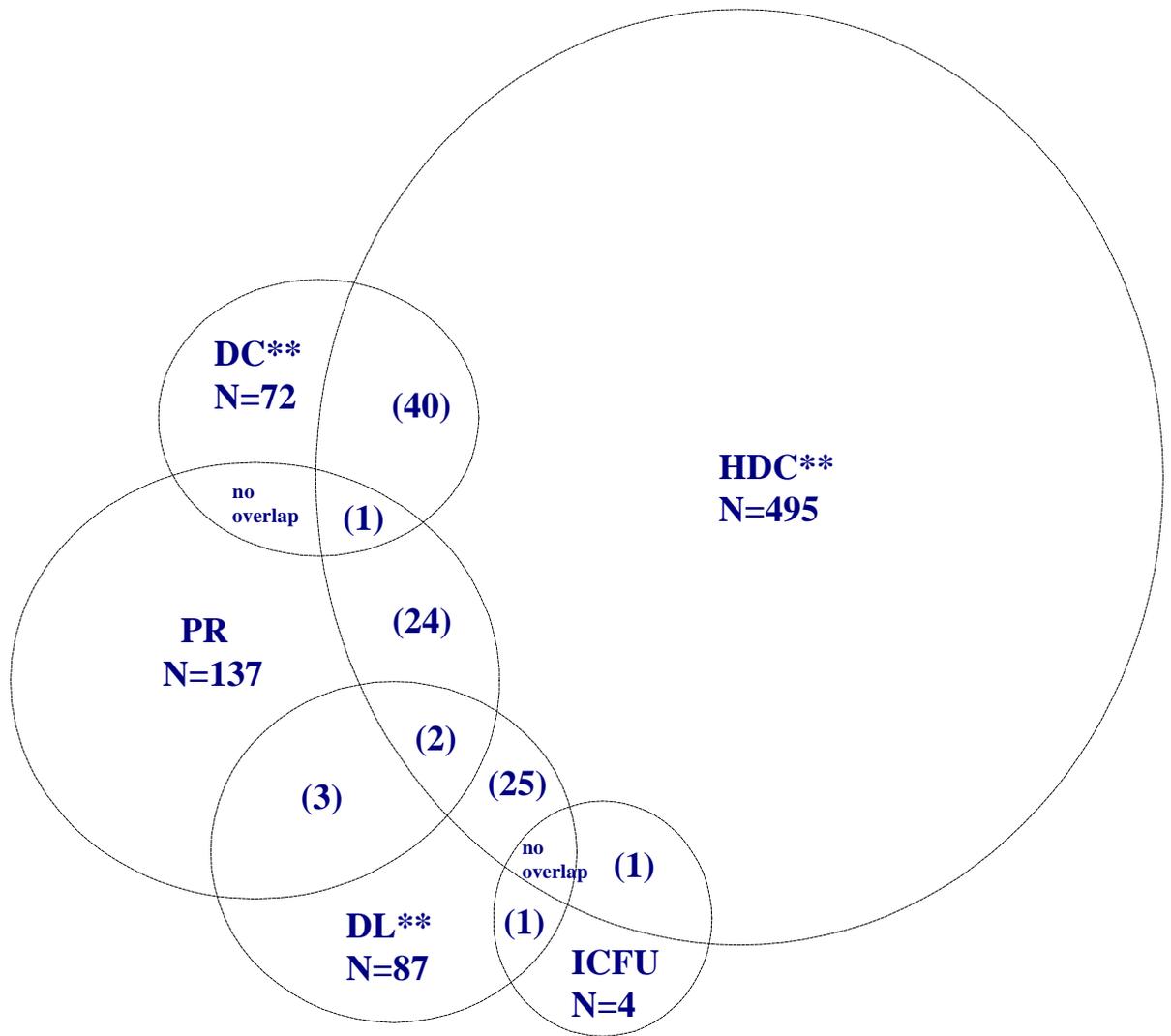
1. Rosenman KD, Stanbury MJ and Reilly MJ. *Mortality Among Persons with Silicosis Reported to Two State-Based Surveillance Systems*. Scandinavian Journal of Work Environment and Health 1995; 21 Supplement 2:73-76.
2. Rosenman KD, Trimbath L, and Stanbury M. *Surveillance of Occupational Lung Disease: Comparison of Hospital Discharge Data to Physician Reporting*. American Journal of Public Health 1990; 80:1257-1258.
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Figure 1. Number of Individuals Confirmed with Silicosis by Year Reported*



* Total number of individuals: 642.

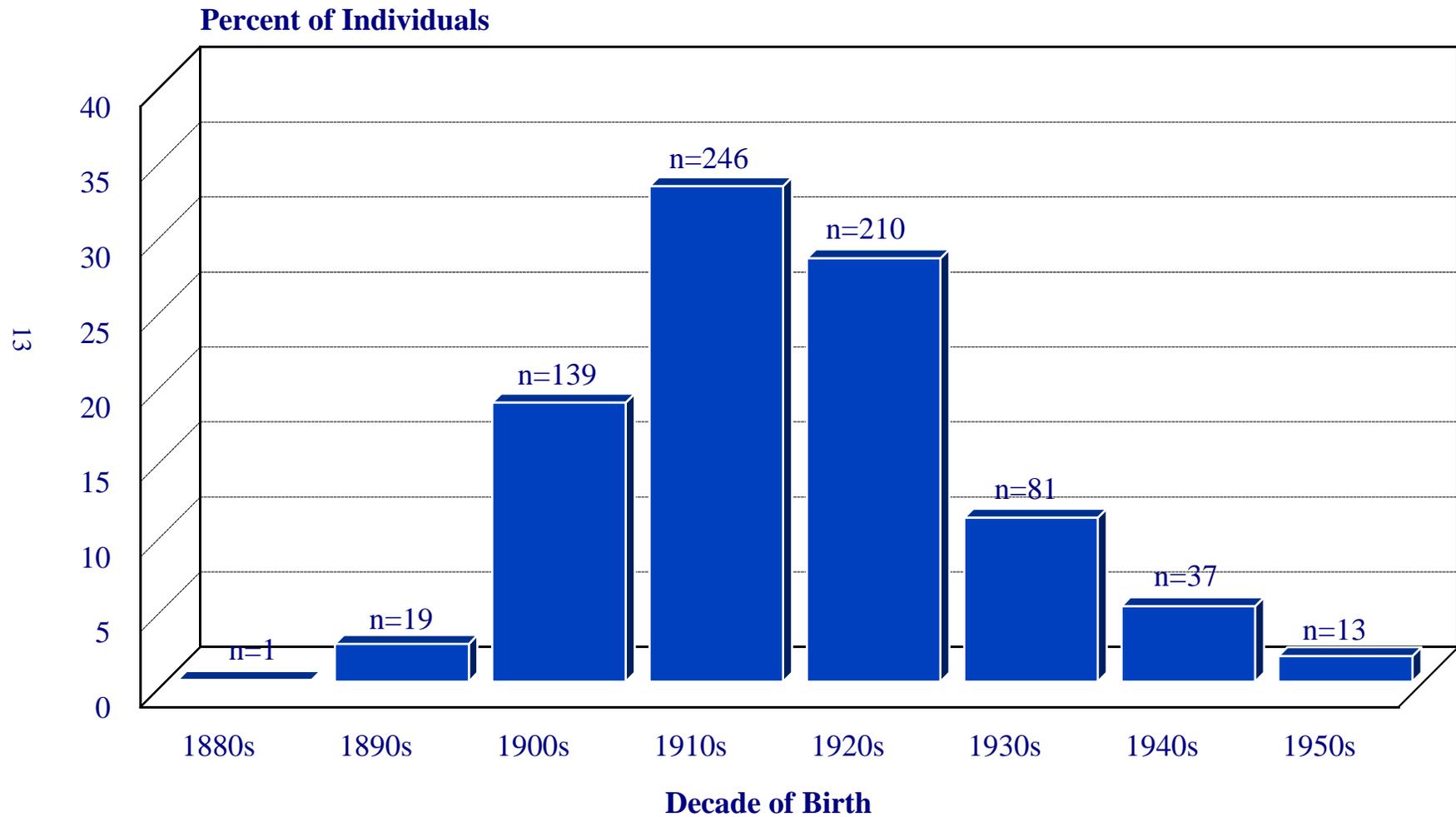
Figure 2. Overlap of Reporting Sources for Confirmed Individuals with Silicosis: 1987-1997*



* Diagram represents 689 individuals initially reported from 1987-1997. Numbers in parentheses represent the overlap of reporting sources. HDC=Hospital Discharge Data; DC=Death Certificate; PR=Physician Referral; DL=Department of Labor; ICFU=Index Case Follow-Up. N's represent the total number for that source.

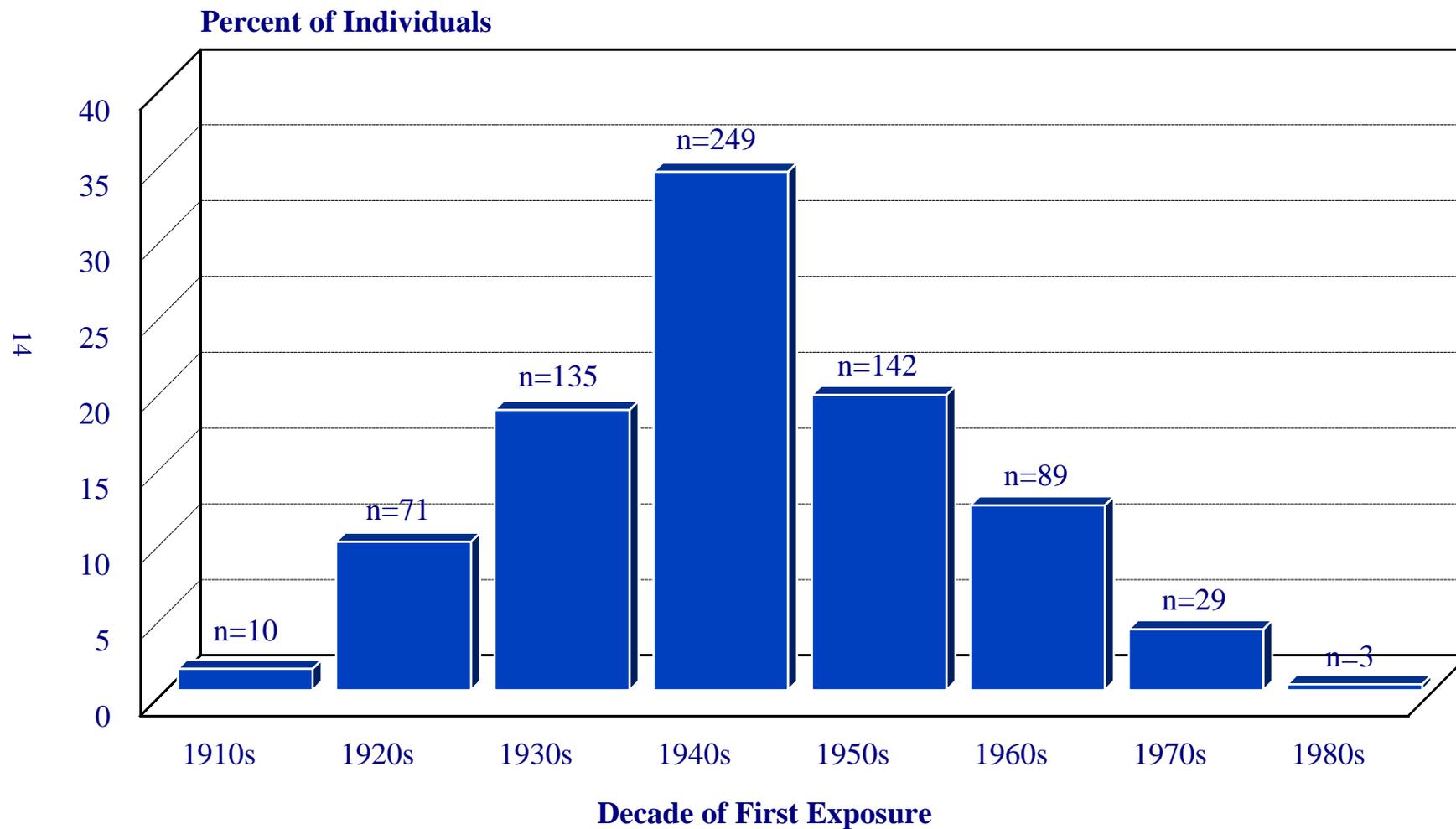
**There was also an overlap of HDC-DC-DL for three individuals.

Figure 3. Distribution of Decade of Birth for Individuals Confirmed with Silicosis: 1985-1998*



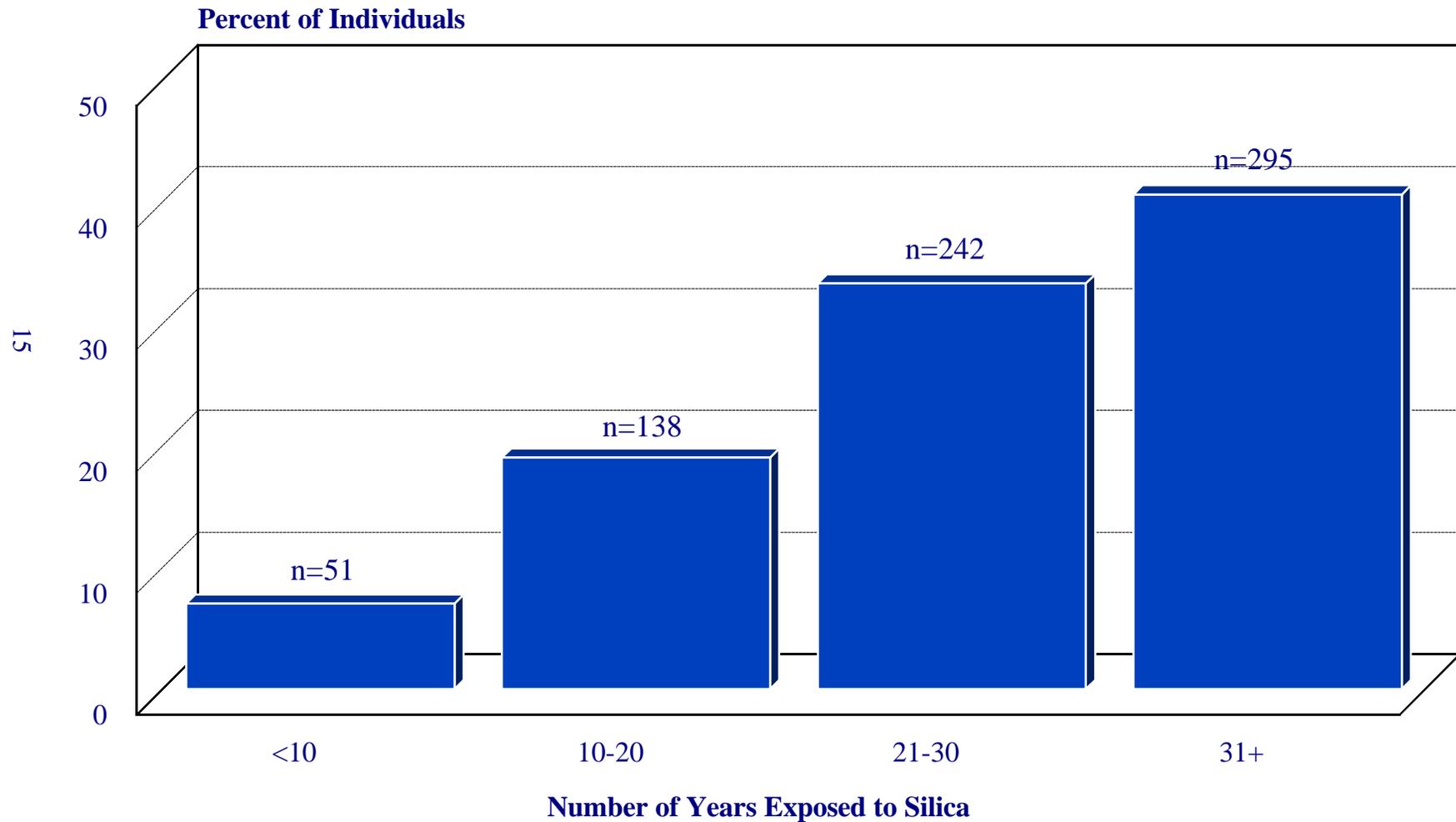
* Total number of individuals: 746.

Figure 4. Distribution of Decade When Silica Exposure Began for Individuals Confirmed with Silicosis: 1985-1998*



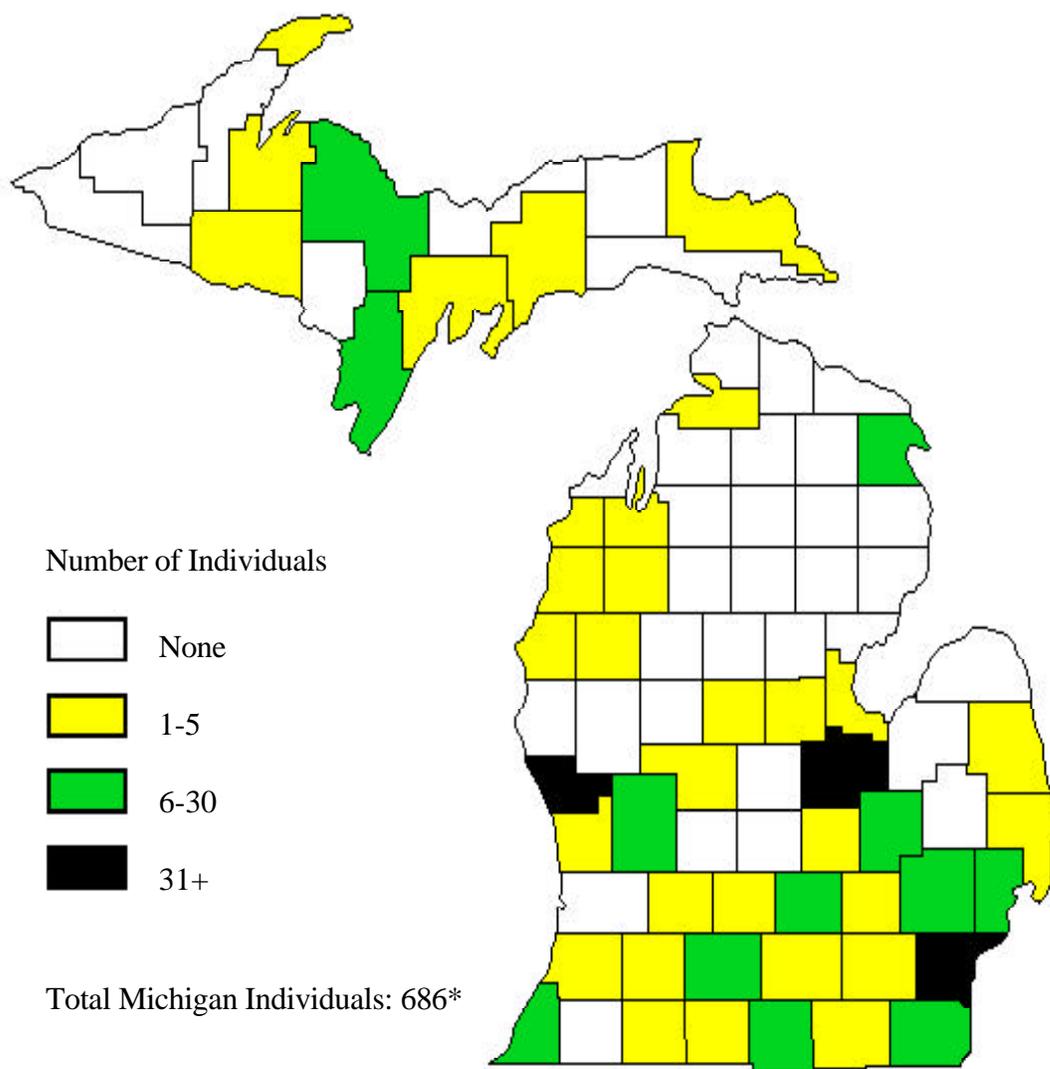
* Total number of individuals: 728. Unknown decade for 18 individuals.

Figure 5. Distribution of Years Worked at a Silica Exposed Job for Individuals Confirmed with Silicosis: 1985-1998*



* Total number of individuals: 726. Unknown decade for 20 individuals.

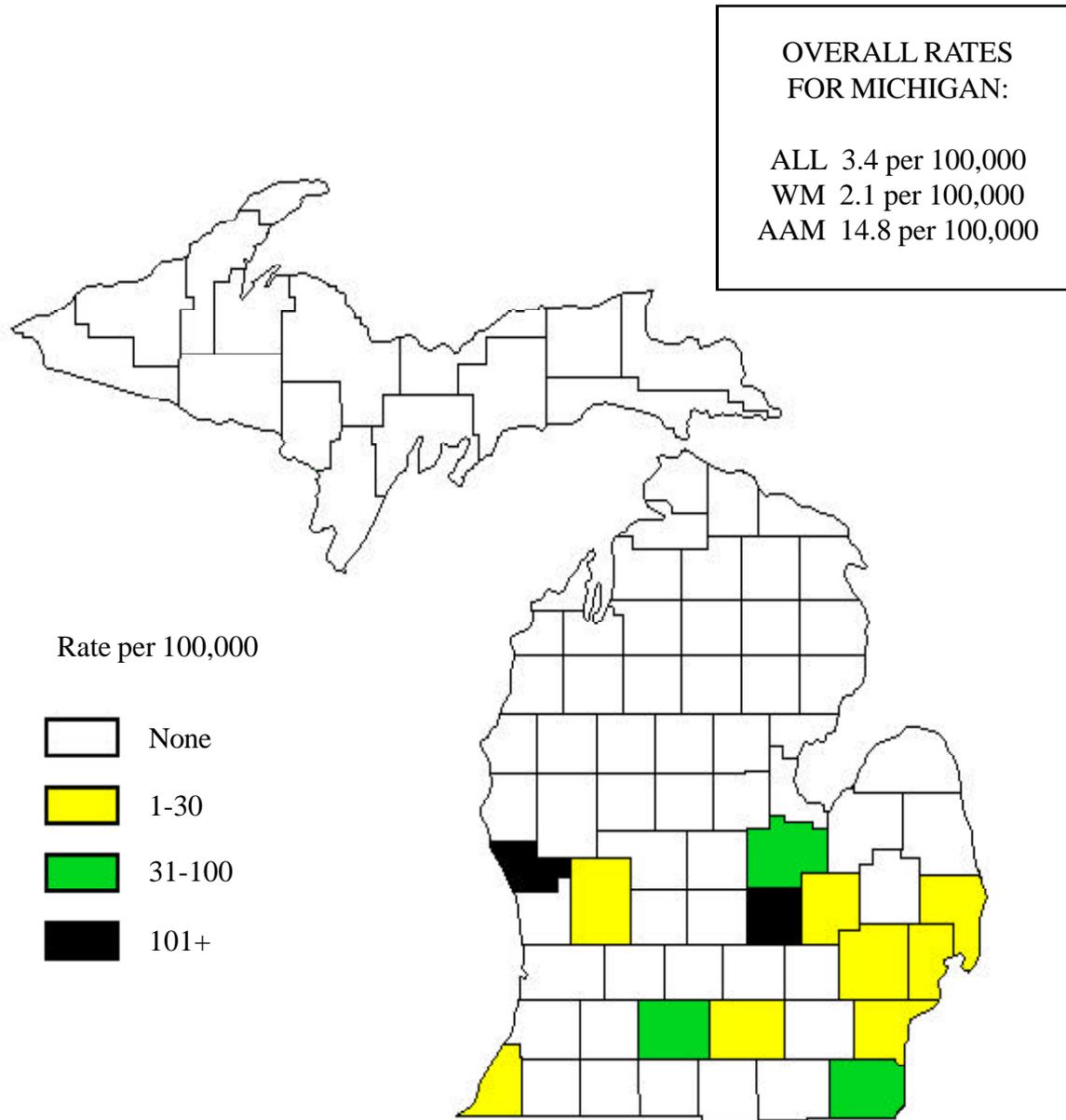
Figure 6. Distribution of Confirmed Silicosis Individuals by County of Exposure: 1985-1998



Muskegon, Saginaw and Wayne counties had the highest number of silicosis individuals, with 181, 118 and 188 individuals, respectively.

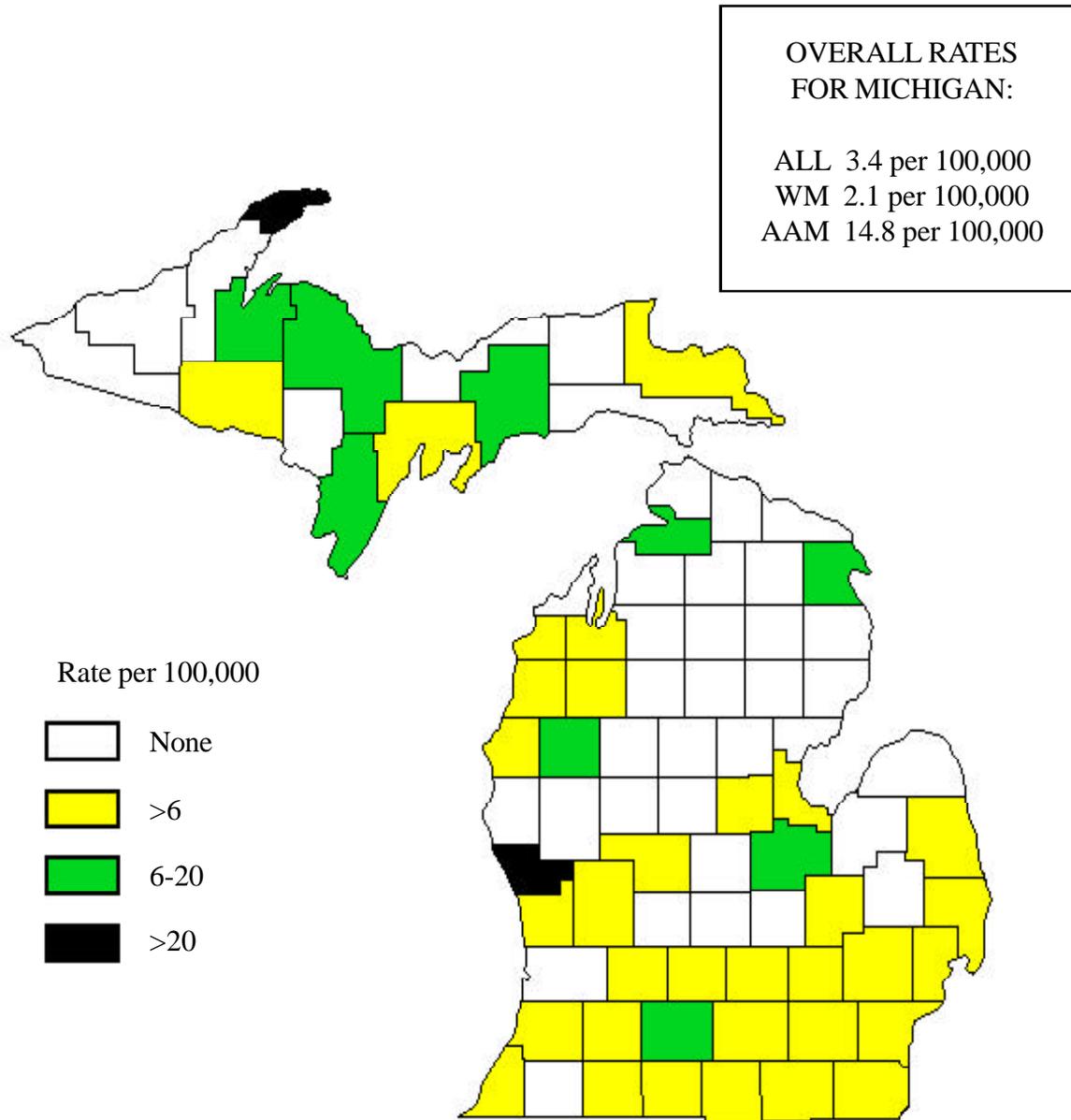
*Fifty-five individuals were exposed to silica out-of-state, and five individuals had an unknown county of exposure.

Figure 7. Average Annual Incidence Rate of Silicosis Among African American Males by County of Exposure: 1987-1996*



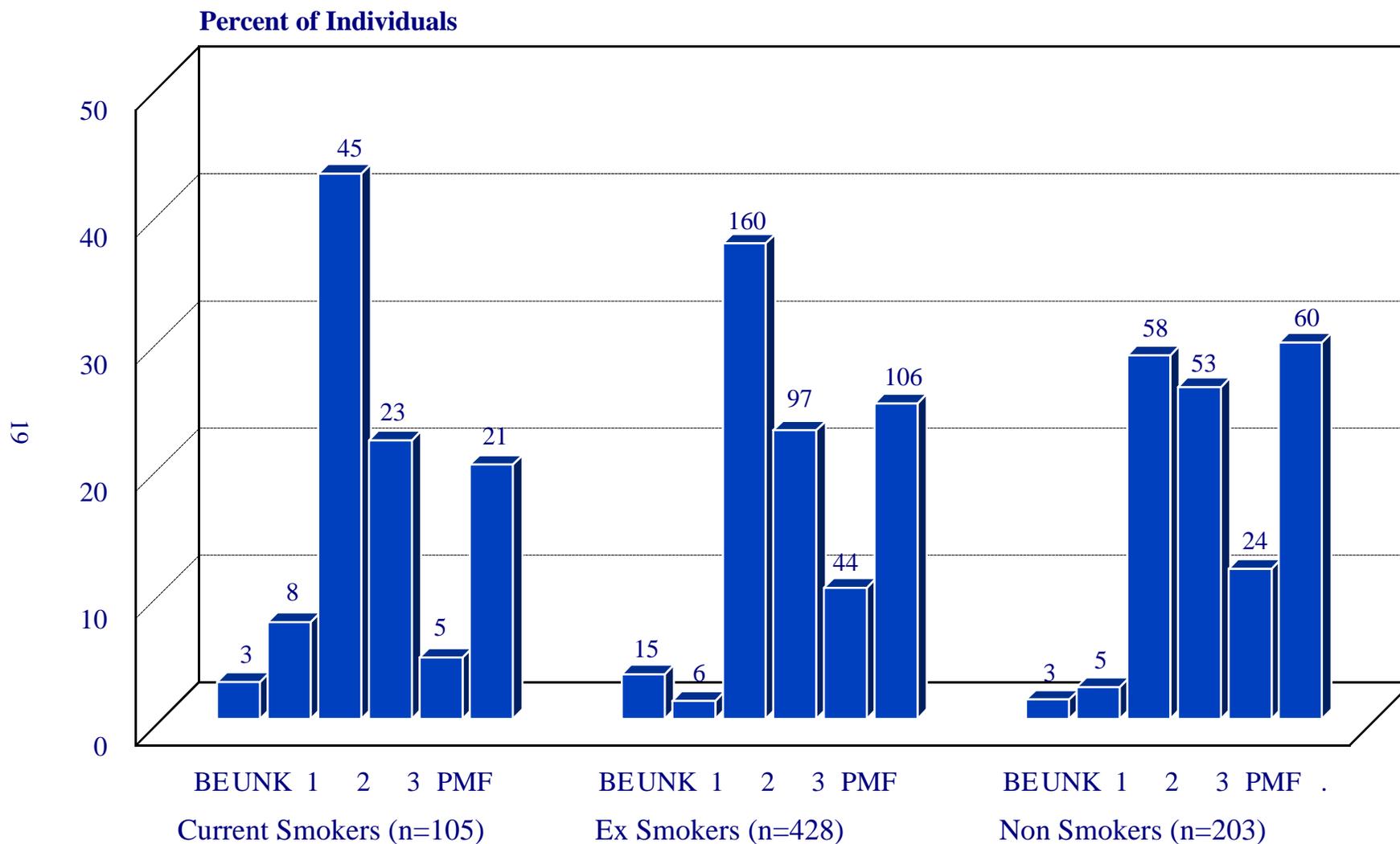
*Rate per 100,000 among African American men age 40+. Numerator is the average number of individuals for the years 1987-1996; denominator is the 1990 U.S. Census population data for African American men age 40 and older, by county. In 1990, there were 174,325 African American males 40 years and older living in Michigan.

Figure 8. Average Annual Incidence Rate of Silicosis Among White Males by County of Exposure: 1987-1996*



*Rate per 100,000 among white men age 40+. Numerator is the average number of individuals for the years 1987-1996; 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.

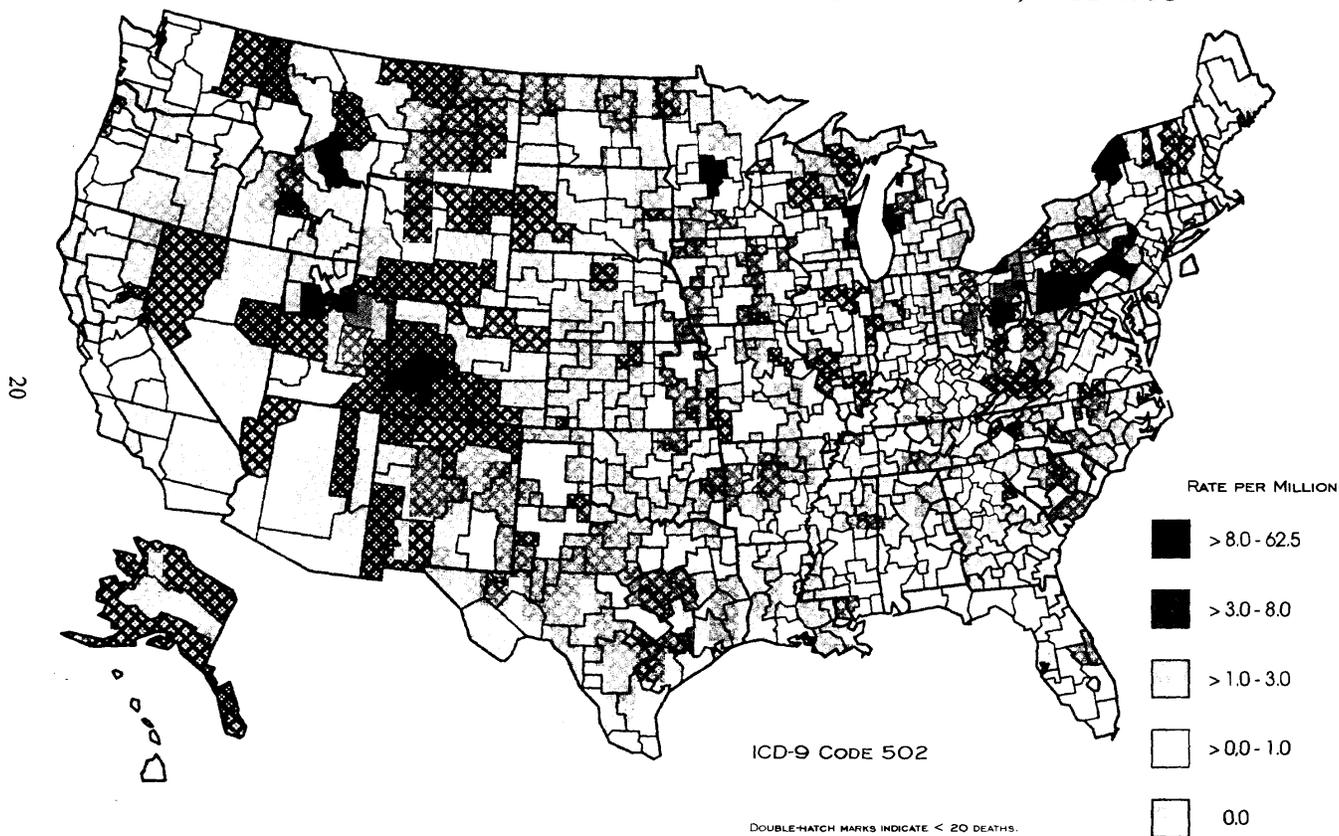
Figure 9. Severity of X-Ray Results* by Smoking Status for Individuals Confirmed with Silicosis: 1985-1998**



* 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.

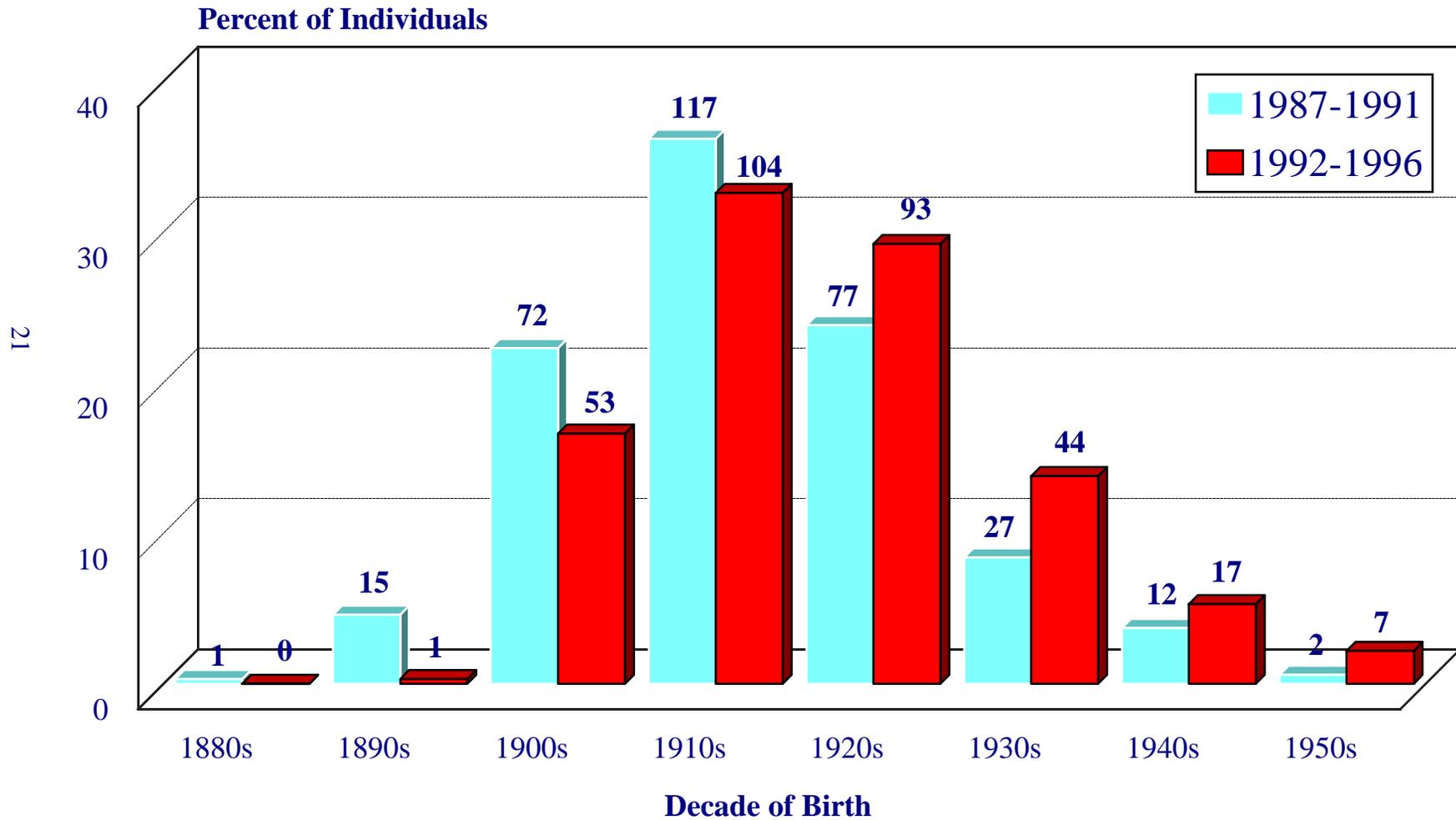
** Total number of individuals: 736. Unknown decade for 10 individuals.

Figure 10. Silicosis: Age-Adjusted Death Rates by Health Service Area; U.S. Residents 15 Years of Age and Older, 1982-1993



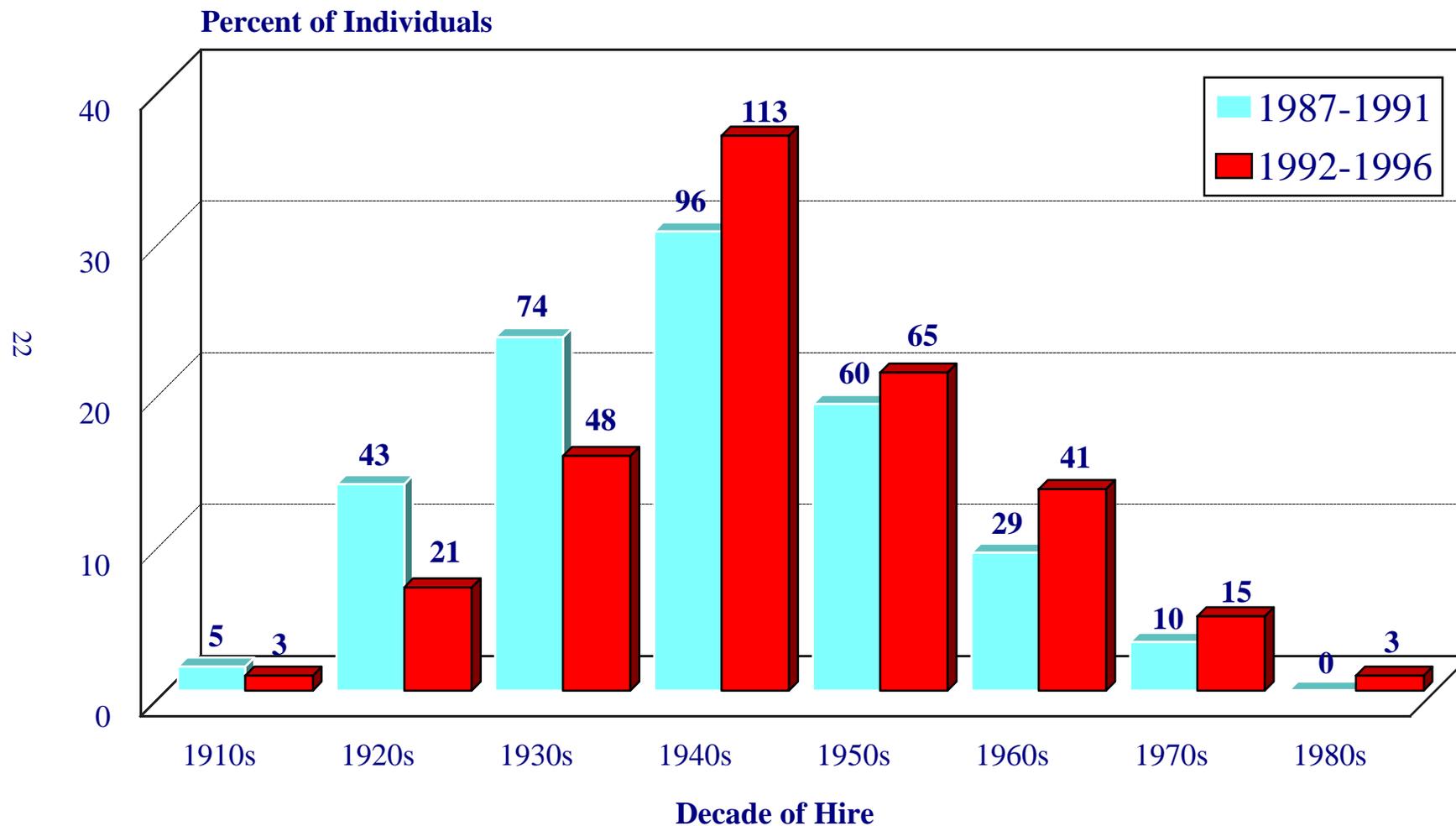
Source: NIOSH. Atlas of Respiratory Disease Mortality, United States: 1982-1993.
U.S. Department of Health and Human Services, PHS, CDC Publication No. 98-157.

Figure 11. Comparison of Decade of Birth Among Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996



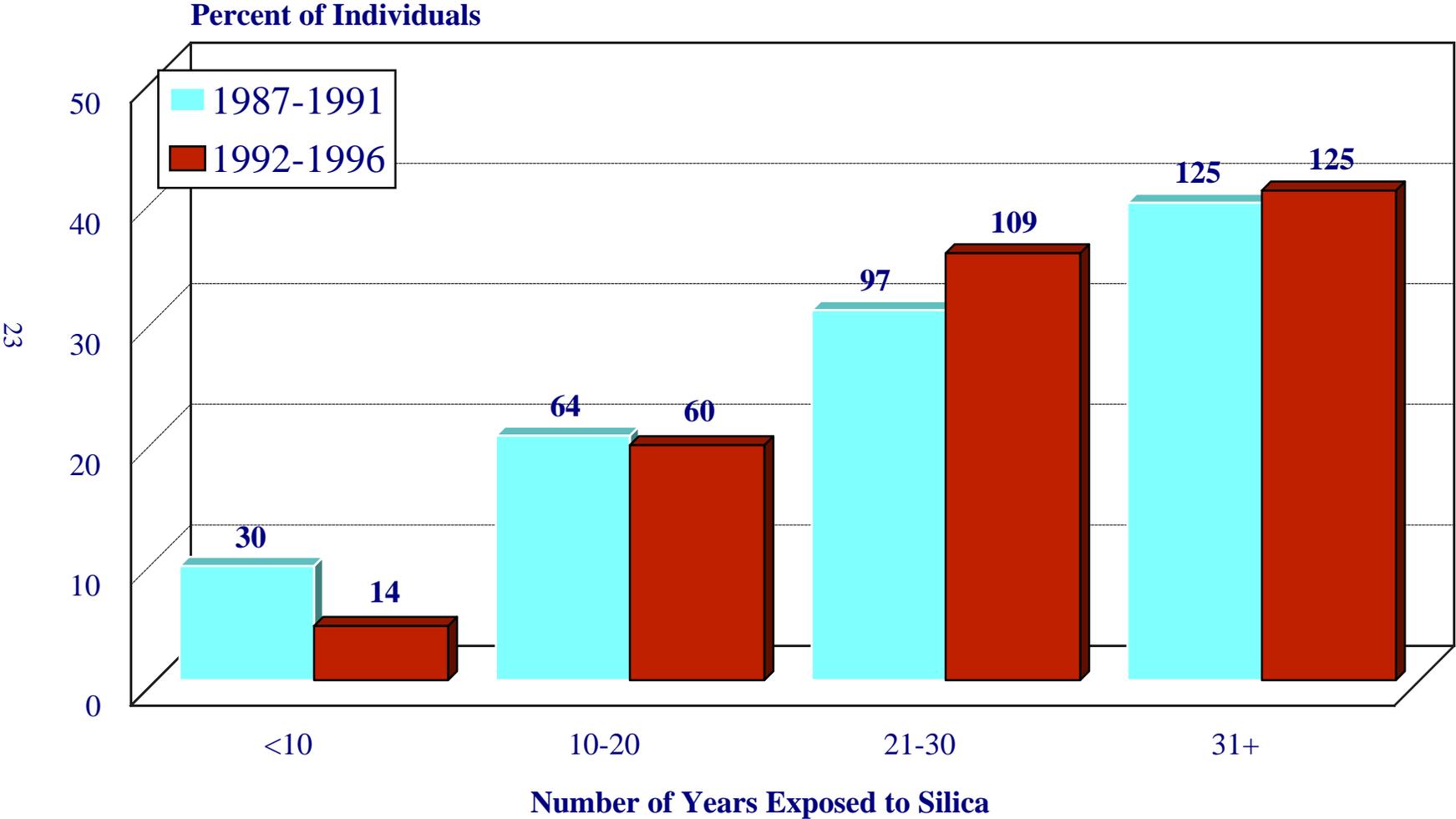
* Total number of individuals: 642.

Figure 12. Comparison of Decade of Hire Among Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996



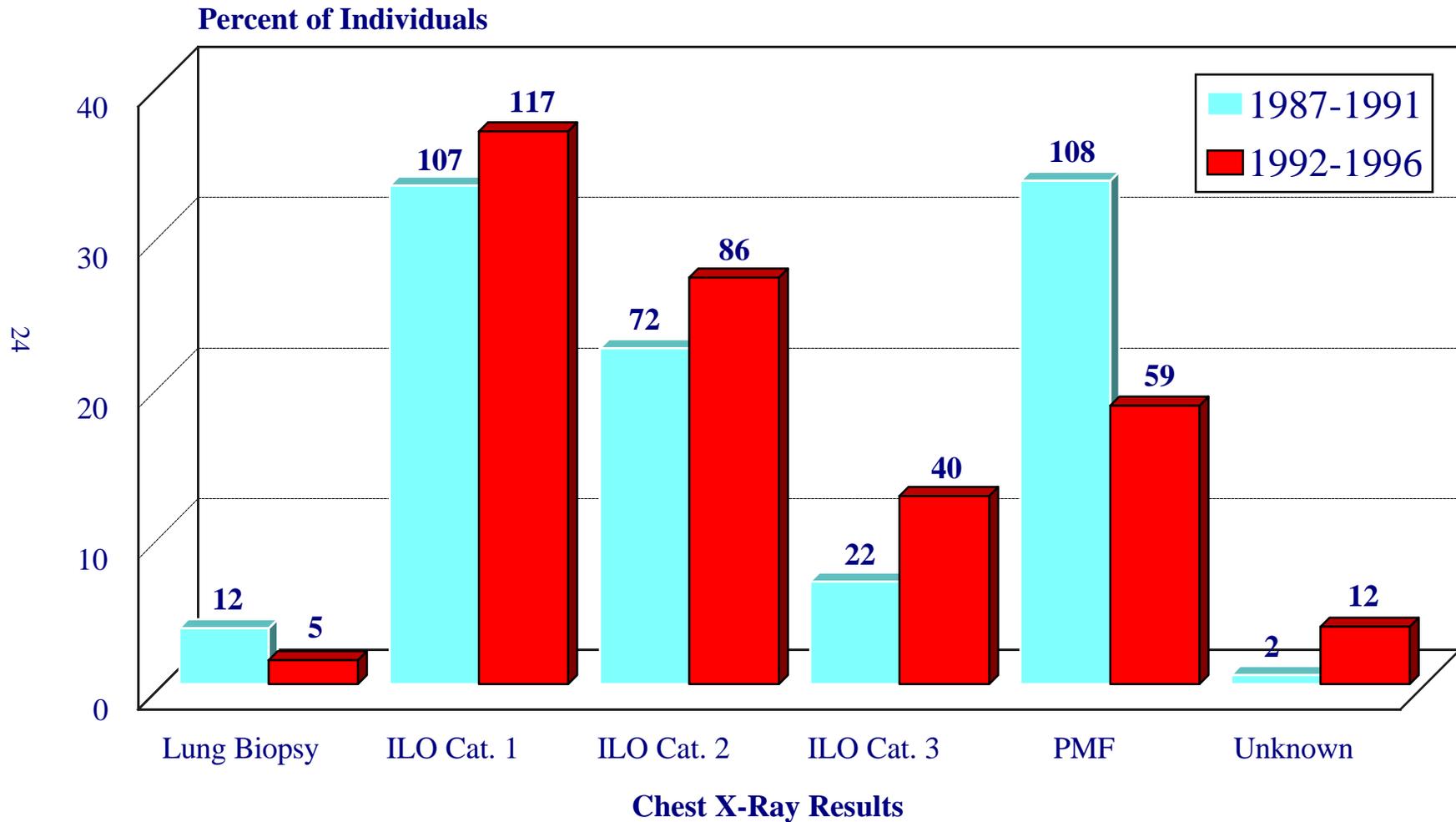
* Total number of individuals: 626. Decade of hire was unknown for 16 individuals.

Figure 13. Comparison of Duration of Exposure to Silica Among Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996



* Total number of individuals: 624. Duration of years exposed was unknown for 18 individuals.

Figure 14. Comparison of Severity of X-Ray Results* Among Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996**



* ILO Cat. 1-3: International Labor Organization categorization system for grading pneumoconioses; Cat. 1=1/0, 1/1, 1/2; Cat. 2=2/1, 2/2, 2/3; Cat. 3=3/2, 3/3, 3/+; PMF=Progressive Massive Fibrosis.

** Total number of individuals: 642.

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

	<u><1985</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>	<u>AllYears</u>
PR	--	--	--	--	--	7	5	5	16	6	7	27	28	13	9	123
HDC	--	--	--	68	57	41	44	36	54	31	36	35	36	24	0	462
DC	--	11	11	12	5	8	0	1	6	0	3	0	0	1	0	58
DL	10	12	13	7	7	4	6	6	2	4	28	0	0	0	0	99
ICFU	--	--	--	--	--	3	1	0	0	0	0	0	0	0	0	4
Total	10	23	24	87	69	63	56	48	78	41	74	62	64	38	9	746

*PR=physician referral; HDC=hospital discharge data; DC=death certificate; DL=department of labor; ICFU=index case follow up.

**Table 2. Primary Industry Where Silica Exposure Occurred
for Individuals Confirmed with Silicosis
for the Years 1985-1998**

<u>Industry (SIC code)*</u>	<u>Number of Individuals**</u>	
Manufacturing		
Primary Metal Industries (33) Includes iron, steel, gray & ductile iron foundries.	586	(78.9)
Stone, Clay, Glass and Concrete Products (32)	37	(5.0)
Transportation Equipment (37) Includes auto bodies and boat building.	27	(3.6)
Fabricated Metal Products (34)	10	(1.3)
Industrial Machinery (35)	8	(1.1)
Miscellaneous (25,26,28,30,36,38) Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment.	10	(1.3)
 Mining (10-14)	 19	 (2.6)
Construction (15-17)	35	(4.7)
Transportation, Communication, etc. Services (40-49)	5	(0.7)
Wholesale Trade (50)	1	(0.1)
Business and Repair Services (73,76)	2	(0.3)
Dental Laboratory (80)	3	(0.4)
<hr/>		
Total	743	(100.0)

* Standard Industrial Classification

** For three 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 1985-1998**

<u>X-Ray Results</u>	Percent FVC**					
	<u><60%</u>		<u>60-79%</u>		<u>>80%</u>	
	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>	<u>Ever Smoked</u>	<u>Never Smoked</u>
Biopsy Evidence	5 (31.3)	0 --	8 (50.0)	1 (33.3)	3 (18.8)	2 (66.7)
Unknown Severity	3 (27.3)	1 (33.3)	4 (36.4)	1 (33.3)	4 (36.4)	1 (33.3)
Category 1	37 (23.9)	14 (33.3)	53 (34.2)	10 (23.8)	65 (41.9)	18 (42.9)
Category 2	28 (31.5)	14 (38.9)	27 (30.3)	11 (30.6)	34 (38.2)	11 (30.6)
Category 3	9 (30.0)	10 (62.5)	12 (40.0)	3 (18.8)	9 (30.0)	3 (18.8)
PMF	31 (35.6)	13 (31.7)	30 (34.5)	15 (36.6)	26 (29.9)	13 (31.7)
Total	113 (29.1)	52 (36.9)	134 (34.5)	41 (29.1)	141 (36.3)	48 (34.0)

* Total number of individuals: 529. Information was missing for 217 individuals.

**Number, percentage in parentheses. Percentages represent the proportion of individuals in each of the x-ray result categories, within smoking status category (ever or never).

**Table 4. Ratio of Forced Expiratory Volume in 1 Second (FEV₁)
Divided by Forced Vital Capacity (FVC) by
X-Ray Results and Cigarette Smoking Status
for Individuals* Confirmed with Silicosis
for the Years 1985-1998**

<u>X-Ray Results</u>	FEV ₁ /FVC**							
	<u><40%</u>		<u>41-59%</u>		<u>60-74%</u>		<u>>75%</u>	
	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked	Ever Smoked	Never Smoked
Biopsy Evidence	2 (12.5)	1 (33.3)	3 (18.8)	0 (--)	5 (31.3)	2 (66.7)	6 (37.5)	0 (--)
Unknown Severity	0 (--)	0 (--)	0 (--)	0 (--)	1 (12.5)	2 (66.7)	7 (87.5)	1 (33.3)
Category 1	16 (10.4)	2 (4.8)	33 (21.4)	3 (7.1)	58 (37.7)	12 (28.6)	47 (30.5)	25 (59.5)
Category 2	3 (3.6)	2 (5.6)	18 (21.4)	5 (13.9)	36 (42.9)	9 (25.0)	27 (32.1)	20 (55.6)
Category 3	1 (3.4)	0 (--)	4 (13.8)	0 (--)	5 (17.2)	5 (31.3)	19 (65.5)	11 (68.8)
PMF	13 (15.5)	4 (9.8)	24 (28.6)	9 (22.0)	26 (31.0)	13 (31.7)	21 (25.0)	15 (36.6)
Total	35 (9.3)	9 (6.4)	82 (21.9)	17 (12.1)	131 (34.9)	43 (30.5)	127 (33.9)	72 (51.1)

* Total number of individuals: 516. Information was missing for 230 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 746 Individuals
Confirmed with Silicosis for the Years
1985-1998 were Exposed to Silica**

	<u>Number of Individuals Represented</u>	<u>Number of Facilities</u>	<u>Percent of Facilities</u>
Inspections	348	68	(24.5)
Closed	289	105	(37.8)
Out of State	45	43	(15.5)
Scheduled for Inspections	1	1	(0.4)
No Longer Use Silica	21	19	(6.8)
Unknown	15	15	(5.4)
Building Trade	26	26	(9.4)
Referred to MSHA	1	1	(0.4)
<hr/>			
Total	746	278	100.2*

*Percent does not add to 100 due to rounding.

**Table 6. Results of Industrial Hygiene Inspections
of 68 Facilities Where Individuals Confirmed
with Silicosis for the Years 1985-1998
were Exposed to Silica**

	<u>Number of Companies</u>	<u>Percent</u>
Air Sampling Performed	48	
Above NIOSH Recommended Standard for Silica	30	(62.5)
Above MIOSHA Enforceable Standard for Any Exposure	21	(43.8)
Above MIOSHA Enforceable Standard for Silica	20	(41.7)
Medical Surveillance Evaluated	59	
Periodic Chest Xrays with B Reader	5	(8.5)
Periodic Chest Xrays without a B Reader	2	(3.4)
Pre-employment Testing Only	19	(32.2)
No Medical Surveillance	22	(37.3)
Periodic Pulmonary Function Testing	15	(25.4)

**Table 7. Comparison of Primary Industry Where Silica Exposure Occurred
for Individuals Confirmed with Silicosis
by Years Reported: 1987-1991 and 1992-1996**

<u>Industry (SIC code)*</u>	<u>1987-1991**</u>	<u>1992-1996***</u>
Manufacturing		
Primary Metal Industries (33) Includes iron, steel, gray & ductile iron foundries.	254(78.9)	250 (78.9)
Stone, Clay, Glass and Concrete Products (32)	18 (5.6)	12 (3.8)
Transportation Equipment (37) Includes auto bodies and boat building.	15 (4.7)	9 (2.8)
Fabricated Metal Products (34)	5 (1.6)	5 (1.6)
Industrial Machinery (35)	2 (0.6)	3 (0.9)
Miscellaneous (25,26,28,30,36,38) Includes chemicals and allied products, rubber parts, metalworking machinery and dental equipment.	5 (1.6)	3 (0.9)
Mining (10-14)	10 (3.1)	8 (2.5)
Construction (15-17)	6 (1.9)	25 (7.9)
Transportation, Communication, etc. Services (40-49)	5 (1.6)	0 B
Wholesale Trade (50)	0 B	1 (0.3)
Business and Repair Services (73,76)	1 (0.3)	0 B
Dental Laboratory (80)	1 (0.3)	1 (0.3)
<hr/>		
Total	322	317

*Standard Industrial Classification

** For one worker, the industrial classification was not known. Number of individuals, percent.

***For two workers, the industrial classification was not known. Number of individuals, percent.

Table 8. Comparison of Ratio of Forced Expiratory Volume in 1 Second (FEV₁) Divided By Forced Vital Capacity (FVC) by Cigarette Smoking Status for Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996

FEV ₁ /FVC	1987-1991				1992-1996			
	<u>Ever Smoked</u>		<u>Never Smoked</u>		<u>Ever Smoked</u>		<u>Never Smoked</u>	
	#	%	#	%	#	%	#	%
<40%	20	(11.0)	7	(11.5)	12	(8.5)	1	(1.7)
41-59%	39	(21.5)	9	(14.8)	33	(23.4)	6	(10.0)
60-74%	65	(35.9)	18	(29.5)	49	(34.8)	19	(31.7)
>75%	57	(31.5)	27	(44.3)	47	(33.3)	34	(56.7)
Total	181		61		141		60	

Table 9. Comparison of Percent Predicted Forced Vital Capacity (FVC) by Cigarette Smoking Status for Individuals Confirmed with Silicosis by Years Reported: 1987-1991 and 1992-1996

<u>Percent FVC</u>	1987-1991				1992-1996			
	<u>Ever Smoked</u>		<u>Never Smoked</u>		<u>Ever Smoked</u>		<u>Never Smoked</u>	
	#	%	#	%	#	%	#	%
<60%	55	(29.3)	21	(34.4)	42	(28.8)	24	(40.0)
60-79%	63	(33.5)	20	(32.8)	49	(33.6)	15	(25.0)
>80%	70	(37.2)	20	(32.8)	55	(37.7)	21	(35.0)
Total	188		61		146		60	