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Silicosis Surveillance in New Jersey: Targeting Workplaces Using Occupational Disease and Exposure Surveillance Data

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To identify workplaces in New Jersey with potential for silica exposure, the New Jersey Department of Health compared four-digit Standard Industrial Classifications (SICs) identified by three different data sources: the National Occupational Exposure Survey (NOES), a new Jersey silicosis case registry, and regulatory agency compliance inspections in New Jersey. In total, the three data sources identified 204 SICs in New Jersey with potential for silica exposure. Forty-five percent of these SICs were identified by NOES only, 16% by registry cases only, 6% by compliance inspections only, and 33% by two or more sources. Since different surveillance sources implicate different SICs, this type of analysis is a useful first step in planning programs for prevention of silicosis.

Key words: surveillance data sources, silicosis, occupational disease, OSHA, MSHA, NOES, SICs, NJDOH

INTRODUCTION

Silicosis is a classic example of an occupational disease that can and should be prevented [Rutstein et al., 1983]. The key to prevention is identification of workplaces with potential for silica exposure, controlling the sources of exposure, and then periodic environmental monitoring to assure that exposure levels are below recommended exposure limits to prevent silicosis [National Institute for Occupational Safety and Health, 1986].

Recognizing that state health departments can play an important role in occupational disease surveillance, the National Institute for Occupational Safety and Health (NIOSH) has initiated cooperative agreements to build occupational disease

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surveillance capacity within state health departments. Under such an agreement begun in 1984, the New Jersey Department of Health (NJDOH) has developed a silicosis surveillance program [Valiante and Rosenman, 1989]. To identify workplaces in New Jersey with potential for silica exposure, the NJDOH compared four-digit Standard Industrial Classifications (SICs) identified by three different surveillance data sources: the National Occupational Exposure Survey (NOES) [Seta and Sundin, 1985], a New Jersey silicosis case registry, and compliance inspections in New Jersey by the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA). This report summarizes the results of this comparison.

BACKGROUND

Standard Industrial Classifications

The Standard Industrial Classification (SIC) system allows establishments to be categorized on a division, two-digit, three-digit, or four-digit code basis. For example, an employer primarily engaged in manufacturing gray iron castings would be placed in Divison D (manufacturing), two-digit SIC 33 (primary metal industries), three-digit SIC 332 (iron and steel foundries), and four-digit SIC 3321 (gray iron foundries) [Office of Management and Budget, 1972].

SICs are assigned on the basis of the primary economic activity of the establishment, determined by its principal product or groups of products produced or distributed, or services performed. In the context of surveillance, the SIC that has been assigned to an employer may have limitations, for example, in establishments with a wide range of industrial activity. Surveillance also may be complicated by changes in SICs related to revisions of the system in 1957, 1972, and 1987 [Office of Management and Budget, 1987].

Exposure Surveys

NIOSH has conducted two national surveys of potential hazardous exposures in general industry [Seta and Sundin, 1985]. The first, conducted in 1972–1974, was the National Occupational Hazard Survey (NOHS). The second, conducted in 1981–1983, was the National Occupational Exposure Survey (NOES). NOHS collected data on a probability sample of 4,536 facilities distributed among 67 geographic sampling units. Twenty surveyors performed walk-through evaluations of the facilities and recorded potential exposures of employees. In NOES, similar in design to NOHS, 15 surveyors collected data on 4,490 facilities in 98 geographic sampling units. For this article, we used information from the more current NOES survey.

The NOES survey has several limitations for purposes of silicosis surveillance. For example, facilities engaged in agriculture, mining, and government are excluded. Although NOES provides estimates of the potential number of workers with exposure, NOES does not include environmental measurement to evaluate the level or severity of exposure. Estimates of the number of workers with potential exposure from NOES computer tapes may vary depending on the number of hazardous agents containing silica that are tabulated. Approximately 100 different potential exposure agents are listed in NOES which may contain free silica. In addition, potential exposures to trade-name products are reported, for which the ingredients may be unknown.

Silicosis Case Registry

The NJDOH established a New Jersey silicosis case registry in 1984. Criteria for a confirmed case are (a) a history of occupational exposure to silica, and (b) a chest radiograph compatible with silicosis (profusion of small opacities International Labour Organization (ILO) Classification Category 1/0 or greater, or lung tissue pathology characteristic of silicosis [Valiante and Rosenman, 1989; Centers for Disease Control, 1990].

Sources of registry cases for this report included New Jersey hospital discharge data from 1979 to 1986, case reports from hospitals (required in New Jersey after October 1985), death certificates, and NJDOH medical screenings at identified companies. Each case is unique (i.e., a case is counted only once if identified on multiple hospital discharges).

Five hundred seventy-five individuals with a diagnosis of silicosis have been identified. Confirmed and unconfirmed cases account for 28% (161) and 54% (313) of the total cases, respectively. Inability to obtain medical records and chest x-ray films, particularly for cases in earlier years, explain the low percentage of confirmed cases. Coal miners diagnosed with silicosis account for the remaining 18% (101) of the Registry cases.

Compliance Inspection Data

OSHA workplace inspections are divided into two broad categories: unprogrammed and programmed inspections. Unprogrammed inspections are in response to imminent dangers, fatalities/catastrophes, complaints, referrals, and follow-ups. Programmed inspections are of worksites which have been scheduled (targeted) based upon selection criteria according to national sampling plans for safety or health or special emphasis programs. Inspections can be conducted in the manufacturing sector, at construction sites, or at maritime facilities.

Information collected by OSHA inspectors during visits to workplaces has been entered since 1979 into a computerized data system known as the Integrated Management Information System (IMIS) [Froines et al., 1986]. Examples of information include company name, address, SIC code, inspection type, contaminant sampled for, sample result, job title sampled, and citation data. The extent to which this database is complete and accurate is unknown (i.e., the files have not been audited to determine if all the exposure data collected by inspectors have been entered and correctly coded).

OSHA has a Health Inspection Plan for targeting health inspections [Office of General Industry Compliance Assistance, October 1, 1986]. Under this plan, OSHA analyzes IMIS data and calculates the ratio of the number of serious health violations found in a four-digit SIC to the number of inspections conducted by OSHA within that four-digit SIC during the previous five calendar years. Industries are then ranked according to the calculated ratios beginning with the highest ratio.

MSHA inspectors conduct safety and health inspections twice a year at full time surface mines and once a year at intermittent (seasonal) surface mines [Mineral Lands and Mining, 1986]. MSHA compliance data for New Jersey for this report are limited to surface mines because New Jersey has no currently operating underground mines.

MATERIALS AND METHODS

The 1972 SIC revision [Office of Management and Budget, 1972] was used for comparing different data sources. A list of four-digit SICs was identified from NOES as having potential for exposure to quartz, silica flour, sand, or flint. NJDOH staff determined the workplace where silica exposure had most likely occurred from the occupational history for each case in the NJDOH silicosis case registry. The occupational history was obtained by telephone interview of the case or from the next of kin listed on the death certificate. For purposes of this report, a case was considered to have identified a SIC as having potential for exposure to silica if the case most likely had resulted from exposures in that SIC. A list of the four-digit SICs associated with both confirmed and unconfirmed silicosis cases is available upon request from the NJDOH.

The OSHA regional office and MSHA district office provided data on four-digit SICs with respirable quartz values measured during compliance inspections in New Jersey between 1979 and 1986. The OSHA data were from IMIS. The MSHA data were from computerized files at the district office. For purposes of this report, OSHA and MSHA inspections were considered to have identified a SIC as having potential for exposure to silica if the time weighted average (TWA) respirable quartz value exceeded the limit of detection. OSHA and MSHA compliance data are presented separately because of the differences in initiating inspections and the different industries covered by these two federal enforcement agencies.

An overall list of four-digit SICs in New Jersey with potential for silica exposure was prepared by combining the lists of four-digit SICs from the NOES, confirmed and unconfirmed cases in the NJDOH silicosis case registry, and OSHA and MSHA compliance inspections for New Jersey. The proportion of four-digit SICs identified by different data sources was then determined.

Estimates of the total number of companies and workers in New Jersey in 1987 for each four-digit SIC were obtained from the New Jersey Department of Labor. Estimates of the number of workers with potential exposure to silica in New Jersey were then calculated by multiplying the proportion of workers with potential exposure to silica listed in NOES by the estimated number of workers in that four-digit SIC in New Jersey. For the four-digit SICs not identified in NOES, a certified industrial hygienist employed by the NJDOH estimated the proportion of workers with potential exposure, based on his experience with those industries in New Jersey.

Lists of four-digit SICs were rank-ordered for each data source. For four-digit SICs identified by NOES, the rank-order was based on the number of workers with potential exposure; for SICs identified by silicosis registry cases, the rank-order was based on the number of cases in these SICs; and for SICs identified by OSHA compliance inspections, the rank-order was based on SICs with the largest number of workers with potential exposure and having at least half of their compliance samples (minimum three) exceed the NIOSH Recommended Exposure Limit (REL) of 50 $\mu g/m^3$ air for respirable quartz. MSHA rank-ordered SICs were not included because of the large number of samples taken in the relatively few SICs covered.

As a possible model for developing priorities for targeting SICs for additional followup, the top six four-digit SICs from each list were combined and rank-ordered based on the number of workers with potential exposure. The number of compliance samples per 1,000 workers potentially exposed was calculated by dividing the number

TABLE I. Four-Digit Standard Industrial Classifications (SICs), Companies, and Workers With Potential for Silica Exposure in New Jersey Identified by Different Data Sources*

	n		
Data source	4-digit SICs	Companies	Workers[a]
NOES	151	38,484	23,185
Registry	88	19,840	12,603
OSHA	43	8,189	7,511
MSHA	7	84	750
All sources[b]	204	41,260	25,572

*NOES = National Occupational Exposure Survey; Registry = New Jersey Silicosis Registry Cases—confirmed and unconfirmed; OSHA = compliance inspections by the Occupational Safety and Health Administration; MSHA = compliance inspections by the Mine Safety and Health Administration.

[a]Based on NOES and NJDOH estimates of workers potentially exposed.

[b]Unique.

of compliance samples by the potential workers exposed. The proportion of silica compliance samples exceeding the NIOSH REL also was determined [National Institute for Occupational Safety and Health, 1974].

RESULTS

A total of 159 four-digit SICs were identified from NOES with potential exposure to quartz, silica flour, sand, or flint. In New Jersey, there were 151 four-digit SICs comprising companies, cases, and/or workers in that SIC (Table I).

The NJDOH silicosis case registry had 575 potential silicosis case reports between 1979 and 1987. One hundred sixty-one cases were confirmed and 313 were unconfirmed cases. NJDOH staff were able to identify a workplace where the silica exposure had most likely occurred in 356 of these cases. The silica exposure had most likely occurred in 167 workplaces. These were in 88 four-digit SICs (Table I).

The OSHA IMIS data for New Jersey between 1979 and 1986 included 191 respirable air samples with silica exposures greater than the limit of detection. These had been collected at 67 workplaces, and in 43 different four-digit SICs. MSHA compliance data for New Jersey from 1979 to 1986 included 584 respirable air samples with silica exposures greater than the limit of detection. These had been collected at 73 mines and quarries, and in 7 different four-digit SICs (Table I).

Combining lists of SICs with potential for silica exposure from NOES, confirmed and unconfirmed cases, and compliance data resulted in a total of 204 four-digit SICs (Fig. 1). Forty-five percent of these SICs were identified by NOES only, 6% by compliance inspection reports only, and 16% by registry cases only. Thirty-three percent of the SICs were common to two or more data sources. Only 9% were common to all three sources.

SICs identified by cases were compared with SICs identified by other data sources. NOES identified 47 of the 88 (53%) four-digit SICs with silicosis cases. These SICs accounted for (60%) of the 356 total cases with identified SICs. OSHA

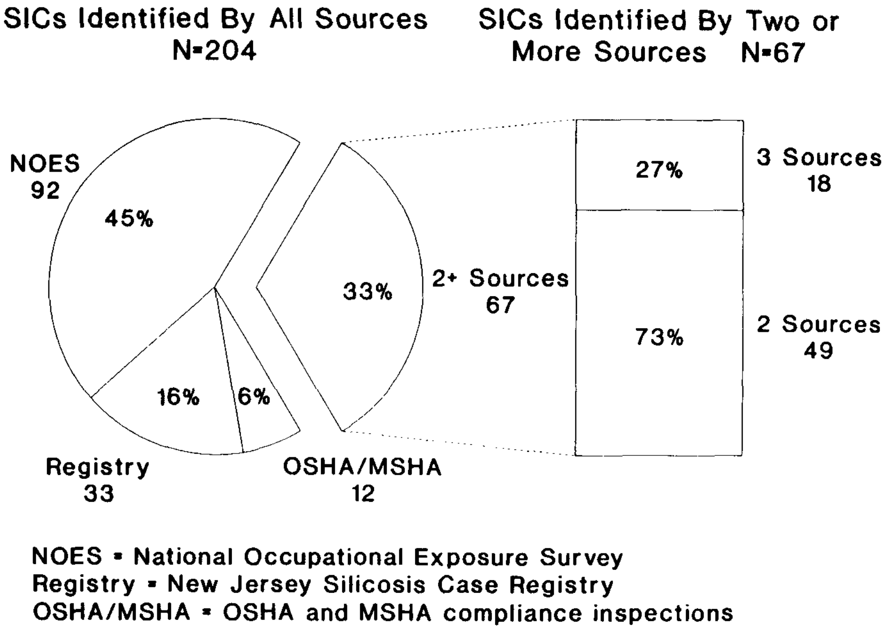

Fig. 1. Distribution of SICs with potential for silica exposure identified from three sources.

compliance data identified 23 of the 88 (26%) SICs with cases. These SICs accounted for 54% of the total cases. MSHA compliance data identified 3 of the 7 mining SICs with cases. These SICs accounted for 7% of the total cases. Eighteen of the 88 SICs with cases were identified by both OSHA data and NOES. These SICs accounted for 43% of the total cases.

Silica levels from the 43 SICs with OSHA compliance inspection data were compared between SICs with and without cases. This was without regard as to whether the compliance inspection had been conducted in the same workplace as the case. Seventy-eight percent of the 23 SICs with cases had at least one silica measurement (TWA) exceeding the NIOSH REL of 50 $\mu g/m^3$ for silica, compared with 60% of the 20 SICs without cases ($p = 0.19$, chi-square test).

Combining the top six four-digit SICs identified from lists for NOES, confirmed and unconfirmed cases, and OSHA compliance data resulted in a total of 16 different four-digit SICs (Table II). For these 16 SICs, a total of 13,173 New Jersey workers were potentially exposed to silica. Twelve of the 16 SICs (75%) had identified cases of silicosis accounting for 49% of the total cases with SICs.

Fourteen SICs were under the jurisdiction of OSHA. Nine SICs (64%) had compliance samples taken by OSHA, with 71% of these samples (55 of 78) exceeding the NIOSH REL. The number of samples that had been collected by OSHA ranged from 0 to 579 samples per 1,000 workers potentially exposed. Two SICs (3261 and 3321) accounted for 65% of the total silicosis cases in these 14 SICs. SIC 1446 and 1011 fall under MSHA regulations.

DISCUSSION

Identification of workplaces with potential silica exposure is one of the first steps in planning silicosis prevention programs. Unfortunately, this information is not

TABLE II. The Top Six Standard Industrial Classifications (SICs) on Lists of Numbers of: Workers in New Jersey With Potential Silica Exposure; Silicosis Cases in New Jersey; and Respirable Silica Samples During Compliance Inspections in New Jersey by the Occupational Safety and Health Administration (OSHA)*

			n					
SIC	Description	Data source	Potential workers exposed	Cases	Companies with samples	Samples	Samples per 1,000 workers	Samples REL (%)
7349	Building maintenance services, NEC	N	3,446	0	0	0	0	0 (0)
1741	Masonry and other stonework	NRC	2,420	6	1	2	1	2 (100)
1761	Roofing and sheet metal work	N	1,736	0	0	0	0	0 (0)
1742	Plastering, drywall, insulation work	N	1,291	0	0	0	0	0 (0)
1521	Single-family housing construction	NR	978	1	0	0	0	0 (0)
1771	Concrete work	NR	855	1	0	0	0	0 (0)
2891	Adhesives and sealants	NC	758	0	2	3	4	2 (67)
3261	Vitreous plumbing fixtures	NRC	631	53	2	5	8	3 (60)
1446	Sand and gravel	RC	494[a]	19	46	367	743	169 (46)
3296	Mineral wool	NRC	196	2	1	5	26	5 (100)
3264	Porcelain electrical supplies	RC	137[a]	17	1	2	15	0 (0)
3399	Primary metal products, NEC	RC	82[a]	1	1	5	61	3 (60)
3321	Gray iron foundries	NRC	76	37	7	44	579	28 (64)
3362	Brass, bronze, copper, foundries	NRC	41	1	1	6	146	6 (100)
3253	Ceramic wall and floor tile	NRC	32	20	1	6	188	6 (100)
1011	Iron ore mining	R	0[b]	18	0	0	0	0 (0)
Total			13,173	176	63	445		224 (50)

*N = National Occupational Exposure Survey; R = New Jersey Silicosis Case Registry; C = OSHA compliance inspections; NEC = not elsewhere classified; REL = Recommended Exposure Limit (50 $\mu g/m^3$).
[a]Estimate by New Jersey Department of Health (not available from NOES).
[b]Mines no longer in operation.

easily obtained because of the multitude of industries using silica and materials containing silica, the difficulties in assessing exposure at these workplaces, and because single disease or exposure data sources do not provide a comprehensive summary of industries where silicosis might occur. Comparing and contrasting the three surveillance data sets and their unique and their overlapping contributions underscores that each is different, each has advantages and limitations, and each is best viewed as a starting point giving hints as to where further evaluation might be appropriate, rather than as the definitive answer.

The silicosis case registry allows SICs to be identified where exposures in the past have been severe enough to cause disease and where such exposures may be continuing. Disease surveillance is advantageous from the perspective of a state health department because mortality and morbidity data already collected for other reasons can be analyzed at relatively low cost. A disadvantage is that workers have to become sick or die before a problem may be noted. Another disadvantage is that health care providers may use variable diagnostic criteria and may not report cases. Also, silicosis may take 20 or more years to become clinically apparent. The latency between exposure and detection of disease may create difficulties in locating and contacting individuals and obtaining complete work histories to identify suspect

TABLE III. Options for Targeting Silicosis Surveillance Efforts, the Advantages and Disadvantages of Those Options, and Examples of the Standard Industrial Classifications (SICs) That Might be Targeted in New Jersey

Option 1: Concentrate activities in industries with multiple cases of silicosis	
Advantages:	Direct causal relationship between job and diseases; may help convince employers that real problem exists; may facilitate obtaining right of entry
Disadvantages:	Disease has already occurred; latency period; probable regulatory agency involvement
Examples of SICs that might be targeted in New Jersey:	
	SIC 14—sand mines
	SIC 32—potteries
	SIC 33—foundries
Option 2: Concentrate activities in industries with cases and little or no regulatory agency involvement	
Advantages:	Increased awareness of disease in affected population; intervention where it is needed
Disadvantages:	Research needed to determine silicosis hazard; silica exposure may occur in relatively small numbers of workers.
Examples of SICs that might be targeted in New Jersey:	
	SIC 17—gunite spraying
	SIC 28—antibiotic production
	SIC 59—jewelry (gold) polishing
Option 3: Concentrate activities in industries with silica exposure data but no cases; the lack of cases may be the result of physicians' being unaware of the link between the specific industry, silica exposure, and silicosis	
Advantages:	Determines if a silica hazard actually exists
Disadvantages:	Silicosis hazard may not exist
Examples of SICs that might be targeted in New Jersey:	
	SIC 38—watch manufacturing
	SIC 75—auto body shops
Option 4: Combination of options 1, 2, and 3	

workplaces. Additionally, environmental changes or business changes may have occurred in the interim. For example, workplaces identified by disease surveillance may have closed, moved out of state, changed processes, installed environmental controls, no longer work with silica, or be operating under a different name.

Measurement of silica dust levels is the most effective means of identifying problem areas, directing control efforts, and subsequently measuring the impact of environmental exposure reduction strategies [National Institute for Occupational Safety and Health, 1986]. Environmental hazard surveillance is essential for preventing silicosis in workers now starting to work in jobs with potential exposure. Environmental sampling is sufficiently time-consuming and resource intensive that a typical state health department would not have sufficient resources and staff to do extensive sampling. However, since state health departments have epidemiological expertise and access to other surveillance data sources, they potentially might have a significant role in the analysis of environmental data collected by regulatory agencies. Intervention strategies are most likely to be improved if very clear targets can be described. The use of IMIS data to target health inspections tends to emphasize SICs where violations have already been documented [Pollack and Keimig, 1987]. Table II illustrates that compliance inspections often have been in SICs traditionally associated with incidence of silicosis (e.g., SICs 14, 32, 33). The comparison of SICs identified by different surveillance sources underscores that other SICs also may need attention and that gaps exist in current strategies for compliance inspections.

As a first step in developing plans for prevention of silicosis, other States might consider doing an analysis similar to Table II. A state could use the results of this analysis to prepare a single list of four-digit SICs, rank-ordered as desired by the state. For a state beginning silicosis surveillance, Table III outlines a number of options available to direct intervention strategy at targeted industries. The use of this targeting system is not limited to silicosis. Surveillance of other occupationally related morbidity, such as heavy metal poisoning, can provide targets for workplace intervention [Rudolph et al., 1990]. Identification of elevated blood lead levels through laboratory and physician reporting, OSHA compliance data, NIOSH NOES, and environmentally based industry surveys can be utilized to compile a list of industries where lead exposure is a potential problem. Medical, industrial hygiene, and educational resources can then be efficiently allocated to those companies having the greatest hazard potential or needing assistance to manage a lead exposure problem. Clearly, occupational disease surveillance will require appropriate targeting strategies for intervention, if it is going to achieve the success of the traditional surveillance system in communicable disease.

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