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Targeting of Workplace Inspections for Lead

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The prevention of occupational lead poisoning requires identification of worksites with ongoing excessive lead exposures. The utility of different sources of surveillance data in identifying worksites was evaluated by comparing a list of companies inspected by the Occupational Safety and Health Administration (OSHA) for lead with 1) Ohio Bureau of Workers' Compensation (BWC) claims for lead poisoning, and 2) the New York Health Department's Heavy Metal Registry (NYHMR) reports of individuals with elevated blood lead levels. For the period 1981 through 1985, the NYHMR identified 179 companies with at least one employee having an elevated blood lead level. Of the 134 OSHA inspections conducted in New York during the same time period, 23 (17%) companies were identified by the NYHMR. In Ohio from 1979 through 1985, 50 companies had workers' compensation claims filed against them involving documented elevated blood lead levels. OSHA inspected 306 companies; 23 (7.5%) were identified by the BWC. In both states, companies inspected by OSHA were concentrated in larger industries with traditional, well-recognized lead hazards (e.g., primary metal and fabricated metals). Companies identified by compensation claims and laboratory reports tended to be in industries dominated by smaller establishments where lead is not a primary part of the industrial process (e.g., automotive repair and construction). Sources of surveillance data, such as workers' compensation claims and laboratory reports, identify worksites that tend not to be routinely inspected by OSHA and which need intervention to prevent excessive lead exposure. To maximize the impact of public health resources devoted to the elimination of occupational lead poisoning, follow-up efforts at companies identified by state health departments and workers' compensation systems offer an important opportunity to complement OSHA's inspection efforts.

Key words: occupational lead poisoning, surveillance, workers' compensation, OSHA, blood lead levels

INTRODUCTION

In the United States, there currently exist regulations to limit workplace exposure to lead, goals to eliminate occupational lead poisoning, and a thorough understanding of the means of preventing this condition [OSHA, 1978; U.S. Department of Health and Human Services, 1980; Goble et al., 1983]. Despite the existence of these essential elements in controlling lead poisoning, cases of work-related lead

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intoxication continue to occur [Kaye et al., 1987; Goldman et al., 1987; Centers for Disease Control, 1989b].

As of January 1, 1991, 14 state health departments have established or are actively developing blood lead surveillance programs [NIOSH, unpublished]. These efforts have documented that excessive lead exposure continues to be a major public health problem, with four states (California, New Jersey, New York, Texas) reporting 1,926 adult cases of elevated blood lead levels in 1987 [Centers for Disease Control, 1989a]. California alone accounted for 1,293 of these reports [Maizlish et al., 1990]. The foregoing, coupled with the observation that there has been limited improvement in airborne lead exposures in high lead industries [Froines et al., 1990], points to the need for a more effective approach toward improving the workplace environment in industries where lead hazards exist.

To evaluate the usefulness of surveillance in targeting for inspection worksites/plants with potential ongoing lead hazards, we compared data from the Occupational Safety and Health Administration's (OSHA) Integrated Management Information System (IMIS) to: 1) companies having cases of lead poisoning identified by the Ohio Bureau of Workers' Compensation (BWC); and 2) companies having employees with elevated blood lead levels reported to the New York Health Department's Heavy Metal Registry (NYHMR).

METHODS

OSHA Integrated Management Information System (IMIS)

For the seven-year period, 1979 through 1985 inclusive, all inspections conducted by OSHA in Ohio and New York for lead or lead-containing compounds and recorded in OSHA's Integrated Management Information System (IMIS) by April 1, 1986 were reviewed. The IMIS system contains information on the name of the company, the type of substance sampled (e.g., lead, lead chromate), the type of inspection (e.g., planned, complaint, follow-up, or referral), the job titles sampled, the number and type of air samples, the results of the sampling (e.g., air lead level in milligrams per cubic meter of air), the sections of the OSHA lead standard violated, and the degree of violation. The OSHA permissible exposure limit (PEL) for an 8-hour time-weighted average exposure of 0.05 mg/M^3 was used to determine whether or not a lead hazard existed at the time of the inspection [U.S. Department of Labor, 1980]. We defined a company as having a lead hazard if one air sample was at or above the PEL. The highest measured sample for a company was used for all subsequent analyses.

New York Heavy Metal Registry

During the period of this study, the State of New York's Heavy Metal Registry (NYHMR) required the reporting by hospitals, laboratories, and physicians of any blood lead level (PbB) greater than or equal to 40 micrograms per deciliter ($\mu g/dl$) [New York State Sanitary Code, 1980]. The registry began collecting data in 1981. A thorough description of the NYHMR is presented elsewhere (Baser et al., 1990]. All reports to the NYHMR for the five-year period 1981 through 1985 (excluding the last three months of 1985) were categorized by standard industrial classification (SIC) [Office of Management and Budget, 1972] and a list of New York companies identified by the surveillance mechanism was prepared. This list was compared with the

names of companies inspected by OSHA between 1981 and 1985. Mean ambient lead levels (as determined from the OSHA data) and blood lead levels from the NYHMR were compared for the companies identified by both OSHA and the NYHMR. Mean lead exposures were compared for those companies identified by both the NYHMR and OSHA with those identified only by OSHA. Similarly, mean PbBs of those companies identified by both data sources were compared with mean PbBs of those companies identified only by the NYHMR. The SIC codes in the non-overlapping companies were compared.

Ohio Workers' Compensation Claims

The Bureau of Workers' Compensation (BWC) receives claims for occupational lead poisoning from Ohio workers. Prior to 1983, an occupational disease claim was coded only if one or more lost work days was incurred. Since 1983, all occupational disease claims are coded, regardless of whether or not lost work days are incurred. For self-insured companies, injury or disease claims must be filed with the BWC if seven or more lost work days have occurred as a result of a particular event.

All coded claims for the seven-year period 1979 through 1985 were reviewed. For a claim to be considered a case of lead poisoning, a PbB $\geq$ 50 μg/dl or a physician's statement of an elevated blood lead level had to appear in the medical file accompanying the claim [Seligman et al., 1986]. A list of companies with cases of lead poisoning was compiled and compared with the list of OSHA lead inspections for the same seven-year period, 1979–1985. The levels of lead exposure and the blood lead levels of companies identified by the BWC and OSHA were compared with those identified by one or the other system, in a manner similar to the treatment of the NYHMR data.

RESULTS

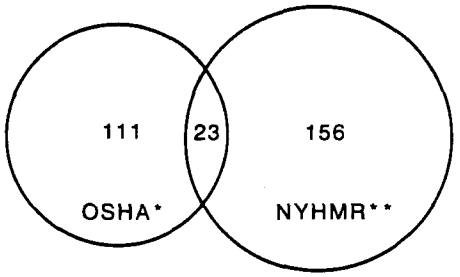
New York Heavy Metals Registry

From 1981 through 1985, the seven New York-area offices of OSHA (Syracuse, Albany, Manhattan, Queens, Long Island, Rochester, and Buffalo) reported 157 lead-related inspections at 134 companies in the state of New York to the OSHA IMIS system. Of these 157 inspections, 92 (59%) were planned, 50 (32%) were complaint, and the remaining 15 (9%) were either follow-ups, referrals from other agencies, or the result of other requests or circumstances.

During a similar time period, 1981–1985, the New York Heavy Metals Registry received 1,349 reports of elevated blood lead levels representing 179 companies. Of these 179 companies, 23 (13%) had been inspected by OSHA (Fig. 1A). If OSHA inspection records back to 1979 are used, then 39 (22%) of the companies in the NYHMR were identified.

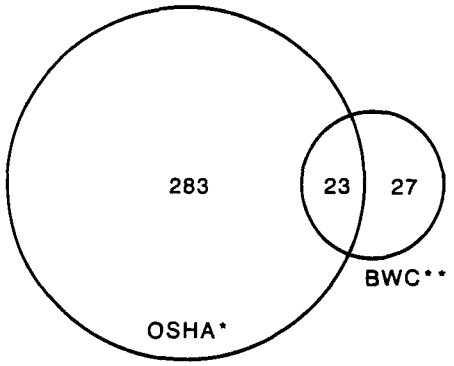
Of the 134 companies inspected by OSHA, 23 (17.2%) were identified by the NYHMR. Of these 23 companies, 17 (73.9%) were found on inspection to have lead exposures in excess of the OSHA PEL. In comparison, 11 (9.9%) of 111 companies inspected by OSHA but *not* identified by the NYHMR had exposures in excess of the PEL (Table I).

The mean exposures of companies identified by both OSHA and the NYHMR were considerably higher than those identified by OSHA alone (0.053 mg/M^3 vs. 0.008 mg/M^3). No data were available for lead exposures in those companies iden-



A

* Federal Occupational Safety and Health Administration
** New York Heavy Metals Registry



B

* Federal Occupational Safety and Health Administration
** Ohio Bureau of Workers' Compensation

Fig. 1. **A:** Companies inspected by OSHA; companies identified by the NYHMR, New York, 1981–1985. **B:** Companies inspected by OSHA; companies identified by the BWC, Ohio, 1979–1985.

tified by the NYHMR alone. However, we may infer, based on the observation that mean PbBs were similar in companies identified solely by the NYHMR and by both data sources (50.31 vs. 49.39 μg/dl), that exposures in those companies appearing exclusively in the NYHMR may be similar to companies identified by the NYHMR and inspected by OSHA (Table II). Of the 156 companies identified by the NYHMR and not known to OSHA, 82 (53%) were found to have at least one PbB greater than or equal to the current OSHA Medical Removal Protection (MRP) value of 50 μg/dl. For the first nine months of 1985, 29 (56%) of the 52 companies identified by the NYHMR had at least one reported PbB at or above the OSHA MRP level.

The Standard Industrial Classifications (SICs) of the companies identified by the NYHMR were ranked by two-digit SICs. Only those SICs with three or more companies were ranked. This list was compared with the SICs for OSHA inspections (Table III). The ranks were significantly different, with the NYHMR identifying automobile repair, services, and garages, and general and special trade contractors in the construction industry more frequently compared with the OSHA inspections (Spearman rank correlation $r = 0.59$, $p = 0.0003$) [Snedecor et al., 1967].

Ohio Workers' Compensation Claims

For the seven-year period 1979–1985 inclusive, 181 claims for occupational lead poisoning were reported to the Ohio Bureau of Workers' Compensation. A

TABLE I. Companies Inspected by OSHA for Lead, New York, 1981–1985*

	Lead exposure[a]		Total no. of cases
	High	Low	
Identified by NYHMR[b]			
Yes	17	6	23
No	11	100	111
Total	28	106	134

*Conditional probability P(High/Yes) ± 2 SD = 73.9% ± 10.2; Conditional probability P(High/No) ± 2 SD = 9.9% ± 6.9. The probability of company having excessive lead exposure given that it is identified in the NYHMR is 73.9%. The probability of company having lead exposure in excess of the OSHA PEL given that it is *not* identified in the NYHMR is 9.9%.

[a]Lead exposure ≥ OSHA PEL of 0.050 mg/M^3.

[b]New York Heavy Metals Registry. A company was identified if an employee was reported to the NYHMR with a blood lead level ≥ 40 μg/dl.

TABLE II. Comparison of Mean Lead Exposure and Blood Lead Levels in New York Companies (1981–1985)

	No. of companies	Exposure[a] (CI[b]) mg/M^3	No. > PEL[c]	PbB[d] μg/dl	# > MRP[e]
OSHA	134	0.008 (0.005–0.012)	28 (21%)		
NYHMR + OSHA	23	0.053 (0.022–0.130)	17 (74%)	49.39(± 6.10)	14 (61%)
NYHMR	156			50.31(± 7.48)	82 (53%)

[a]Geometric mean of 8-hour TWA samples for lead in mg/M^3.

[b]95% confidence interval.

[c]Permissible exposure limit of 0.050 mg/M^3.

[d]Arithmetic mean of blood lead levels.

[e]Medical removal protection limit of 50 μg/dl whole blood.

workers' compensation claim was considered a case if evidence was available on the medical record accompanying the claim of excessive lead absorption, defined as a blood lead level (PbB) ≥ 50 μg/dl or a physician's statement of an "elevated blood lead level." Of the 181 claims filed, 140 (77%) were documented as cases. These cases occurred in 50 companies.

During the same seven-year period, 337 lead-related inspections at 306 companies were conducted by the four Ohio area OSHA offices (Cincinnati, Cleveland, Columbus, and Toledo). Of these 337 inspections, 101 (30%) were planned, 188 (56%) were complaint, and the remaining 48 (14%) were either follow-ups or referrals from other agencies.

Of these 306 companies inspected by OSHA, 23 (7.5%) were identified in the review of BWC cases (Fig. 1B). Of these 23 companies inspected by OSHA, 20 (87.0%) companies were found on inspection to have lead exposures in excess of the OSHA PEL. By comparison, 77 (27.2%) of 283 companies inspected by OSHA but *not* identified by the BWC had exposures in excess of the PEL (Table IV). Compa-

TABLE III. Rank of Companies by SIC, Reported To NYHMR vs. Inspected By OSHA, 1981–1985

Standard industrial classification	Rank (No. of companies) NYHMR	Rank (No. of companies) OSHA
75 Automotive repair, services, and garages	1 (27)	10 (5)
33 Primary metal industries	2 (22)	1 (23)
34 Fabricated metal products, except machinery/transport	3 (19)	4 (18)
16 Construction other than building—general contractors	4 (13)	[a]
17 Construction—special trade contractors	4 (13)	5 (11)
28 Chemicals and allied products	6 (8)	8 (6)
50 Wholesale trade—durable goods	6 (8)	16 (1)
92 Justice, public order, and safety	6 (8)	[a]
35 Machinery, except electrical	9 (7)	1 (23)
36 Electrical & electronic machinery, equipment and supplies	9 (7)	1 (23)
37 Transportation equipment	11 (6)	6 (10)
15 Building construction—general contractors	12 (4)	14 (2)
32 Stone, clay, glass, and concrete products	12 (4)	7 (8)
82 Educational services	12 (4)	[a]
27 Printing, publishing, allied industries	15 (3)	8 (6)
48 Communication	15 (3)	[a]

[a]No companies reported in SIC.

TABLE IV. Companies Inspected by OSHA for Lead, Ohio, 1979–1985*

	Lead exposure[a]		Total no. of cases
	High	Low	
Identified by BWC[b]			
Yes	20	3	23
No	77	206	283
Total	97	209	306

*Conditional probability P(High/Yes) ± 2 SD = 87.0% ± 11.8; Conditional probability P(High/No) ± 2 SD = 27.2% ± 15.6. The probability of company having excessive lead exposure given that it is identified by the BWC is 87.0%. The probability of company having lead exposure in excess of the OSHA TLV given that it is *not* identified by the BWC is 27.2%.

[a]Lead exposure ≥ OSHA PEL of 0.050 mg/M^3.

[b]Ohio Bureau of Workers' Compensation. A company was identified if medical information accompanying the workers' compensation claim indicated that the employee had an elevated blood lead level or a PbB ≥ 50 μg/dl.

nies identified by both OSHA and BWC had higher mean lead exposures than those companies identified by OSHA alone (0.173 mg/M^3 vs. 0.017 mg/M^3) (Table V).

The Standard Industrial Classifications (SICs) of the companies identified by the BWC were ranked by two-digit SICs. Only those SICs with three or more companies were ranked (Table VI). This list was compared with the SICs for OSHA inspections. The BWC identified special trade and general contractors in the construction industry more frequently when compared with the OSHA inspections (Spearman rank correlation r = 0.57, p = 0.007) [Snedecor et al., 1967].

TABLE V. Comparison of Mean Lead Exposure in Ohio Companies, 1979–1985

	No. of companies	Exposure[a] (CI[b]) mg/M^3	No. > PEL[c]
OSHA	283	0.017 (0.013–0.022)	97 (34%)
BWC + OSHA	23	0.173 (0.075–0.397)	20 (87%)

[a]Geometric mean of 8-hour TWA samples for lead in mg/M^3.
[b]95% confidence interval.
[c]Permissible exposure limit of 0.050 mg/M^3.

DISCUSSION

In this paper, we compare the experience of those companies inspected by OSHA for lead with those companies whose workers had filed a claim for compensation for lead poisoning in Ohio or whose workers had been reported to a laboratory-based surveillance system in New York. The data indicate that companies identified through surveillance based on workers' compensation claims or laboratory reports and identified by OSHA are likely to have excessive lead exposure, and thus, a greater potential for lead poisoning, than those companies inspected by OSHA and *not* detected by the surveillance systems. In order to meet the goal of eliminating occupational lead poisoning, sources of surveillance data need to be used to target intervention efforts to those plants having the worst experience.

Surveillance in public health has been defined by Langmuir as the systematic collection, consolidation, and evaluation of the distribution of and trends in disease morbidity and mortality, and the dissemination of these data to those "who need to know." [Langmuir, 1963] Rutstein et al. [1983] have defined a sentinel health event as the occurrence of a "disease, disability, or untimely death" that serves as a "signal that the quality of preventive medical care may need to be improved."

In both approaches to surveillance, the recognition of a failure to prevent illness is vital in directing further public health interventions to prevent subsequent failures. Surveillance and intervention represent two arms of a reflex arc. The use of surveillance to identify areas of disease outbreaks in the campaign to eradicate smallpox and to identify health professionals and practices with cases of maternal perinatal mortality [New York Academy of Medicine, 1933] are two examples that demonstrate the use of surveillance in targeting intervention.

The prevention of occupational disease in general, and occupational lead poisoning in particular, has not often utilized the surveillance/intervention arc. Rather, prevention has depended on the promulgation, promotion, and adherence to regulations designed to prevent lead poisoning. OSHA's efforts to ensure adherence have depended on routinely scheduled inspections or on inspections initiated in response to complaints by workers. General or routine inspections may be constrained by both policy decisions and the number of available OSHA inspectors. While there is provision in the OSHA Lead Standard for biological monitoring of workers exposed beyond the action level, there is no provision for the collection, analysis, or use of these data to target future OSHA inspections.

The comparisons made in this article depend on both the quality and completeness of the OSHA IMIS data system. Virtually all records of OSHA inspections where environmental lead sampling was performed are part of the IMIS system. The

TABLE VI. Rank of Companies by SIC, Reported To BWC vs. Inspected By OSHA, 1979–1985

Standard industrial classification	Rank (No. of companies) BWC	Rank (No. of companies) OSHA
33 Primary metal industries	1 (14)	1 (62)
17 Construction—special trade contractors	2 (11)	11 (5)
34 Fabricated metal products, except machinery/transport	3 (5)	2 (54)
35 Machinery, except electrical	4 (4)	3 (49)
36 Electrical and electronic machinery, equipment and supplies	4 (4)	5 (22)
50 Wholesale trade—durable goods	4 (4)	13 (3)
16 Construction other than building—general contractors	7 (3)	[a]
28 Chemicals and allied products	7 (3)	6 (15)
37 Transportation equipment	7 (3)	4 (38)
92 Justice, public order, and safety	7 (3)	14 (2)
30 Rubber and miscellaneous plastic products	11 (2)	8 (10)
55 Automotive dealers and gasoline service stations	11 (2)	12 (4)

[a]No companies in SIC.

IMIS is probably less complete for those companies inspected by OSHA for lead for which no sampling was obtained. Such a systematic underreporting would bias the Venn diagrams (Fig. 1A, B) toward underestimating the overlap in companies identified. The effect of OSHA inspections conducted prior to 1979, when the Lead Standard came into effect, was not considered in this comparison. Similarly, visits by OSHA consultative programs, which are not recorded in the IMIS, may account for companies that instituted blood lead monitoring programs and thus appear in the NYHMR or BWC records. Estimating the magnitude of these potential biases would require examinations of the OSHA area office and OSHA consultative files.

In the years following institution of the Lead Standard, OSHA targeted its inspection efforts to those industries with well-recognized lead hazards, including non-ferrous foundries, primary and secondary lead smelters, and battery manufacturers. Companies identified by the NYHMR and BWC data include these industries. However, these two data sets also identified industries where lead exposure is less common, such as construction (which is exempt from the Lead Standard), and where the size of the companies is generally small, such as in automotive/radiator repair. Industries where lead hazards are intermittent or where exposures are occurring in thousands of small shops present a challenging problem to OSHA inspectors and the public health community [Rudolph et al., 1990]. These latter groups may require a different targeting and preventive approach to control exposures than the larger manufacturers.

Given the limited resources of OSHA and other public health agencies, a strategy which incorporates the identification of companies where an elevated blood lead level has been reported, or where a workers' compensation claim for lead poisoning has occurred, will offer the opportunity to maximize the impact and value of worksite inspections in reducing lead exposures. Other avenues for identifying potentially hazardous worksites, including physician reports of cases of lead poisoning, offer similar opportunities to maximize the utilization of limited resources. Similarly, making OSHA inspection data routinely available to lead surveillance efforts will increase the effectiveness of these systems.

The goal of eliminating occupational lead poisoning through the control of lead hazards can only be achieved by a coordinated effort among Federal, state, and local public health and enforcement agencies. Such an approach requires not only worksite inspections, but also efforts to educate employers and employees at risk about the means to control lead exposure. The best use of limited public health resources will be to have programs that complement, not duplicate, inspection efforts.

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