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COMMENTARY

Occupational Lead Poisoning: Can It Be Eliminated?

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The continued occurrence of occupational lead poisoning and overexposure in the United States represents a serious challenge to the occupational health community. We outline a proposed action strategy which integrates case-based surveillance, hazard surveillance, increased requirements for biological monitoring, and targeted educational activities, with a goal of eliminating occupational lead poisoning. The system provides a simple mechanism for monitoring compliance in lead-using employers, in order to identify employers for enforcement action. Lead poisoning should be viewed as an eradicable condition; successfully solving the persistent lead overexposure problem can serve as a model for approaching other occupational diseases.

Key words: lead poisoning, public health surveillance, hazard surveillance, occupational diseases, blood lead levels, disease eradication

INTRODUCTION

Knowledge of the hazardous properties of lead has existed since antiquity, and scientific evidence of low-level toxicity continues to accumulate [Landrigan, 1991; Staessen et al., 1992]. Based on current knowledge of lead's health effects in adults, the US Public Health Service declared a health objective for the year 2000: *Eliminate exposures which result in workers having blood lead concentrations greater than 25 μg/dl* [US Department of Health and Human Services, 1991]. While no action strategy has been published to meet this objective, the National Institute for Occupational Safety and Health has supported states in developing surveillance activities in order to ascertain the extent of occupational lead poisoning and to target intervention efforts. These passive surveillance programs have documented the presence of tens of thousands of workers each year with levels greater than 25 μg/dl despite massive under-reporting [Harrell et al., 1993; Rudolph et al., 1990].

Several states and localities have launched excellent small-scale activities designed to learn more about lead overexposure in specific industries or areas, and to educate employers and workers on health effects and exposure control techniques

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TABLE I. List of Items to be Reported When Testing Adult Blood Lead Levels*

Name of the person tested
Blood lead level of the person tested
Collection date of blood sample, or date specimen received by lab
Name, address, telephone number of health care provider who ordered the blood lead test
Date of birth or the age of the person tested
Sex of person tested
Race and ethnicity of person tested
Whether blood specimen was venous or capillary
Result of zinc protoporphyrin or zinc protoporphyrin/heme ratio, if performed
Address and occupation of the person tested
Name, address, and telephone number of the employer

*This information should be reported by the laboratory. The health care provider should be required to provide all necessary information to the laboratory as a responsibility of supervising a biological monitoring program.

[Papanek et al., 1992; Bellows and Rudolph, 1993; Nunez et al., 1993]. The Occupational Safety and Health Administration (OSHA) has recently closed one of the major gaps in the regulatory control of lead poisoning by promulgating a standard of lead exposure in the construction trades [OSHA, 1993]. However, an integrated approach to preventing occupational lead poisoning and overexposure nationwide has not been proposed.

In communicable disease control, "eradication" is defined as the "termination of all transmission of infection by extermination of the infectious agent through surveillance and containment." "Elimination" is the term used to describe disease eradication from a specific geographic or political area [Last, 1988]. A realistic short-term goal is the virtual elimination of occupational lead poisoning in the United States. We propose an action strategy to achieve this goal.

PROPOSAL

As in communicable disease control, the elimination of an occupational disease will require a combination of surveillance activities and direct prevention activities. This paper outlines the elements we believe would result in virtual elimination of occupational lead poisoning and overexposure, and reviews the current status of these elements.

Case-Based Surveillance

Proposal. To implement nationwide state-run, laboratory reporting of all blood lead tests, regardless of level. Information reported should include the information listed in Table I, to the extent possible. In order to facilitate laboratory compliance, health providers who order tests as part of occupational biological monitoring programs must provide all required patient information to the laboratory. In addition, for specimens processed out of the originating state, the reporting requirements should include reciprocal reporting to the originating state.

Current. As displayed in Table II, 23 states require laboratory reporting of elevated blood lead levels to a central state authority, and five states are developing this requirement. Of these, three states (Iowa, Michigan, and Washington) require

TABLE II. States Requiring Laboratory Reporting of Lead Levels*

Alabama	New Hampshire
Arizona	New Jersey
California	New York
Colorado	Oregon
Connecticut	Pennsylvania
Florida	South Carolina
Illinois	Texas
Iowa	Utah
Maryland	Vermont
Massachusetts	Washington
Michigan	Wisconsin
Nebraska	

The following states are currently developing reporting requirements
Delaware
Georgia
Maine
North Carolina
Rhode Island

*Source: NIOSH, telephone contact in certain cases.

reporting of all blood lead tests, regardless of whether the level is elevated. These "lead registries" were recently described [Baser, 1992].

The surveillance information provided by current lead registries has significant limitations. Most importantly, many workers at risk for lead overexposure do not have their blood lead levels tested [Rudolph et al., 1990]. Second, the information currently reported to state registries is usually limited, and requires extensive follow-up to be useful. For example, laboratories that report lead levels do not routinely report (or even have access to) the case address, phone number, occupation, or employer, although adequate follow-up requires that information. Finally, state registries have faced the obstacle of noncompliance with reporting requirements by out of state laboratories, which, in some states, can present a major problem.

Despite these limitations, lead registries have proved to be a valuable source of information on the presence of lead overexposure in working Americans, and the location of important index cases for investigation. When under-reporting is minimized (or at least stabilized), these registries may also prove useful in providing information on secular trends in lead poisoning, and in evaluating the effectiveness of interventions.

Hazard Surveillance

Proposal. To create and continually update lists of "lead users" in each state, developed from a wide variety of sources. All employers in established lead-hazard industries should be initially included, with additional employers from environmental databases, sentinel case reports, and so forth. New users and industries would be added as information is gained. Employers would be removed from the list once the absence of lead exposure has been well documented (such as by demonstrating no lead on premises, and by consecutive low biological monitoring results). The database of lead users would include information on each user obtained from multiple sources, including the case-based lead registry, environmental databases (on toxic

TABLE III. Some Job Tasks Associated With Overexposure to Lead*

Where lead-containing coatings or paint are present:
abrasive blasting and associated cleanup and enclosure movement and removal[a]
welding, cutting, and torch burning[a]
manual demolition of structures (e.g., dry wall)[a]
manual scraping and sanding[a]
heat gun applications[a]
cleaning using power tools for cleaning[a]
rivet busting[a]
Spray painting with lead-containing paint[a]
Radiator repair
Using lead-containing mortar[a]
Applying or heating lead-containing glazes of ceramics
Breaking, recycling, or manufacture of lead-containing batteries
Casting of objects using lead, brass, or lead-containing alloys
Operation or cleaning of a firing range
Formulation or processing of lead-containing paint or pigment
Cutting, burning, or melting of lead-containing materials

*This proposal suggests that all lead-exposed employees in workplaces where these tasks are performed should receive periodic biological monitoring, until the absence of a lead-exposure problem is documented.
[a]Tasks identified in OSHA Interim Rule on Lead in Construction, effective June 3, 1993.

use, storage, and release), and from workplace inspection data such as the Occupational Safety and Health Administration (OSHA) Integrated Management Information System (IMIS).

Current. Hazard surveillance has been proposed as a part of the armamentorium to prevent occupational diseases [Froines et al., 1989]. Lists of lead-hazard industries have been created [Froines et al., 1990]. In Los Angeles County, a model program has been developed to identify users from several sources (including community "right to know" databases, air pollution or sewer permit records, and other environmental databases) and target educational outreach to these users [Papanek et al., 1992]. Other jurisdictions, including Massachusetts, are developing lists of lead users [M. McDonald, personal communication]. Databases from a variety of public sources exist but have not been organized into a usable system.

Expand Biological Monitoring Requirements

Proposal. To require biological monitoring with at least annual whole blood lead levels for all lead-exposed workers in workplaces where specified lead-hazard tasks are performed. A partial list of such tasks is found in Table III. Employers who demonstrate that all blood lead levels are consistently low can suspend testing unless changes in processes suggest the possibility of lead overexposure.

Current. The 1978 OSHA General Industry standard for lead relies on the results of air sampling to dictate whether biological monitoring is required (29 CFR 1910.1025). Employers are required to conduct an "initial determination" for lead including representative full-shift personal samples if they have any information which would indicate employee exposure to lead. If air sampling indicated levels above the action level of 30 $\mu g/m^3$, then other components of the standard are required, including medical surveillance. Despite the major impact of this standard on

occupational lead exposure in the past 15 years, this system has at least two deficiencies.

First, a large number of employers do not conduct needed air sampling, so biological monitoring never follows [Rudolph et al., 1990]. Reasons include lack of knowledge of the air sampling requirement and the high cost of the industrial hygiene consultation typically needed to perform the sampling. (In Washington State, the typical cost for one 8 hr air sample for lead by a private industrial hygiene consultant, including a report, is approximately $500. Representative sampling often requires multiple samples, with each additional sample adding approximately $25.) Second, blood lead levels over 25 μg/dl can be achieved at air lead levels below the OSHA action level of 30 $\mu g/m^3$, most likely through ingestion as a route of exposure.

The 1993 Interim Standard on Lead in Construction offers an improvement, in that it requires employers whose employees perform certain tasks to consider those employees' exposure to be over the action level and provide them with all the relevant protections of the standard, including biological monitoring, unless air sampling shows that the exposure levels are below the action level [OSHA, 1993]. The listed job tasks are shown in Table III.

Targeted Educational Activities

Proposal. To provide all employers on the list of lead users with written educational information on lead health effects, relevant regulatory requirements, and general exposure control guidelines. Provide targeted educational assistance to all employers with elevated lead levels found through case-based surveillance, in order to reduce exposures. Targeted assistance should include a workplace visit when practical, and specific and feasible recommendations in order to reduce exposures.

Current. Except in specific areas or targeted industries, as in Los Angeles County and New York City [Papanek et al., 1992; Bellows and Rudolph, 1993; Nunez et al., 1993], few efforts have been reported of extensive educational efforts targeted at groups of employers identified through surveillance systems, with a goal of achieving reduced lead exposures.

Closing the Loop on Lead Poisoning and Overexposure

Proposal. To link case-based surveillance records to the list of lead users and use those results to supervise, and when necessary to enforce, biological monitoring requirements among employers on the lead users list. Registry results and linkages can be used to add or remove employers from the list. The program must guarantee continual information exchange between surveillance program staff and educational program staff. The threat of traditional enforcement activity should be maintained while encouraging timely voluntary exposure controls. The lead registry is used to monitor whether lead-using employers are complying with biological monitoring requirements, and to target noncomplying employers for educational assistance. Employers whose performance has not improved following targeted assistance should be referred to enforcement officials. The overall flow of information and activities is shown in Figure 1.

Current. Seligman and Halperin [1991] proposed that follow-up enforcement activities by OSHA and other public health agencies should be focused on companies where an elevated blood lead level has been reported or where a workers' compen-

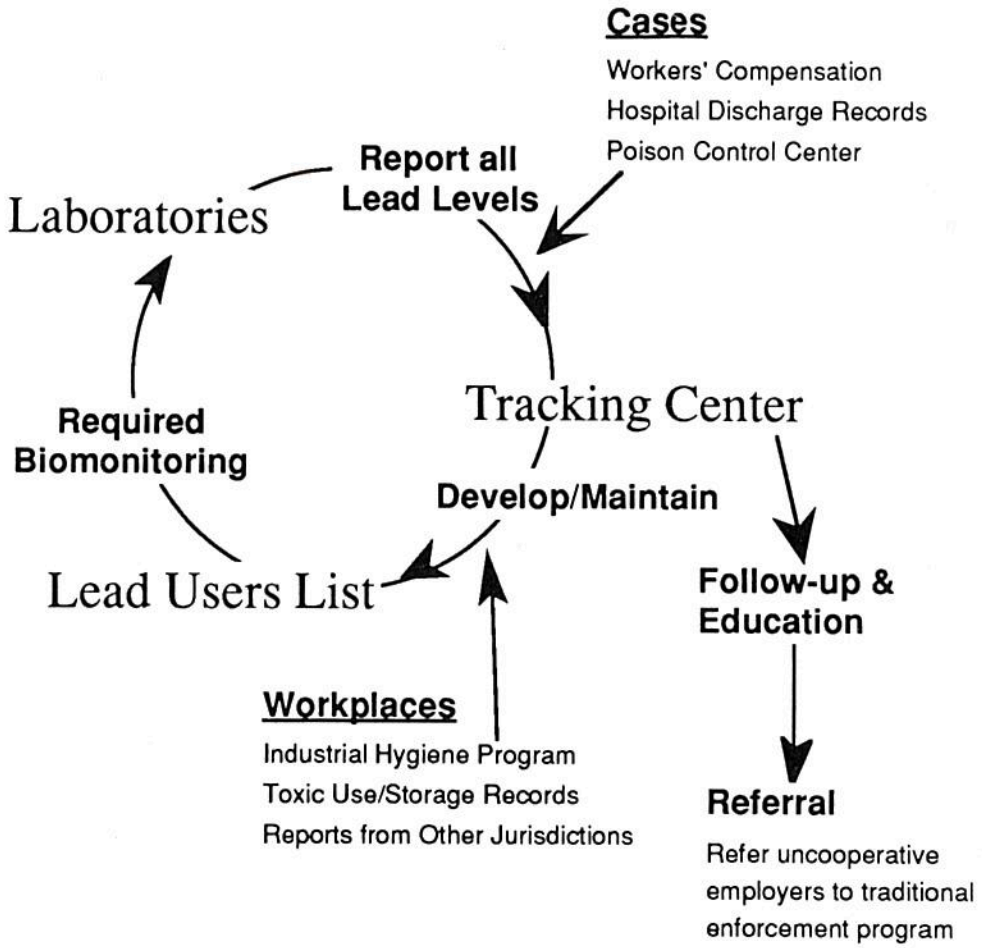

Figure 1. Closing the loop on occupational lead poisoning.

sation claim for lead poisoning has occurred, in order to maximize limited resources. There are no data available to assess whether this has occurred.

In many jurisdictions, health agencies sponsor the case-based registry without linking it to other activities. In some states, like Alabama, all elevated blood lead levels are referred to OSHA for follow-up [Seligman, 1993]. In New Jersey, such a referral is a last resort after the failure of educational efforts [Valiante, 1993]. To our knowledge, however, a lead registry to evaluate whether or not lead-using employers are performing the required biological monitoring has been used only in a pilot program in California [Bellows and Rudolph, 1993]. In no jurisdiction does an integrated program allow health officials to "close the loop" on occupational lead poisoning.

DISCUSSION

It is generally stated that all occupational diseases are preventable. While many efforts to prevent occupational disease through exposure reduction and control have been notably successful, the *elimination* of an occupational disease through the com-

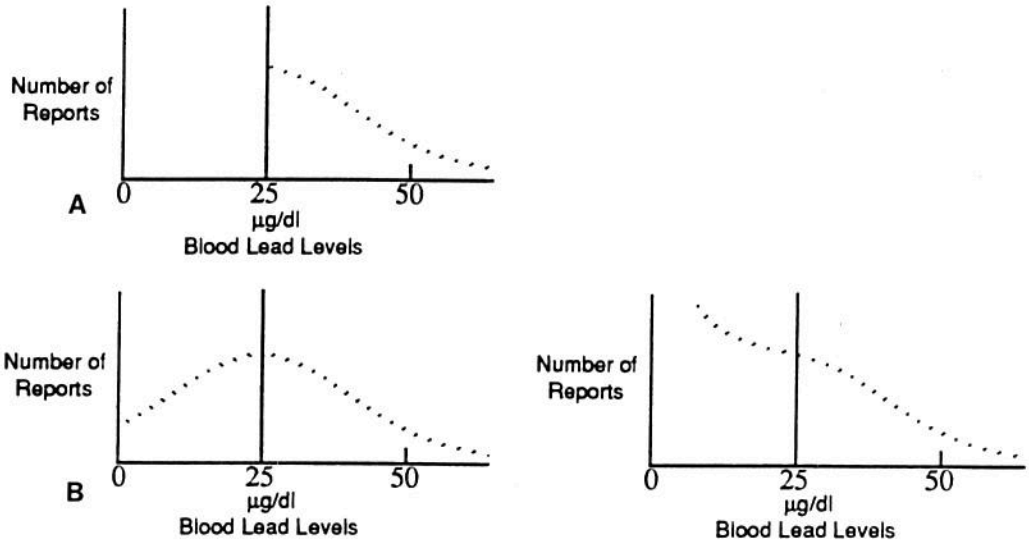

Figure 2. Illustrative distribution of blood lead levels with/without cutoff level. **A.** Reports of blood lead levels with arbitrary cut-off level. **B.** Two potential distributions of blood lead levels, based on findings in Figure 2A.

municable disease model of "surveillance and containment" is not typically realized. We argue that lead poisoning, because of its persistence despite "comprehensive" regulation and the presence of an excellent biological marker of recent integrated exposure, should be the target of disease elimination efforts.

Our proposal presents a series of steps which, if carried out and successfully coupled, can result in the elimination of occupational lead poisoning. Some aspects of this proposal may be controversial or politically difficult. In addition, other associated actions are probably needed to combat lead overexposure, but are not critical to the surveillance and containment plan.

Reporting of All Blood Lead Levels

In typical disease reporting practice using laboratory tests, the tests are characterized as "disease" or "no disease" and only the "disease" cases are reported. In the case of occupational lead poisoning, by analogy, some cutoff level would be selected, and only lead levels over perhaps 25 µg/dl (the Public Health Service goal) would be reported. For the purpose of surveillance and disease elimination, however, all levels need to be reported for two reasons. First, to determine the distribution of all adult lead levels, all levels must be reported. This is illustrated in Figure 2. This will allow evaluation of the success of disease elimination efforts. Second, all levels are needed in order to differentiate the lead-using employer who has not provided biological monitoring to employees from one whose employees have been tested and all found to be low. Without this information, use of the registry for supervising compliance with biological monitoring requirements will be impossible.

Potential Problems of This Approach

We anticipate two problems in the implementation of this approach. First, lead-using employers may take actions to avoid appearing in any of the central

databases. If this appears to be occurring, keeping the databases complete will require vigilance.

Second, and more important, is the potential for lead-using employers to discriminate against workers with high lead levels, either at preplacement or periodic testing. Since employers will be under closer scrutiny if their employees have high lead levels, there will be an incentive to not employ individuals with high levels. (At the same time, there is a positive incentive to keep levels low through exposure controls.) While there are antidiscrimination provisions in the Occupational Safety and Health Act, the Americans with Disability Act, and some state laws, these are not generally applicable in these situations, and special statutory or regulatory protections are needed to guarantee the employability of workers with high lead levels. Extra efforts to prevent discrimination will need to be made to protect individuals with high body burdens of lead as a result of years of occupational or environmental lead overexposure.

It can be anticipated that some employers, especially small businesses, will balk at the added requirement of biological monitoring. However, annual blood testing for a small number of employees is inexpensive compared with the air sampling currently required (and often not performed). Employers that can repeatedly document the absence of a lead overexposure problem can be excused from further blood testing, unless changes in processes, materials, or personnel affect the likelihood of lead overexposure.

Associated actions. In addition to the proposal discussed above, two other actions are justified to control lead overexposure. First, the lead standard should be revised to include a provision which requires employers to take actions to assess and correct lead overexposure that has resulted in employees' elevated blood lead levels. The employer must not merely remove the lead-exposed worker, but must also investigate the source of the problem, and correct the cause of the overexposure. While such action seems intuitive in response to a medical surveillance program, it is not required for lead; among OSHA standards, it is required only in the recently promulgated cadmium standard (29 CFR 1910.1027) [Silverstein, 1994].

Second, the medical removal provisions of the lead standard need to be updated to be consistent with current scientific knowledge. While a full review of this information is beyond the scope of this commentary, the current medical removal level of 50 μg/dl whole blood is clearly in conflict with the Public Health Service's goal for the year 2000 to achieve all levels below 25 μg/dl.

Other innovative steps may be needed to make this proposal work, including finding sources of funding for these programs. The 1991 California Occupational Lead Poisoning Prevention Act authorized the Department of Health Services to impose fees on businesses at risk of overexposing employees to lead. These fees range from about $180 per year for employers with 10 to 99 employees in low-risk industries to about $2,000 per year for employers with more than 500 employees in high-risk industries. Employers with fewer than 10 workers are exempt [BNA, 1993]. Linking such a fee structure to the lead users list in our proposal appears to be an attractive approach.

The Need for a New Approach

This surveillance-based approach to disease elimination represents a departure from the current regulatory approach to the prevention of occupational diseases. The

traditional approach involves the promulgation of rules governing exposure to hazardous chemicals, and the reliance on voluntary compliance with the threat of enforcement activity. Neither epidemiologic surveillance nor central tracking of any element of regulatory compliance has been a part of any OSHA standard. If OSHA could inspect every workplace regularly, the traditional approach might be successful, but this is not the case. While the lead standard has likely reduced the number of cases of frank lead poisoning over the last 15 years, there is little documentation of this effect, and lead overexposure clearly still exists. OSHA inspections (or the threat of inspections) have likely improved the lead-exposure situation; however, this impact is probably greatest among larger employers. Most dramatic cases of lead poisoning from lead registries have come from employers with fewer than 100 workers.

The proposal suggests a way to achieve the goal of eliminating lead poisoning while acknowledging limited resources available for public health activities, by developing and linking centralized databases on lead users and lead overexposure cases. Sources of lead exposure can then be targeted for cost-effective follow-up. In addition, the databases can be used inexpensively to ensure that employers comply with the new biological monitoring portion of an expanded comprehensive lead standard.

The most resource-intensive portions of this proposed strategy are establishment of the reporting systems, databases, and the educational programs. If the strategy is successful in reducing lead exposure, states should be able to scale back the program to a smaller maintenance staff within a few years of implementation. If the program is not successful upon strict evaluation, the program should be revised or discontinued in favor of a new action strategy.

To some, this approach may appear to represent a change in occupational health practice, moving emphasis from primary prevention to secondary prevention, since this approach relies on detecting incident cases. However, this surveillance-based control should be viewed as a complement to exposure-based controls, allowing the integration of information of all sorts (potential exposure, measured exposure, and measured health outcome) to be used in the effort to prevent future overexposure. We believe that this allows for an augmented approach to primary prevention.

CONCLUSION

Occupational lead poisoning and overexposure continue to be unacceptably prevalent. A new approach is needed to eliminate lead overexposure in the workplace, integrating surveillance information with other strategies. By maintaining an accurate list of lead-using employers, mandating blood lead testing in those workplaces, and requiring laboratory reporting of all blood lead tests, public health officials can: (1) identify problem industries and workplaces; (2) target educational activities; (3) monitor noncompliance; and (4) refer employers for enforcement action when educational assistance fails to improve performance.

While obstacles can be anticipated, and other associated steps are also needed, there is reason to be optimistic about this approach. Applying this type of traditional public health practice to occupational lead poisoning may prove useful for other workplace health and safety problems as well.

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