Trends in Occupational and Adult Lead Exposure in Wisconsin 1988 – 2005

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ABSTRACT

Seventeen years of adult blood lead surveillance data (37,694 individuals and 71,622 total tests) reveal a Wisconsin success story. While lead continues to be widely used, most Wisconsin industries have made substantial strides toward reducing occupational lead exposure. The improvement is reflected in the reduced number of blood lead levels >40 µg/dL. In 2005 only a single adult blood lead test was >50 µg/dL, and since 2003 none have been reported above 60 µg/dL. However, as long as lead is used industrially, lead-based products remain in use, and new consumer products containing lead are marketed to the public, lead poisoning will remain a threat, not only to workers handling lead, but also to children exposed to lead-containing products already in existence. Wisconsin industry and workers, as well as the medical and public health community, must remain vigilant about new and reemerging lead exposures. Wisconsin's Adult Blood Lead Epidemiology and Surveillance program will continue to investigate unusual lead exposure circumstances identified through statutorily mandated physician and laboratory reporting of adult blood lead levels. However, Wisconsin will need further advances if it is to achieve the *US Healthy People 2010* objective of no adult blood lead level >25µg/dL.

INTRODUCTION

Lead is a malleable metal that has been used by humans for more than 3 millennia. The poisonous effects of inhalation of lead fume or ingestion of lead products were well known to the early Greeks and Romans. Colic, neuropathy, nephropathy, sterility, and coma were all problems noted by Hippocrates. Early descriptions of disease among miners and smelters make lead poisoning among the oldest recognized occupational health hazards. Environmental lead poisoning, especially childhood lead poisoning from lead-contaminated house dust and lead-containing paint chips, is a more recently recognized problem, and the elimination of childhood lead poisoning continues to be a major public health priority. Using lead for cooking vessels and myriad other household items has historically led to outbreaks of lead poisoning, and such concerns are still with us as modern use of lead-containing glazes on some folk pottery has resulted in lead poisoning. The historic impact of lead poisoning was recently highlighted when the Energy Department's Argonne National Laboratory outside of Chicago, analyzing hair and skull fragments from the composer Beethoven, confirmed earlier hints that lead may have caused the composer decades of poor health, culminating in a long and painful death in 1827 at age 56.[1]

During early Wisconsin statehood, lead mining and smelting were important industries in Southwestern Wisconsin. In recognition of the health hazards of lead exposure, lead poisoning was on the 1911 first listing of Wisconsin public health reportable diseases. Although the law required reporting, few reports were made until Wisconsin's public health statutes were revised, modern reporting levels adopted, physician and laboratory reporting promoted and publicized, and clinical laboratory-based blood lead report tracking initiated. In 1987 Wisconsin was among the first states to successfully compete for National Institute of Occupational Safety and Health (NIOSH) Adult Blood Lead Epidemiology and Surveillance program (ABLES) funding and has continuously maintained this NIOSH partnership for the past 18 years.

In a 1993 *Wisconsin Medical Journal* article, Wisconsin ABLES estimated that 4703 (4%) of the 120,000 employers in the state were using lead and between 56,000 and 114,000 workers were exposed to lead at work.[2] Subsequent reports have described progress being made as well as alerting the medical com-

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munity to the hazards of home remodeling and hobbies and craft work involving lead.[3]

The Wisconsin State Health Plan, *Healthiest Wisconsin 2010*, includes a broad outcome goal that features adult lead poisoning: "By December 31, 2010, the incidence of occupational injury, illness, and death will be reduced by 30%."[4] The national *Healthy People 2010* initiative, published by the US Department of Health and Human Services in January 2000 includes an objective of total elimination of occupationally related lead poisoning, defined as an adult having a blood lead result of >25µg/dL.[5]

Current Occupational Lead Exposure Standards

Since the Occupational Safety and Health Act of 1970, private industry in Wisconsin must comply with the federal Occupational Safety and Health Administration (OSHA) workplace standards.

OSHA has 2 separate standards that address occupational lead exposures: 29 CFR 1910.10256 is the lead standard for general industry and 29 CFR 1926.627 is the lead standard for construction. Provisions required by the standards such as air monitoring, medical surveillance, use of respirators and protective work clothing and equipment, engineering, work practice and administrative controls, employee notification, and training are triggered by air lead levels measured at the worksite. The OSHA enforcement standard known as a Permissible Exposure Limit (PEL) for lead states that the employer shall assure that no employee is exposed to lead at concentrations >50 µg per m^3 of air averaged over an 8-hour period.

OSHA Required Medical Surveillance

Only a few OSHA standards include requirements for medical monitoring. The OSHA lead standards use venous blood lead levels (BLL) along with the recommendation to include zinc protoporphyrin (ZPP) to assess lead exposure. Medical monitoring is required when air measurements of lead exceed 30 µg/m^3 (called the Action Level in the standards). An employee with a blood lead result of 40-49µg/dL will need repeat blood tests every 2 months until 2 consecutive BLL tests are <40µg/dL. Any employee with a BLL ≥50µg/dL must be removed from lead exposure. The employee can return to work when 2 consecutive BLL tests are ≤40µg/dL.[6] For employees exposed to lead, medical evaluations need to be performed annually and as deemed appropriate when BLLs have been ≥40µg/dL at any time during the preceding year.

METHODS

In 1979, Wisconsin Statute 151 made reporting of all adult blood lead values ≥60µg/dL mandatory. In 1987, the required reporting level was lowered to 25µg/dL and in 1993 all blood lead test results became reportable. This state law requires all health care professionals to report BLLs, but they can rely on the laboratory they use to send the reports directly to the state. This laboratory reporting fulfills the health care professionals' responsibility. All laboratories must report blood lead results for Wisconsin citizens regardless of the state where the laboratory's facilities are located.

The Wisconsin ABLES program is a passive surveillance system. Unlike the childhood lead poisoning prevention program, which actively supports screening children through city and county public health departments, ABLES provides no screening. Instead, it relies on physicians or other responsible health professionals to determine who needs to be screened due to either OSHA occupational lead standard requirements or as part of an evaluation of health complaints. Laboratory reports of blood lead tests of Wisconsin residents aged ≥16 become part of the ABLES data system; all other reports are entered into the childhood lead program data. The ABLES program is part of a national network that utilizes the same data collection system that allows summary data to be sent to the National Centers for Disease Control and Prevention to compile national summaries. Through employer questionnaires and employee interviews, ABLES investigates the circumstances associated with adult blood lead levels >40µg/dL, including employer awareness of lead hazards and regulatory requirements. Educational outreach efforts include education about the health effects of lead and regulatory requirements to employers, employees, and the general public. Worksites can request technical assistance from the Wisconsin OSHA Consultation Program to reduce lead hazards.

RESULTS

The OSHA lead standards medical monitoring provisions facilitate state-based adult blood lead surveillance. OSHA requires the testing, but does not require the results to be reported to any federal or state governmental authority. However, Wisconsin state law requires all blood test results to be reported to the state health department. For the past 17 years, the ABLES program has collected the required adult laboratory reports. The ability to track the numbers of screened individuals and their BLLs over time has been extremely valuable, not only for monitoring advancement toward the *Healthy People 2010* goals, but also for early identification of emerging industries and exposures needing technical as-

sistance and education.[3] It is not possible to estimate the number of non-occupationally exposed adults who are tested for lead, because only 15% of reports received include sufficient occupation and industry information to make such a determination. In-depth investigations can only be made on the highest 1% of reports (those >40µg/dL).

Figure 1 shows the total number of reports received and the number of new individuals entered into the system by year. "Total number of reports" includes all reports entered into the database for that year and includes some individuals with more than 1 reported result. "A new individual" is defined as someone who had not had a blood lead test entered into the system in the previous 2 years. The increase in numbers of reports and individuals in 1995 and 1996 are the result of implementation of the 1993 reporting revisions, which made all blood lead tests reportable.

Table 1 summarizes the distribution of BLLs by age. Except for those >65 years having fewer individuals with levels >25 µg/dL, all age groups appear equally at risk of elevated blood lead. Among those tests reported, 7% were over age 65 and 13% were between the ages of 15 and 25.

Overall, 62% of the individuals in the ABLES system are males and 38% female (data not shown). Males predominated in the ages 26-64, comprising 71% of that group, while among those over age 65 there are equal numbers of males and females. Race was identified on 27% of reports; among these, 87% were non-Hispanic white, 8% black, and 5% other (data not shown).

Figure 2 shows the number of BLLs of >40µg/dL reported each year from 1988 through 2005. Blood lead levels of ≥40µg/dL were required to be reported throughout this period. A decreasing trend in the number of reports ≥40µg/dL, and especially those >50µg/dL and 60µg/dL, can be seen. Since 2003, there have been no reports >60µg/dL and in 2005 only 1 report >50µg/dL.

Not only have the number of individuals >40µg/dL, 50µg/dL and 60µg/dL been decreasing, the overall mean of annual reports also has been declining, as seen in Figure 3. The precipitous decline in the mean blood lead prior to 1995-1996 is an artifact of the change in BLLs required to be reported. Once all adult blood lead values were required to be reported and laboratories were in compliance, the mean value decline continues and is a good reflection of the exposures of the approximately 4000 Wisconsin workers tested annually. These declines in mean values show that employer efforts to

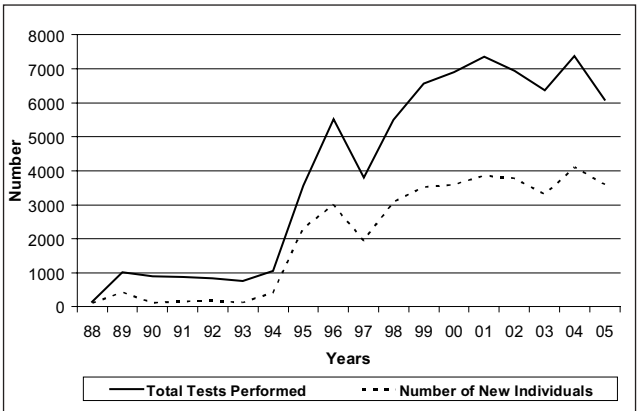

Figure 1. Wisconsin blood lead test reports, 1988–2005.

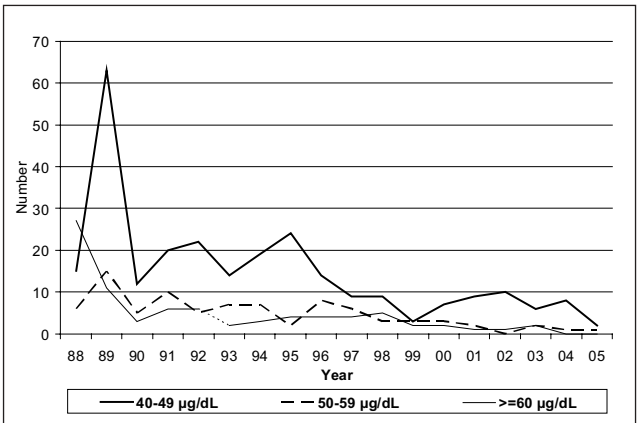

Figure 2. Wisconsin blood lead reports >39µg/dL, 1988-2005.

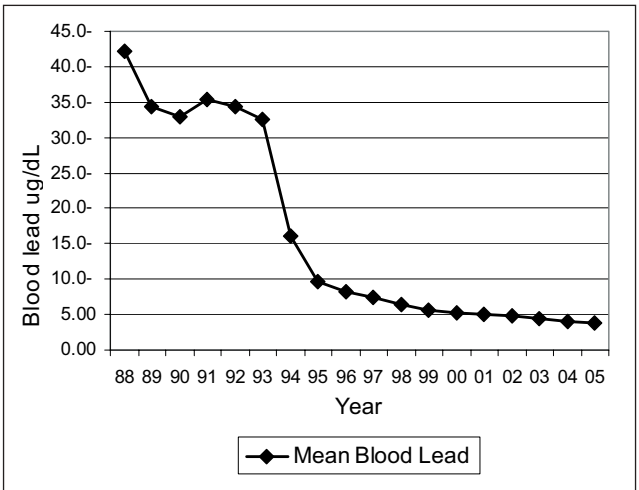

Figure 3. Wisconsin mean blood lead (µg/dL) by year, 1988-2005.

Table 1. Adult Blood Lead Level (µg/dL) by Age, Wisconsin Residents, 1988-2005

Age	0-24 µg/dL (%)	25-39 µg/dL(%)	40-49 µg/dL(%)	50-59 µg/dL(%)	>60 µg/dL(%)
15-24 yrs	4807 (95.0)	202 (4.0)	28 (0.6)	8 (0.2)	10 (0.2)
25-44 yrs	17940 (93.2)	1056 (5.5)	147 (0.8)	50 (0.2)	54 (0.3)
45-64 yrs	9949 (94.5)	443 (4.2)	87 (0.8)	27 (0.3)	17 (0.2)
64+ yrs	2750 (98.6)	29 (1.0)	4 (0.2)	1 (0.1)	2 (0.1)
Total	35446 (94.3)	1730 (4.6)	266 (0.7)	86 (0.2)	83 (0.2)

Table 2. Percent of Adult Blood Lead by Employer Standard Industrial Code Classification, 1988-2005

	0-24 µg/dL %	25-39 µg/dL %	40-49 µg/dL %	50-59 µg/dL %	≥60 µg/dL %
Electronic and Electrical Equipment	85.5	13.5	0.9	0.0	0.1
Fabricated Metal Products	77.7	18.6	2.3	0.7	0.7
Primary Metal Industries	65.2	26.1	4.9	1.7	2.1
Construction Industries	91.3	4.9	1.4	1.0	1.4
Rubber and Miscellaneous Plastic Products	66.9	28.7	3.6	0.8	0.0
Industrial and Commercial Machinery and Computer Equipment	96.0	2.8	0.6	0.3	0.3
All Other Industries	89.3	5.8	3.2	1.3	0.4

reduce lead exposure in their facilities are benefiting all workers, especially those who previously had exposures resulting in BLLs >40µg/dL.

Although state statutes and rules require inclusion of demographic information—including occupation and industry—along with the blood lead result, laboratories seldom receive all the information from the ordering medical facilities and thus cannot forward it to ABLES. As noted previously, only 1 in 4 reports contained data for race or ethnicity and only 15% contain sufficient occupation and industry information. Personal interviews with employers and employees remain the best means to classify the employer and the job categories of workers. Unfortunately, interviewing is resource intensive and Wisconsin ABLES can do such interviews on only 1% of the reports received. This results in contacting only those with BLLs >40µg/dL to confirm the employer and type of work performed. Additionally, for reports of BLLs >40µg/dL, surveys are sent to employers asking for information on their knowledge of the OSHA regulations, especially the medical monitoring and removal provisions. Individual identities are confidential and surveys are not sent until after the employee has been interviewed and it is clear they cannot be identified. Not all reports come from employer-sponsored medical monitoring.

For individuals and employers with BLLs <40µg/dL, and especially those <25µg/dL, we must rely on the employer, physician, or medical facility to fully complete the laboratory order form so the laboratory can provide ABLES the required demographic information, including industry and occupation. Too frequently the information is not reported to the laboratories and thus not available to the ABLES program. Of the 37,694 individuals in the ABLES system, 85% do not have sufficient information to confidently categorize the industry in which the individual worked. ABLES continues to encourage compliance with data requirements to maximize the utility of the information received.

Table 2 summarizes the employer Standard Industrial Codes (SIC) for the reports that had information or who had been interviewed by the ABLES staff. Primary metal industries and rubber and miscellaneous plastic products manufacturing had the highest percentage of reports >40µg/dL and only two thirds of individuals <25µg/dL.

The ABLES system can be used to passively track the time trend for individuals in a medical monitoring program and indirectly assess the success of employer efforts to reduce individual lead exposures. Among the 37,694 individuals in the data set, 24% had more than 1 blood lead test result. Individuals with blood lead >50µg/dL are required by OSHA to be removed from lead exposure and not return to work until 2 sequential tests are <40µg/dL. Table 3 describes the changes over time by individual. Among 110 individuals who reached a BLL of ≥50µg/dL and had subsequent test results, the last blood lead on the individual had decreased for 69% of individuals. Unfortunately, in 24% of individuals the values had increased. If the value of 40µg/dL is used as the trigger, there were 360 individuals with multiple

test results; 62% had decreased and 28% had increased between the trigger BLL and the last test recorded. ABLES does not have information to determine why the values went up in some instances. Further investigation is needed.

Table 3. Change in BLL Subsequent to Identified Elevated BLL, Wisconsin 1988-2005

	No. of Individuals	BLL Decreased	BLL Increased
BLL >50µg/dL	110	70%	24%
BLL >40µg/dL	360	62%	28%
All with multiple tests	8962	47%	33%

DISCUSSION

The US Department of Labor lists more than 900 occupations that are associated with lead use, and Wisconsin workers exposed to lead reflect these diverse sources.

The number of Wisconsin adults tested annually for blood lead has remained between 3000 and 4000 since 1996. Adult lead poisoning (BLLs >40µg/dL) is becoming infrequent but still occurs. The health consequences can be significant. The ABLES surveillance data supports the conclusion that Wisconsin's traditional lead-using industries have instituted better exposure controls in their facilities. When blood lead values >50µg/dL are reported, it is now likely that the exposure occurred in an emerging setting such as workers in small construction/renovation businesses, home renovation involving removal of lead paint done by homeowners, or hobby work involving lead (stained glass, indoor shooting ranges, home manufacturing of fishing weights and lures).[3] In these circumstances the lead exposure hazard may not be recognized, and any symptoms being experienced may not be attributed to the lead exposure. Parents employed in any of these occupations may bring lead dust on their persons or clothing into the home, which can lead to significant exposure for children and others in the home.[9] Occupational and environmental exposure histories can be crucial physician tools to identify such unrecognized lead exposure hazards and alert the physician that non-specific symptoms may be lead related. Such suspicions should and often do trigger diagnostic testing, preventive action, and treatment.[10]

Childhood lead poisoning surveillance has emphasized the reservoir of lead in paint, resulting in a thriving lead abatement industry in Wisconsin and elsewhere. Because lead abatement industry workers are frequently young and inexperienced and the businesses small, Wisconsin requires that workers complete appropriate training and be certified, as well as requiring supervisor training and certification. This program should help reduce the lead exposure to these workers. Lead abatement by a certified contractor is expensive and homeowners too frequently attempt to avoid these costs by doing the work themselves. Because of their lack of training, they may inadvertently expose themselves and their children to lead. Expanded educational efforts work to reach homeowners and alert them to the potential health hazards associated with lead if improper methods of removing lead are employed. Health care professionals can assist in this effort by asking about their patients' occupations, as well as work done in the home, so these significant non-occupational exposures are avoided.

The ABLES program will continue to provide a means to evaluate the efforts to control and reduce occupational lead exposure in Wisconsin, identify emerging hazardous circumstances, and provide information to employees, employers, and health care professionals.

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Wisconsin Medical Journal

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The *Wisconsin Medical Journal* (ISSN 1098-1861) is the official publication of the Wisconsin Medical Society and is devoted to the interests of the medical profession and health care in Wisconsin. The managing editor is responsible for overseeing the production, business operation and contents of the *Wisconsin Medical Journal*. The editorial board, chaired by the medical editor, solicits and peer reviews all scientific articles; it does not screen public health, socioeconomic or organizational articles. Although letters to the editor are reviewed by the medical editor, all signed expressions of opinion belong to the author(s) for which neither the *Wisconsin Medical Journal* nor the Society take responsibility. The *Wisconsin Medical Journal* is indexed in Index Medicus, Hospital Literature Index and Cambridge Scientific Abstracts.

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