CLN'S REDISCOVERED VALUE: THE LABORATORY IN 2002 SERIES

Adult Blood Lead Testing

A Pivotal Role for Labs in Interpretation and Surveillance

By Michael Ottlinger, PhD; Ralph Zumwalde; Robert Roscoe, MPH; Michael Kosnett, MD, MPH; Karen Hipkins, MPH, RN, NP-C, Raymond Meister, MD, MPH; and Barbara Materna, PhD, CIH

Accounts of adult lead poisoning are among the oldest and best known in the toxicological literature. Dr. Alice Hamilton, a pioneer in the area of occupational illnesses, described lead as one of the oldest industrial poisons, dating back to ancient Roman times (*1*). Today, however, it is children and not adults who are usually the focus of lead toxicology, because research has shown that their developing central nervous systems are more susceptible to the ill effects of lead. Nevertheless, attempts to reduce blood lead levels (BLLs) among adults should not be overlooked as an important public health priority—especially in the occupational setting.

To ensure uniform clinical diagnosis and management of children with lead poisoning, the Centers for Disease Control and Prevention (CDC) published clinical guidelines in 1997 for health care providers on the evaluation and treatment of children with elevated BLLs (*2*). The guidelines make specific recommendations with respect to pediatric patient management, and they provide clinical laboratories with a framework for including interpretive information for clinicians based on reported BLLs. However, these guidelines were not intended or validated for the adult population. Recommendations for the medical management of children and adults with lead poisoning differ significantly, and currently no national guidelines exist for managing adults with lead poisoning. Because occupational exposure to lead in certain industries remains problematic, there is a significant need for such guidance in the medical community.

Clinical laboratorians, with their expertise and knowledge of biochemical testing, are well positioned to play a pivotal role in detecting cases of lead poisoning. Moreover, in the absence of consensus recommendations for management of adults with lead poisoning, laboratorians can step into a leadership role and help guide other medical professionals in the appropriate, cost-effective identification and prevention of elevated BLLs in adults.

SOURCE: GETTY IMAGES

Lead Exposure in Adults

According to recent data from the Adult Blood Lead Epidemiology and Surveillance program (ABLES), more than 90% of elevated lead concentrations in adults result from workplace exposure (*3*). National Health and Nutrition Examination Survey (NHANES) data for 1999 indicate that from 1991 to 1994, the mean BLL of U.S. adults dropped from 2.1 and 3.1 µg/dL for ages 20–49 and 50–69, respectively, to 1.4 and 1.9 µg/dL for ages 20–39 and 40–59, respectively (*4,5*). Although the mean BLL of the entire U.S. population is relatively low, thousands of adult workers continue to be exposed to high concentrations of lead in more than 100 industries, including battery manufacturing, painting, nonferrous smelting, radiator repair, brass and bronze foundries, pottery production, scrap metal recycling, firing ranges, and wrecking and demolition.

Permissible exposure limits for lead in the workplace and worker monitoring are regulated by the Occupational Safety and Health Administration (OSHA) [29CFR 1910.1025 and 1926.62]. The General Industry and Lead in Construction standards differ slightly. A detailed comparison of the standards has been published elsewhere(*6*). When airborne lead concentrations exceed the action level of 30 µg/m^3, OSHA requires medical surveillance which includes biological monitoring with BLLs performed by an OSHA-approved laboratory.

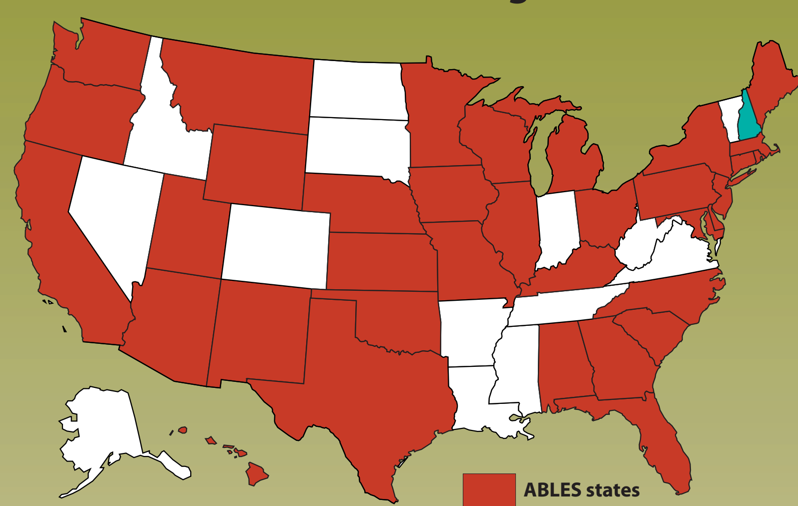
Under OSHA standards first introduced in 1978 and still in effect today, a worker must be removed from significant lead exposure when his or her average BLL is ≥50 µg/dL or when the worker has a "detected medical condition" that places him or her at increased risk of "material impairment to health" from lead exposure. Moreover, the OSHA lead standards also state that chelation therapy should be administered only when "frank and severe symptoms are present," and that worker removal from exposure is the preferred action.

Elevated BLLs in adults may also be due to exposure to non-occupational (i.e., ambient or environmental) sources of lead such as recreational target shooting, home remodeling, casting bullets and fishing weights, making stained glass and ceramics, cookware, pica behavior (ingestion of nonfood items), traditional remedies, and retained bullets in or near a synovial joint. Consequently, when occupational exposure is not suspected, elevated BLLs may be the result of one of these factors.

Health Concerns

Even in the presence of overt symptoms characteristic of lead intoxication, some clinicians may overlook the possibility of lead exposure and consequently not order lead testing. Adults with a BLL of 25–60 µg/dL may exhibit a number of nonspecific symptoms, including irritability, fatigue, headache, sleep disturbance, decreased li-

States Reporting to CDC, NIOSH's Adult Blood Lead Epidemiology and Surveillance (ABLES) Program in 2002



bido, and depressed mood (*7*). A number of studies have reported a variety of adverse health effects such as hypertension, subtle or subclinical central nervous system deficits, and adverse reproductive outcomes in adults exposed to lead at concentrations below existing regulatory exposure limits (*8–12*).

Although the significance of these subclinical effects on long-term health continues to be studied, the CDC recommends that BLL from work exposures be reduced to <25 µg/dL in all adults by 2010 as a preventive health measure (*13*).

Lead readily crosses the placental barrier to the fetus. The source of lead exposure for a fetus may be the mother's recent exposure to lead and/or mobilization of lead into the blood during pregnancy from bone stores due to past exposure. The American Conference of Governmental Industrial Hygienists (ACGIH) advises women of child-bearing age that if their BLL is >10 µg/dL, they are at risk of delivering a child with a BLL >10 µg/dL, which is the level of concern in the pediatric CDC guidelines (*14*). Although research findings have been inconsistent, the results of some recent investigations indicate that maternal BLL <10 µg/dL may be related to adverse reproductive outcomes, including preterm birth and spontaneous abortion (*11,12*).

The Adult Blood Lead Epidemiology and Surveillance Program

Since 1987, the CDC's National Institute for Occupational Safety and Health (NIOSH) has sponsored a statewide surveillance program known as the ABLES program to track laboratory-reported BLLs in adults. The public health goal of the ABLES program, as stated in Healthy People 2010, is to reduce the number of people with work-related BLLs ≥25 µg/dL (*13*). The ABLES program aims to accomplish this objective by building capacity at the state level to initiate or improve surveillance programs that can accurately measure trends in adult BLLs and effectively intervene to prevent further exposures to lead. To date, intervention strategies administered by the states include conducting follow-up interviews with physicians, employers, and workers; investigating work sites; providing technical assistance on exposure reduction or prevention; providing referrals for consultation and/or enforcement; and developing and disseminating educational materials and outreach programs. For 2002, NIOSH increased its funding commitment, allowing ABLES to expand funding to 35 states (see map, above).

One ABLES mandate is that states in the program require their affiliated laboratories to report BLL results—both occupational and non-occupational—to the state health department or designee. The minimum BLL that must be reported varies from state to state, but it must not exceed 25 µg/dL. Moreover, reporting of all BLLs is encouraged, since these data are useful for analyzing exposure trends and providing the basis for future intervention strategies. In fact, this also applies to lead testing in children, since it is estimated that 2%–3% of children with BLL ≥10 µg/dL reach those levels from "take-home" lead that is brought home from the workplace on the clothes or in the vehicles of their adult caregivers (*15*).

State ABLES programs are also encouraged to develop effective working relationships with other federal and state agencies involved in preventing adult lead poisoning—for example, OSHA, the Department of Housing and Urban Development, the Environmental Protection Agency, the Department of Transportation, and the Department of Defense. Data and findings from the ABLES program are periodically published in the CDC's *Morbidity and Mortality Weekly Report* and elsewhere (*16,17*).

In 2000, 24 of the ABLES states reported a total of 10,361 adults with BLLs ≥25 µg/dL, with 2001 of these adults testing ≥40 µg/dL (3). It is likely that ABLES data underreport the extent of elevated BLLs in adults because not all employers provide BLL testing to lead-exposed workers and because some laboratories may not be in compliance with the reporting requirements. To prevent adult occupational and take-home lead exposures, many ABLES states have developed educational programs in cooperation with NIOSH.

Reducing Elevated BLLs in Adults

Increasing the awareness of health care providers about the sources of adult occupational exposures to lead is an essential first step in identifying exposed workers. Armed with this knowledge, as well as information about the prevention efforts of NIOSH and the state ABLES programs, health care workers are likely to increase surveillance of at-risk populations through more frequent BLL testing. Once identified, exposed workers can receive appropriate medical management along with education for workers and employers about reducing exposure in the workplace. The laboratory can play an important role in this process by giving health care providers accurate information about the clinical interpretation of the test results.

To address the need for a consensus approach for the recognition, treatment and management of adults with elevated BLLs, public health professionals from several of the ABLES states have formed the Ad Hoc National Committee for the Development of Adult BLL Medical Management Guidelines. The committee's goal is to improve the accuracy and uniformity of interpretive information accompanying BLL test results provided to clinicians caring for lead-exposed adults. The Committee has developed a draft document entitled "Blood Lead Level Medical Management Guidelines for Adults," which is intended for use by health care providers, laboratories, and other medical professionals who participate in the care of adults exposed to lead. Once finalized, these recommended guidelines can be adopted by laboratories for interpreting BLL results and managing adults with elevated BLL, as well as educating health care professionals and others.

Reporting Practices of Clinical Laboratories

Clinical laboratory practice guidelines developed by laboratory organizations such as the National Committee for Clinical Laboratory Standards (NCCLS) play an essential role in the care of lead-exposed adults by promoting excellence in clinical laboratory testing. Although it is now recognized that adverse health effects may occur at BLLs formerly considered to be safe, there are currently no national consensus guidelines available to assist laboratories in characterizing the health implications of low to moderate BLLs in adults. However, the findings of the 1999 NHANES can be used by laboratories as a source of normative reference values for blood lead in the United States adult population (see box, right). In 1999 the geometric mean and 90th percentile BLL for adults age 20–39 years were 1.4 µg/dL (95% confidence interval 1.2–1.5) and 2.8 µg/dL (95% confidence interval 2.5–3.2). The corresponding BLLs for adults age 40–59 years were 1.9 (CI 1.7–2.0) and 3.8 (3.6–4.4), respectively. By knowing the pertinent state and federal OSHA lead standards, as well as the recommendations of ACGIH, NIOSH, and other agencies or organizations engaged in the prevention of elevated BLLs among adult workers, laboratories can take a leadership role in identification of adults with elevated BLLs.

Clinical Labs at the Forefront

The information that is contributed to the blood lead registry—which is mandated by individual state public health agencies—helps states assess the extent and distribution of lead exposure in workers, employer compliance with lead-testing requirements, and the progress of companies and industries in reducing mean BLLs. Numerous factors, however, make it difficult to achieve these endpoints. For example, not all states require laboratories to report BLLs, and some states do not require reporting of every BLL result. Also, the information that laboratories send to state blood lead registries is often incomplete and lacking in key epidemiological information needed to characterize the workplace or occupational setting in which the exposure took place. Participation and leadership by clinical laboratories in helping to capture and submit all the required information is essential to the success of this system. Clinical laboratories are an important component in supporting these public health programs and helping them reach their goal of ensuring the health of working men and women and their families. By doing so, laboratories will also provide a model for other efforts to assess and reduce toxic occupational exposures.

Resources for More Information About Lead Exposure and Blood Lead Testing

- List of OSHA-approved blood lead testing laboratories is available at www.osha-slc.gov/OCIS/toc_bloodlead.html
- U.S. Department of Health and Human Services. Tracking Healthy People 2010. Washington D.C.: U.S. Government Printing Office, 2000. Also available at www.cdc.gov/nchs/hphome.htm
- NIOSH ABLES home page at www.cdc.gov/niosh/ables.html
- 1999 NHANES data on geometric mean and selected percentiles of blood lead concentrations for the U.S. population by selected demographic groups at www.cdc.gov/nceh/dls/report/results/Lead.htm
- CDC's National Report on Human Exposure to Environmental Chemicals. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, 2001. [Lead CAS No. 7439–92–1]. Also available at www.cdc.gov/nceh/dls/report

REFERENCES

1. Hamilton A. Exploring the dangerous trades: the autobiography of Alice Hamilton, MD. Boston, Mass.: Little, Brown, 1943.

2. Centers for Disease Control and Prevention. Screening young children for lead poisoning: guidance for state and local public health officials. Atlanta, Ga.: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, 1997.

3. Roscoe R. Personal communication with Robert Roscoe, Project Officer, Adult Blood Lead Epidemiology and Surveillance (ABLES) Program, National Institute for Occupational Safety and Health, Cincinnati, Ohio. 2002.

4. Pirkle JL, Kaufmann RB, Brody DJ, et al. Exposure of the U.S. population to lead, 1991–1994. Environ Health Perspect 1998;106:745–50.

5. NHANES. National Health and Nutrition Examination Survey. Hyattsville, Maryland: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Health Statistics, 1999. Database.

6. Hipkins KL, Materna BL, Kosnett MJ, et al. Medical surveillance of the lead exposed worker: current guidelines. AAOHN J 1998;46:330–9.

7. Kosnett MJ. Lead. In: Poisoning and drug overdose: a Lange clinical manual. 2nd ed. Stamford, Conn.: Appleton and Lange Publishers, 1998.

8. Mantere P, Hanninen H, Hernberg S et al. A prospective follow-up study on psychological effects in lead workers exposed to low levels of lead. Scand J Work Environ Health 10:43-50; 1984

9. Schwartz J. Lead, blood pressure, and cardiovascular disease in men. Archives Environ Health 50:31-37; 1995

10. Hu H, Aro A, Payton M, et al. The relationship of bone and blood lead to hypertension. JAMA 275:1171-1176; 1996

11. Torres-Sanchez LE, Berkowitz G, Lopez-Carrillo L. Intrauterine lead exposure and preterm birth. Environ Res 1999;81:29–301.

12. Borja-Aburto VH, Hertz-Picciotto I, Rojas Lopez M. Blood lead levels measured prospectively and the risk of spontaneous abortion. Am J Epidemiol 1999;50: 590–7.

13. U.S. Department of Health and Human Services. Healthy people 2010: understanding and improving health. 2nd ed. Washington, D.C.: U.S. Government Printing Office, 2000.

14. American Conference of Governmental Industrial Hygienists. TLVs and BEIs: Threshold limit values for chemical substances and physical agents and biological exposure indices agents. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 2001.

15. Roscoe RJ, Gittleman JL, Deddens JA, et al. Blood lead levels among the children of lead-exposed workers: a meta-analysis. Am J Ind Med 1999;36:475–81.

16. Centers for Disease Control and Prevention. Adult blood lead epidemiology and surveillance—United States, second and third quarter 1998, and annual 1994–97. Morbid Mortal Weekly Rep 1999;48:213–6, 223.

17. National Institute for Occupational Safety and Health. Worker health chartbook 2000. Washington, D.C.: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2000. [DHHS (NIOSH) Publication Number 2000–127]. CLN

Michael Ottlinger, PhD, is Senior Toxicologist with the Centers for Disease Control and Prevention–National Institute for Occupational Safety and Health (CDC–NIOSH), Cincinnati, Ohio.

Ralph Zumwalde and Robert Roscoe are Senior Scientists with CDC–NIOSH, Cincinnati, Ohio.

Michael J. Kosnett, MD, MPH, is Associate Clinical Professor of Medicine, Division of Clinical Pharmacology and Toxicology, University of Colorado Health Sciences Center, Denver, Colo.

Raymond K. Meister, MD, MPH, is the Public Health Medical Officer in the California Department of Health Services' Occupational Lead Poisoning Prevention Program, Oakland, Calif.

Karen Hipkins RN NP-C, MPH, is Nurse Practitioner with the Public Health Institute under contract to the California Department of Health Services' Occupational Lead Poisoning Prevention Program, Oakland, Calif.

Barbara Materna, PhD, CIH is Chief of the Occupational Lead Poisoning Prevention Program, California Department of Health Services, Oakland, Calif.