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Occupational Health Effect and Biologic Exposure Indicators: Results from the Core States Pilot Project

March 2004

Council of State and Territorial Epidemiologists
In Collaboration with the National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention
Council of State and Territorial Epidemiologists

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Topic: OCCUPATIONAL EXPOSURES

INDICATOR #13: ELEVATED BLOOD LEAD LEVELS AMONG ADULTS

Demographic Group: Employed persons

Numerators:
1. All reported state residents age 16 years or older, with a blood lead level of > 25 µg/dL
2. All reported state residents age 16 years or older, with a blood lead level of > 40 µg/dL

Denominator: Employed population age 16 years or older for the same calendar year

Measures of Frequency:
Annual number of residents with elevated blood lead levels (numerator)
Annual prevalence rate per 100,000 employed persons age 16 years or older
Annual number of incident cases of residents with elevated blood lead levels
Annual incidence rate per 100,000 employed persons age 16 years or older

Time Period: Calendar year

Significance and Background: In 2001, reporting systems operating in 23 states enumerated nearly 10,000 adults with blood lead levels (BLLs) greater than or equal to 25 µg/dL. About 20 percent had levels greater than or equal to 40 µg/dLl. Lead adversely affects multiple organ systems and can cause permanent damage. Effects include anemia, nervous system dysfunction, kidney problems, hypertension, decreased fertility, and miscarriages. Children are more sensitive than adults to the effects of lead and about 24,000 U.S. children with BLLs of 10 µg/dL or greater are estimated to be exposed from lead unintentionally brought home by a parent from the workplace. Pediatric effects include neurologic damage, learning disabilities, and behavior problems.

Rationale: Among adults, lead poisoning is a persistent, mainly occupational, health problem that continues to be an important public health problem. The single best diagnostic test for exposure is the BLL. Federal Occupational Safety and Health Administration (OSHA) regulations to protect
workers from lead-associated health effects include requirements for monitoring BLLs among employees who meet certain exposure criteria.

Limitations of Indicator: BLLs are a good indicator of recent exposure over the 3 to 5 weeks preceding the test, but are
not a valid indicator of body burden of lead resulting from long-term exposure. Therefore, an elevated body burden of lead may not be detected in an individual if the lead test is done more than several weeks after the most recent lead exposure.

Data Resources: Reports of elevated BLLs from laboratories (numerator)
BLS Current Population Survey Data (denominator)

Limitations of Data Resources: Some states do not require laboratories to report elevated BLLs. Even with a reporting
requirement, data from laboratories are frequently incomplete. Many workers with significant occupational lead exposure are not appropriately tested. An individual's lead exposure and BLL testing may be done in the same or in different states (which may not be the individual's state of residence). Approximately 10-15% of elevated BLLs among adults can be caused by non-occupational exposures. Not all states may be able to distinguish occupationally exposed individuals from non-occupationally exposed individuals. Not all states may be able to determine both state of employment/exposure and state of residence of their reported cases.

HP2010 Objectives: 20-7
20-7 Reduce the number of persons who have elevated blood lead concentrations from work exposures.
Target: Zero persons per 1 million.

Baseline: 93 per million persons aged 16 to 64 years had blood lead concentrations of 25 µg/dL or greater in 1998 (25 States).

Target setting method: Total elimination.

Data source: Adult Blood Lead Epidemiology and Surveillance Program, CDC, NIOSH.

Data for population groups currently are not collected.

CSTE Positions: 1990-Env-9; 1995-Env-14; 1999-Env-02; 2000-Occ-01; 2001-Occ-01

Other Available Data: Age, gender, industry, occupation, individual BLL, and all lead test reports (i.e., not just those exceeding the specified criteria)

Recommendations: Many states have data elements that can be used to better define the pattern of elevated blood lead levels. Report numbers and rates for occupational cases only, rather than including both occupationally and non-occupationally exposed persons in the numerator. Include occupationally exposed cases working in your state (e.g., employer is based in your state, or, if able to determine, worksite is in your state), regardless of their state of residence. Age, gender, and race/ethnicity specific counts and rates can be used to better define the pattern of elevated BLLs. Industry and occupation information can be used to provide additional insight. Individual BLLs can help identify particularly egregious exposures. Obtaining reports on all BLLs can provide insight about the overall frequency of BLL testing. Follow-up of selected cases and/or clusters can help identify where/how individuals with high BLLs were exposed.

HOW-TO GUIDE – INDICATOR #13:

ELEVATED BLOOD LEAD LEVELS AMONG ADULTS

13.1 Persons age 16 years or older with a blood lead level of > 25 µg/dL

13.1.1 Annual number of residents with elevated blood lead levels (>=25 µg/dL)
• Contact state Adult Blood Lead Epidemiology Surveillance (ABLES) program: www.cdc.gov/niosh/ables.html
• Request data according to the following criteria for the calendar year:
– Blood lead level (BLL) > 25 µg/dL
– Age 16 years and older
– Earliest date of either draw date, date laboratory received sample, or date laboratory analyzed sample
– If a person is reported more than once during the time period, count that person one time only, at his/her highest BLL
– Include all cases, both occupationally and non-occupationally exposed
– Include all residents of state and unknown residence
– Exclude out-of-state residents
• This will yield the '**Annual number of residents with blood lead levels > 25 µg/dL**'.

13.1.2 Annual prevalence rate per 100,000 employed persons
a) To obtain the denominator for the rate:
• Go to Current Population Statistics: http://www.bls.gov/opub/gp/laugp.htm.
• For data prior to 2002, click on the appropriate year of 'Geographic Profile of Employment and Unemployment'.
• Locate Table 12 – "Employment status of the civilian noninstitutional population by sex, age, race and Hispanic origin'.
• Find your state from the first column.
• Read the 'Total' row for your state and the 4th data column – "Employment Number'. This is the '**Number of Employed Persons 16 years of age or older**' (in thousands). Multiply by 1000.
b) To calculate the rate:
• Divide the numerator (13.1.1) by the denominator (13.1.2a).
• Multiply this result by 100,000 to get the '**Annual prevalence rate per 100,000 employed persons age 16 years or older**'.

13.1.3 Annual number of incident cases
Use the ABLES definition of an incident case: Case with a BLL of > 25 µg/dL reported in the calendar year, but was not reported in the immediately preceding year with a BLL of > 25 µg/dL (may appear in earlier years with a BLL of 25 µg/dL or greater).

13.1.4 Annual incidence rate per 100,000 employed persons
a) To obtain the denominator for the rate:
Follow directions for 13.1.2.
b) To calculate the rate:

• Divide the numerator (13.1.3) by the denominator (13.1.2a)
• Multiply this result by 100,000 to get the **'Annual incidence rate per 100,000 employed persons age 16 years or older'.**

13.2 Persons age 16 years or older with a blood lead level of > 40 µg/dL

13.2.1 Annual number of residents with blood lead levels >= 40 µg/dL
Follow data request from 13.1.1 for BLL > 40 µg/dL

13.2.2 Annual prevalence rate per 100,000 employed persons
a) To obtain the denominator for the rate:
Follow directions for 13.1.2.
b) To calculate the rate:
• Divide the numerator (13.2.1) by the denominator (13.2.2a)
• Multiply this result by 100,000 to get the **'Annual prevalence rate per 100,000 employed persons age 16 years or older'.**

13.2.3 Annual number of incident cases
Use the ABLES definition of an incident case: Case with a BLL of > 40 µg/dL reported in the calendar year, but was not reported in the immediately preceding year with a BLL of > 40 µg/dL (may appear in earlier years with a BLL of 40 µg/dL or greater).

13.2.4 Annual incidence rate per 100,000 employed persons
a) To obtain the denominator for the rate:
Follow directions for 13.1.2.
b) To calculate the rate:
• Divide the numerator (13.2.3) by the denominator (13.1.2a).
• Multiply this result by 100,000 to get the **'Annual incidence rate per 100,000 employed persons age 16 years or older'.**

http://www.cste.org/ps/2001/2001-occ-01.htm

01-OCC-01

Committee: Occupational Health

Title: Improved Protection for Lead-Exposed Workers: Updating the OSHA Lead Standards for General Industry and Construction

Statement of the Problem(s):
This resolution is aimed at petitioning the Federal Occupational Safety and Health Administration (OSHA) to update its standards for the protection of workers exposed to inorganic lead, 29 CFR 1910.1025 (general industry) and 29 CFR 1926.62 (construction).

Since the late 1980s a growing number of states have conducted surveillance of occupational lead poisoning, coordinated by the National Institute of Occupational Safety and Health (NIOSH) under the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program. To date, 27 states report surveillance data quarterly to NIOSH for publication in the Morbidity and Mortality Weekly Report. In addition to collecting and analyzing blood lead data, ABLES state programs conduct follow-up investigations of lead poisoning cases to identify failures in prevention, target educational interventions, and in some cases refer specific employers to OSHA for enforcement action.

Based on the experience of the ABLES Program, state-based health professionals have become keenly aware of needed improvements in OSHA's lead standards that should be addressed by initiating a rulemaking process to update them. Individuals or organizations may petition OSHA for new rulemaking under section 6(b)(1) of the Occupational Safety and Health Act of 1970.

The primary reasons for taking this action are described below:

1. OSHA STANDARDS ARE BASED ON OUTDATED TOXICITY INFORMATION. The existing lead standards are based on the level of scientific knowledge about lead toxicity that was available in the late 1970s, and significant new toxicity information is now available. Even the 1993 construction standard was modeled after the 1978 general industry standard and did not consider new information about the health damage caused by lead. Under the current standards, workers can legally be exposed to lead when their blood lead levels (BLLs) are as high as 49 micrograms per deciliter (ug/dl), and higher in some instances (see below). Studies published during the 1980s and 1990s show that health effects such as male and female reproductive damage, hypertension, and decrements in reaction time, visual-motor coordination and mood can occur when BLLs are well below 49 ug/dl. Attached is a listing of key literature references on the toxicity of lead (Attachment 1).

2. TECHNOLOGY TO CONTROL AIRBORNE LEAD EXPOSURES HAS IMPROVED. When the 1978 lead standard was passed, OSHA noted that it may not be technically and/or economically feasible to maintain BLLs at or below 40 ug/dl for all exposed employees. In over

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20 years, technology has improved and it is far more feasible for employers in lead industries to provide better control of airborne lead levels. In addition, because the average BLL among the general population has dropped dramatically since the 1970s due to the removal of lead from gasoline, it should be feasible to reduce OSHA's maximum allowable BLL for workers by 15-20 ug/dl without major technological change.

3. OSHA STANDARDS ARE NOT CONSISTENT WITH NATIONAL PUBLIC HEALTH GOALS. The Centers for Disease Control and Prevention's "Healthy People 2010" aims to maintain the BLLs of all lead-exposed workers below 25 ug/dl, with a long-term target to reduce exposures that result in workers having BLLs greater than 10 ug/dl. (Note that the mean adult BLL for the U.S. population has been reported to be 2 ug/dl). The OSHA lead standards allow a worker's BLL to be as high as 49 ug/dl for construction workers, or 62 ug/dl (equivalent to 59 micrograms lead per 100 grams blood, ug/100g) for general industry workers, without mandating that employers take any action to decrease BLLs.

4. WORKER PROTECTIONS BASED ONLY ON AIR LEAD LEVELS ARE INADEQUATE. The OSHA lead standards are structured so that air lead levels must exceed specified levels before the majority of protective measures (e.g., blood lead testing, protective clothing, respiratory protection, comprehensive training) are required. This approach is not adequate because 1) most employers do not conduct air monitoring frequently enough to correctly evaluate exposure levels; and 2) dangerous exposures can occur through ingestion of lead, despite relatively low air lead levels. The OSHA standards should include language which requires routine blood lead and zinc protoporphyrin testing for all lead-exposed workers, so that workers poisoned through inhalation and/or ingestion are identified and protected. OSHA should also consider requiring surface wipe sampling to identify lead contamination in order to provide additional protection from ingestion of lead.

5. CONSTRUCTION AND GENERAL INDUSTRY WORKERS DESERVE EQUAL PROTECTION. Under the current standards, construction workers are eligible for removal from lead exposure with full pay (i.e., Medical Removal Protection or MRP) at a BLL of 50 ug/dl, while for general industry workers a level of 60 ug/100 g is required (if only one test is available). The general industry MRP level, expressed in the outdated units of ug lead/100 g blood, is equivalent to 63.4 ug/dl. There is no justification for providing a higher level of protection for lead-exposed construction workers than for workers in general industry.

Statement of Desired Action(s) to be Taken:

1. CSTE shall submit a petition request to the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), requesting initiation of a rulemaking to update the OSHA lead standards for general industry (29 CFR 1910.1025) and construction (29 CFR 1926.62).

2. CSTE shall send a letter to the Director, Centers for Disease Control and Prevention, requesting that the National Institute for Safety and Health (NIOSH), under its mandate to provide scientifically valid recommendations to OSHA for protecting workers, update the Criteria Document for Occupational Exposure to Inorganic Lead.

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3. CSTE shall send copies of the petition request to the following organizations:

· Adult Blood Lead Epidemiology & Surveillance (ABLES) State Programs
· US Environmental Protection Agency
· US Department of Housing and Urban Development
· US Department of Transportation
· American Federation of Labor – Congress of Industrial Organizations (AFL-CIO)
· Lead Industries Association
· American Public Health Association – Occupational Health Section
· American Industrial Hygiene Association
· American Conference of Governmental Industrial Hygienists
· American Conference of Occupational and Environmental Medicine
· American Association of Occupational Health Nurses
· Association of Occupational and Environmental Clinics

Public Health Impact:
The desired impact of this resolution is for Federal OSHA to initiate rulemaking to update the lead standards, enabling development and adoption of more protective regulations that will better ensure the health of lead-exposed workers nationwide. A key aspect of updating the standards is to lower the blood lead level that triggers a period whereby a worker is removed from significant lead exposure and allowed to recover from excessive exposure while still maintaining full salary and benefits (i.e., Medical Removal Protection). In light of more recent lead toxicity information that indicates health effects at lower blood lead levels, preventing continued exposure at high levels will reduce the risk of workers experiencing adverse health effects such as damage to the renal, nervous and reproductive systems.

Attachment 1 – Important References on Lead Toxicity Published Since the 1978 OSHA Lead Standard

Coordination:
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References:

Attachment 1 – Important References on Lead Toxicity Published Since the 1978 OSHA Lead Standard

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CSTE Position Statements 2000 OCC #1

Committee: Occupational

Title: Designation of Adult Blood Lead Epidemiology and Surveillance as the initial core component of state-based occupational health and safety surveillance

Position To Be Adopted:

CSTE supports the National Institute for Occupational Safety and Health (NIOSH) Surveillance Strategic Plan and its recognition of the importance of establishing core state-based occupational health and safety surveillance programs in every state. CSTE recommends that establishment of Adult Blood Lead Epidemiology and Surveillance (ABLES) programs in all states seeking to address this core capacity is the highest priority with respect to occupational health surveillance requiring federal assistance.

CSTE will promote maximal utilization of ABLES data through expanded partnerships with federal agencies/programs active in lead poisoning prevention (e.g., NIOSH, HUD, EPA, OSHA, NCEH, HRSA, NCHS).

Background And Justification:

The role of public health practitioners in state health agencies is to assess factors that adversely impact the public's health and implement effective intervention activities to reduce the extent of illness and injury. In the area of occupational health and safety, public health prevention activities are also needed to support efforts in regulation and enforcement carried out by the Occupational Safety and Health Administration (OSHA).

In 1987, NIOSH and four states established the ABLES Program, a surveillance system for identifying and preventing cases of elevated blood lead levels (BLLs) among U.S. adults, most of whom are exposed to lead at work. There are currently 28 ABLES states with programs that:

- Collect, analyze and report BLL data reported from laboratories and other sources;
- Conduct follow-ups of lead poisoning cases with workers, physicians, and employers;
- Target on-site investigations of work sites;
- Provide referrals to cooperating agencies;
- Identify new exposures and failures in prevention;
- Target educational and other interventions; and
- Disseminate information on adult lead poisoning regularly in Morbidity and Mortality Weekly Report, a world-wide public health publication (note: this is the first occupational disease condition reported on a regular basis in MMWR).

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Twenty-one of the 28 ABLES state programs currently (fiscal year 2000) receive funding support from NIOSH ranging from $19,000 to $26,000 per year, and approximately 5 to 7 states are interested in developing programs if additional funding were to become available.

The experience of NIOSH and the ABLES state programs has shown that effective state-based surveillance of elevated blood lead levels is straightforward and minimally achievable with limited resources. The diagnosis of elevated blood lead levels is clear cut. Mandatory state requirements for laboratory reporting of BLLs to state health departments provide usable data for public health action. These data enable ABLES state programs to perform case follow-up of individual workplaces and targeting for broader interventions. Providing education and training about appropriate prevention measures has been effective in improving workplace conditions and preventing future disease. Many ABLES programs also make referrals of problem workplaces to OSHA for enforcement action and/or have memoranda of understanding with OSHA to use ABLES data for targeting purposes.

The ABLES Program provided input to CDC in the development of a Healthy People 2010 objective for adult lead poisoning prevention (1). This objective seeks to eliminate exposures to lead that result in adults with blood lead levels above 25 ug/dl by the year 2010.

Each quarter, approximately 4000 individuals nationwide are identified with BLLs 25 micrograms per deciliter (ug/dl) or higher by the 28 state-based ABLES programs (2). However, these data likely represent only the tip of the iceberg with respect to the extent of occupational lead exposure in the U.S. ABLES programs have found that many workers do not receive routine blood lead testing despite OSHA regulations requiring testing. ABLES case follow-up often identifies additional workers at risk and new sentinel exposures.

In addition to the adults identified with elevated BLLs and potential lead poisoning, ABLES programs identify children at risk from lead brought home from the workplace on workers' clothes, shoes and bodies ("take-home lead"). Several significant studies have documented lead contamination in the homes of lead-exposed workers and elevated BLLs among their children (3,4), and NIOSH has issued a Report to Congress on this topic (5). ABLES programs work closely with childhood lead poisoning programs to refer the children of lead-exposed workers for testing and work with employers to reduce risk factors for take-home lead exposure. A recently published ABLES meta-analysis of workers and their children's lead levels estimated that 2 to 3% of child lead poisonings (potentially 24,000 out of 890,000 children with BLLs over 10 ug/dl) may result from take-home lead exposure (6).

Nationwide, there is currently a major focus on addressing the problem of childhood lead poisoning, in particular that which results from exposure to lead paint and dust in housing. Several federal agencies (CDC, HUD, EPA, HRSA) have major initiatives and resources devoted to this effort. The primary intervention for child lead exposure is remediation of deteriorated paint and contaminated dust in housing; this work requires a vast workforce of construction workers to accomplish this task in an estimated 77 million privately-owned housing units that contain lead-based paint (7). If not done properly, this work will expose both workers and building occupants to unsafe levels of lead. In a recent Report to Congress, NIOSH recommended that evaluation of the safe progress of remediation, renovation and remodeling

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work requires the effective surveillance systems for adult lead poisoning established by the state ABLES programs (8). The report stated that, "State surveillance programs should be expanded to all states where workers are exposed to lead-based paint hazards to identify high-risk workplaces and conduct follow-up investigations where needed." In addition, several ABLES programs have conducted projects aimed at educating contractors and workers about working safely around lead-based paint, and at evaluating work methods that reduce lead exposure and the potential for contamination during renovation activities.

Over the last several years, a NIOSH-State Work Group representing the approximately 30 states with surveillance programs for various occupational health endpoints established an overall goal of conducting core occupational health surveillance and prevention activities in 50 states (9). The NIOSH Surveillance Strategic Plan has as a major goal to strengthen the capacity of state health departments and other state agencies to conduct occupational health and safety surveillance (10). The ABLES Program is an essential step toward meeting that goal, as for most states the only occupational health condition currently under surveillance is elevated BLLs. State-based ABLES programs can serve as the basic infrastructure on which to expand to include other occupational or environmental health endpoints. Many of the states that conduct occupational health surveillance started with an ABLES program and have gone on to obtain state funds for increasing state health department-based occupational health prevention activities.

Leadership is needed from NIOSH in establishing partnerships with other federal agencies/programs with a stake in lead poisoning prevention to support the capacity of ABLES programs nationwide.

CSTE adopted a position (11) in 1995 recommending the addition of elevated adult BLLs to the National Public Health Surveillance System (NPHSS). In 1999 CSTE adopted a position (12) which established a surveillance case definition of 25 ug/dl or higher for adult BLLs to be reported to NPHSS. This Position Statement is intended to promote the capacity of state-based occupational health surveillance programs to contribute occupational lead poisoning surveillance data to NPHSS by maintaining ABLES programs in the current 28 states and continuing to develop the capacity for collecting such data in all states nationwide.

Coordination With Other Agencies

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Implementation of this resolution will be a priority activity of the CSTE Environmental and Occupational Health Committee and its Occupational Health Team.

Agencies for Information:

For information on NIOSH policies and data on adult lead exposures, telephone the NIOSH hotline: 1-800-356-4674. For further information including contact persons and publications from the 28 states participating in the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program, contact the NIOSH home page (www.cdc.gov/niosh/ables.html). For information on OSHA, EPA, and HUD lead policies and publications, contact their home pages: www.osha.gov, www.epa.gov, and www.hud.gov.

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12. 1999 CSTE Annual Meeting, Position Statement #ENV 2, Surveillance Case Definition for Adult Blood Lead Levels to be Reported to the National Public Health Surveillance System, NPHSS.

http://www.cste.org/ps/1999/1999-env-02.htm

CSTE ANNUAL MEETING

POSITION STATEMENT 1999 ENV 2

COMMITTEE: Environmental

TITLE: Surveillance Case Definition for Adult Blood Lead Levels to be Reported to the National Public Health Surveillance System, NPHSS

POSITION TO BE ADOPTED

An adult blood lead level that should be maintained under surveillance by the NPHSS is defined as an adult (16 or older) with a venous (or comparable) blood lead level equal to or greater than 25 micrograms per deciliter (mcg/dL) of whole blood.

BACKGROUND AND JUSTIFICATION

The CSTE adopted a position in 1995 recommending the addition of elevated adult blood lead levels to the NPHSS; this position statement adds the case definition to the previously adopted position.

The case definition above is in accordance with the current U.S. Public Health Service objective for adult lead exposures (Objective 10.8 in Healthy People 2000), "Eliminate exposures which result in workers having blood lead concentrations greater than 25 micrograms per deciliter (mcg/dL) of whole blood." (1) However, current research indicates that some of the adverse effects on the developmental nervous system and on the cardiovascular system which can be measured in exposed populations, occur at blood lead levels (BLLs) as low as 10 mcg/dL. The National Institute for Occupational Safety and Health (NIOSH) recommends that to minimize the risk of adverse health effects in workers and their children, employers should continually strive to reduce workplace lead exposures.

Laboratory Criteria

The primary source of blood lead level reports is public and private laboratories; physician reporting may supplement laboratory reporting. Laboratory reporting of BLL results to State lead registries must be mandatory under State law and should include basic demographic information, including personal identifiers to differentiate between new and ongoing cases and to account for multiple reports on the same individual. It is strongly recommended that information be included on occupation and/or industry, lead-avocations, and whether the laboratory is approved for occupational lead testing by the Occupational Safety and Health Administration (OSHA). It is

also strongly recommended that laboratories report data on all adults tested for lead. The collection of all test results, regardless of BLL, is extremely helpful in following sequential test results on adults who have elevated blood lead levels. The collection of all test results also provides denominator data that allow calculation of screening penetration rates (i.e., compliance with OSHA requirements) and prevalence rates of elevated lead levels among adults tested.

The U.S. Food and Drug Administration has approved a field portable electro-analytic instrument for the on-site s blood lead levels which provides test results in about=testing of children five minutes. This instrument may use capillary blood and has been found to yield results comparable to venous blood lead samples analyzed by approved laboratories. It is possible that field portable instruments will be approved for workplace blood lead testing of adults. If portable, on-site BLL testing for adults is approved, effective State controls must be instituted to make certain that the results of these tests are reported to the State lead registries.

Lead

Lead (Inorganic) is a bluish gray metal that has been used since ancient times because of its useful properties, such as low melting point, pliability, and resistance to corrosion. The ancient Romans and Greeks first discovered its toxic effects. Lead is ubiquitous in U.S. urban environments because of the widespread use of lead compounds in industry, gasoline, and paints during the past century.

Lead is not an essential element nor does it serve any useful purpose in the body. It adversely affects multiple organ systems and can cause permanent damage. Research shows that lead has adverse health effects, including reproductive hazards, at levels once believed safe. Despite the fact that sources of lead exposure and effective preventive measures have been known for decades, occupational lead exposure continues to be an important public health problem.

Adult Lead Exposure

Industries in which workers have been occupationally exposed to lead include: battery manufacturing and recycling, nonferrous foundries, radiator repair shops, lead smelters, construction sites (during activities such as lead-based paint removal), demolition sites, firing ranges, ceramics, aluminum extruded products and the U.S. armed forces. Avocations in which persons are exposed to lead include: making pottery or stained glass, casting ammunition or fishing weights, sport shooting, and renovating or remodeling homes containing lead paint.

Human exposure to inorganic lead occurs when dust and fumes are inhaled and when lead from lead-contaminated hands, food, water, cigarettes, and clothing is ingested. Lead deposited in the respiratory and digestive systems is released to the blood, which distributes the lead throughout the body. More than 90 percent of total body lead content is accumulated in the bones, where it is stored for decades. Lead in bones may be internally released to the body long after the external environmental exposure occurs.

Among adults, lead poisoning is a persistent, mainly occupational, health problem (2). Adult exposure to lead can damage the central and peripheral nervous (3,4), hematological and renal

(5,6), reproductive (7,8), and cardiovascular (9,10) systems. Lead that is taken home from the workplace can also harm children and household members (11). Lead has been shown to be an animal carcinogen (12), and authors of recent studies suggest that occupational lead exposure increases the risk of cancer (13,14). Lead poisoning often goes undetected since many of the symptoms such as stomach pain, headaches, anxiety, irritability, and poor appetite, are nonspecific and may not be recognized as symptoms of lead poisoning.

Testing for Lead Exposure

There are several biological indices of lead exposure. Measurement of protoporphyrin (free or zinc protorporphyrin) concentration in red blood cells can be a good indicator of inhibition of heme synthesis by lead. There are, however, other causes (e.g., iron-deficiency anemia and inflammatory conditions) of elevated protoporphyrin levels. Lead concentrations in urine, bones, teeth, and hair can be used as biological indicators of current or past lead exposure. Recent advances in the measurement of bone lead levels will eventually provide a more accurate method for determining cumulative lead exposure and the total body burden of lead. At present, however, the best available method for monitoring biological exposure to lead is measurement of the BLL in whole blood. The frequency and severity of symptoms associated with lead exposure generally increase as the BLL increases although there is much individual variability. No such relationship between symptoms and the other indices of lead exposure have been established.

The federal Occupational Safety and Health Administration's (OSHA) regulations to protect workers from lead-associated health effects include requirements for monitoring BLLs among employees who meet certain exposure criteria.

The adult BLL of 25 mcg/dL is defined as "elevated" in relation to national data on BLLs among adults in the U.S. Data from the Centers for Disease Control and Prevention (CDC's) Third National Health and Nutrition Examination (NHANES III) Survey 1988-91 estimated that the geometric mean BLL for U.S. adults ages 20-74 was 3.0 mcg/dL (95% confidence interval, 2.8-3.2) and that 0.4% of the 6,922 in the sample had BLLs of 25 mcg/dL or greater (15). Extrapolated to the entire U.S. population of adults ages 20-74, this suggests that about 700,000 adults had BLLs of 25 mcg/dL or greater.

In the 1978 general industry standard for lead, OSHA advised that the maximum acceptable BLL was 40 mcg/dL and that men or women planning on having children should limit their exposure to maintain a BLL less than 30 s=mcg/dL. The CDC has recommended an action level of 10 mcg/dL for children exposure to lead (16). OSHA said that at that time feasibility constraints prevented it from establishing a lead standard that would prevent all physiologic changes, reproductive effects, and mild signs and symptoms in exposed workers (17). As required by Title X, in 1993 OSHA provided an equivalent level of protection to construction workers in its interim final rule for lead in the construction industry (29 CFR 1926.62). During the 1993 rule making, OSHA performed no additional analysis of health data and did not reexamine the feasibility of protecting workers from all the known health effects of lead.

The feasibility and utility of laboratory-based surveillance of BLLs for adults and children have been documented in many states. CDC currently supports adult lead toxicity surveillance

activities and collects data from 27 State health departments. Data from the CDC's Adult Blood Lead Epidemiology and Surveillance Program for 1997 indicated that 12,716 individuals from 27 reporting states had blood lead levels > 25 mcg/dL, including 777 individuals with blood levels > 50 mcg/dL (18). Extrapolated to the entire U.S., this suggests that about 18,000 adults had BLLs > 25 mcg/dL and about 1,100 had BLLs > 50 mcg/dL in 1997. The most recent analysis of the nationwide adult blood lead data suggest that the number of persons with BLLs > 25 mcg/dL has been relatively constant since 1994. ABLES surveillance data underestimate the prevalence of adult lead toxicity because not all workers with significant lead exposure are being tested appropriately for BLL.

Reporting of elevated BLLs by clinical laboratories to State occupational lead surveillance systems has led to a wide variety of public health prevention and intervention activities, including industrial hygiene on-site consultations at lead-using work sites, referrals to OSHA for enforcement actions, referral of exposed workers to physicians for clinical follow-up, education of reported individuals and their physicians, and targeted outreach to high-risk industries.

Lead exposure at work can also affect the families and children of lead exposed workers. A meta-analysis of several studies has suggested that about one half of the children of lead-exposed workers have BLLs > 10 mcg/dL. Lead contamination in the homes of workers who have brought lead dust home on their clothing has been documented.

Agencies for Response:

Agencies for Information: For information on NIOSH policies and data on adult lead exposures, telephone the NIOSH hotline: 1-800-356-4674. For further information, including contact persons and publications from the 27 states participating in the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program, contact the NIOSH home page: (http://www.cdc.gov/niosh/ables.html).

For information on OSHA, EPA and HUD lead policies and publications, contact their home pages at: http://www.osha.gov, http://www.epa.gov, and http://www.hud.gov, respectively.

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