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Lead Hazards for Pregnant Women and Children: Part 2

More can still be done to reduce the chance of exposure to lead in at-risk populations.

Overview: In the United States the risk of lead exposure is far higher among poor, urban, and immigrant populations than among other groups. And even slightly elevated blood lead levels increase children's risk of significant neurobehavioral problems extending through adolescence. Research has shown that blood lead levels in pregnant women well below the Centers for Disease Control and Prevention's "level of concern" of 10 micrograms per deciliter can cause miscarriage, premature birth, low birth weight, and subsequent developmental delays in their children. Despite these well-established dangers of lead exposure, routine prenatal lead screening and education is not a standard of care in the United States.

Part 1 of this two-part article (October) presented the case of a pregnant woman with lead poisoning and described the epidemiology of lead exposure in the United States, the main sources of it, and its effects on a pregnant woman and her developing fetus and child. **Part 2** describes recommendations for prenatal screening and strategies for dealing with lead exposure when it occurs: education, reduction in environmental exposure, treatment options, and developmental surveillance.

In January 2000 the U.S. Department of Health and Human Services released its goals for Healthy People 2010, one of which was the complete elimination in children of blood lead levels of 10 micrograms per deciliter or higher by 2010.[1] Many successful efforts at surveillance and screening were initiated, and a special focus was placed on "primary prevention." In 2005 the Centers for Disease Control and Prevention (CDC) announced that national and local strategies should focus on eliminating lead in two primary sources of contamination in children: housing and "nonessential" products such as toys and home remedies.[2] The American Academy of Pediatrics (AAP) soon followed suit, emphasizing a move "from case identification and management to primary prevention, with a goal of safe housing for all children."[3]

The CDC and the AAP recommend screening of all Medicaid-eligible children, as well as targeted screening of children who are not eligible for Medicaid.[3] While such screening of at-risk populations remains essential, it is not enough. Earlier this year Mary Jean Brown, a nurse who is also the chief of the Lead Poisoning Prevention Branch at the CDC, wrote, "In many communities where the risk of lead poisoning is disproportionately high"—including, she noted, areas with large populations of immigrants and refugees—"the 2010 goal will not be achieved if we continue to conduct business as usual."[4] Poor and immigrant populations are at particular risk for exposure to "house dust contaminated by deteriorated lead-based paint" and "soil contaminated by both lead-based paint and decades of industrial and motor vehicle emissions,"[5] both sources seen frequently in the old and deterio-

Lead Harms © 2006 City of Philadelphia Mural Arts Program / Cliff Eubanks. Photo by Stephen Weinik.

The mural above, entitled *Lead Harms,* by Cliff Eubanks, was painted in 2006 on the wall of a recreation center in an area of Philadelphia where lead poisoning is disproportionately high among children. Depicted in the mural are some of the sources of lead, such as lead pipes and paint, and ways to prevent lead poisoning, such as handwashing and eating foods high in calcium, iron, and vitamin C, such as broccoli. Said Jill Ann Coleman at the Philadelphia Department of Public Health, "The artist originally wanted to use asparagus, but that community—which helped to design the mural—said they didn't even know what asparagus was" because it's so rarely available in their neighborhood. The Philadelphia Department of Public Health's Childhood Lead Poisoning Prevention Program, along with several neighborhood organizations and the Temple University Department of Nursing, came together to educate the public. The mural was one outgrowth of that effort. For more information, go to www.muralarts.org.

rating housing often found in inner cities and in some rural communities.

As described in Part 1 of this article (October), blood lead levels well below the CDC's "level of concern," 10 micrograms per deciliter, can produce adverse effects. In this article we discuss specific preventive public health strategies, as well as the treatment of those with elevated blood lead levels.

SCREENING

Pregnant women. "No national organizations currently recommend screening pregnant women for elevated lead levels." So stated the U.S. Preventive Services Task Force in 2006.[6] However, many cities with high-risk populations have their own guidelines and policies, and New York and Minnesota (and possibly other states) take a more aggressive approach to antepartum lead screening. These states recommend that pregnant women receive an initial screening questionnaire (for an example of one that was adapted from a questionnaire used by the CDC to assess women's level of risk, see *Blood Lead Screening Risk Questionnaire for Pregnant Women,* page 42). If a woman responds "yes" or "don't know" to any of the seven screening questions, she should have a blood lead test; New York State provides detailed guidelines on the management of elevated leads levels in pregnancy (see Table 1, page 43).

Children. Children should be screened for lead according to state recommendations. In the absence of recommendations, the CDC suggests that the blood lead levels in children be determined at one and two years of age.[7] In addition, children 36 to 72 months of age should be tested if they haven't previously been screened or if they live in a zip code in which 27% or more of the housing was built before 1950, they receive public assistance, or a parent or guardian answers "yes" or "don't know" to any of the following three questions[7]:

- "Does your child live in or regularly visit a house that was built before 1950?"
- "Does your child live in or regularly visit a house built before 1978 with recent or ongoing renovations or remodeling (within the last six months)?"
- "Does your child have a sibling or playmate who has or did have lead poisoning?"

Blood Lead Screening Risk Questionnaire for Pregnant Women

Health care providers should use a blood lead test to screen pregnant women if they answer "yes" or "don't know" to any of the following questions.

1. Do you or others in your household have an occupation that involves lead exposure?
2. Sometimes pregnant women have the urge to eat things that are not food, such as clay, soil, plaster, or paint chips. Do you ever eat any of these things—even accidentally?
3. Do you live in a house built before 1978 with ongoing renovations that generate a lot of dust (for example, sanding and scraping)?
4. To your knowledge, has your home been tested for lead in the water, and if so, were you told that the level was high?
5. Do you use any traditional folk remedies or cosmetics that are not sold in a regular drugstore or are homemade?
6. Do you or others in your household have any hobbies or activities likely to cause lead exposure?
7. Do you use non–commercially prepared pottery or leaded crystal?

Adapted from the Blood Lead Screening Risk Questionnaire for Pregnant Women in Minnesota. Minnesota Department of Health. Environmental Health Division. *Blood lead screening guidelines for pregnant women in Minnesota.* St. Paul, MN; 2007 Dec. www.health.state.mn.us/divs/eh/lead/reports/pregnancy/pregnancy1page.pdf.

INTERVENTIONS FOR PREVENTION

After a child has been found to have an elevated blood lead level, identification and containment of the lead source should be the first priority.[8] Patient education on potential sources of lead is critical during this process.[9] Once health care professionals identify the source of lead exposure, the goal will be removing it; if that isn't feasible, the goal will be creating a barrier between living areas and lead sources. If lead is identified in bare soil surrounding a home, families can prevent children from coming in contact with the soil by planting grass or laying mulch or wood chips.[10] If lead paint cannot be removed (usually because of the cost of abatement), a process called encapsulation can be used. This involves covering the paint with an encapsulant, a sealant that can prevent lead paint and lead dust from entering the living environment. Families should be advised not to remove lead paint without seeking the help of a professional certified in the management of lead-based paint.

When an elevated lead level is identified, a clinician should report it to the local health department. Some health departments provide services to assist with environmental inspection and follow-up. Nurses can play an important role in helping families find necessary resources.

Described below are several simple recommendations for controlling environmental lead in the home or changing behaviors that increase a person's exposure to lead. These suggestions can be provided to families with children who have elevated blood lead levels or who have been judged to be at risk for exposure. However, while parent education programs are an important component in preventing or controlling lead exposure, too often they occur after lead exposure has taken place and only modestly reduce the blood lead levels of the children involved.[11] At the same time, too few educational programs include solutions other than lead abatement. If possible, programs should combine both nutritional and developmental education components.

Dust. Most programs target parent education on household cleaning to reduce blood lead levels in already-exposed children.[11] Household cleaning programs have shown moderate success but are often labor- and cost-intensive.[12-14] Vacuuming floors with a high-efficiency particulate air (HEPA) vacuum before washing them is often recommended, but these vacuums may be too expensive for many families.[9] As an alternative, a conventional vacuum can be used with a "HEPA-type" or "allergy" filter bag. Hard surfaces may be cleaned with common household products, and floors should be mopped weekly with soapy water. In addition, family members should be reminded to wash their hands before eating to prevent hand-to-mouth transmission of lead particles.

Family members may be exposed when lead dust and particles are brought into the home on clothing and shoes. Clinicians should ask about the occupations and hobbies of all family members and frequent visitors.[15, 16] In the case of an occupational exposure, the person should be advised to change or remove work clothing and shoes before entering the house.

Water. Advise families served by a public water system to request an annual water-quality report showing contaminants found in public water sources; many states post these reports online. If a family has a private water source such as a well, they should be advised to contact their state certification officer for a list of certified laboratories that can check for contaminants.[17] (For more information on lead in drinking water and how to avoid exposure, see "Tainted Water on Tap," November 2005.)

Pica. If lead toxicity has occurred as a result of pica—the ingestion of nonnutritive substances such as clay—interventions should be individualized to that patient. Education on nutrition may be helpful and may help correct any nutritional deficiencies that have contributed to the pica, such as a lack of iron in the person's diet. Behavioral interventions should be centered on reinforcing desired behav-

Table 1. Guidelines on the Management of Lead Poisoning in Pregnant and Postpartum Women*

Blood lead level	Action to be taken
0–9 µg/dL	Provide information on sources of lead, information on how to avoid exposure, and nutrition information.
10–19 µg/dL	Retest blood lead level to determine whether the level is increasing. If there is a significant rise in the blood lead level (to 20 µg/dL), seek consultation with an information center for further risk-reduction and patient-management information. If there is no upward trend, repeat blood lead testing during the third trimester, close to term, to assess the need for newborn evaluation. Provide counseling on possible sources of lead and information on how to reduce or eliminate exposure. Provide nutrition counseling to reduce absorption of ingested lead.
20–44 µg/dL	Retest blood lead level to determine whether the level is increasing. If the new level is between 10 and 19 µg/dL, repeat blood lead testing during the third trimester, close to term, to assess the need for newborn evaluation. If the blood lead level remains at 20 µg/dL or above, seek consultation with an information center for further risk-reduction and patient-management information. Provide counseling on possible sources of lead and information on how to reduce or eliminate exposure. Provide nutrition counseling to reduce absorption of ingested lead. Refer the patient to an occupational health clinic if occupational exposure is suspected. Refer the patient to the local public health agency for an environmental investigation if occupational exposure, hobbies, and folk remedies have been ruled out as sources of lead exposure. For advice about counseling patients on teratogenic effects, consult a teratogen information service.
45 µg/dL or higher	Consult a regional lead poisoning prevention resource center or other professional (if the level is severely elevated) with expertise in the clinical management of lead poisoning in adults. Early symptoms of lead poisoning may include fatigue, irritability, and depression; difficulty sleeping and concentrating; stomach cramps; constipation; weakness in the arms and legs; and problems with coordination. Very high levels may cause convulsions, coma, and even death. Consider hospitalization. Immediate removal from the contaminated environment may be indicated. Provide counseling on possible sources of lead and information on how to reduce or eliminate exposure. Provide nutrition counseling to reduce absorption of ingested lead. Refer the patient to an occupational health clinic if occupational exposure is suspected. Refer the patient to the local health agency for an environmental investigation if occupational exposure, hobbies, and folk remedies have been ruled out as sources of lead exposure. For advice about counseling patients on teratogenic effects, consult a teratogen information service.

* If a pregnant woman is at risk for current lead exposure, a blood lead test should be performed. If an infant is born to a mother with an elevated blood lead level (10 µg/dL or greater), umbilical cord blood should be tested and the infant's blood monitored. If a mother with an elevated blood lead level is breastfeeding, the infant's blood lead level should be tested frequently.

Adapted from New York State Department of Health. *Physician's handbook on childhood lead poisoning prevention.* http://www.health.state.ny.us/environmental/lead/handbook/phc10.htm#phc10part1.

Is Breastfeeding Safe?

Currently, there is no consensus on a maternal lead level that permits safe breastfeeding. Since the concentration of lead in a mother's blood is known to be considerably higher than that in her breast milk,[1] most recommendations suggest that the benefits of breastfeeding outweigh the possible negative effects on the infant. But very high lead levels in the mother or a continued and unexplained rise in the infant's blood lead levels while breastfeeding may provide a strong counterargument in certain cases. As Part 1 of this article described, an infant's risk of developing lead toxicity from the breast milk of a mother with an elevated blood lead level may not be as great as one might expect[2]; at the same time, commercial infant formula or the water that it's mixed with may contain lead.[3] Although recommending formula use over breastfeeding may not significantly reduce an infant's risk of lead exposure, more extensive research is needed before health care providers can offer definitive advice to patients regarding the safety of breastfeeding in the presence of elevated maternal blood lead levels.

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iors; in the case of a child with a learning disability as well as pica, this might mean praising that child for eating from a plate.[18] It should be kept in mind that pica is not always harmful and is considered normal in certain cultures. Not every case requires intervention. But some patients with pica should be screened and treated for conditions such as obsessive-compulsive disorder and anxiety.[18]

Nutrition. Lead is more readily absorbed by an empty stomach, and frequent meals and regular snacks should be recommended for those with elevated blood lead levels. Diets deficient in iron, calcium, and zinc enhance lead toxicity[19]; iron deficiency increases lead absorption,[20] and diets low in calcium may cause more rapid bone turnover and release of lead from the bones in pregnant women.[21] One researcher discovered that supplementing the diet of lactating women with 1,200 mg of calcium per day resulted in a modest decline in blood lead levels; the reduction was more impressive (1.16 micrograms per deciliter) in women with higher bone lead levels who were compliant with the supplementation regime.[21]

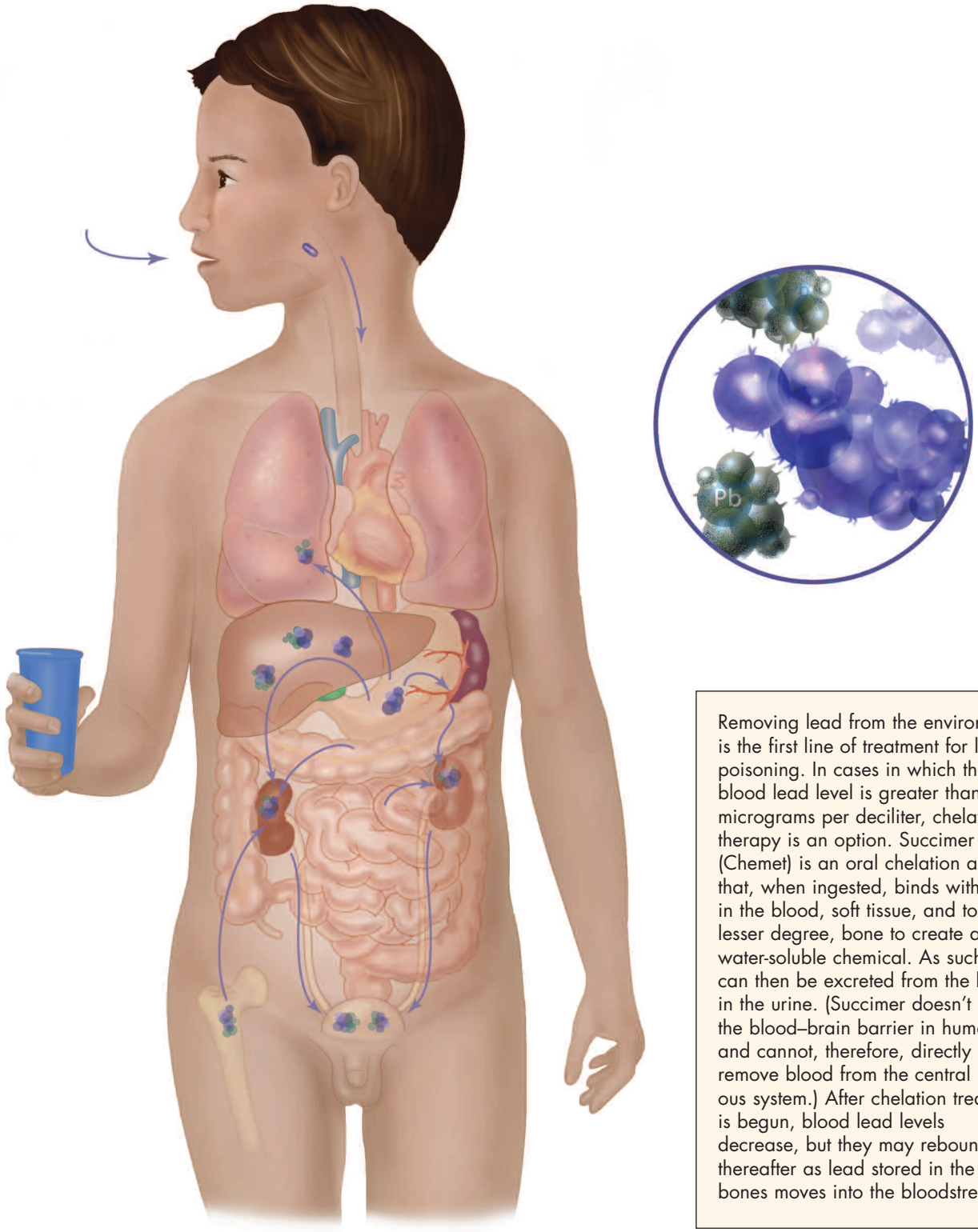
TREATMENT: CHELATION

Chelation therapy, the only form of medical treatment available for lead poisoning, converts toxic metals in the body to chemically inert forms; however, *chelation is not a cure for lead poisoning and will not reverse neurologic damage that has already occurred.* Chelating agents are administered either parenterally or orally; they act by binding with lead to form a complex that can be excreted from the body through the urine and bile. Agents often used for chelation include succimer (Chemet), which is also known as dimercaptosuccinic acid or DMSA and can be given orally; edetate calcium disodium (Calcium Disodium Versenate); and dimercaprol (BAL in Oil). Edetate calcium disodium should not be confused with the similarly named drug edetate disodium (Endrate), which is indicated for emergency treatment of hypercalcemia and other uses but *not* for the treatment of lead poisoning; in January the Food and Drug Administration issued a public health advisory based on reports of several deaths in both children and adults when edetate disodium was mistakenly administered instead of edetate calcium disodium; both drugs are sometimes referred to as EDTA.[22] All chelating agents present a risk of significant adverse effects, including kidney damage, chelation of essential minerals, nausea, vomiting, diarrhea, and death. The benefits of using them must be weighed against the potential harm, and they should be administered by an experienced provider.

As Ettinger describes, blood lead levels in children of 70 micrograms per deciliter or higher "are deemed medical emergencies" and "usually involve hospitalization for parenteral chelation therapy, as patients require intensive monitoring."[23] In addition, most guidelines agree that blood lead levels between 45 and 69 micrograms per deciliter "require medical and environmental management, usually including chelation therapy after the blood lead level has been confirmed." Because of the mobilization of lead stores in the body during chelation, rebound elevation of blood lead levels usually occurs after chelation therapy, and a blood lead level test should be performed again seven to 21 days after the discontinuation of therapy.[24] (For more on how chelation therapy works, see Figure 1, page 45.)

Chelation is contraindicated during pregnancy. In a review of the available literature, most of it based on animal studies, Gardella notes that chelation is unlikely to improve fetal blood lead levels and should not be administered for this purpose, adding that some chelating agents given to pregnant women may damage the fetus because they may reduce essential trace elements in the developing fetus.[15] Because of the potential harm to the fetus and the increased risk of pregnancy complications, chelation therapy is recommended for pregnant women only when the woman's life is in danger. The limited treatments for lead exposure in pregnant women only reinforce the need to prevent exposure. In 2005 the AAP released a position statement on preventing, detecting, and managing lead exposure

Figure 1.
Chelation Therapy for Lead Poisoning



Jay LeVasseur / applied art studio

Removing lead from the environment is the first line of treatment for lead poisoning. In cases in which the blood lead level is greater than 45 micrograms per deciliter, chelation therapy is an option. Succimer (Chemet) is an oral chelation agent that, when ingested, binds with lead in the blood, soft tissue, and to a lesser degree, bone to create a water-soluble chemical. As such, it can then be excreted from the body in the urine. (Succimer doesn't cross the blood–brain barrier in humans and cannot, therefore, directly remove blood from the central nervous system.) After chelation treatment is begun, blood lead levels decrease, but they may rebound thereafter as lead stored in the bones moves into the bloodstream.

in children that provides more detailed information on chelation therapy with succimer and edetate calcium disodium, with information on indications, dosing, and where to find pediatricians skilled in administering chelation therapy (http://aappolicy.aappublications.org/cgi/content/full/pediatrics;116/4/1036).

DEVELOPMENTAL SURVEILLANCE

As described in Part 1 of this article, children with blood lead levels as low as 5 micrograms per deciliter are at risk for neurobehavioral and cognitive deficits affecting intelligence, fine motor skills, attention, and social behavior.[25] The CDC recommends developmental surveillance for any child with a blood lead level greater than 20 micrograms per deciliter and for some children with levels lower than this who have "other significant developmental risk factors."[8] Particular attention should be paid to the child's behavior and cognitive development during the first, fourth, and sixth and seventh grades.[8]

Chelation is not a cure for lead poisoning and will not reverse neurologic damage that has already occurred.

In addition, we recommend a thorough neuropsychological assessment. This should include assessment of mental status, neurologic integrity, and motor reflex function, as well as a clinical history that includes examination of blood pressure, height, weight, and head circumference. In Project LIFE, short for "Lead Investigation and Family Education" in San Antonio, Texas, assessments of children's neurocognitive development were conducted according to age group; all children were assessed using the Adaptive Behavior Assessment System-II and either the Mullen Scales of Early Learning or the Wechsler Preschool and Primary Scales of Intelligence-III, but many other assessment tools are available.

Bellinger and Rappaport point out that some "evidence suggests that certain characteristics of children and their families are associated with the children's increased risk of neurodevelopmental impairments from a given level of lead exposure."[8] In a separate article, Bellinger hypothesizes that providing "enriched" environments for lead-exposed children can limit the appearance of deficits or encourage more rapid recovery.[26] Results of testing should be provided to the child's school, where appropriate cognitive and behavioral interventions can be implemented. Early childhood intervention programs are meant for children younger than three years old, although older children may be eligible, depending on local guidelines, to receive special education services. In addition, parents can be offered programs that teach them skills with which to stimulate their children's cognitive development. ▼

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