INTERVENTION

INTERVENTION: GETTING THE LEAD OUT

In 1904, an Australian doctor published the first warnings of the toxic effects of lead-based paint in children (106), and five years later France, Belgium and Austria became the first countries to ban leaded paint. Most other European nations as well as Cuba phased out lead-based paint in the 1920s and 1930s. The U.S. did not ban lead from household paint until 1978. Regulation, however, is only one of the tools—albeit an effective one—for reducing exposure to lead. In this section, we discuss some of the approaches that have been found to be useful, usually in combination.

SCREENING

Screening of children and adults has long been a catalyst for action. However, screening only indicates elevated lead levels after exposure and when generally irreversible damage has already occurred. To the extent that BLL screening is used as a safety net to be certain that no one is being inadvertently exposed to lead and as a very effective outreach and education tool, it is an important part of a comprehensive lead elimination program. However, elevated lead levels must be tied to an effective program to eliminate lead exposure, and children should not be used as "mine canaries" to identify lead-contaminated and substandard housing. For that, regulations requiring inspection and remediation of residential properties need to be in place. In other words, the screening of humans—especially children, and housing are two different needed screening approaches. Screening of housing only on the basis of discovering lead-poisoned children living in the housing is unacceptable. Prevention is key.

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Cultural Sensitivity

Although seldom discussed, effective screening of individuals and housing requires sensitivity to the language, cultural context and the realistic options available in each situation. In many Gulf Coast neighborhoods, trained promotores de salud (community healthcare workers) recruited from the neighborhoods may be more effective, and generally less costly, than public health investigators—at least initially. In 2004, for example, Dr. Larry Lowry and associates of the Southwest Center for Pediatric Environmental Health in Tyler, the pediatric environmental center for EPA region 6, which includes Galveston, conducted a study of an 11-month-old female Hispanic child who had an extremely high BLL at birth, which gradually decreased (176). Numerous attempts to identify the source of the poisoning by the English-speaking investigators were unsuccessful. Only after the mother spoke with the one Spanish-speaking investigator privately did the mother note that she had chewed on ceramic during her pregnancy (pregnancy pica). Subsequent testing found significantly elevated levels of lead in the ceramic pieces.

Screening Individuals for Exposure

Medical / Environmental History

The first step in screening for potential exposure is an environmental history. Overt signs and symptoms of acute lead poisoning are relatively uncommon but include headaches, abdominal pain, loss of appetite, constipation, clumsiness, agitation, and/or decreased activity and somnolence (10). These symptoms can then lead to vomiting, stupor, convulsions and death (66). In the 1930s and 1940s, not long after the introduction of lead-based paint and lead additives in gasoline, childhood death by lead poisoning was not uncommon. Today, children dying from lead poisoning are relative rare, although a four-year-old child died in 2006 in Minnesota after swallowing a metal charm containing high levels of lead. The child's BLL was 180 µg/dL (196). The diagnosis and effective treatment depend on a thorough and thoughtful environmental history (125).

Most children and adults with elevated BLLs are asymptomatic or have general complaints easily attributed to stress or other causes. An environmental history is the critical first step in diagnosis and should be included in all initial work-ups of new patients (125). The ATSDC, National Academy of Sciences Institute of Medicine (IOM), American Academy of Pediatrics and others stress the importance of an environmental history and are currently advocating that environmental health training be integrated into all aspects of the training of physicians and other healthcare professionals. Currently, most physicians receive little or no training in environmental health. Several forms for obtaining an environmental health history are available. A short environmental history form developed by the National Environmental Education Foundation (NEEF) is included in the "Appendices." Links to several others are included in the "Useful Resources" section.

The AAP Committee on Environmental Health suggests the following inquiries for a clinical evaluation for lead exposure (10):

- For medical history, physicians should ask about symptoms, developmental history, mouthing activities, pica, previous blood lead concentration measurements, and family history of lead poisoning.
- For the environmental history, physicians should ask the following questions. With regard to paint and soil

exposure: What is the age and general condition of the residence or other structure in which the child spends time? Is there evidence of chewed or peeling paint on woodwork, furniture, or toys? How long has the family lived at that residence? Have there been recent renovations or repairs to the house? Are the windows new? Are there other sites at which the child spends significant amounts of time? What is the condition/make-up of indoor play areas? Do outdoor play areas contain bare soil that may be contaminated? How does the family attempt to control dust and dirt?

- With regard to relevant behavioral characteristics of the child: To what degree does the child exhibit hand-to-mouth activity? Does the child exhibit pica? Are the child's hands washed before meals and snacks?
- With regard to exposures and behaviors of household members: What are the occupations of adult household members? What are the hobbies of household members? (Fishing, working with ceramics or stained glass, and hunting are hobbies that could involve risk for lead exposure). Are painted materials or unusual materials burned in household fireplaces?
- Miscellaneous questions: Does the home contain vinyl miniblinds made overseas and purchased before 1997? Does the child receive or have access to imported food, cosmetics, or folk remedies? Is food prepared or stored in imported pottery or metal vessels? Does the family use imported foods in soldered cans?
- Nutritional history: Take a dietary history, evaluate the child's iron status by using the appropriate laboratory tests, ask about history of food stamps or participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

Blood

A blood test can determine an individual's blood-lead concentration. Venous samples are ideal, but "carefully collected finger-stick" (capillary) samples are a viable option. The AAP and the TX CLPPP recommend that all children be screened at 12 and 24 months (9,10,273). Children on Medicaid, many of whom are at high risk for elevated BLLs, are required by federal law to be screened (5). See also "How Is Lead Exposure Measured?"

Screening blood lead not only informs parents and primary care-givers of children's BLLs, but it also provides statistics for state and federal agencies, often in collaboration with the CDC's CLPPP program (59), seeking to eliminate sources of lead exposure. Separately, CDC's NHANES provides national tracking data on the levels of lead and other chemicals in the nation's population (218). The NHANES is unique in that it combines interviews and physical examinations, examining a nationally representative sample of about 5,000 persons across the country each year. These data are freely available online at *www.cdc.gov/nchs/nhanes.htm*. The NHANES data, which are more comprehensive than STELLAR data, can be used to examine relationships, for example, between BLLs and nutrition. The laboratory collection methods used in the NHANES are generally the "gold standard."

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Bone

Bone-lead levels are increasingly the preferred method to measure long-term or cumulative exposure. Current KXRF generally uses cadium-109 as the low gamma radiation to provoke the emission of fluorescent photons from the anatomical target area. The measurement is automated and takes approximately 30 minutes. The signal is then converted into µg of lead per gram of bone mineral, adjusted for the calcium in the bone (this adjusts for variations in bone density and shape). See "How Is Lead Exposure Measured: Bone?" (page 22) for more information about this screening technique.

Screening Potential Sources

As noted earlier ("Sources of Lead Exposure") deteriorating lead-based paint continues to be the most common source of exposure to lead for most individuals and especially for children. Eliminating sources of lead contamination before exposure should be the focus of any lead program.

Housing

A building's history and condition often provide valuable information regarding the likely risk of lead exposure. Any building built before 1978 should be assumed to have lead-based paint until proven otherwise. In addition, the condition of the building is an important indicator of the availability of lead in paint chips and dust.

Lanphear and associates suggest the inclusion of the following characteristics in determining risk levels: rental status, floor dust lead levels, and housing conditions (161). For example, if a house has 5 µg/ft^2 of lead dust—a fairly high amount, it is 90% likely that a child living in the building will have a BLL ≥ 10 µg/dL (159).

Accurate lead screenings are performed by certified lead-based paint inspectors or risk assessors (284). They should follow the HUD/EPA standard of lead-based paint as having 1.0 mg/cm^2 or 0.5% by weight lead content. They should have the XRF Performance Characteristic Sheet so that the XRF lead-paint analyzer may be used in the inspection. The sheet can be obtained by calling the National Lead Information Center Clearinghouse (1.800.424.LEAD) or downloading the form at *www.hud.gov/offices/lead* (284).

The results from do-it-yourself home testing kits are highly variable according to the U.S. CPSC. In an extensive OSHA-requested product evaluation of lead test kits, lead scientist Adler notes that although "a positive response is evidence of the presence of lead . . . a negative response, however, is not conclusive evidence of the absence of lead" (4). Adler noted at the time (1994) that the Hybrivet Lead Check test kit is fairly effective, as well as the Sensidyne Pace Environs Lead Alert™ Test Kit. More recent studies continue to question the results of do-it-yourself testing. Korfmacher and Dixon, for example, investigated the accuracy of a leading brand of lead-based paint spot-testing kit, Hybrivet's LeadCheck Swabs (138), which are relatively inexpensive ($18.45 for a set of 8 swabs) and easily available through online sources and local hardware stores (150).

Both the OSHA product evaluation and Korfmacher and Dixon's analysis indicate that numerous factors can interfere with the accuracy of the tests, including dirt that may interfere with the reaction between the dye in the swabs and reactive lead in the dust, leading users to think that the "brown" result was negative, as red and pink are positive, when in fact the test was contaminated by dirt and may have been positive (138).

In spite of the frequent inaccuracy of spot tests, do-it-yourself-testing methods are improving and can, if carefully performed, provide some useful information. However, individuals need to know that contamination can result in inaccurate negative results and that the methods used in these tests usually measure free ions that dissolve in the swab's reagent, thereby missing lead strongly bonded with other substances (138). In general, however, inspection by a certified lead inspector is preferable. Extensive XRF, dust-wipe and soil-sample analyses of a ≤ 2,000 ft^2 home will cost roughly $350, according to quotes we received.

In a recent pre-1900 frame home in Galveston that underwent XRF lead-based paint testing and analysis, and dust-wipe and soil analysis by a certified inspection company, lead was found throughout the structure and in the yard. This is probably typical for similar structures in much of Galveston, as well as in older neighborhoods in Houston, Texas City and elsewhere. In this instance, the report indicated elevated levels of lead throughout most of the house, with one bedroom window frame, which was peeling, having a XRF reading of 18.9 (anything over 1.0 is positive). The dust-wipe test of the bedroom window sills indicated 2,000 µg/ft^2 in bedroom 1 and 1,900 µg/ft^2 in bedroom 2. The EPA guideline for interior window sills is ≤ 250 µg/ft^2 (see Table 2). The soil was also contaminated, with a lead level of 2,200 µg/g near the drip line and 1,200 µg/g in a play area (the EPA maximum for play areas is 400 µg/g). A child living in this environment, based on data presented earlier, would have significantly elevated BLLs.

The GCHD performs paint and soil analyses, using validated methods, in homes where children have elevated lead levels, generally over 20 µg/dL, for no charge. Lack of funding for lead testing currently prevents them from initiating a more extensive lead-testing program. However, lead samples can be sent to reputable laboratories and there are numerous certified lead inspectors who can assess housing. We have suggested that the GCHD, the City of Galveston and the Galveston Historical Foundation make a list of local certified inspectors available on their websites. In the interim, homeowners, renters, developers and others should call 1-800-424-LEAD or visit HUD's Lead Hazard Reduction Office online at www.hud.gov/offices/lead/labs/nllap.cfm to receive a list of laboratories that have passed proficiency testing for analysis of lead in paint, soil, and/or dust samples. The Texas Environmental Lead Program also maintains lists of qualified inspectors; the lists can be downloaded at www.dshs.state.tx.us/elp/locate.shtm. Although it is preferable that a qualified inspector collect the samples, a number of labs will work with homeowners who do not have access to an inspector to collect and mail samples for analysis.

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A number of municipalities and states offer analysis of property-owner collected samples at a reasonable price. For example, the Madison, Wisconsin, Department of Health offers paint and water testing to all Madison residents at a cost of $20 for each paint sample, and $25 for each water sample, with specific sample collection guidelines (www.ci.madison.wi.us/health/envhealth/leadpoisonprev.html). Such a program would be very useful in Galveston where the GCHD has the in-house capability to analyze a limited number of samples but currently has insufficient staff to offer a larger for-fee program.

The EPA has an excellent booklet on lead-paint testing, which can be downloaded from *www.epa.gov/lead/pubs/leadtest.pdf*.

Soil

Soil around homes or in playgrounds is another source of exposure. See "Sources of Lead Exposure: Soil" for more details about where lead has been found in soil.

A study by Clark and associates investigated whether or not exterior dust and soil lead influenced interior dust lead levels in housing that had already undergone lead-based hazard control (68). The sample groups came from 12 different cities and states that had participated in the HUD Lead-Based Paint Hazard Control Grant Program Evaluation, with a total of 541 dwelling units participating in the study. The locations of the dwelling units ranged around the country, with the most represented cities being New York City, NY, Baltimore, MD, Cleveland, OH, and Milwaukee, WI. The investigators took exterior entry and street dust samples from the dwelling units using a vacuum method, and took soil samples with a stainless steel coring device. Clark and associates concluded that "exterior entry dust lead loading was found to contribute directly to interior entry, floor, and windowsill dust lead loadings, and also, indirectly, to floor dust lead through interior entry and windowsill dust lead loading" (308). Thus it is important that any analysis include yard soil samples and floor dust samples.

Other Sources

When screening homes, investigators and property owners should seek less obvious sources of lead. Ceramic dishes, bone china, porcelain and earthenware containing lead-based glaze can leach onto food and cause lead contamination. In one instance a New York City 20-month-old boy experienced elevated BLLs as a result of contact with imported French ceramic dinnerware (52). The infant's 12-month BLL was 15 µg/dL, increased to 18 µg/dL three months later, and after another three months increased again to 23 µg/dL. An investigation of the home revealed that although lead-based paint hazards were absent, the frequently used ceramic dinnerware did contain lead. In another example, a 16-year-old young woman whose house showed no evidence of lead hazard had a BLL of 91.9 µg/dL, while her brother had a 59 µg/dL BLL and the rest of the family had normal levels. Investigators discovered that the female patient had been drinking up to 2 liters of tea per day from a ceramic pot with lead glaze, while her brother had drunk less, and the rest of her family, none at all (308).

"When screening homes, investigators and property owners should seek less obvious sources of lead. Ceramic dishes, bone china, porcelain and earthenware containing lead-based glaze can leach onto food and cause lead contamination."

TREATMENT OF POISONED INDIVIDUALS

Treatment of childhood lead poisoning involves clinical interventions, lead education and removal of lead from the child's environment to reduce BLLs and, presumably, the body burden of lead. Current research is conflicting as to whether reducing the body burden can reverse previous damage although eliminating future exposure should reduce some of the long-term effects of lead in the body.

Case Management

Case management reflects the system in place to manage children and adults with elevated BLLs. In the most comprehensive programs, children with BLLs ≥ 10 µg/dL on initial screening are re-screened, preferably using a venous blood sample, and entered into a program that includes a medical workup and environmental history, investigative screening of their house or apartment, investigation of other possible sources of exposure, screening of other family members if warranted, elimination of the source(s) of exposure, and periodic rescreening. A comprehensive overview of case management, "Managing Elevated Blood Lead Levels Among Young Children: Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention," is available at the CDC's National Center on Environmental Health website (58). This comprehensive set of recommendations is accessible at *www.cdc.gov/nceh/lead/CaseManagement/caseManage_chap1.htm*. As noted earlier, the GCHD does not currently have funding for this level of case management, although a recent analysis of the GCHD has made specific recommendations for modest increase in funding that would allow additional staffing specifically for lead-related surveillance, outreach and case management (154).

Chelation

Chelation therapy is the primary clinical treatment for significantly elevated BLLs. The process consists of an oral or intravenous administration of a chelating agent, which are drugs that bind to lead in the blood and allow them to be excreted from the body in urine and bile (233). The CDC recommends chelation therapy only for those with BLLs ≥ 45 µg/dL (51).

Physicians use three main agents for chelation therapy (115). Dimercaprol treats encephalophathy or severe symptoms of lead toxicity, with dosages of 75 mg/m2 intramuscularly every four hours for five days the most common regimen (115). Calcium ethylene diamine tetra-acetic acid (CaEDTA) is also used in cases of severe encephalopathy; the most common regimen is 1000–1500 mg/m2/day given intravenously for five days in conjunction with a four-hour prior administration of dimercaprol (115). Without pretreatment with dimercaprol, CaEDTA can increase lead redistribution to the central nervous

system (CNS) (115). Meso-2,3-dimercaptosuccinic acid (succimer) is the primary chelating agent used today. It is given orally for mild or asymptomatic lead toxicity cases. The most common protocol is 350 mg/m2 three times per day for five days (115).

Chelation therapy is effective at lowering BLLs; however, it may not prevent or reverse the cognitive defects and neurotoxicity associated with lead exposure (55,115), and chelation carries with it considerable risk as well. Chelation increases the excretion of not just lead, but of other metals as well including arsenic, cadmium, calcium and zinc. A 2005 death from chelation-induced hypocalcemia of Texas of a child underscores the risk. In this instance, a two-year-old girl with a venous BLL of 48 µg/dL was begun on intravenous CaEDTA and oral succimer. The next day, a dose of intravenous Na2EDTA, another chelating agent seldom used for children, was

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mistakeningly given instead of CaEDTA. An hour later, the girl's serum calcium had decreased to 5.2 mg/dL (normal value for pediatric patients: 8.5–10.5 mg/dL), and the child's mother noticed that the child was limp and not breathing. All attempts at resuscitation failed and the child died (55). Some researchers are currently attempting to combine chelation with nutritional supplements to lower its toxicity (115).

Also, not all children respond to chelation therapy [133], and recent studies suggest that even if chelation is successful in lowering BLLs, it may have no measurable effect on neurological sequelae of lead poisoning, especially at lower levels (84). There is also some evidence that chelation may increase neurological damage, in part by releasing tissue- and bone-sequestered lead into the blood where, especially the plasma faction, is more toxic. On the other hand, some recent evidence in a rat model suggests improvements in learning in lead-poisoned animals but chelation-induced learning impairment in animals who were not lead poisoned (262). Chelation should not be attempted if the exposure to lead has not been eliminated or significantly reduced (51). Indeed, a number of studies suggest that eliminating exposure is a more effective and safer approach to lowering BLLs (84). Relocation to a lead-safe environment has been shown to statistically reduce BLLs (188).

Reducing Absorption or Bioavailability

In addition to reducing exposure and body burden, there is increasing interest in reducing the absorption of lead and in reducing the deleterious effects of residual lead in the body, possibly through binding to deactivate lead or sequestration in bone or elsewhere. One area of especially active research is nutrition (182,185,239).

Nutrition

Nutritional status influences both the intake and effects of lead. Nutrient supplementation with iron, calcium and zinc may reduce susceptibility, while fasting increases the likelihood and quantity of absorption. Several studies have demonstrated that calcium intake prior to exposure reduces lead absorption in animals, just as calcium deficiency increases absorption (13). Correspondingly, Mahaffey and associates reported that BLLs are lower in children with higher calcium intakes (99). However, according to Gulson and associates, calcium supplementation may not make a "statistically significant" difference when lead levels in adults and older children are low. (120)

In addition to calcium, iron may be an effective and sustainable strategy to accompany environmental lead abatement (162). Zimmerman and associates conducted a randomized, double-blind, controlled school-based feeding trial with 5- to 9-year-old iron-deficient children in Bangalore, India, with a high prevalence of lead poisoning. After 16 weeks on an iron-fortified rice diet (approximately 15 mg of iron per day as ferric pyrophosphate) or an identical control meal without added iron, the percent deficiency in the iron group decreased significantly (70% to 28%), compared with the control group (76% to 55%).

Although the increased presence of iron in the experimental group resulted in decreased BLLs, Zimmerman cautions that this study was conducted on 5- to 9-year-old children, whereas the highest risk group for lead poisoning and iron deficiency is among children < 3 years of age (309). Zimmerman also notes that previous investigations of the effects of iron supplementation with regard to BLLs are conflicting; in some cases it is possible for the iron to redistribute out of the kidneys and decrease urinary lead excretion (309).

Fat intake may also attribute to a higher BLL. Gallicchio and associates conducted a study that investigated whether dietary components had an effect on BLLs in young children (100). Their findings support a dietary intervention to reduce the amount of total calories, total fat, and saturated fat among children 1 year of age at risk for lead exposure, while maintaining adequate intake of these dietary components. The investigators emphasize, however, the most crucial factor in lowering BLLs is the removal of lead paint hazards from the home.

Other

Several investigators have suggested that exercise, a reduction in stress, and other healthy activities may, independent of improved nutrition, help reduce lead levels and/or the deleterious effects of lead. This may relate to increased excretion efficiency, reduced ROS, or other not clearly understood mechanisms.

Of particular importance, however, is accepting that children with lead levels of roughly 2 µg/dL and higher have measurable neurologic damage that may result in difficulty learning, and with problems with impulse control, attention, and social behavior. Although eliminating exposure early may help, these children need extra help in school and in the home. Miranda and associates recently studied performance on end-of-grade tests in North Carolina children and BLLs and found significant reductions in performance associated with BLLs, with the relationship apparent at BLLs as low as 2 µg/dL (199). Miranda notes that, based on recent NHANES data that indicate that 50% of children 1–5 years old nationwide have BLLs ≥ 3 µg/dL, then as many as half the children in the U.S. may be experiencing negative effects associated with lead exposure. This is a much higher percentage than suggested by using CDC's action level of 10 µg/dL. Special education is effective but at what BLL should it be offered to lead-poisoned children? Special education is expensive. Stefanak and associates recently estimated that it costs approximately $18,000 per year to give extra support to a lead-poisoned child, vs. $7,700 for other students (263). Earlier studies suggested that children with BLLs ≥ 25 µg/dL would need special education for a minimum of three years, but recent studies suggest that the cognitive and psychosocial damage is significant at much lower levels (158) and many feel that these borderline children might be most helped by early intervention. It is clear in studies of children with dyslexia and other reading problems that early intervention makes a huge difference (28,258,295). Although the cost of special education is significant, most if not all economic evaluations suggest that the cost of not helping lead-poisoning children is much greater (38,210,215,216). Innovative community-based programs to augment school-based programs may be one approach (241).

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REDUCING EXPOSURE

When sources of lead exposure are identified it is imperative to stop the exposure and begin lead abatement strategies. A study by Case Western Reserve University involving children with BLLs 30–45 µg/dL found that chelation therapy and environmental remediation reduced BLLs by the same amount (220). The subsequent section of this report addresses a number of approaches to eliminate or greatly reduce exposure to lead, especially in housing.

Housing

Primary prevention means lead-safe housing. The TX CLPPP is committed to the elimination of lead poisoning in the state of Texas by 2010 (273). To do so requires elimination of exposure, particularly in housing. In most cases this requires exterior and interior lead paint abatement, along with replacement of any contaminated soil. Different methods are used, depending on the situation, but each attempts to create a lead-safe environment. Specific guidelines in place in Galveston and elsewhere are included in the "Regulations and Policies" section, beginning on page 75.

Paint Removal

Paint removal, according to HUD, involves separating the paint from the substrate using heat guns, chemicals, or certain contained abrasive measures.

The following abatement methods are prohibited in the HUD lead-abatement guidelines: open flame or torching; machine sanding or grinding without a high efficiency particulate air filter (HEPA) local vacuum exhaust tool; uncontained hydroblasting or high-pressure wash; abrasive blasting or sandblasting without HEPA local vacuum exhaust tool; and heat guns operating above 1,100 degrees Fahrenheit. Methods that are not recommended by HUD and may be prohibited in some jurisdictions include: methylene chloride paint removal products and dry scraping (except for limited surface areas).

An excellent 84-page booklet co-produced by the EPA, CDC and HUD and titled "Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work" can be downloaded from *www.epa.gov/lead/pubs/leadsafetybk.pdf*. The guide includes key information on techniques to avoid creating and spreading dust, methods to protect workers and occupants from exposure (children should stay away from the work area), the use of respiratory protection, clean up, disposal of contaminated debris and water, and pre- and post-paint removal testing. The guide contains specific information about exterior and interior surfaces, as well as about how to handle delicate trim in historical homes. The booklet also has links to more information and specific instructions (with drawings) for safe lead-abatement efforts, such as building a "dust room" for working on windows and trim that can be moved. See also Appendix 7.

Encapsulation

In many instances encapsulation, which is the process of applying a sealant between the lead-based paint and the environment, is a more cost- and time-effective lead-mitigation method. See chapter 13, "Encapsulation," of HUD's Technical Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (284). According to the HUD lead-abatement guidelines, there are several requirements that the encapsulant must meet before it can be used: it must be capable of being applied safely and must not contain toxic substances, it must adhere to existing paint films, it must have the ability to remain intact for an extended period of time when exposed to weathering, and its application procedure must comply with fire, health, and environmental regulations.

"In many instances encapsulation, which is the process of applying a sealant between the lead-based paint and the environment, is a more cost- and time-effective lead-mitigation method."

Multiple methods of encapsulation depend on the encapsulant category. Nonreinforced liquid coatings may be applied with a brush, roller or spray and are used indoors and outdoors. Liquid coatings reinforced with cloth, mat, or fibers may be applied in two steps with a brush, roller, spray, or trowel on the interior or exterior. Materials attached to an adhesive such as fibermat or vinyl floor tile are usually applied with the adhesive first and the encapsulant product second. In its lead abatement guidelines, HUD lists several advantages and disadvantages of encapsulating:

- Advantages: Residents may not need to be relocated; dust generation should be minimal if surface preparation is minimal; application training requirements are moderate; the cost and time required is less than for other abatement techniques; encapsulating products are widely available; and finish carpentry work may not be required.

- Disadvantages: Experience and information on long-term durability is limited; the procedure cannot be used on friction surfaces; durability depends on the condition of previous paint layers; patch testing (field compatibility testing of encapsulant with particular lead-based paint surface) is necessary; the encapsulant system success depends on proper surface preparation; the owner must monitor and maintain the encapsulated area since the lead is still present; water damage could lead to extensive system failure; application may depend on weather and temperature and therefore require several coats; and some systems may contain toxic ingredients.

Interim Measures

Lead removal eliminates the risk of lead poisoning; encapsulation reduces significantly the potential of lead exposure. In the interim, anyone living in pre-1978 housing that has not been certified as lead safe should vigorously practice various temporary methods to reduce lead hazards and get the building, soil and water tested. If contaminated, arrangements to move or remediate should be made. The following procedures can usually reduce exposure and BLLs, even in contaminated housing, but must be practiced daily.

Dust control appears to reduce exposure slightly, although the effect on BLLs has been minimal or equivocal in most studies. Wet wiping is the preferred method. Vacuuming, even with HEPA vacuums, is not generally effective. Because of the importance of paint dust in the exposure of young children, the results of several studies examining the efficacy of reducing dust are discussed below.

- Charney and associates demonstrated in a trial involving 14 intervention homes and 35 control homes that careful control of lead-contaminated dust after abatement reduced BLLs by up to 18% in children with high initial values (mean BLL 39 µg/dL) (61).

- In a randomized trial of 113 urban children between the ages of 6 and 36 months (mean BLL 12.0 µg/dL), Rhoads and associates found that dust removal by professional cleaners, accompanied by maternal education, reduced BLLs by 17% in the intervention group (232). In homes cleaned 20 or more times throughout the year, children had an average BLL reduction of 34%.

- Tohn and associates concluded that dust-cleaning significantly reduced dust lead loadings on floors, windowsills, and window troughs immediately following the work (274). However, at six months and one year post-intervention, dust lead loadings on bare floors and windowsills did not significantly differ from the pre-intervention loadings.

- Within a primarily low-income, urban, minority population living in old, deteriorated housing, Brown and associates demonstrated that a home-visiting program with quantitative information regarding lead contamination was sufficient to enable parents to significantly reduce dust-lead levels in their homes (40). However, this intervention did not reduce BLLs of moderately poisoned children any more than a less intensive strategy that did not decrease dust lead levels. The mean level of floor lead dust in the intervention group dropped from 13.9 µg/ft^2 to 5.5 µg/ft^2, compared with a mean of 8.8 µg/ft^2 in the control group without dust control intervention. Mean BLLs were similar in the intervention and control groups (9 vs. 8.3 µg/dL, respectively).

- A randomized trial of HEPA vacuuming every 6 weeks in smelter town homes (without wet mopping) produced only a minimal and nonsignificant reduction in BLLs of 0.3 µg/dL (130).
- In general, dust control appears to have a minimal effect, especially with children who already have moderately high BLLs (40,130,162,165,232,274).

In addition to dust control, several other temporary measures can reduce exposure.

- Put duct tape or contact paper on window wells, window sills, walls or other surfaces with peeling paint or plaster. Clean these areas often. Window wells and sills can be cleaned more easily when contact paper or duct tape are put down first.
- If a window well is in bad condition, keep the lower part of the window closed and open only the upper part. This will prevent children from putting their hands or objects in the window well where lead dust collects. It also helps keep lead dust from blowing into the house.
- Move furniture to block contact with peeling paint and plaster.
- If a child's bedroom has chipping paint or plaster, consider using another room without chipping paint for the bedroom.
- Wash children's hands and toys often. Young children are primarily exposed to lead by putting their hands and toys into their mouths. This activity, called pica, is normal for young children.
- Feed children food high in iron, calcium, and vitamin C and low in fat.

Historical Housing

Cities with considerable important historical housing, such as Galveston, face additional—but not insurmountable—challenges. First, in the core city of Galveston, virtually all of the housing is contaminated. Second, preservation of historical features and detail in home that were often exquisitely built can be difficult and often costly. Third, designated historical housing must meet guidelines to preserve not only the look of the building and as many historical details as possible, but must often preserve the historical legacy as much as possible which may mean, for example, preserving all layers of previous paint for historical documentation. Fourth, public funding is limited for major private historical projects, largely because of the cost involved. In general, it is felt that more people can be removed from lead exposure by concentrating lead-abatement efforts on homes in which, for example, windows can be easily replaced.

Nevertheless, HUD, the EPA, the City of Galveston, the Galveston Historical Foundation and many others across the nation are committed to making historical homes lead-safe and have put into place technical guidelines

"Cities with considerable important historical housing, such as Galveston, face additional—but not insurmountable—challenges."

and private-public funding partnerships to help property owners of historical buildings make them safe. See chapter 18, "Lead Hazard Control and Historic Preservation," of HUD's Technical Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (284). These guidelines note that every historical structure demands a customized approach, and emphasizes the need for collaboration between owners, state and local historical preservation departments, and local community historical organizations and foundations. Having a historical residential property does not, in any way, exempt property owners from requirements that their property be safe for habitation. See also several local programs in place in the City of Galveston, beginning on page 79, as well as links under "Useful Resources."

Healthy Homes Programs

Within the last decade, there has been a move toward a more inclusive approach to healthy homes that includes, but is not limited to, lead abatement. The U.S. HUD and the CDC have developed the "Healthy Homes Initiative (HHI)", which seeks to address multiple housing-related health and safety issues that affect children, including lead hazard control, building structural safety, electrical safety, and fire protection. For more information, visit *www.hud.gov/offices/lead/hhi* and *www.cdc.gov/healthyplaces/healthyhomes.htm*. HHI activities focus on:

- Broadening the scope of single-issue public health programs, such as childhood lead poisoning prevention and asthma programs, to address multiple housing deficiencies that affect health and safety.
- Building capacity and competency among environmental public health practitioners, public health nurses, housing specialists, managers, and others who work in the community, to develop and manage comprehensive and effective healthy homes programs.
- Promoting, developing, and implementing cross-disciplinary activities at the federal, state, tribal, and community levels to address the problem of unhealthy and unsafe housing through surveillance, research, and comprehensive prevention programs.

- Facilitating the collection of local data and monitor progress toward reducing or eliminating housing deficiencies and hazards.
- Expanding collaborations with the CDC, HUD, national associations and organizations, academia, community-based organizations, and others, including the American Public Health Association, National Environmental Health Association, and the World Health Organization.
- Promoting research to determine causal relations between substandard housing and adverse health effects.
- Developing guidelines to assess, reduce, and eliminate health and safety risks.
- Identifying and implementing low-cost, reliable, and practical methods to reduce health and safety risks in substandard housing

Both HUD and CDC offer numerous resources for the HHI. Another excellent source is the National Center for Healthy Housing (NCHH) (www.centerforhealthyhousing.org), which offers a four-part training program and sample community initiatives to empower communities to improve housing and quality of life. The City of Houston DHHS, in partnership with the University of Texas School of Public Health in Houston, is a NCHH training partner and offers regular courses in the Houston-Galveston area that are open to all interested individuals. See Appendix 6.

Soil

Soil can be a major source of contamination outdoors, as well as a source of recontamination of lead-safe homes. As noted in the "Sources of Lead Exposure: Soil," many investigators feel that soil may be playing a larger role in lead-poisoning in children than previously recognized (39,45,68,129,139,163,164,192-195,242,251,297). Interventions to reduce exposure from contaminated soil include removal of the soil, covering contaminated soil with uncontaminated soil, using vegetation to hold the soil in place, use drop cloths and dust control during exterior paint removal, and efforts to keep soil from being tracked indoors. Use of exterior and interior door mats, and removing shoes upon entry can reduce the amount of lead tracked indoors. Lead-safe homes are often re-contaminated by lead from outdoors being tracked into the interior of the home.

Water

Lead in tap water in the home is an additional predictor of lead intoxication (160). Although no cases of lead poisoning from tap water have been recorded in Galveston, GCHD investigators note that few home have been tested, and that the age of many of the plumbing systems make it likely that some homes have elevated water lead levels.

Despite a growing awareness of lead contamination of water, few municipalities have extensive residential testing programs, making it difficult to know the extent of the problem. New York City (NYC) is one of the few cities in the U.S. that has an extensive residential water program, despite levels in NYC being lower than in many other cities. NYC has offered free tap water testing to all residents since 1995. Good record-keeping and a limited number of water sources have allowed NYC, which adds two anticorrosives—sodium hydroxide (to offset fluoride) and orthophosphoric acid—to its water, to both monitor and take effective steps to lower lead levels in residential tap water. Between 1992 and 1996, the City measured a distinct lowering of median lead levels with a leveling off at around 2 µg/L since then (Figure 14).

"Although no cases of lead poisoning from tap water have been recorded in Galveston, GCHD investigators note that few home have been tested, and that the age of many of the plumbing systems make it likely that some homes have elevated water lead levels."

To reduce the potential of lead in tap water, residents should do the following:

- Flush pipes
  - Anytime the water in a particular faucet has not been used for six hours or longer, "flush" pipes. One minute is a common guideline to reduce lead levels but it varies by usage and system. The longer water has been sitting in a home's pipes, the more lead it likely contains.
- Use cold water
  - Use only water from the cold-water tap for drinking, cooking, and especially for making baby formula. Hot water is likely to contain higher levels of lead.
- Have water tested
  - The only way to be sure of the amount of lead in household water is to have it tested by a competent laboratory. Testing is especially important for apartment dwellers, because flushing may not be effective in high-rise buildings with lead-soldered central piping. Testing should include samples before and after flushing the pipes.

Proximity to Major Roadways

Lead from now-banned lead in gasoline and from degrading lead-based paint, which is still in use on bridges, overpasses and used for painting lane markers on highways, pollutes our roadways and the adjacent areas (168,300). Kept airborne by moving traffic, this lead is a source of potentially

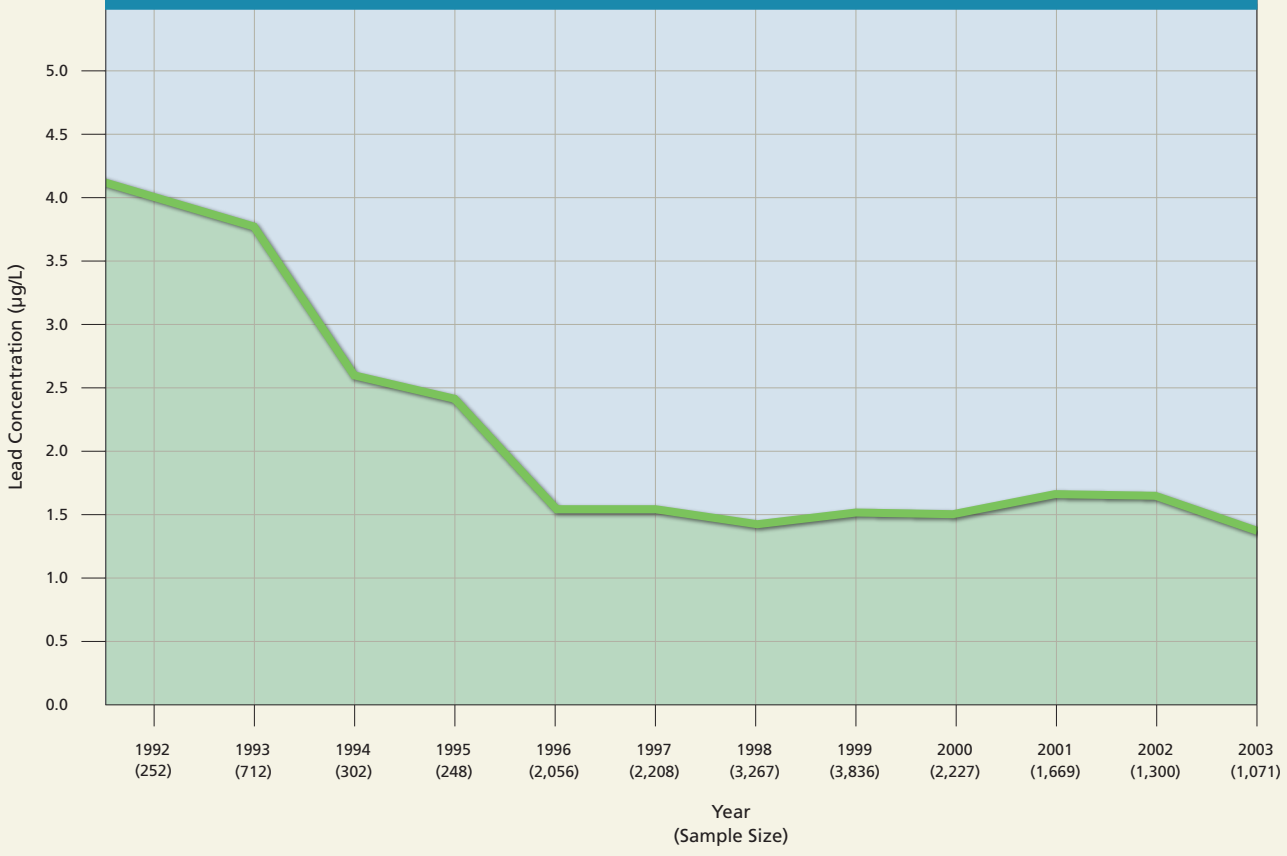
significant exposure, especially for homes or schools located in close proximity to older roadways where lead will have accumulated. People who commute extensively may as well be exposed to higher lead levels, as particle levels in the interior of vehicles generally approximates outside levels. Recent studies demonstrated that the pollution levels return to background levels at approximately 300 meters (three football fields) from the edge of a major roadway. Viard and associates conducted a multipart study involving highway pollution in France; one of these parts focused on the bioaccumulation of lead in soil, Graminaceae (autochthonous plants) and land snails (297). Snails that were placed near the highway had higher lead levels than snails in the reference group. Correspondingly, lead concentrations decreased as the distance from the highway increased. Overall, lead contamination in the environment reached as far as 320 meters away from the highway, with the maximum contamination between 5 and 20 meters. Plants yielded a lead concentration of 2.1 mg/kg by dry weight in this area. A veterinary study conducted by Dey and Dwivedi found that horses in highway-adjacent areas had the highest BLLs, with 0.55 ± 0.02 ppm (78). Horses living near industrial areas were next highest, with 0.47 ± 0.02 ppm, and horses living in rural areas had the lowest BLLs, with 0.38 ± 0.03 ppm. Dey and Dwivedi's study demonstrates that proximity to highways can have an effect on BLLs.

When possible, individuals should avoid spending extended periods of time near major roadways. When doing so is unavoidable, individuals should ensure that children do not ingest or touch nearby soil; if children do make contact they should wash their hands immediately afterward.

Superfund Sites and Industrial Sources

According to the U.S. EPA, 1,262 of the 1,675 designated National Priority Listing (NPL) superfund sites are contaminated with lead. Smelters, battery reclamation operations, municipal incinerators and other industrial concerns that use lead can expose nearby residents to significant levels of lead. As noted earlier, residents of Houston's Fifth Ward have elevated lead levels in their bodies and throughout the neighborhood in large part because of the Superfund site in their neighborhood (see "Sources of Exposure: Soil"). Efforts to reduce exposure from industrial sources generally require monitoring, community activism, and government intervention. The EPA and the ATSDR are the federal governmental agencies charged with protecting

FIGURE 14



Median lead concentration in first-draw residential water samples, New York City, 1992–2003. Redrawn from Maas et al (180).

residents from pollution from these sources, although much of the responsibility is often given to the state environmental agency which, here in Texas, is the Texas Commission on Environmental Quality (TCEQ). The TCEQ has established Protective Critical Levels (PCLs) for lead-affected soils for residential (500 mg/kg) and commercial/industrial (1,600 mg/kg) properties under the Texas Risk Reduction Program (TRRP). These levels may vary based on the leaching potential of the soil or groundwater. For more information about the TCEQ's TRRP, visit *www.tceq.state.tx.us/remediation/trrp*.

Fetal Exposure

Bellinger (24), Gulson and associates (119,121) and others (90,91,237,255) suggest that pre- and post-natal lead exposure resulting from mobilization of maternal bone-lead stores during pregnancy and subsequent exposure of the fetus or newborn via blood or milk, respectively, may be reduced by calcium supplementation. Currently, researchers are trying to determine the interval of time during which prenatal lead exposure is most damaging. In 2006, Schnaas and associates reported that fetal lead exposure during the third trimester is most damaging to intellectual development (244), whereas Hu and associates reported in the same year that exposure during the first trimester is most damaging to mental development (136). Thus, Hu recommends implementing such prenatal lead exposure prevention strategies as calcium supplementation "very early in pregnancy to maximize the benefit to fetal neurodevelopment" (136). Hu also notes that if future research "confirms this finding, ascertaining women at risk and identifying effective strategies for prevention of fetal lead exposure may become an important public health priority." Hu and others are increasingly discussing the efficacy and potential importance of prepregnancy interventions, as intervention after the first trimester may be too late to prevent the most deleterious fetal neurotoxic effects. Similar to chelation, bone-leaching may also increase lead levels in tissue compartments as well as bone, potentially exacerbating pregnancy-related hypertension, gestational diabetes and kidney function. Interventional techniques to reduce bone leaching during pregnancy may not only reduce pre- and post-natal exposure but may have a positive effect on the pregnancy in other ways as well. This is an active area of research. In addition to reducing bone-leaching, additional efforts are needed to eliminate lead exposure in women of child-bearing age.

Endogenous Exposure

Reducing the amount of lead leached primarily from bone is potentially an effective approach to reducing exposure, particularly to the most bioavailable form of lead: plasma lead. Endogenous exposure is most likely during physiologic stress (such as pregnancy), during active bone growth, and in certain disease states such as osteoporosis and parathyroid disease. Addressing the underlying problem is the most efficacious approach to reducing bone leaching. In most cases good nutrition and possibly calcium supplementation will reduce release of lead into the blood. Although poorly understood, the health of the major excretory pathways for lead, which largely involve the liver, kidneys and intestines, may also reduce the amount of lead stored in soft tissues and bone and thereby reduce the potential for subsequent endogenous poisoning.

EDUCATION

Although the CDC, EPA, ATSDR, HUD, NCHH and most state and municipal departments of public health have available excellent materials on lead exposure, this information often does not reach the public or, in many cases, public health officials and government leaders. In recent conversations with key people in Galveston, most were not aware of the severe lead-contamination problem in Galveston, few knew that the City of Galveston has regulations that largely prohibit the use of power sanders and other power tools for removing exterior paint on all pre-1978 buildings, and few were aware that realtors and landlords are required by federal law to give out specific materials about potential lead contamination whenever a residential building or apartment is sold or rented. In speaking with GCHD investigators, the single biggest need they described was awareness. As noted earlier, the lack of any information about lead exposure and lead-safe renovation practices on the City of Galveston and the Galveston Historical Foundation websites is a significant omission, especially when one compares these websites with those in other cities with historical stock and strong lead-safe programs. More involvement of neighborhood associations, schools, historical societies, building inspectors, realtors and developers may help the regional departments of health more effectively reach homeowners, schools and renters. Primary care physicians and other health care workers also need to include lead exposure questions in all medical histories and to obtain BLLs regularly as required by law or whenever there is the slightest suggestion from the history that lead exposure may have occurred.

"More involvement of neighborhood associations, schools, historical societies, building inspectors, realtors and developers may help the regional departments of health more effectively reach homeowners, schools and renters."

Healthcare Provider Education

Most physicians receive a total of 7 hours of environmental and public health education while in medical school. There is a critical need, as noted by the AAP, CDC, IOM, Pew Foundation and others to better educate physicians and other healthcare providers and educators about environmental hazards and to encourage them to take an environmental history (125). See also "Screening: Medical/Environmental History" on page 62.

At the Clinic or Doctor's Office

Because primary care providers, especially pediatricians, have direct access to parents and their children, they are in the ideal position to provide information about the environmental risks themselves, as well as nutritional advice to lower susceptibility. The AAP encourages the communication of information about lead exposure to parents for primary prevention (9). An excellent resource for Houston-area medical providers is "The ABC's of Lead Screening for Children," the link to which is listed under "Useful Resources: Houston Department of Health and Human Services." Other excellent publications for parents and others are available through EPA, CDC, OSHA and community organizations. Links to many of these are provided in "Useful Resources."

Educational materials, in English, Spanish and other languages as appropriate, should be available in waiting rooms, and healthcare workers should use the environmental history as an opportunity for additional education.

Community Health Fairs

Houston and Galveston, along with corporate sponsors and community groups, regularly organize health fairs. These are ideal opportunities to offer blood-lead screening and make available culturally appropriate educational materials about lead exposure and how to get tested. See the HCHD website listed in "Useful Resources" for a health fair calendar in Harris County. The GCHD normally hosts or participates in approximately 20 health fairs each year.

Handymen and Construction Workers

Handymen, construction workers and others involved in renovation of pre-1978 buildings are at high risk for exposing themselves, their families, residents of the structure undergoing renovation, and neighbors to high levels of lead if not properly trained. Education can make a significant difference in exposure of workers and their families. Buzzetti and associates provided eight-hour lead-safe work training sessions and measured their effectiveness through questionnaires administered before, immediately after, and a few months after the training session was completed. The results were "statistically significant" and "attitudes and behavioral intentions changed in a favorable direction" (43). Buzzetti and associates note that partnerships with a local organization were ideal for recruiting, and that trainees had an increased confidence in handling lead concerns during renovation, remodeling or maintenance activities after completing the sessions. Many excellent materials are available for educating renovators and construction workers including, as noted earlier, the 84-page booklet titled "Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work" that can be downloaded from *www.epa.gov/lead/pubs/leadsafetybk.pdf*. In general, persons involved in lead-abatement should be certified and should:

"Handymen, construction workers and others involved in renovation of pre-1978 buildings are at high risk for exposing themselves, their families, residents of the structure undergoing renovation, and neighbors to high levels of lead if not properly trained."

- Keep all non-workers, especially children, pregnant women, and pets outside of the work area while doing remodeling or renovation work until cleanup is completed.
- Break large projects into several small projects to control the amount of lead dust created.
- Clean up after each phase of the project.
- Wear a properly fitted respirator equipped with a HEPA filter.
- Wear protective clothing such as coveralls, shoe covers, goggles, and gloves to keep dust off of the skin.
- Change clothes and shoes before leaving the work area.
- Machine wash work clothes separately from other family laundry.
- Shower and wash hair right after finishing work to reduce dust contamination.
- Do not eat, smoke, or drink in the work area to avoid accidentally swallowing lead dust.
- Wash hands and face before eating, smoking, or drinking.
- Dispose of used wash water down a toilet (never pour wash water on soil).

Homeowners, Landlords and Renters

Although we strongly recommend (see "Recommendations," page 82) that all renters and home owners have in hand results

of lead testing of their residence at the time of rental or sale, that families already in contaminated homes be encouraged to move, and that contaminated properties be remediated before being able to be sold or rented, we realize that this is far from the current situation in Galveston and many other places—where lead-poisoned children are regularly sent back to their contaminated residences. Given the current situation, there are a number of techniques that can at least temporarily lower lead levels and exposure. Jordan and associates in Minneapolis, Minnesota, conducted a study that measured the effect of culture-specific, intensive peer educational strategies on BLLs in a local community (142). Educators distributed brochures from the state health department concerning lead in their own language (142). All children participating in the study were screened initially and later at regular intervals (142). Parents were educated by peers with similar cultural backgrounds about the importance of dust control through household cleaning, hygiene such as hand washing, nutrition, and new habits such as removing shoes at the door, using cold water for cooking and baby formulas, and letting the tap water run for a few minutes before using (142). By the end of the study the investigators observed a 34% reduction in elevated BLLs (142). The investigators concluded that while the education did help to lower body burdens of lead overall, "an educational approach alone is not sufficient to prevent lead burden in high-risk, low-income populations" (142). They note that, in spite of their efforts, seven children in the intervention group had BLLs ≥ 20 µg/dL (142). The following factors appear to increase the effectiveness of lead-education programs for residents: length and intensity of the educational program, an emphasis on multiple strategies beyond housecleaning, a curriculum and delivery approach

"The investigators concluded that while the education did help to lower body burdens of lead overall, 'an educational approach alone is not sufficient to prevent lead burden in high-risk, low-income populations.'"

targeted at specific ethnicities, and a consistent relationship between educator and resident (142). In Harris County—and presumably Galveston County as well, the use of community healthcare workers (*promotores de salud*) appears particularly useful for this kind of education.

In Galveston, all buyers, sellers and renters of pre-1978 properties must receive an "Addendum for Seller's Disclosure of Information on Lead-Based Paint and Lead-Based Paint Hazards as Required by Federal Law," as well as an approved pamphlet on lead poisoning. The addendum can be downloaded from *www.trec.state.tx.us/pdf/contracts/OP-L.pdf*. The currently approved pamphlet, "Protect Your Family from Lead in Your Home," can be downloaded from *www.epa.gov/lead/pubs/leadpdfe.pdf*. See also Appendices 4 and 5.

Home Buyers

Individuals interested in buying a pre-1978 home or commercial property should ask about the building's history and, if there is any concern whatsoever, include lead testing as part of the inspection process. By federal regulation, sellers are required to disclose to potential buyers any lead-risks of which they are aware. This unfortunately sometimes results in owners choosing not to have their property tested. First-time area home buyers who qualify for Southeast Texas Housing Finance Corporation (SETH; *www.sethfc.com*) assistance have some protection against purchasing contaminated housing. Current SETH programs exist in Montgomery and Fort Bend counties and in the City of Pasadena, as well as for multi-family developments in the counties of Austin, Brazoria, Chambers, Galveston (excluding the City of Galveston), Liberty, Matagorda, Walker, Waller, and Wharton, Texas and the Cities of Baytown, Deer Park, Dickinson, LaMarque, LaPorte, League City, Pasadena, Santa Fe, Shoreacres, Texas City, and Tomball. The Lead Safe Housing Rule applies to any housing unit built prior to 1978 and states the following:

- During the inspection of any house built before 1978, both the interior and exterior painted surfaces must be inspected for defective paint. Defective paint is paint that is cracking, flaking, chipping or peeling from a building component or the house.
- Defective paint surfaces must be corrected by workers trained in lead-safe work practices or workers supervised by a trained and certified supervisor or contractor. (SETH can provide information on how to locate appropriately trained workers).
- If defective paint is not found, no corrective work or clearance testing is required.
- Seller must disclose presence of lead if known and provide any reports to buyer.
- Buyer cannot waive opportunity to get lead-based paint risk assessment done in the sales contract.

Homeowners

Homeowners planning to renovate older houses should have the home tested before they begin, including XRF analysis of earlier layers of paint. Even if the home tests as lead-safe, disruption of previous layers of paint—indoors or outdoors—can lead to significant exposure. If at all possible, residents should move out of the building and have the renovation done by trained professionals. If this is not possible, the

homeowner should undergo training in lead-safe renovation (see "Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work"; *www.epa.gov/lead/pubs/leadsafetybk.pdf*) and children should be kept away from the work area until the renovation is complete and the residence has been tested and determined to be lead-safe. Some types of renovation, such as encapsulation, are less likely to increase exposure.

Landlords

Many of the homes in question are lower-income rentals; for this reason it is important to inform the landlords of possible risks and to advise them of the appropriate steps to reduce that risk. By federal regulation landlords are required to disclose to residents of any lead-risks of which they are aware.

One method other areas have used in encouraging landlords to remediate their properties is through publicity. In 2003 the mayor of Indianapolis published a list in The Indianapolis Star and listed the city's ten landlords with the most code violations (1). The state of Rhode Island publishes a list of the highest risk properties, properties with ongoing violations, and properties that have multiple cases of elevated lead levels in children (6). In the City of Galveston, we found that 20% of children with BLLs ≥ 10 µg/dL listed addresses in properties owned by 12 landlords. Although these properties may have undergone lead abatement or the source of lead poisoning could be unrelated to housing, such findings require further investigation. If testing verifies that these properties pose an unusually high risk to residents, publication of the properties and the names of the owners in The Galveston Daily is warranted. In many states and municipalities, landlords are required to submit to testing and to remediate their properties if children are found to have elevated lead levels attributable to the housing (see "Regulations and Policies"). Directly working with these landlords to find cost-effective ways to remediate their properties can have significant public health benefits, and lead-safe certification by a reputable authority can protect landlords from litigation.

Renters

Renters similarly should be aware of potential lead contamination and ask the landlord if the property has been tested. If renters seek out certified lead-safe properties, not only do they protect themselves but they create market pressure for all rental properties to become lead-safe. As noted earlier, renters in Galveston are required by federal law to receive and sign an "Addendum for Seller's Disclosure of Information on Lead-Based Paint and Lead-Based Paint Hazards as Required by Federal Law," noting that they are aware of potential lead-exposure risk and that they have read the approved pamphlet, "Protect Your Family from Lead in Your Home," on lead poisoning *(www.trec.state.tx.us/pdf/contracts/OP-L.pdf)*. Legal protections in place elsewhere are discussed in the next section.

REGULATIONS AND INITIATIVES

The only way to protect children from the adverse health effects of lead poisoning is to control and eliminate lead hazards in the environment. The steep decline in elevated BLLs among children in the U.S. is almost entirely due to federal regulations to ban the use of lead in gasoline, paint, water and food cans. The success of these public health initiatives is an example of how regulatory interventions at the federal level of government can drastically improve the well-being of the population.

"The only way to protect children from the adverse health effects of lead poisoning is to control and eliminate lead hazards in the environment."

State and municipal regulations and initiatives vary greatly across the U.S., including several states and local governments that have created lead laws to ensure that their housing stock is lead-safe. A discussion of the many different plans is beyond the scope of this report. Instead, we discuss several selected approaches than may be of particular use to the Galveston area. In addition, two sources are particularly useful when examining various programs across the U.S.:

- CDC's National Center on Environmental Health Lead Poisoning Prevention Program Interactive Map of State and Local Programs *(www.cdc.gov/nceh/lead/grants/contacts/CLPPP%20Map.htm)* (49). Forty-five states, including Texas, and six local governments (Chicago, Detroit, DC, Los Angeles County, New York City and Philadelphia) have active CLPPP programs. In general, for each of these, the website lists contacts, confirmed data, screening plan, and strategic elimination plan. In many instances, the state links take you to the official CLPPP site for that state. For example, the Massachusetts CLPPP link includes the MA Lead Law, fact sheets, lists of licensed lead inspectors, and more. In most cases, the CLPPPs provide their general guidelines.
- National Conference of State Legislatures Lead Statutes Database Interactive legal database by state and legal topic (e.g., property maintenance, certification and licensing, enforcement, abatement, and screening/reporting) *www.ncsl.org/programs/environ/envhealth/leadStatutesdb.cfm* (207).

In this database, one can easily find the exact legislation in place for each state. Texas, for example, has no abatement legislation, whereas Alabama, Arkansas, California, Colorado, Connecticut, Georgia, Illinois, Iowa, Kentucky, Louisiana, Maine, Massachusetts, Minnesota, New Hampshire, North Carolina, Oklahoma, Rhode Island,

South Carolina, Tennessee, West Virginia, and Wisconsin do. The more rigorous of these give authority, usually to the Department of Health, to inspect a residence whenever a child living there is found to have an elevated BLL and to require remediation of any lead hazard within a specified time period. In some states, such as South Carolina, the building is posted as "unfit for human habitation" until remediation is complete. Other states have legislation establishing funds for abatement.

In this section, a number of regulations in effect in states or municipalities in the U.S. are briefly discussed. It is hoped that this section will be useful for municipalities such as Galveston in determining approaches that may be useful in reducing lead exposure in their communities. As state regulations and guidelines are constantly undergoing change, we urge you to check the above websites for the most up-to-date information.

Federal

The Residential Lead Hazard Reduction Act of 1992 (Title X of the 1992 Housing and Community Development Act. Public Law 102–550) developed numerical standards to protect the public from the lead hazards associated with house dust. The legislation also provides background material for standardizing house dust sampling techniques, basic concepts, summaries of house dust sampling methods, conclusions and recommendations for future research. As of December 1996, Section 1018 of the Residential Lead Based Paint Hazard Reduction Act of 1992 (a.k.a. Title X) stipulated that sellers and landlords must disclose information on known lead-based paint and lead-based paint hazards in residential housing, and provide any available reports to prospective buyers or renters. Sellers and landlords must give buyers and renters the pamphlet, "Protect Your Family from Lead in your Home" and keep a record of such distribution. All real estate closings should include a disclosure form as part of the transaction. A copy of the Title X legislation, as well as additional federal regulation relative to lead can be accessed at *www.epa.gov/lead/pubs/regulation.htm*.

As of June 1999, section 406(b) of the Toxic Substance Control Act, Title XV-Lead Exposure Reduction, renovators and remodelers working for compensation are required to distribute the same pamphlet as above to owners and occupants of most residential housing built before 1978, before commencing renovation activity. Minor housing repairs, maintenance, and emergency repairs are excluded from this notification.

State Medicaid programs are required to pay for home inspection of Medicaid children who are reported to have lead poisoning, although this has been interpreted to be optional by many states *(see www.ncsl.org/programs/health/forum/leadscreening.pdf)*.

State

Illinois

Illinois state regulations require every physician or health care provider to screen children 6 months-6 years old who live in high risk areas for lead poisoning, and require blood-lead screening for admission to any daycare center, daycare home, preschool, nursery school, kindergarten or other childcare facility, unless parent or guardian objects. In addition, lead hazard mitigation or abatement is required anytime a child living in a home or apartment is found to have (1) a BLL ≥ 25 µg/dL; (2) a BLL > 15 µg/dL and the next screening is ≥ 20 µg/dL; or (3) three BLLs in a row ≥ 20 µg/dL and the physician requests an inspection. A child must have an elevated BLL before the state requires a landlord or homeowner to inspect the home and fix any lead hazards. The state allows rent to be withheld until the residence is lead-safe. In Chicago, city inspectors may identify lead hazards and compel landlords to mitigate or abate even if no child with an elevated BLL lives there.

Maine

All childcare facilities in Maine are required to have an annual lead inspection in order to be licensed.

Maryland

Maryland Environmental Article 6-8, also referred to as Maryland Housing Bill 760, "The Lead Poisoning Prevention Program" statute, was signed into law in May 1994 and became fully effective on February 24, 1996. In essence, all homes built before 1950 must satisfy certain housing unit registration requirements and pass lead-dust tests or undergo a set of risk reduction measures upon change in tenant occupancy. Owners may opt to do the same for houses built between 1950 and 1978 in order to be entitled to limited tort immunity. Rates of elevated lead levels dropped 28% in Baltimore City, MD in one year due to increased enforcement of Maryland's "Reduction of Lead Risk in Housing" law.

Massachusetts

The Massachusetts Lead Law requires the removal or covering of lead paint hazards in homes built before 1978 where any children under six years of age live. Lead paint hazards are defined to include loose lead paint and lead paint on windows and other surfaces accessible to children. The law requires that owners, including owners of rental property as well as owners living in their own single family home, to comply with the law by doing the following.

- Having all lead hazards removed or covered. The owner must first hire a licensed lead inspector who will test the home for lead and record all lead hazards. After the work is approved, the owner will receive a Letter of Full Compliance.

- Having only urgent lead hazards corrected, while controlling remaining hazards. This temporary method is called interim control. The owner must first hire a licensed risk assessor who will explain what work needs to be done for interim control. After the work is approved, the owner will receive a Letter of Interim Control. Owners then have up to two years before they must have the remaining lead hazards removed or covered and receive a Letter of Full Compliance.

If a home is found to be in noncompliance with the law after inspection by a licensed lead inspector, a plan to make the property lead-safe for children must be undertaken. Some work must be done by a licensed deleader. However, an owner or agent (someone working for an owner without a deleader's license) can perform some specific tasks, if the owner or agent is properly trained to perform the deleading work. Training and financial help (through tax credits, grants and loans) are available through the Massachusetts program.

If a child is lead poisoned by lead hazards where the child lives, the owner is legally responsible. Compliance with the Massachusetts Lead Law, however, offers significant owner protection from liability. An owner cannot avoid liability by asking tenants to sign an agreement that they accept the presence of lead paint. Nor can an owner evict or refuse to rent to anyone because of lead paint, including a family with children under six if there is lead paint in the home, as this is deemed discrimination. For more detailed information, visit *www.state.ma.us/dph/clppp*.

Massachusetts also requires that each child present documentation of lead poisoning screening upon entry to preschool and kindergarten. The State also recommends that certain children at risk by virtue of where they live, parental occupation, or ongoing renovations of an older home be screened every 6 months or more. Pregnant women living in high-risk situations are recommended to be screened, as lead crosses the placenta and can be particularly devastating to the unborn fetus.

In addition, all children must receive a two-part "Lead Toxicity Screening": a verbal risk assessment and blood lead testing. The verbal component consists of the following questions and must be performed at every periodic visit between the ages of 6 mo and 72 months. The questions include the following:

- Does your child live in or regularly visit a house built before 1960? Does the house have peeling or chipping paint?
- Was your child's day care center/preschool/babysitter's home built before 1960? Does the house have chipping or peeling paint?
- Does your child live in a house built before 1960 with recent, ongoing, or planned renovation or remodeling?
- Have any of your children or their playmates had lead poisoning?
- Does your child frequently come in contact with an adult who works with lead? Examples include construction, welding, pottery, or other trades practiced in your community.
- Does your child live near a lead smelter, battery recycling plant, or other industry likely to release lead?
- Do you give your child home or folk remedies that may contain lead?
- Does your child live near a heavily traveled major highway where soil and dust may be contaminated with lead?
- Does your home's plumbing have lead pipes or copper pipes with lead solder joint?

If any of the answers are positive, the child is considered high-risk for lead poisoning. All children, low-risk and high, must be checked for blood lead. The frequency with which the blood lead test is to be administered depends upon the results of the verbal risk assessment. For children determined to be at low risk for high doses of lead exposure, a screening blood lead test must be performed once between the ages of nine and 12 months, and annually thereafter until the age of 48 months. For children determined to be at high risk for high doses of lead exposure, a screening blood lead test must be performed at the time a child is determined to be a high risk beginning at six months of age.

Last, the Massachusetts Department of Environmental Protection has had since 1988 an aggressive program to eliminate lead in drinking water in schools. The Massachusetts law sets the allowable lead in school drinking water at 15 ppb, lower than the EPA's guideline of 20 ppb, but notes that the goal is 0.

For additional information, visit *www.cdc.gov/nceh/lead/grants/Massachusetts/macontact.htm* and click on the CLPPP.

North Carolina

North Carolina law requires (1) remediation of found lead hazards in a residential housing unit when occupied by a child with lead poisoning, (2) approval of remediation plan before commencement, (3) remediation plan to be completed within 60 days of approval of plan, or the department may issue another order, and (4) compliance inspection.

In order to receive liability relief from potential lead-poisoning litigation, owners may voluntarily abide by a housing maintenance standard, which includes the following.

- Conduct annual visual inspection for deteriorated paint inside the dwelling unit. If deteriorated paint is found, repair and re-paint the area with deterioration.
- Adjust doors and windows to minimize friction that may create lead-contaminated dust.

- Use specialized cleaning methods inside the unit to remove lead-contaminated dust.
- Make horizontal interior surfaces smooth and easy to clean. Owners may be required to re-coat deteriorated hardwood floors, replace or recover worn-out linoleum floors, repair and repaint inside window sills, and/or cover window troughs with vinyl or aluminum.
- If the unit was built before 1950, the owner must repair and repaint exterior deteriorated paint, correct the cause of paint deterioration, and cover bare soil within three feet of the building foundation (e.g., cover with grass or mulch).
- Verify compliance with the standard through an annual on-site monitoring inspection conducted by a certified lead inspector or risk assessor.

Rhode Island

The Rhode Island program requires that all facilities that are licensed to serve children, such as schools and nurseries, be certified as lead safe. It also requires landlords to notify tenants of lead hazards. In 1999, Rhode Island filed suit to get the companies that used to sell lead-based paint to clean up the lead paint still contaminating many houses and apartments in Rhode Island. In February 2006 the jury decided in favor of the State and said that Sherwin-Williams, NL Industries and Millennium Holdings would have to pay for a clean up of lead paint in Rhode Island.

Rhode Island has several helpful resources for lead poisoning prevention. The Rhode Island Department of Health's CLPPP provides screening and surveillance, environmental inspection and enforcement, case management, public health and outreach, and links to additional resources and information. See *www.health.state.ri.us/lead/responsibilities.php*. The State of Rhode Island Housing Resources Commission has online information and resources available, including pdf links to a Landlord Tenant Handbook (see pages 30-36 for lead-related issues), fact sheets, frequently asked questions, and a list of lead-education courses *(www.hrc.ri.gov/misc/lead_mitigation.php)*.

Texas

The TX CLPPP recommends universal blood-lead screening for children at 12 and 24 months of age (273), and requires that all children in the Texas Health Steps (Medicaid) program have a lead test at 12 and 24 months of age. Texas law mandates that all blood-lead screening results be sent to the TDSHS as apart of a statewide surveillance system. However, approximately 13.4% of Texas children under 6 were screened for lead in 2004 (63). The TX CLPPP 2007 strategic plan calls for an increase by 10% annually the number of at-risk children screened for lead (273). In addition, there is increasing pressure to incorporate routine lead testing as part of preconception and prenatal care to reduce pregnancy-related fetal exposure. Improved nutrition, for example, may reduce the likelihood of fetal poisoning.

In 2005, two lead laws were introduced in the Texas legislature, neither of which passed. The first of the bills (House Bill 2642) would have required home inspections for lead hazards when a resident had an elevated BLL and the subsequent removal of lead hazards. The bill also allowed penalties if homeowners did not address the lead hazards when notified (2). The second bill (House Bill 2643) would have established a comprehensive program on childhood lead poisoning prevention that focused on screening all children that are at high-risk for elevated BLLs (1). The failure to pass these bills was thought to be primarily due in part to the fact that the proposals were unfunded, although property owner resistance also likely played a role. Recently, the Texas legislature was successful in passing a lead law (Senate Bill 814), which will become effective in September 2007, that authorizes the Texas DSHS to conduct environmental lead investigations in homes and child-care and child-occupied facilities when a child has a confirmed BLL. However, before conducting an inspection, the DSHS must first obtain written consent from the facility's owner (3).

The following is a short description of the responsibilities and requirements of the Environmental Lead Program (ELP) in Texas. The ELP ensures that those who conduct lead inspections, lead risk assessments, and lead abatements in target housing and child-occupied facilities built before 1978 are trained, certified, and are adhering to minimum standards that protect the health of workers and building occupants. These regulations are listed in the ELP's Texas Environmental Lead Reduction Rules (TELRR). In addition to requiring certification for lead inspections, lead risk assessments and lead abatements, TELRR requires accreditation of lead training programs, inspections of lead abatement projects and other lead-based paint activities to determine compliance with the TELRR, and enforcement-related activities in response to some compliance inspections. See "Useful Resources" for links to TELRR inspection, abatement and notification forms, and for more specific information.

The TDSHS also requires written notification seven working days prior to all lead-based paint abatement in child-occupied facilities and target housing. According to TDSHS, the term "child-occupied facilities" refers to a building or a part of a building constructed before 1978, including, but not limited to, a daycare center, preschool or kindergarten classroom, that is frequented by the same child, age six or younger, at least two days per week if the visits are (a) three hours per day; and (b) 60 hours per year. "Target Housing" refers to any housing (residential dwelling, multi-family dwelling, unit), constructed before 1978, except housing for the elderly or persons with disabilities (unless a child age six or younger lives or will live there) or any zero-bedroom dwelling. The notification must be sent to both the Environmental Lead Program Abatement Notifications and to the regional DSHS office.

County

Harris County, TX
The Lead Hazard Control Program of Harris County (operated by HCPHES, which in turn is funded by the Harris County Community and Economic Development with Community Development Block Grant Funds), provides low-to-moderate-income persons in the Harris County service area with outreach and education regarding lead-based paint, case management for children with elevated BLLs, coordination with local health care facilities screenings for children under age six, assessments and identifications of housing units with lead based paint hazards, and implementation of lead abatement and relocation for families in housing units where lead hazards have been identified. See *www.cedd.hctx.net/pheslead.aspx* for more information.

Monroe County, NY
Monroe County, NY, has one of the more comprehensive county-level CLPPPs. Elements of its program include:

- A database registry with over 90,000 children who have been tested for elevated BLLs throughout the county, including medical and environmental management information on each child;
- Medical case management and educational outreach for families of children with BLLs ≥ 10 µg/dL;
- Investigation of primary and secondary residences of children 0–72 months of age with BLLs ≥ 15 µg/dL;
- A Notice and Demand that requires Lead Safe Work Practices Training for all persons conducting the lead-hazard control work;
- Free training classes in lead-abatement;
- Community-wide education concerning lead risks to the general public, health professionals, property owners, painting contractors, parent groups, etc.; and
- Response to reports of improper/unsafe lead hazard control activities, including the issuance of Cease and Desist Orders to stop unsafe practices, order cleanup of lead contamination, and assure that cleanup is performed properly.

Monroe County greatly expanded its program after receiving funding through the HUD Lead Based Paint Hazard Control Grant Program from March 2003–September 2005 (see "Funding Assistance" for more information about U.S. HUD funding). For more information about the Monroe County program, visit *www.monroecounty.gov/eh-leadpoisoning.php*.

Municipal

Galveston, TX
On November 17, 1993, Galveston officials closed two parks because of reported lead soil contamination, which then led to the November 19, 1993 Ordinance No. 93-110. A revised Ordinance 95-35 dated May 12, 1995, provided a penalty clause. The current Chapter 18.5, "Lead Abatement," of the City of Galveston Building Code applies to all structures built before 1978, defined as "all residential and commercial structures, or parts removed from such structures, including but not limited to doors, windows, shutters, or awnings, with the corporate limits of the city." The ordinance does not apply to piers, bridges, ships, boats or other water vessels, or water storage tanks. The regulations target the removal of exterior paint on pre-1978 buildings. Key points include:

- Dropcloths must be secured to the base of the work area of the structure and must extend 30 feet to the property line, whichever is less. If the property line is less than 30 feet, the dropcloths shall extend onto the neighboring property, with the consent of the adjacent property owner(s).
- If a building has three or more stories, dropcoths must extend an additional five feet for every story greater than two.
- All vegetation must be covered with dropcloths.
- After completion of work each day, the dropcloths must be carefully folded and disposed of, and all paint and paint dust removed from the premises, adjacent properties and public rights-of-way, to the extent reasonably possible. All window sills and other ledges must be brushed off, and all work areas swept and wiped with water and a preferably phosphate-containing detergent.
- Windows must be kept closed during the paint-removal process except when working on a window area.
- No work can be conducted during rain or when the wind exceeds 15 miles per hour.
- No power-assisted equipment can be used for exterior paint removal except under the direct supervision at all times of an individual who has received a city lead-abatement permit. Only city-approved, EPA-approved or state-approved methods using power-assisted equipment can be used. A separate permit is required for each site.
- Any healthcare provider or veterinarian receiving notification of a BLL ≥ 10 µg/dL must report the case to the GCHD within 30 days.

Both homeowners and contractors can be fined not less than $100 or more than $2,000 per day for noncompliance. For a copy of the complete ordinance, contact the

City of Galveston Building Division at 409.767.3520 or buildingdivision@cityofgalveston.org. The ordinance is not currently available on the city's website.

The City of Galveston has available on its website comprehensive "Design Standards for Historic Properties in Galveston." These can be accessed, by chapter, at *www.cityofgalveston.org/city_services/planning_and_community_dev/plan_hpnp.cfm*. The standards do not currently include information about lead exposure or safe lead-abatement practices.

The City of Galveston also manages a number of grant programs, primarily from HUD, that make funds available—primarily to families with low to moderate income—to help with housing rehabilitation. For more information about the "Community Development Block Grant (CDBG), "HOME Investment Partnership" and "Housing Rehabilitation" programs, contact the City of Galveston Grants & Housing Department at 409.766.2102 (grants), 409.766.2187 (housing), or visit their website at *www.cityofgalveston.org/city_services/grants_housing_administration*.

The Galveston Historical Foundation (see also "Useful Resources") has several programs to help owners with lead-contaminated properties, although they are not currently labeled as such. The Foundation, however, has expressed interest in adding a section to their website about lead exposure, abatement and resources to help ensure lead-safe practices. Currently the Foundation has a program called Paint Pals, Paint Partnership," which provides paint and volunteers to help with the painting of the exterior of low-to-moderate homeowners in need of help. For more information, visit *www.galvestonhistory.org/Paint_Pals-Paint_Partnership.asp*. Although training in lead-safe techniques is supposedly included in the program, this is not noted on the website.

The Galveston Historical Foundation recently became certified by the City of Galveston as a Community Housing Development Organization (CHCO), which allows the Foundation to apply for federal HOME grants to purchase and rehabilitate historic homes in Galveston. The intent is to rehabilitate the homes, including making them lead safe, and then sell the homes as affordable housing. The program, named the "Historic Neighborhood Booster Program," has begun its first rehabilitation, an 1882 cottage with lead contamination. The Foundation has purchased the cottage and is overseeing an extensive lead-abatement and historical restoration of the home, which will be sold as affordable housing for significantly less than the purchase price and cost of remediation and restoration.

For more information about the Galveston Historical Foundation's new "Historic Neighborhood Booster Program," visit *www.galvestonhistory.org/Community_Housing_Development_Organization.asp*.

Houston, TX

Houston has responded to the lead problem with several approaches, using funding from federal, local and private sources. In March of 2000 the City of Houston received $160,000 from HUD for lead-based paint hazard control in privately-owned housing. The City of Houston received $3 million in 2004 to renovate 250 inner-city homes. In 2005 HDHHS received a $3 million Lead Based Paint Hazard Control Program (LBPHCP) grant from HUD (285). The Houston LBPHCP uses these funds to reduce lead paint hazards in the home, temporarily relocate families during the renovation process, and educate families on lead-exposure prevention.

The City of Houston Department of Health and Human Services (HDDHS), in partnership with the University of Texas School of Public Health in Houston, is a training partner in National Center for Healthy Housing Healthy Homes Initiative (HHI), which is in collaboration with the CDC and HUD HHI programs (see "Healthy Homes Programs " beginning on page 69). Regular courses are being offered in the Houston-Galveston area that are open to all interested individuals. For more information, visit *www.healthyhomestraining.org*. Lead abatement is among the subjects covered. In addition to the Essentials course, three other courses are available.

Several other programs exist in Houston to mitigate the childhood lead problem. One is the Houston LBPHCP, which focuses on identifying young children with elevated BLLs, and providing intervention for qualifying families by reducing the hazards. See "Useful Resources" for contact information.

One of the abatement strategies of the HDHHS for low-income lead-contaminated homes is relocation. Between 1996 and the summer of 2004 HDHHS remodeled and lead-abated 947 homes in the Houston area (131). The program used funds from HUD received in 2003 as well as bond funds from Houston's Department of Housing and Community Development totaling $3.4 million (131). At no cost to residents, HDHHS removed and replaced contaminated housing components, in addition to stabilizing or enclosing painted surfaces (131). To date, nearly 1,500 Houston low-income homes have been made "lead-safe" through this and other related programs. In 2007, Houston and Harris County received a new HUD grant for $8.1 million which will allow the program to continue through 2010.

The City of Houston CLPPP is also collaborating with Harris and Galveston counties to share expertise and possibly make additional funding available to the whole region.

RESEARCH

Recent medical research has demonstrated conclusively that low levels of lead are deleterious and, based on what we know now, it is clear that no amount of lead in the body—in children or adults—is safe. In general, public

funding is probably better used for remediation technologies and low-income housing remediation to reduce common sources of exposure than for additional research. Additional epidemiologic studies on the long-term consequences are, however, still needed to help drive protection legislation to better protect public health. In addition, a better understanding of the underlying pathophysiologic mechanisms may help lead to better and less toxic approaches to removing lead from exposed individuals.

Geospatial Analysis and Mapping

Geospatial analysis and mapping is a new and effective tool not only for identifying "hot spots" for focused remediation efforts, but also for engaging the public and helping to find resources to better protect public health. Geospatial mapping can also be used for on-going surveillance and to potentially locate clusters of elevated lead levels to identify sources, such as lead-contaminated drinking water, that might not be recognized with traditional surveillance methods.

FUNDING ASSISTANCE

Despite the fact that we all pay when a child or adult is poisoned by lead, those most affected are generally poor and cannot afford lead-abatement. In 2000, the U.S. government estimated that it would cost $16.6 billion per year for 10 years for the complete remediation of all pre-1960 housing in the nation (229). At the same time conservative analyses estimate that that annual cost due to the effects of lead poisoning in children is $43.3 billion (155). Despite this, the U.S. government allocated only $139 million for lead abatement in 2005.

This means that communities need to find creative collaborative solutions to end lead exposure.

HUD provides financial support to states, Native American tribes, local governments, private sector and nonprofit organizations to undertake programs that identify and control lead-based paint hazards in housing units (280-282,284). For more general information on HUD funding, visit *www.hud.gov/offices/lead/lhc*. Some of the current U.S. HUD programs include the following:

- Lead-based Paint Hazard Control Program (LHC). Up to $3 million is available for a wide-ranging program that identifies and controls lead-based paint hazards in eligible private housing.
- Lead Outreach Program (LOR). Up to $500,000 is available for public awareness of childhood lead poisoning prevention, training and education, and technical assistance to grantees participating in the U.S. Department of Housing and Urban Development Office of Healthy Homes and Lead Hazard Control (HUD-OHHLHC) lead grant programs.
- Lead Technical Studies Program (LTS). Up to $1 million can be awarded for research to gain knowledge and to improve the efficacy and cost-effectiveness of methods for evaluation and control of residential lead-based paint hazards.

In addition, grant opportunities related to lead are sometimes available through other federal agencies; these can be found through the search feature of *www.grants.gov*. Last, a number of foundations, such as the Robert Wood Johnson Foundation *(www.rwjf.org)* are particularly interested in healthy homes and healthy community initiatives. Other foundation opportunities can be located by subscribing to Foundation Directory Online *(http://fconline.fdncenter.org)*.

Regardless of the type of housing and degree of contamination, a number of strategies can be utilized to remove, contain or reduce lead exposure. The key is an aware community working together.