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EXECUTIVE SUMMARY

According to the Centers for Disease Control and Prevention (CDC), 310,000 children in the U.S. five years of age or younger are poisoned by lead each year (48). A disproportionate number of these children live in Galveston, Texas. Children in the City of Galveston are roughly nine times more likely than children in Texas and nationwide to have significantly elevated blood lead levels (BLLs), defined by the CDC as a BLL greater or equal to (≥) 10 micrograms per deciliter (µg/dL). In 2003, for example, lead-screening data from the Galveston County Health District (GCHD) and Texas Child Lead Registry indicated that 19.0% of City of Galveston children younger than 6 years of age had BLLs ≥ 10 µg/dL, compared with 2.4% of children across Texas (102) and 2.0% nationwide (57).

“Children in the City of Galveston are roughly nine times more likely than children in Texas and nationwide to have significantly elevated blood lead levels.”

Although different sampling and reporting protocols make comparisons between Galveston, state and federal registries potentially misleading, other surveillance efforts in Galveston have reported similar percentages. Javier and associates at the University of Texas Medical Branch (UTMB) in Galveston, for example, tested 1,571 low-income children in the city of Galveston and found that 19.1% of the children had BLLs ≥ 10 µg/dL (141). And, although the percentage of children 6 years of age and younger with BLLs ≥ 10 µg/dL. as reported by CDC’s Childhood Lead Poisoning Prevention Program (CLPPP) has consistently decreased in Texas and the U.S. in recent years, from 3.9% to 0.7% in Texas and from 7.7% to 2.0% in the U.S. between 1997 and 2003 (57), the percentage of BLLS ≥ 10 µg/dL in the City of Galveston has shown little change over the same period (23.0% in 1997 and 19.0% in 2003) (102).

It is beyond the scope of this report to comprehensively discuss all aspects of lead poisoning. There are numerous detailed and authoritative reports and resources available elsewhere, primarily through federal agencies such as the Agency for Toxic Substances and Disease Registry (ATSDR), CDC’s National Center for Environmental Health (NCEH), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Housing and Urban Development (HUD). The Texas Department of State Health Services (TDSHS) Childhood Lead Poisoning Prevention Program (TX CLPPP) and several nonprofit organizations, such as the National Center for Healthy Housing (NCHH), also offer excellent materials for departments of health, physicians, parents and educators. We provide links to these resources, as well as to particularly useful brochures and other materials.

This report is intended to increase awareness of the very serious problem of childhood lead poisoning, with an emphasis on the City of Galveston, and to bring together examples of what other communities have done to significantly reduce exposure to lead. Knowing what we know today, no person in the U.S. should regularly be exposed to lead. We hope that this report will help make this a reality.

The report is organized into four key sections, followed by suggestions for action based on our research and initiatives in place elsewhere. A brief overview is provided below.

BACKGROUND

In this section, we discuss the history of lead use and its regulation in the U.S., the primary sources of exposure, and how the definition of “lead poisoning” has changed as researchers and clinicians have become more aware of the long-term effects of low levels of lead in children and throughout adulthood. The primary sources of exposure in Galveston, as elsewhere in the U.S. today, are lead-contaminated paint from older deteriorating housing and contaminated soil. The City of Galveston, founded in 1836 but with a colorful past that reaches back into the 1500s, was not only a pirate haven at one time but much later a thriving economic center known widely as the “Wall Street of the Southwest.” Much effort has been put into protecting this legacy as well as the homes and public buildings that make up the human texture of that history. This also means that almost all of the residential structures in the City of Galveston have at some point in their history been painted—inside and outside—with lead-based paint, which was not banned in the U.S. until 1978. Before 1950, most paint contained approximately 50% lead by weight. Few people realize that, if ingested, a single dime-sized chip of pre-1950 lead paint can poison a two-year-old child. Contamination of soil, from paint particles and from lead added to gasoline, which was not fully eliminated from gasoline until 1996, is also a problem in Galveston. Although historically designated housing is generally more challenging and expensive to make lead-safe than non-historically designated housing, many communities across the U.S. that are both older and have more protected housing have made great strides toward eliminating exposure to lead. In the most successful initiatives, this has been driven locally by a collaboration of property owners, developers, realtors, historical foundations, community groups, school districts, municipal governments and healthcare professionals—reinforced by equitable but rigorous regulations.

HEALTH EFFECTS

In this section, we review the current understanding of the adverse effects of lead on key physiologic systems, including neurological, cardiovascular, immune and endocrine effects. Although a BLL of 10 µg/dL is used by many public health
Concomitant with the realization that tiny amounts of lead do irreparable harm to young children is a growing body of evidence linking early exposure to lifelong health problems. We now know that much of the lead to which one is exposed is stored in the body, generally in bone, and this lead can continue to damage health throughout life. Levels of lead in bone in adults have now been undeniably linked to hypertension, cardiovascular disease, premature death, problems with fertility, and immune and neurodegenerative disorders (115, 140, 166, 210, 226, 237, 256, 276, 303). Although the focus of this report is primarily on children, lead exposure in children and in adults is inextricably linked. One particular area of intense interest is fetal exposure. During pregnancy, even if a woman is not being exposed to lead in her home or workplace, lead leaching from her own bones from past exposures can expose her fetus to deleterious amounts of lead at a critical time in her yet-to-be-born child’s neurodevelopment.

In this section we also discuss some of the mechanisms by which lead appears to damage normal biologic mechanisms.

“We know now that much of the lead to which one is exposed is stored in the body, generally in bone, and this lead can continue to damage health throughout life.”

Some of the mechanisms include the substitution of lead for other essential metals, especially calcium and zinc; the alteration of the structure and function of metal-binding proteins; the inhibition of key enzymes necessary for the synthesis of heme which is, in turn, important for proper red blood cell formation and for regulating metabolism; interference with proper DNA binding and gene expression by destabilizing the zinc-finger domains necessary for the proper shape of DNA; disruption of neural transmission by altering calcium transport; and the promotion of damaging reactive oxygen species within blood vessels, a key mechanism underlying lead-associated hypertension and cardiovascular disease.

Because of the number of people affected and the lifetime legacy of early exposure to lead, the human, social, public health and economic burden in the U.S. is immense (7, 23, 92, 107, 115, 149, 155, 156, 245). Landrigan and associates at Mount Sinai School of Medicine, for example, conservatively estimate that the annual cost in the U.S. attributable to childhood lead poisoning is $43.5 billion (155). They note that this does not include pain and suffering or diseases of adulthood, such as hypertension or premature mortality, linked to childhood exposure to lead (208).

### HOT SPOTS

The research core of this report is our “hot spot” analysis of BLLs and the risk of exposure in the City of Galveston, focusing on the area between 81st and 1st streets. Our analysis used data from three main sources: individual BLLs and other patient-level information collected by the GCHD and the Texas Child Lead Registry between 1993 and 2006; building information from the Galveston Central Appraisal District (GCAD); and Census 2000 demographic information at the block and block-group levels. We used ESRI’s ArcGIS 9.2 and SAS 9.1 to create the merged databases for the generalized linear mixed model (GLMM) analysis. The model examined a number of variables potentially associated with higher lead levels in the 2,171 children included in the analysis. The mean BLL of the 2,171 children was 8.1 µg/dL, and 31.9% of the children in the study area had BLLs greater than 10 µg/dL. By age, children between 2 and 3 years had the highest mean level (9.4 µg/dL). By location, children living in zip code 77550 had the highest mean BLL, 9.0 µg/dL (103, 141).

In the final model, the dependent (outcome) variable was each child’s maximum BLL. The independent (predictor) variables examined included age, residential building type, year that the residential building was built, median household income, race and ethnicity, education, percent owner occupancy, total value of the residential property, and the median year buildings in each block group were built. From the results of the GLMM, we predicted the BLLs in all 13,473 residential parcels in the study area, effectively ranking the potential for each residential building in the study area to expose children to lead. Two maps generated by the study are shown on the next two pages. On the left, the age built of the 13,473 residential buildings is shown. The map on the right shows the predicted BLLs in the most vulnerable age group, two-year-old children, of all 13,473 residential parcels. In this map, other variables that were found to be significant predictors of elevated BLLs—in addition to age of housing, help to better define the areas of greatest concern. In the final GLMM, younger age, building type, older age of home
or apartment, and lower median household income were associated with higher BLLs. Lower BLLs were found in areas where most of the residents were White, Hispanic or Asian. All of the data generated and the methodology developed are being given to the GCHD to help with their surveillance, outreach and intervention efforts.

INTERVENTION

The last of the major sections of the report reviews key federal, state and municipal guidelines and programs used to reduce and, preferably, eliminate lead exposure. This section discusses specific interventional methods—such as blood-lead screening, education, dust control, soil replacement, water treatment, and paint removal or encapsulation—and their relative efficacy in reducing exposure and/or BLLs. We also discuss some of the current approaches to reduce exposure of the fetus, the efficacy of chelation to reduce BLLs, the role of nutrition to reduce uptake and/or reduce the deleterious effects of current or past exposure, and the effect of additional education and behavioral support to help children and their families deal with lead-induced disabilities.

The section begins with an overview of blood-lead screening guidelines. In 2001, the TX CLPPP developed a plan recommending that all Texas children be screened for lead in their blood at 12 months and again at 24 months of age (273). For children enrolled in the Texas Health Steps (Medicaid) program, this is required. Texas law also mandates that all blood-lead screening results be sent to the TDSHS as part of the statewide surveillance program. In 2004, approximately 13.4% of Texas children under the age of six years were screened for lead (63). In Galveston county, recent loss of federal funding and persistent underfunding
of the lead program has made it difficult for the county to fully participate in the TX CLPPP and CDC blood-lead surveillance programs, although the GCHD continues to screen and support screening through clinics and health fairs and by private physicians (154). In 2005, 1,468 (7.0%) of the county’s 20,954 children under the age of 6 years were screened for lead (57). Although there is some disagreement about whether funding is best used for universal screening or for lead abatement, Briggs and associates demonstrated in an elegant statistical model that the economic benefits of universal screening significantly outweigh the costs beginning in communities where approximately 14% of one-year-old children have BLLs ≥ 10 µg/dL. The percentage of lead-poisoned children in the City of Galveston is considerably higher.

Although blood-lead screening is important to identify problems and notify parents and schools so that action can be taken both to eliminate exposure and to provide extra educational and psychosocial support, health departments rarely initiate environmental investigations or remediation unless the BLL is over 10, 20 or even 40 µg/dL, depending on the resources of the department. Dr. Steven T. Lamb, a UTMB MPH student, recently evaluated the remaining components of the GCHD lead program. In his report he argues for a modest increase in funding of around $100,000 annually for additional staffing that would, at a minimum, allow environmental investigations of all children with BLLs ≥ 20 µg/dL (154). Beyond this, however, these children need to be removed from continued exposure. Currently, this is not being done because there is no publicly supported abatement program in place and no “safe houses” where families can go during lead-abatement activities. Thus physicians and environmental inspectors are placed in a frustrating situation of knowingly sending poisoned children.
back to contaminated environments. Although education can, for example, increase children’s hand washing and reduce exposure slightly, education alone is an insufficient intervention strategy.

The problem, as was recently enunciated at a pediatric environmental health symposium here in Houston by Dr. Bruce P. Lanphear, MD, MPH, one of the world’s authorities on childhood lead poisoning, is that identifying lead-poisoned children is “too little, too late” (156). Another leading authority on lead poisoning, Dr. Jerome A. Paulson, MD, co-director of the Mid-Atlantic Center for Children’s Health and the Environment at George Washington University in Washington, DC, goes further, “Using children to identify unsafe housing is unethical. It needs to stop” (225). The key is not to screen children, although that remains an important safety net, but rather to require screening of high-risk, older housing units and soil to identify lead hazards before a child is poisoned—before occupancy and after renovation or abatement. In addition, the data provide sufficient evidence to ban all nonessential uses of lead, such as in plumbing fixtures and highway paint (161).

**RECOMMENDATIONS**

The focus in childhood lead-poisoning policy should shift from case identification and management to primary prevention, with a goal of safe housing for all children and adults (251). With this in mind, we suggest that the Galveston community, at high risk for lead exposure, work together to become a prototype of what a relatively small cohesive community can do to eliminate a severe public health problem. We conclude by offering several specific recommendations, based primarily on initiatives in place elsewhere that are making a measurable difference:

- Appoint a “lead czar” and lead-elimination task force that would include representatives from public health, area residents, the Galveston Historical Foundation, the Galveston Board of Realtors, developers, the Galveston Independent School District, daycare centers, and others as appropriate. This formal collaboration is especially important in a smaller community such as Galveston, which may not be eligible for some federal funding based on number at risk. Such collaboration is therefore important for obtaining funding from multiple sources, putting in place a comprehensive and consistent lead-elimination plan, and making it well known throughout the community. Ideally, this would be in the context of a Healthy Homes or similar initiative, of which lead-safe housing would be a key component.

- Institute an intensive media campaign to ensure that all Galveston residents are fully aware of the problem and have easy access to fact sheets on testing, including a list of certified inspectors and interim controls. This information should be made available via television, radio, newspapers, clinic and physician offices, flyers sent home from schools, buses and other venues as appropriate. Awareness should be the number one immediate goal. The majority of people simply do not know the seriousness of lead exposure in general or the level of contamination in much of the city of Galveston.

- Require blood-lead screening of all children within the City of Galveston as a prerequisite for enrolling in day care or kindergarten, with all data made available to parents, the school system and the GCHD. Educational and psychosocial help should be available, possibly through volunteer organizations, for all children with BLLs ≥ 5 μg/dL, and a list of investigative resources and actions to identify and reduce exposure should be provided to parents with the blood-lead results. We would suggest that the screening be done at school and that a donation of $20 be suggested for those able to pay. Our conversations with area residents suggest that most would welcome easy mandatory screening and most would be willing to pay.

- Require testing by a certified inspector of all residential buildings (exterior and interior), tap water and surrounding soil, with the results made available, along with the “Addendum for Seller’s Disclosure of Information on Lead-Based Paint and Lead-Based Paint Hazards as Required by Federal Law” and an approved brochure on lead exposure before selling or renting any residential property.

- Institute a phased-in program that would prohibit the sale or rental of any residential property unless certified lead-safe by a reputable laboratory. Sales could also be conditional on establishment of an escrow account with lead abatement within a certain period after sale, usually six months, with no habitation until certified lead-safe.

- Require testing by a certified inspector of all schools, day care centers, playgrounds and other areas where children spend large amounts of time as part of the permitting process. Such facilities would have to be certified lead-safe before use.

**EXECUTIVE SUMMARY**

“We suggest that the Galveston community, at high risk for lead exposure, work together to become a prototype of what a relatively small cohesive community can do to eliminate a severe public health problem.”
EXECUTIVE SUMMARY

- Increase awareness and enforcement of the City of Galveston’s current “Lead Abatement” regulations, which apply to all pre-1978 residential and commercial buildings and require a number of measures—including extensive use of dropcloths and restrictions on the use of power-assisted equipment—to protect soil and neighborhoods from lead contamination during exterior paint removal. The regulation includes up to a $2,000 per day fine for noncompliance.

- Expand the City of Galveston’s “Lead Abatement” regulations to include interior lead-abatement activities, based on regulations in place elsewhere, which generally include pre-renovation testing by a certified laboratory; use of workers certified in lead-abatement activities or completion of a lead-abatement course by homeowners doing their own work; protection of workers and residents from exposure during interior paint removal, which generally includes prohibiting habitation in a structure during lead-abatement (children especially should not be in a home during renovation); written information on lead poisoning for workers, residents and neighbors for any pre-1978 renovation; and post-renovation certification by a qualified inspector that the structure is lead-safe before habitation.

- Add the City of Galveston’s lead abatement regulations to its “Design Standards for Historic Properties of Galveston, Texas” (67) and to its website for easy access.

- Create several lead-safe houses, possibly in collaboration with the Galveston Historical Foundation or Section 8 public housing, where families can move during lead abatement in their homes or apartments.

- Increase funding for the GCHD, as outlined in “Childhood Lead Poisoning Prevention: A Program Plan for Galveston County” (154), to enable the GCHD to do more outreach, blood-lead screening and environmental inspections, as well as to participate fully in the CDC’s STELLAR and the TX CLPPP surveillance programs.

- Screen blood-lead levels in high-risk pregnant women, with recommendations for reducing current exposure and bone-leaching.

- Consider legal action against makers of lead-based paint as has been done in a number of other communities with less of a lead-poisoning problem than Galveston. St. Louis, Milwaukee, Philadelphia, New Orleans, Chicago, Oakland, San Francisco and the New York Housing Authority have pending lawsuits, and Rhode Island settled in 1998 with three paint companies for $206 million to remove lead-paint hazards from public buildings accessible to children. Most of the lawsuits seek to recover public money spent on screening, education and lead abatement.

- Encourage federal funding support of smaller communities with demonstrated lead-remediation needs.

We recommend that the Galveston community begin immediately to phase in programs aimed at eliminating lead exposure in home, public space and work environments, using this public health emergency as a rallying point for the community and creating an example that will generate positive publicity for Galveston and serve as a prototype for other similar communities in the U.S.
Early exposure to lead leads to persistent reductions in cognitive ability and increases in behavioral problems. In addition, early exposure is increasingly linked to adult health problems later in life including cardiovascular and neurodegenerative diseases, and early mortality \(^1\). The human, societal and public health costs are immense. In 2003, a year for which we have fairly complete data, children in the City of Galveston were roughly nine times more likely than children nationwide to have lead levels of concern, currently defined by the Centers for Disease Control and Prevention (CDC) as greater or equal to \((\geq) 10\) micrograms per deciliter \((\mu g/dL)\), with 19.0% of children in the city of Galveston having a blood lead level \((BLL)\) above 10 \(\mu g/\) dL \(^{102}\) compared with 0.7% in Texas and 2.0% in the U.S. \(^{57}\). Although Galveston is certainly not the only city in the U.S. with a high percentage of lead-poisoned children, this is a preventable occurrence and public health officials have known for decades of lasting sequelae of low-level lead poisoning. Indeed, new evidence demonstrates that there is no safe level of lead in the body. Unfortunately, insufficient awareness, political will and funding continue to fail to adequately address this problem. As a result, hundreds of thousands of children and adults continue to be poisoned each year, and most do not receive the help they need to help manage the sequelae of lead poisoning.

This report is divided into four main sections:

- Background
- What Are the Health Effects?
- Galveston: Using GIS To Identify Hot Spots
- Intervention: Getting the Lead Out

The third section describes our analysis of lead hazards in Galveston, TX, and the use of Geographic Information Systems (GIS) to identify “hot spots” where the risk of exposure to children is predicted to be highest. This analysis, which forms the center of this report, is bracketed by, in the beginning, a literature review of the current understanding of lead exposure and its health effects and, after the analysis, a compilation of actions that can be taken to reduce exposure and the effects of lead poisoning. The latter includes examples and information on the relative effectiveness of various interventional strategies.

This report is intended to increase awareness of the very serious problem of childhood lead poisoning, with particular emphasis on the situation in the City of Galveston, as well as to bring together examples of what other communities have done to greatly reduce lead exposure. Knowing what we know today, no person in the U.S. should regularly be exposed to lead. We hope that this report will help make this a reality.

It is beyond the scope of this report to comprehensively discuss all aspects of lead poisoning. There are many excellent articles and reports that have already done so, and to which we refer for those interested in more detail. We have tried to tailor this report in such a way as to provide particularly useful information for a community, such as Galveston, to collaboratively address the problem. It is not a problem that can be “fixed” by any department of health without the support of parents, health professionals, educators, nonprofit organizations, realtors and government officials of the affected community.

This report is intended to increase awareness of the very serious problem of childhood lead poisoning, with particular emphasis on the situation in the City of Galveston, as well as to bring together examples of what other communities have done to greatly reduce lead exposure. Knowing what we know today, no person in the U.S. should regularly be exposed to lead. We hope that this report will help make this a reality.