Final Report

Dallas Lead Project

Brad Walsh, Sue Pickens and Marcene Royster
Parkland Health & Hospital System
September, 2003

Executive Summary

Current and former residents of two Dallas neighborhoods were exposed to lead from lead smelters in operation from 1936 to 1990. Parkland Health & Hospital System carried out a two-phase project to assess the health of those exposed in these neighborhoods. The project screened 4,215 participants at the first visit, and completed both phases on 2,797 of these (see Table 1 on next page). Additional funds are being sought to offer the second phase screening to the remaining ~1,400 in order to complete all procedures.

In this study population, blood lead levels over the currently accepted upper limits of normal are uncommon; this suggests only that there are no current lead exposures in these neighborhoods. Testing for other potential health effects from past lead poisoning, including reduced kidney function, nerve damage, and a history of learning disabilities and other disorders were also carried out. Recent cluster studies from the Texas Department of Health Cancer Registry and the Texas Department of Health Birth Defects Registry found some intriguing results in these communities, although their connection to lead exposure is far from certain at this time.

This study has explored important new ground for the health of the Texans exposed to this lead source. Few definite conclusions can be made from project data; ultimately only the weight of multiple studies on this population has the power to prove whether lead from smelters has caused damage to the health of those who were exposed in these communities.

I. The problem

Lead smelters in operation at several sites in Dallas from 1936 to 1990 may have exposed residents of some Dallas neighborhoods to high levels of environmental lead. City of Dallas Health Department pediatric lead testing began in the 1970s and found an unusual number of Dallas children with high blood lead in neighborhoods near the RSR smelter in the West Dallas area and in the Cadillac Heights neighborhood of South Dallas near two other lead smelters. The RSR smelter in West Dallas ceased to operate in 1984. Two smaller smelters (Dixie Metals, National Lead/Exide) in the Dallas neighborhood called Cadillac Heights continued to be used; the last one closed in 1990. Recently, results from a City of Dallas Health Department blood lead testing effort conducted in the Cadillac Heights neighborhood from the 1970's through about 1995 have become available, giving important information about progress in reducing lead poisoning from the days when the smelters were still operating (Gratton, A Retrospective Review of Environmental and Health Data in the

Cadillac Heights Neighborhood of Dallas, August 2002). See Table 3 for more information from this report.

The United States Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (now the Texas Commission of Environmental Quality) did extensive testing and cleanup around the RSR site in the 1990's. The RSR site was declared a federal Superfund site, which meant that specially designated federal dollars to help clean up the environmentally compromised areas of West Dallas became available. Although the Superfund cleanup activities have been completed, questions still remain among people who lived in West Dallas and Cadillac Heights about lead from smelters and their health. No population-based research into the health of these citizens has been undertaken other than these City of Dallas blood lead testing programs.

II. Project activities

With a grant from the Texas Department of Health, Parkland Health & Hospital System has carried out a cooperative lead project with the active participation of community leaders in the respective neighborhoods. Beginning in September, 2002, current and former residents of the two neighborhoods were invited to participate in this project. The purpose of the project is to assess the current health status of people who were exposed to lead from these smelters while they were in operation, and of their children. On the initial visit, a comprehensive medical history, a family medical history and a brief lead exposure history were obtained on each participant. At a second visit, each participant had their blood pressure, height and weight recorded, and each participant had blood drawn for a battery of blood tests. Based on medical history some participants were also given a brief neurological assessment. The project sought to go beyond blood lead testing and evaluate the health of the citizens in a number of categories, some of which could possibly reflect lingering damage due to past lead exposure. Testing was also performed for several common chronic diseases, which are not necessarily related to lead exposure, such as diabetes mellitus.

Table 1. Dallas lead project phases

Phase	Evaluations performed	Number of participants
Phase 1: Screening	Medical history with focus on potential lead exposure; family medical history	4,215
Phase 2: Exam and lab testing	Focused physical examination and laboratory testing, intended to detect lead poisoning and several important health problems	2,797

The number of individuals who turned out for the project exceeded expectations. Although the project was designed and budgeted for 3,150 participants, the initial visit was completed on 4,215 eligible people. Twenty-two came from out of state to participate. Over 95% of project participants gave their race as African American. See Table 2 for a breakdown of the demographics of the project participants. 2,797 participants returned for the second visit and

blood draw. Additional funds area being sought to offer the second phase screening to the remaining 1,418 participants.

Table 2. Demographics of participants.

	Number	Percent
Participants	4,215	
Race		
African American	4,026	95.5%
Hispanic	107	2.5%
White	23	0.5%
Native American	3	0.1%
Other	11	0.3%
No answer	47	1.1%
Sex		
Females	1,959	46.5%
Males	1,177	27.9%
No answer	1,081	25.6%
Age		
0-4	125	3.0%
5-14	388	9.2%
15-24	401	9.5%
25-44	1,358	32.2%
45-64	1,278	30.3%
65-74	304	7.2%
75+	143	3.4%
No answer	220	5.2%
Residence		
Dallas County	4,028	95.5%
Other Counties in Texas	167	4.0%
Outside Texas	22	0.5%
Former smelter employees	124	3.1%

All participants who have completed both phases have been informed by mail of their test and exam results. Because the project was a screening only, and was not designed to treat any problems found, project participants who were found to have any abnormal results were advised of their unusual results by mail and referred to their regular medical care provider. In case participants were uninsured or did not have a primary medical provider, all participants received instructions on how to enter the Parkland primary care system. A few participants had test results that indicated an urgent need for treatment. These participants were called by project physicians, who discussed and explained the laboratory results. These participants were advised to obtain prompt medical attention, and project physicians asked about access to care to assure that the participant had an definite medical provider and could get treatment without delay.

III. Findings

Blood lead. As expected, few of the participants were found to have a blood lead level above the values currently defined as safe by the CDC. Of 2,797 lab results reviewed, 5 adults have had blood lead levels above the level of 20 micrograms per deciliter level which the Centers for Disease Control considers unsafe for adults and children over 14 years of age. None of the children 14 and under had a blood lead level at or over the 10 micrograms per deciliter level which the Centers for Disease Control considers unsafe for children. Table 3 gives the prevalence of elevated blood lead by age group from this study, and comparable figures from City of Dallas blood lead testing conducted in the Cadillac Heights neighborhood from 1970 to the present.

Table 3. Number and percent of elevated blood lead results by age

		Present Study		Historical City of Dallas Data	
Age group	CDC "level of concern" blood lead level	West Dallas/Cadillac Heights, 2002	Percent	Cadillac Heights, 1970's-1995	Percent
Children 0-6	10 mcg/dl	0 of 105	0.0%	374 of 424	88.2%
Children 7-14	10 mcg/dl	0 of 274	0.0%	377 of 534	70.6%
Children 15-20	20 mcg/dl	0 of 148	0.0%	34 of 74	45.9%
Adults 21+	20 mcg/dl	5 of 2,203	0.2%	125 of 284	44.0%

Clearly the closure of the smelters and EPA cleanup has made a huge difference in the risk of lead poisoning in this community. These data also suggest that further large-scale population screening for elevated blood lead is not likely to benefit this community. However routine blood lead testing in young children, who are the most vulnerable to environmental lead absorption and to neurological and other damage from lead, and in adults who are occupationally exposed to lead, should be continued as recommended by CDC guidelines.

The attached graphs (Figures 1-2 and Table 4) give the lead test results for adults and children.

Figure 1. Blood lead results, adults 15 and over (n=2,319)

Dallas Lead Project, 9/8/03

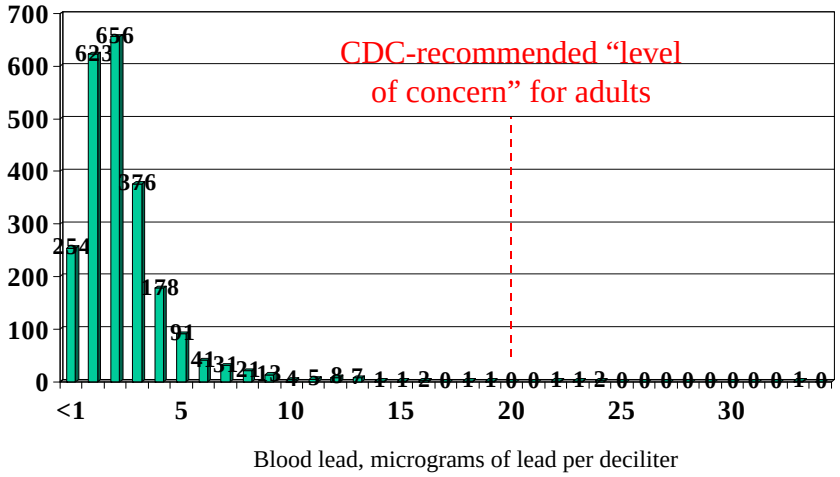

Figure 2. Blood lead results, children ages 1-14 (n=379)

Dallas Lead Project, 9/8/03

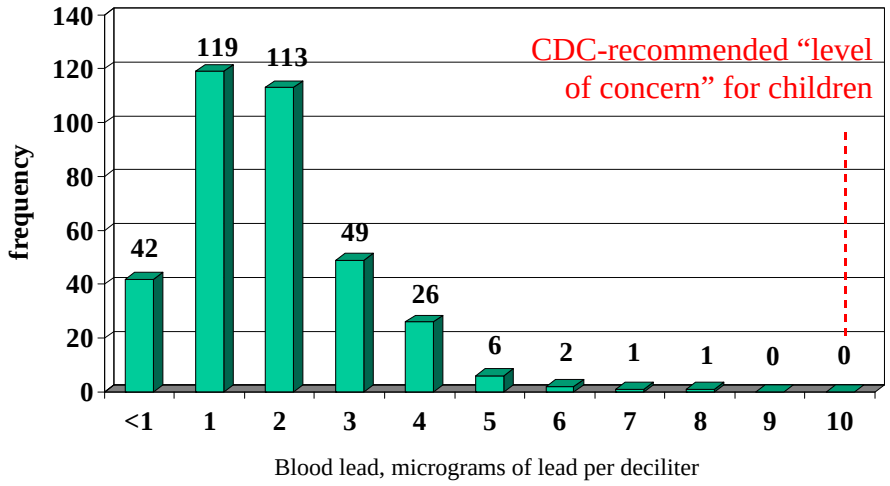

Table 4. Blood lead findings, children under age 6, and comparison to national figures from NHANES III-1999*, in micrograms of lead per deciliter of blood

	Median BLL	Mean BLL (95% Confidence Interval)	Geometric Mean BLL (95% Confidence Interval)
Dallas Lead Project	2.0	2.45	2.02
West Dallas	2.0	2.20 (1.90, 2.50)	1.96
Cadillac Heights	3.0	2.56 (1.80, 3.32)	2.21
NHANES-1999	1.9		2.0 (1.7, 2.3)

*NHANES-III-1999 is a 19-state sub-sample of the ongoing NHANES data collection effort (Centers for Disease Control and Prevention, MMWR, December 22, 2000, 49(50);1133-7); NHANES-III data were age-standardized to the 1980 US population based on the 1980 decennial census

Table 4 gives the study data for children ages 0-5, the group that is most vulnerable to permanent neural damage from lead exposure. None of these children had a blood lead level which exceeded the 10 mcg/dl level that CDC considers the point at which preventive actions should take place. However it should be noted that some researchers in the field of lead toxicity believe that there is really no such thing as a safe blood lead level in children, that even blood lead levels below the CDC guidelines given above still imply some level of damage from lead (see for example Lidsky and Schneider, Lead neurotoxicity in children: basic mechanisms and clinical correlates, Brain, 126(1), 5-19, January 2003). The mean blood lead level for children from Cadillac Heights might suggest that more lead exposures of some kind are happening to that group than to the children of West Dallas, albeit at a very low level compared to historical data (see Table 3 above). Factors such as age of housing should be examined, as should parental occupations and soil lead levels. Analysts from the CDC have stated that although child blood lead levels in the general US population declined during the 1990s, “elevated blood lead levels remained more common among low-income children, urban children, and those living in older housing.” (Blood lead levels in young children – United States and selected states, MMWR, 12/22/00, 49(50); 1133-7).

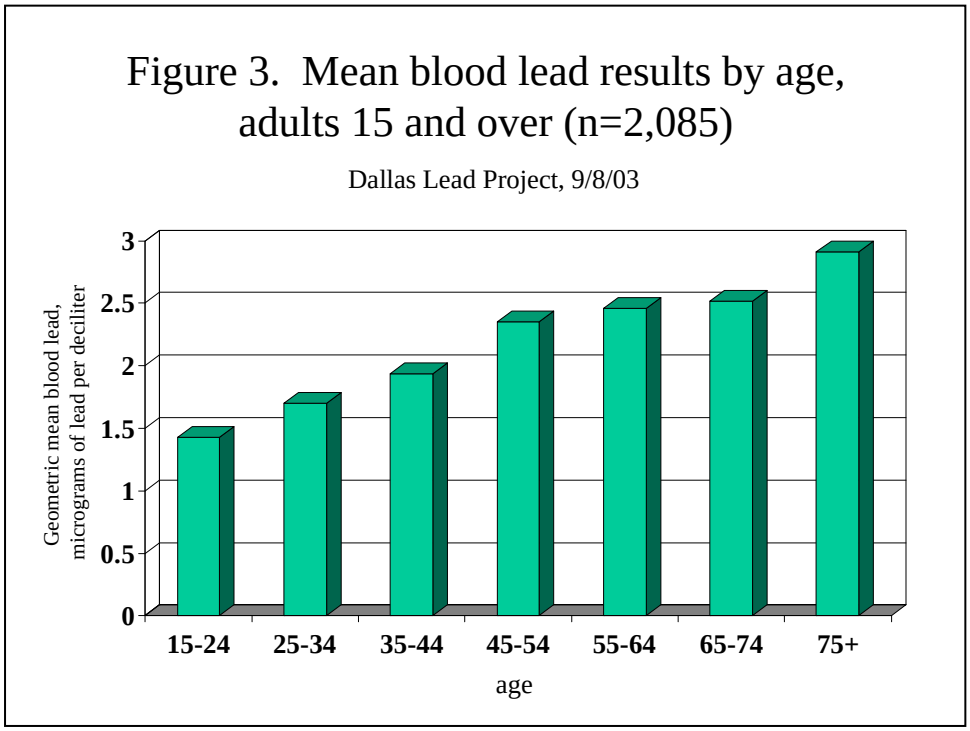

Figure 3 shows mean blood lead level by age for older teens and adults in the current study. *Harrison's Principles of Internal Medicine* (Brunwald, et al., eds., New York: McGraw-Hill, 2003, online version http://www.harrisonsonline.com) states that blood lead levels appear to increase slowly with age. Even for the oldest age group the mean blood level is less than 3 mcg/dl, well below the level of 20 mcg/dl that CDC gives as a level of concern for adult blood lead.

These data do not prove, however, that environmental lead has never caused damage to the health of the citizens of these Dallas neighborhoods. The medical consensus is that once a person is removed from all environmental sources of lead, their blood lead test level will typically return to normal within days or weeks. After that time, almost all lead remaining in the body is deposited in soft tissues such as brain cells, where it can remain for up to 2 years, and in bone tissue, where it can remain for decades (Lidsky and Schneider, Lead neurotoxicity in children: basic mechanisms and clinical correlates, Brain, 126(1), 5-19, January 2003). However, the damage that lead can cause, either during the initial exposure, or as it is released slowly from bone and other tissues later on, can be permanent. These types of damage will be described below. Bone lead release can accelerate during times when bone tissue is demineralizing, especially during pregnancy, lactation and late in life during osteoporosis (Brunwald, et al., eds., *Harrison's Principles of Internal Medicine*, New York: McGraw-Hill, 2003, online version http://www.harrisonsonline.com).

High blood pressure. A recent journal article (Nash, et al., Blood lead, blood pressure, and hypertension in perimenopausal and postmenopausal women, Journal of the American Medical Association, March 26, 2003, 289:12, 1523-1532) described an association between elevated blood lead and elevated blood pressure in women ages 40-59. This is thought to be in part a result of lead being released from bone during menopause, as bone material is restructured. Data from the Dallas Lead Project were analyzed to try to duplicate this finding. We found no association between blood lead and blood pressure in either perimenopausal women or in all participants taken together.

Kidney function. One effect of lead poisoning is reduced kidney function. People who have suffered lead poisoning in the past may show reduced kidney function for the rest of their lives (Brunwald, et al., eds., *Harrison's Principles of Internal Medicine,* New York: McGraw-Hill, 2003, online version http://www.harrisonsonline.com). Participants in this study were tested for single-sample serum creatinine level, a standard measure of kidney function. There are several common causes of poor kidney function in humans—uncontrolled diabetes and uncontrolled high blood pressure are the two of the most common in the U.S., and both of these non-lead causes of kidney damage are very prevalent in the participants of this study. Increasing age also results in some loss of kidney function (Lin, Ja-Liang, et al., Environmental lead exposure and progression of chronic renal diseases in patients without diabetes, NEJM, January 23, 2003, 438:4, 277-286). Since participants in this study were also evaluated for these conditions, kidney damage due to these factors could be removed from the calculations. That the remaining cases of kidney damage are due to lead exposure cannot be proven. But further study to examine this possibility is certainly suggested by these findings. See Tables 5 and 6 for serum creatinine findings in this population.

Table 5. Adult participants with elevated creatinine, and comparison to national estimates (NHANES III).

	Percent with elevated creatinine, Dallas Lead Project (adult participants without diabetes or hypertension)	Percent with elevated creatinine, Dallas Lead Project (all adult participants)	Age-standardized prevalence rates, Dallas Lead Project (all adult participants except diabetics)	Percent with elevated creatinine, NHANES III
Men	36 of 255 (14.1%)	167 of 809 (20.6%)	9.7%	9.7%
Women	4 of 434 (0.9%)	67 of 1,376 (4.9%)	1.6%	1.8%
TOTAL	40 of 689 (5.8%)	234 of 2,185 (10.7%)		

Diabetics were removed from the analysis before age-standardization in order to make it more comparable to NHANES, since diabetics were excluded from the NHANES database for this calculation. Table 4 demonstrates that although poor kidney function is a fairly common problem in this population, when the population findings are adjusted for it age distribution the prevalence of poor kidney function in this population was very comparable to

the national data from NHANES. This would seem to suggest that a previous history of lead exposure has not had a pronounced effect on the renal health of this population. This does not mean that subgroups within this Dallas population who did experience greater lead exposure do not show increased levels of kidney damage.

Table 6. Participants with poor kidney function (elevated serum creatinine)

	Number	Percent
1. Number and proportion of all participants with poor kidney function	241 of 2,704	8.9%
2. Number and proportion of all participants with poor kidney function, among participants who do not have either hypertension, diabetes or lupus erythematosis	43 of 1,147	3.7%
3. Number and proportion of all participants who are former employees of one of the Dallas smelters who have poor kidney function, who do not have either hypertension, diabetes or lupus erythematosis (that is, the number of former smelter employees who have unexplained poor kidney function).	4 of 19 Age-adjusted Odds Ratio 7.80 (95% C.I. 1.40, 43.45)	21.1%
4. Number and proportion of all participants who are children of former employees of one of the Dallas smelters who have poor kidney function, who do not have either hypertension, diabetes or lupus erythematosis (that is, the number of children of former smelter employees who have unexplained poor kidney function).	9 of 78 Age-adjusted Odds Ratio 0.96 (95% C.I. 0.18, 5.22)	11.5%

Thus former smelters employees (line 3), who presumably absorbed more lead while the smelters were in operation than other citizens of these neighborhoods, have significantly more kidney damage. This is consistent with other researchers' findings in regard to smelter workers in other cities. Project participants who were the children of lead smelter workers (line 4) make up another potential risk group. Because it is possible that smelter employees may exposure their families to lead by bringing home lead dust on their clothes, Texas Department of Health and others screen children with an elevated blood lead result for this exposure. Therefore it is reasonable to assume that participants whose parents worked at the smelters might have had more lead exposure, and therefore might have poorer kidney function now. However this group's risk of poorer kidney function appears to be no greater than any other project participants'.

Abnormal neurological findings. Lead exposure can cause permanent nerve damage which results in slowed reflexes, numbness, or vision or hearing problems, or other observable nerve damage (which we will call "abnormal neurological findings," defined as one or more abnormal findings on the physician-conducted neurological exam). Examples include both peripheral motor or sensory impairment (such as slow reflexes or numbness) and cranial nerve damage such as visual or hearing impairment or balance problems. Other causes of these findings in the population include diabetes, stroke, alcohol abuse, and other neurological diseases (such as polio or cerebral palsy).

18.7% of project participants were given a brief neurological examination. Of the project participants with abnormal neurological findings, the project determined from their medical histories and tests how many have no other explanation. Those patients with abnormal neurological findings but without any evidence of these other known causes of neurological disease could be suffering the effects of past lead poisoning. Since not all participants were given a neurological exam, the percentage of abnormal neurological exams itself cannot be used as evidence for health problems caused by lead in this population. See Table 7 for abnormal neurological findings in this population to date.

Table 7. Participants with abnormal findings on the physician neurological exam

	Number	**Percent**
1. Number and percent of participants with abnormal neurological findings	184 of 657	28.0%
2. Number and percent of participants with abnormal neurological findings among participants who do not have either diabetes, a history of stroke, a history of other neurological disease (e.g. polio, cerebral palsy), or evidence of alcohol abuse	51 of 282	18.1%
3. Among participants who are **former employees of one of the Dallas smelters** whose medical history is complete, and who do not have either diabetes, a history of stroke, a history of other neurological disease (e.g. polio, cerebral palsy), or evidence of alcohol abuse, the number who have abnormal neurological findings (that is, the number of smelter employees who have unexplained abnormal neurological findings)	0 of 9	0.0%
3. Among participants who are **children of former employees of one of the Dallas smelters** whose medical history is complete, and who do not have either diabetes, a history of stroke, a history of other neurological disease (e.g. polio, cerebral palsy), or evidence of alcohol abuse, the number who have abnormal neurological findings (that is, the number of children of smelter employees who have unexplained abnormal neurological findings)	2 of 10 Odds Ratio 0.81, (not significant)	20.0%

Thus the project has found no higher rate of unexplained abnormal neurological findings in smelter workers or their children than among the other project participants.

Learning and behavioral problems and psychological disorders. One of the most troubling health effects of lead is its ability to lower IQ scores in children. It is also associated with learning disabilities, behavioral problems and psychological disorders ("neuropsychiatric disorders"), particularly in those exposed during childhood. For various reasons children's bodies absorb a higher proportion of the lead that passes through their system than adults do (Brunwald, et al., eds., *Harrison's Principles of Internal Medicine*, New York: McGraw-Hill, 2003, online version http://www.harrisonsonline.com). A number of biomedical mechanisms may then result in these neuropsychiatric problems (Lidsky and

Schneider, Lead neurotoxicity in children: basic mechanisms and clinical correlates, Brain, 126(1), 5-19, January 2003). Although such neuropsychiatric damage can be profound, diagnosis is often difficult, and requires extensive evaluation. One of the most commonly used methods of evaluation, intelligence testing (IQ testing), can be very controversial because of charges of cultural bias (see for example Stephen Jay Gould, "Curveball," in *The New Yorker*, November 28, 1994). IQ testing and professional assessment for learning disabilities in this population are beyond the scope of this project. However, participants were asked if they or their family members were diagnosed with learning disabilities, attention deficit/hyperactivity disorder, retardation, depression, mental illness or neurological disease. They were also asked about symptoms that could potentially indicate undiagnosed depression. See Table 8 for the self-reported mental illness and psychiatric findings.

Table 8. Self-reported neuropsychiatric disorders, of 4,219 participants with complete medical histories

Disorder	Number	Percent
Memory problems	1,544	55.2%
Frequent headaches	1,556	55.6%
Difficulty sleeping	1,531	54.7%
Often anxious or depressed	1,350	48.3%
Difficulty concentrating	1,329	47.5%
Diagnosed with depression	875	31.3%
Migraines (self-reported)	843	30.1%
Tremor	475	17.0%
Diagnosed with a learning disability	408	14.6%
Deafness, hearing loss (self-reported)	166	5.9%
Diagnosed with attention deficit disorder	152	5.4%
Diagnosed with neurological disease	148	5.3%
Diagnosed with mental illness	137	4.9%
Seizures	119	4.3%
Diagnosed with mental retardation	53	1.9%

Project medical staff felt that the prevalence of some neuropsychiatric disorders in this population clearly exceeded what might be expected. One national psychiatric research survey, the National Comorbidity Survey, estimates the proportion of young adult respondents who might say they are "often anxious or depressed" at less than 25% (Kessler RC and Walters EE, Epidemiology of DSM-III-R major depression and minor depression among adolescents and young adults in the National Comorbidity Survey, Depress Anxiety, 1998:7(1):3-14), as compared to 57.5% in Table 8 above.

Reproductive issues and birth defects. There is some research suggesting that lead and other metals may contribute to infertility and birth defects (US Department of Energy Risk Assessment Information System, http://risk.lsd.ornl.gov/tox/profiles/lead.shtml). Female

participants were asked about difficulty conceiving, and about whether any of their children were born with birth defects or were stillborn. Study participants were allowed to define birth defects however they chose, and many defined it more loosely than a healthcare provider might. For example some respiratory birth defects were recorded, along with notes saying it was because the child had asthma. This is inconsistent with typical practice in medicine and public health. The number of inappropriately recorded birth defects cannot be determined. See Table 9 for birth defects and birth outcomes results.

Table 9. Adverse reproductive outcomes

	Number	Percent
1. Birth defects	200 of 655	30.5%
2. Ever had miscarriage	195 of 656	29.7%
3. Difficulty getting pregnant	123 of 656	18.8%
4. Infant mortality	81 of 660	12.3%

Another problem with these data is that a complete reproductive history (number of pregnancies and live births, number of stillbirths, etc.) was not asked. Therefore important information to help assess whether the events in Table 9 were unusual or typical is missing.

The project coordinators also filed a request for a birth defects cluster investigation with the Texas Department of Health (TDH) Birth Defects Registry. TDH Birth Defects Registry has records of all birth defects in Texas since 1997. The results of that cluster investigation revealed a greater than expected incidence of two classes of birth defects in children born to mothers who lived in seven ZIP codes near the smelters. Specifically the report found statistically significantly more births with two types of birth defects, obstructive genitourinary defects, and reduction defects of the upper limbs, than found in the state of Texas or in Public Health Region 3 (north central Texas). Since the smelters were operational for decades before 1997, this TDH cluster investigation describes only part of the burden of birth defects in this community since the smelters began operations. TDH Birth Defects Registry is currently conducting a followup investigation, comparing results from the Dallas ZIP codes with birth defect epidemiologic patterns from other areas of Texas, both those with lead exposure from a smelter and those with no known excess lead exposure.

Other known risk factors for birth defects besides lead should also be examined in this population. Of the metals found in soils near the smelters by the EPA, cadmium is the one with the strongest association with birth defects in animal studies, in some cases involving forelimb shortening in rodents. It should be mentioned at this point that not one of the 171 participants given a cadmium blood test in this project had more than the normal amount of cadmium detected for humans.

Cancer. Links between lead and cancer are not firmly established, although another metal sometimes associated with smelters, arsenic, is known to be associated with skin, lung and digestive cancers. EPA soil testing in the West Dallas area during Super Fund cleanup

efforts did detect the presence of arsenic in soil in some areas, with levels exceeding what is considered safe. Participants were asked about their cancer history. See Table 10 for their responses.

Table 10. Cancer diagnoses, self-reported, out of 2,797 participants to date

Cancer type or site	Number
Breast	51
Cervical	42
Blood	40
Brain	39
Digestive/Colon	35
Lung	34
Prostate	24
Bone	5
Throat	2
Bladder	2
Liver	2
Skin	1
Thyroid	1
TOTAL	298

It is not clear that these results represent more than the expected amount of cancer in this community. A similar number of project participants were given an arsenic blood test, and again none had more than the normal amount of arsenic in the blood.

All adult male project participants were given a blood test for PSA, a marker for prostate cancer. See Table 11 for these results.

Table 11. Prostate antigen blood test results

	Prostate cancer blood test positive	Prostate cancer blood test negative	TOTAL
Patient reported prostate cancer diagnosis on history	5	15	20
Patient reported no current or former prostate cancer	25	620	645
TOTAL	30	635	665

The 25 men who tested positive for prostate cancer by blood test but who didn't mention it in their medical history were advised by telephone call from a project physician. There is no

mention in the literature of any link between lead or other metals and prostate cancer, and no conclusions were drawn in this study regarding the impact of lead for this disease process.

The project coordinators also filed a request for a cancer cluster investigation with the Texas Department of Health (TDH) Cancer Registry. TDH Cancer Registry has records of all newly diagnosed cancers in Texas since 1996. The results of that cluster investigation revealed a greater than expected incidence of bladder cancer in women who lived in four ZIP codes near the smelters. All other cancer rates in this population were within expected limits based on national cancer figures. Environmental lead exposure has never been associated with bladder cancer in previous research. Since the smelters were operational for decades before 1996, this TDH cluster investigation describes only part of the cancer burden in this community since the smelters began operations. Other known risk factors for bladder cancer, such as smoking and aniline dye exposure should also be examined in this population.

Other heavy metals. Because the US EPA found arsenic and cadmium in soil near one of the smelters (RSR), a blood test for arsenic, cadmium and mercury was performed on a selected number of the project participants; criteria were individuals who had family or personal histories that indicated symptoms potentially associated with arsenic or cadmium poisoning. Of the over 210 participants tested, none have had high levels of these three metals. Like blood lead testing, these tests should only remain high for a few weeks or months after the patient has been separated from the source of the metal in the environment. These findings suggest that any arsenic, cadmium or mercury deposited by the smelters no longer presents an exposure risk to these citizens.

One symptom of chronic cadmium poisoning which can persist is osteomalacia, a syndrome defined by weakened bone strength, often resulting in more frequent fractures (Brunwald, et al., eds., *Harrison's Principles of Internal Medicine*, New York: McGraw-Hill, 2003, online version http://www.harrisonsonline.com). Participants were asked about their bone fracture history, and those with 3 or more bone fractures in their lives (other than bones of the hand and foot) were recorded. Table 12 shows these findings.

Table 12. Participants reporting frequent fractures.

	Number	**Percent**
1. Number and proportion of participants under 75 years of age reporting frequent fractures	37 of 2,500	1.5%
2. Number and proportion of participants who are former smelter employees under 75 years of age reporting frequent fractures.	2 of 118 age-adjusted Odds Ratio 2.14, 95% CI (0.48, 9.71) (Note: a CI range which includes 1, such as seen here, is not significant)	1.7%

It would appear that smelter workers under age 75 are no more likely to have suffered frequent bone fractures than anyone else in this population.

Burden of chronic disease. Project participants were evaluated for a number of other chronic diseases during the course of the project. Some of these, such as obesity, high blood pressure or diabetes, are important to the project because they can cause the same damage (kidney damage, abnormal neurological findings) that lead does. A few other tests, like liver functions, blood counts, and cholesterol/lipids, were performed even though they have less direct bearing on lead poisoning issues. Project planners hoped to take advantage of the opportunity to develop a broader picture of the health of this community, and to screen these participants for other threats to their health, so that they could seek earlier medical attention for their conditions. The costs of these tests were not great compared to the lead-related tests and procedures, and it was thought that the offer for a more comprehensive medical workup might result in more community participation in the project. See Tables 13 and 14 for these findings.

Table 13. Burden of chronic disease from history and exams/labs

	1. Self-report in medical history, but lab or exam did not detect	2. Con-firmed by exam or lab test, but not men-tioned in medical history	3. Both self-report-ed and con-firmed	4. Total partici-pants with condi-tion (total of columns 1-3)	5. Percent of all project partici-pants re-viewed to date with this condition	6. Expected preva-lence, from Texas BRFSS data (survey year)	7. Expected prevalence among Texas African American respon-dents, BRFSS * data (year)
Diabetes mellitus	83	417	268	768	30.1%	7.0% (2002)	9.0% (2000)
High blood pressure	371	368	583	1,322	69.4%	25.6% (2001)	35.7% (2001)
Obesity, high body mass index	20	1,226	361	1,607	64.6%	62.8% had physician diagnosis (2002)	66.8% had physician diagnosis (2000)
High choles-terol	271	659	393	1,323	51.2%	31.8% had physician diagnosis (2001)	29.2% had physician diagnosis (2001)

*Behavioral Risk Factor Surveillance System, Centers for Disease Control

Table 14. Self-reported chronic disease, out of 2,797 participants with complete medical history

Disease/condition/ exposure	Number	Percent	Expected prevalence, from Texas BRFSS data (survey year)	Expected prevalence among Texas African American respondents, BRFSS* data (year)
Asthma	550	21.2%	11.6% (2002)	12.5% (2002)
Smoker	602	23.2%	22.9% (2002)	21.4% (2004)
Heart disease				
Occurring before age 55	209	8.1%	Not available	Not available
Occurring after age 55	93	15.2% (of those older than 55)	Not available	Not available
Stroke	123	4.7%	Not available	Not available
Thyroid disease	181	7.0%	Not available	Not available
Tuberculosis	79	3.0%	Not available	Not available
Ulcer	288	11.1%	Not available	Not available

*Behavioral Risk Factor Surveillance System, Centers for Disease Control

It would appear that the burden of chronic illness in this community, as with many American communities, presents a considerable threat to the public's health.

IV. Ongoing research

Completing second visits and coordinating results. Project planners still hope to complete second visit/blood draws on the 1,418 participants who attended the initial screening but did not return for a followup visit and blood draw. All these participants had at least one opportunity to attend a second visit. Once funding becomes available, additional screening dates will be established and when completed, these data must be entered, collated and evaluated.

Blood lead. Once all blood lead results are available, careful analysis of the results is warranted. Although very few project participants have had lead levels exceeding CDC's "level of concern," population lead levels should be carefully compared to other comparable studies. Recent research suggests than any reductions in environmental lead exposure and blood lead levels in this community will have a positive impact on the community's health. This project may be able to shed additional light on health issues arising from "low" lead levels in this population.

Creatinine. Further research with serum creatinine may shed more light on this aspect of the community's health. Additional research may shed light on the strength of the connection between poor kidney function and past lead exposure in this community. If the prevalence of unexplained high creatinine in this population exceeds what is expected based on the literature, this might suggest an effect of past lead poisoning on this population.

V. Future activities/Recommendations

The project planners believe that this project has opened some new fields of inquiry with this lead-exposed community. They propose the following lines of investigation in the future.

Neuropsychiatric findings. The project planners want to carry out additional screenings for the over 1,500 study participants who reported suffering depression, or have been diagnosed with learning disability, mental illness, retardation or attention deficit/hyperactivity disorder. This phase would seek to discover and record the type and severity of these disorders, and also refer those project participants who may have received inadequate treatment for neuropsychiatric disorders to existing mental health providers. Careful study of neuropsychiatric findings in the project population may allow comparisons to other populations in the literature, both those with high lead exposure and those with lead exposure which is typical for U.S. populations.

Cancer and birth defects case-control studies. Both the Texas Department of Health Cancer Registry and the TDH Birth Defects Register cluster study for this project only addressed the incidence of cancer and birth defects, not their possible causes. Both TDH Registry programs have committed to this project that they are available to assist with an expanded investigation into the possible causes of the birth defects and bladder cancer observed. Case-control studies using questionnaires to interview the TDH-reported bladder cancer cases or their families, the parents of children born with birth defects, and also interview comparable people from the project population as controls. Both families of cases and community controls would be given a questionnaire asking about known causes of cancer and birth defects, and a broad sampling of other possibilities.

Other studies on the project population. Other studies, including syndrome case definition, bone lead testing using X-ray fluorescence, studies of geo-coded residence information and other more precise exposure estimators, and analyses of birth cohorts and other exposure groups, are also possible with the project population. Some can be analyzed with data that has already been collected, while others could be conducted using inexpensive mail surveys and graduate student help.

VI. Conclusions

Even before examining the issues of lead smelters and health, it should be said that the value of this project to planners at the Dallas County Hospital District, to city and county public health agencies, and to the citizens of the community, should not go unrecognized. Such extensive surveys of the general health of sub-county level populations are rare and difficult to find. The data about the burden of chronic disease, blood lead levels and mental illness and disability will be useful to planners for years to come. Community members themselves can use the information to address fears about the smelters and their aftermath, and as a measure of the impact of lead in general on the community. Also the information the study provides about the burden of chronic disease on this community is valuable to citizens as they go about making personal healthcare decisions and lifestyle choices.

Insufficient information is available to make many firm conclusions from this study about the impacts of the smelters on the health of the population. On bright spot is that blood lead and blood metals testing results suggest that no large environmental sources of lead, arsenic, cadmium or mercury remain in the neighborhoods near the former smelter sites. The source of the difference in mean child blood lead levels between the two communities (West Dallas and Cadillac Heights) deserves more scrutiny, since higher blood lead levels in young children suggest recent exposures.

But any elevated blood lead test results or other lead-related health effects this study finds cannot be linked beyond any doubt to the lead from the closed smelters. As with most other U.S. populations, people in these Dallas neighborhoods were exposed to many environmental sources of lead (e.g. paint, gasoline, household items) during the 1930s to 1970s, which could have added to the lead burden of this community. Factors such as the age of housing occupied (and therefore the risk of exposure to lead-based paint) and occupational exposures must be carefully quantified, and still may not convincingly eliminate all possibilities.

A single research study like this one can really never solve these kinds of questions to the satisfaction of scientists. However, this study may demonstrate previously unknown findings about this population and spur new interest in research. Ultimately only the weight of multiple studies on this Dallas population has the power to prove whether lead smelters damaged the health of those who were exposed in these communities.