United States
Environmental Protection
Agency

Region 5
77 W. Jackson Blvd.
Chicago, Il 60604-3507

Illinois, Indiana
Michigan, Ohio
Minnesota, Wisconsin

Environmental Sciences

7 November 1992

905-R-92-002

EPA

Project LEAP— Phase 1

Spatial And Numerical Dimensions of Young Minority Children Exposed to Low-Level Environmental Sources of Lead

Summary Report

SPATIAL AND NUMERICAL DIMENSIONS OF YOUNG MINORITY CHILDREN EXPOSED TO LOW-LEVEL ENVIRONMENTAL SOURCES OF LEAD

Summary Report— Phase 1

BY

WILLIAM H. SANDERS III
Director, Environmental Sciences Division
U.S EPA Region 5

United States Environmental Protection Agency
Region 5, Chicago
Environmental Sciences Division
Project LEAP (Lead Education and Abatement Program)
77 West Jackson Blvd, Chicago, Illinois 60604-3507

5198764

EXECUTIVE SUMMARY

This research considers the known environmental sources of lead in 83 cities in the Midwest, estimates the probability distribution of lead in African-American and Hispanic children (as well as the total childhood population) under seven years of age in each of the cities, and compares the numbers of children at risk. The approach thus developed is a population comparative risk screening methodology for ranking geographic areas as to potential lead toxicity. This data analysis report is the first phase of a three phase effort. Phase 2 will be to conduct sampling in a small number of communities, as well as to begin public outreach and education on the dangers of environmental exposure to lead. Phase 3 will be to conduct remediation of environmental sources of lead (e.g., soil and dust) in one or two communities.

The objective of Phase 1 is to estimate relative blood-lead levels in childhood populations and to compare geographic areas to ascertain the severity. For each metropolitan statistical central city area, environmental data were obtained for the major sources of exposure. This included stationary source air facilities, municipal waste combusters, ambient air quality measurements, drinking water supplies, and operating as well as abandoned hazardous waste sites. Where available, actual concentrations were used. Default values were established for each environmental medium where actual measurements had not been taken. Major air emission sources were modeled to calculate associated air concentrations. The results were used in a qualitative assessment of environmental exposure.

Demographic data were obtained from a geographic information systems application (provided by the Geographic Information Systems Management Office, Region 5, U.S. EPA). That office provided data at the census tract and community area (aggregation of census tracts) levels for each city. In general, a census tract has a population of about 4,000 people. Environmental data (air, drinking water, soil and dust concentrations) associated with each tract were obtained in order to calculate blood-lead level distributions in affected populations.

Based upon these environmental concentrations for each census tract/community area, the Uptake Biokinetic Model was run to calculate an expected percent exceedance for each area. The percentage, applied against the population data for the tract, provided an estimate of the number of children under seven years of age at risk of lead exposure. Further aggregations allowed for a city total, as well as a numerical ranking of cities.

Data from a single geographical area, Minneapolis/St. Paul,Minnesota, was selected to test the methodology. That area had available measured blood-lead levels, along with pertinent demographic information. Two statistical procedures were performed. A simple correlation analysis was conducted to ascertain whether modeled blood-lead levels, based primarily upon the environmental data for the area, were associated with actual measured blood-lead levels. An association would indicate the viability of the approach in comparing cities. The correlation analysis indicates a correlation coefficient of 0.3. It is only statistically significant, however, at the 0.10 level.

The second statistical procedure was conducted to further analyze the contribution of environmental pathways of exposure to elevations in blood-lead levels and, in particular, to ascertain whether mobile sources (i.e., proximity to a major transportation corridor) could account for a portion of the elevation in blood-lead levels. No association was found.

An analysis of environmental data indicates that a tremendous quantity of lead is still being released into the environment, and that quite typically a small (relative) number of sources contribute most of the contaminant. For the six Midwest states, industry released nearly 450,000 pounds of lead and lead compounds into the air in 1988. Seventeen sources out of nearly 350 reporting facilities accounted for almost one-half of the total emissions. Nevertheless, air quality, based upon measurements of the ambient air, was excellent, with few exceedances of the primary air quality standard for lead. Point sources of emissions, although many in number, generally do not cause concerns (a measurable increase in the ambient air-lead concentration). The notable exceptions are a few high emitting industries. For those industries, the increased ambient air-lead concentration, as modeled, is expected to occur near the source. Although there is a large amount of lead emitted into the air, only a few sources emit lead and lead compounds in sufficient amount to exceed the ambient air quality standard for air. Only two of 17 modeled stationary sources of air-lead emissions had calculated maximum point downwind air-lead concentration values projected to exceed the air quality standard of 1.5 $\mu g/m^3$. Drinking water supplies are also typically safe, although exposure does continue in some communities. Violations of the drinking water standard are rare.

Exposure to lead through soil and dust, associated with operating and abandoned hazardous waste sites, may occur in a few cities. The majority of sites, however, are located beyond the boundaries of the central cities assessed and, consequently, do not generally pose a threat.

The research placed special emphasis on the risk posed by low-level environmental sources of lead to African-American and Hispanic children. These populations are thought to be at particular risk. For children residing in central cities of one million population or more, and annual family income less than $6,000, 68 percent of African-American children are projected to have blood-lead levels exceeding 15 μg/dL. For white children in the same socioeconomic strata, the percent projected to exceed that value is much smaller, at 36 percent.

Seven cities in Region 5 are in the top 10 of the 83 cities assessed in the Midwest by virtue of having both the highest percentages of children as well as the greatest numbers of children that may exceed 10 μg/dL blood-lead concentration. Those cities are Milwaukee, Wisconsin; Detroit, Michigan; Minneapolis and St. Paul, Minnesota; and Cincinnati, Akron, and Cleveland, Ohio.

The analysis indicates that the States of Illinois and Michigan had the largest numbers of African-American and Hispanic children under seven years of age calculated to exceed 10 μg/dL blood-lead level. This includes 28,000 and 16,000 minority children, in the respective states, due to environmental sources of lead. Every Region 5 state has community areas where elevated blood-lead levels are of concern.

For the six Region 5 states, all cities combined, the total childhood population under seven years of age was 1,359,000 in 1988. The findings indicate that 154,000 children, or 11 percent of the total, would have blood-lead levels exceeding 10 μg/dL. The predominant environmental sources are lead contaminated soil and dust. This includes 55,000 African-American and 12,000 Hispanic children.

The cities with the highest potential for sizable numbers of African-American and Hispanic children with blood-lead levels calculated as above 10 μg/dL are Chicago, Illinois, 27,000; Detroit, Michigan, 13,000; Milwaukee, Wisconsin, 5,000; Cleveland, Ohio, 4,000; Cincinnati, Ohio, 2,000; and Indianapolis, Indiana, 2,000.

It is important to note that this methodology is for population screening purposes. It expands upon the use of an Uptake Biokinetic Model for derivation of blood-lead levels. Such use of the model has not been attempted before. The Uptake Biokinetic Model was developed specifically for application at abandoned hazardous waste sites for which measured environmental lead concentrations are known. The Uptake Biokinetic Model has only been validated at that spatial scale. This methodology applies it at a much larger spatial scale. It includes both estimated and measured environmental concentrations, and uses the model as part of a population risk screening approach. Consequently, the results may have no practical value as a prediction of the actual number of children expected to have elevated blood-lead levels. Nor was that the intent of the methodology. The value of the approach is in the comparison between cities. It is specifically to locate areas within a city that may be expected to have higher rates of lead exposed children than other areas. The intent of the population screening methodology is to use the relative number to set priorities for intervention efforts within a city or region. The reader is particularly cautioned that the numbers of children cited in this research are as derived by the computerized methodology. ***The methodology is a screening tool. It is not a methodology to predict actual number of children at risk.***

The Spatial and Numerical Dimensions of Young Minority Children Exposed to Environmental Sources of Lead

Introduction

In 1987 the U.S. EPA (EPA) published a document entitled *"Unfinished Business"*. The report provided a best professional judgment review of agency programs and environmental problems from the perspective of comparative risk. Since that time, all individual medium program offices at EPA headquarters, as well as each of the 10 regional offices, have developed a comparative risk analysis pertinent to the program or geographic region of concern. The intent of the approach was to discern and prioritize environmental problems affecting human health and the environment; to determine whether Agency programs were adequately addressing the existing and emerging environmental concerns; and to assess whether resource shifts (at the margin) could impact priority environmental problems that otherwise would not be addressed. The Region 5 office completed its comparative risk study in the summer of 1990. The analysis identified several cross-cutting concerns. Several program areas identified lead as one of the multi-program pollutants of concern. The region thus selected lead as a priority area, and charged the program managers, and a project director, with development of a comprehensive strategy and implementation plan to address and remediate lead contamination in the six state region.

The group recognized that many in the public health community consider lead poisoning in children to be a national epidemic. Lead exposure from exterior and interior residential paint, in particular— as well as exposure from contaminated soil and dust in and around structures present in most urban areas, drinking water, air emissions, food, occupational settings, and hobby activities— result in multiple pathways of exposure. These exposures are responsible for several adverse health effects in humans, especially in children. Children are at greater risk than adults when exposed to the same amount of lead. This is due to increased inhalation, increased absorption, mouthing and behavior patterns, and other factors. Consequently, a targeted population has been chosen to be children under seven years of age. Within this population group, African-American and Hispanic children are particularly targeted, in recognition of the greater risk of these populations to the uptake and effects of lead exposure.

Project LEAP is a multi-media and multi-program approach having four basic components: data analysis and targeting; pollution prevention; education and intervention activities; and abatement activities. Region 5 is implementing the project over a three year period. It is both a regional initiative and a component of the Agency Lead Strategy. This report is a summary of the initial efforts of Project LEAP, which focused upon data analysis, air modeling of major sources, prioritization of sources and areas for targeting purposes, and selection of geographic areas for attention during the second and third years of the Project.

The study area includes 83 cities located in 60 metropolitan statistical areas in the Midwest. These cities represent the central cities in all of the metropolitan statistical areas in the States of Illinois, Indiana, Minnesota, Wisconsin, Michigan, and Ohio.

Background

The effects of lead toxicity on human health has been extensively researched and recognized for decades. Indeed, scientific research extends as far back as 1892. High exposure, in particular, can cause encephalopathy, colic, anemia, nephropathy, electrocardiographic abnormalities and, in extreme cases, death. Reports of spontaneous abortion, decreased fertility in men, still births among pregnant women, and sundry other health effects, are replete in the scientific literature.

The insidious effects that lead causes on the health of children have received increased attention in recent years. Due to mouthing behavior, increased uptake of lead compared to adults, nutrition and other factors, children under seven years of age present a subpopulation at increased risk to the adverse effects of lead exposure. Within this population subgroup, it has been well demonstrated that African-Americans, particularly in lower socio-economic situations, are a subpopulation group at even greater risk. Hispanic children may also be at higher risk. The reasons for a dissimilarity between white and African-

American children are unclear. It is clear, however, that the difference is seen at all socioeconomic levels. Measurements and projections of blood-lead levels for African-American children consistently reflect elevated blood-lead levels.

Reports from the second National Health and Nutrition Examination Survey, based upon data from 1976 to 1980, illustrates the substantial difference in blood-lead prevalence levels based upon ethnicity. Among African-American children six months to five years of age, only 2.5 percent of African-American children, compared to 14.5 percent of white children, had blood-lead levels less than 10 µg/dL[1]. For families with an annual family income < $6,000, 18.5 percent of African-American children, contrasted to only 5.9 percent of white children, exceeded 30 µg/dL (children aged six months to five years). The percentage was 10.9 percent exceeding 30 µg/dL for all races. For that same age group, the geometric mean blood-lead level was 19.6 µg/dL for African-American children, 14 µg/dL for white children, and 14.9 µg/dL for all races. Although complete data are not available for children of Hispanic origin, the Agency for Toxic Substances Disease Registry postulates that it is reasonable to assume that the association between high blood-lead levels and lower socioeconomic income status would hold true for this population as well. Hispanic children, accordingly, may also be at elevated risk.

As research continues, the level of blood-lead concentration of concern continues to be lowered. More and more studies add to the weight of evidence for health effects in children at levels previously thought to be safe. The fact that lead is a transplacental contaminant is even more alarming because internal exposure can begin in the fetus. The exposure can continue to contribute to body tissue burden of the young child if the child is subsequently brought into a lead-contaminated environment. A significant evolving concern is that many of the effects of low-level lead exposure are not readily observable in the individual child, unlike physical manifestations caused by acute lead poisoning. Acute (observable) effects are usually associated with lead-based paint. Health effects are generally ascertained

---

[1] The reader is referred to the complete report for references.

not through clinical diagnosis of the individual patient, but rather through epidemiologic study of large groups of children already suffering from the chronic effects of lead exposure. These chronic effects are generally not observed in the individual child. Effects may include lower intelligence and other neuropsychologic deficits, hearing impairment, stunted growth, reduction in attention span, and other reported health impacts. Some studies suggest the lack of a threshold. This is extremely problematic. Even though acute poisoning and exposure have been recognized, generally associated with lead-based paint contamination, chronic exposure and effects caused by low-level lead exposure in the environment are difficult to recognize.

This nation has experienced a tremendous reduction in lead emitted into the environment by the phase down of lead in gasoline. The reduction has been paralleled by a significant concomitant reduction of the average blood-lead levels in this country. Lead, however, remains pervasive in our environment. It is in the homes of tens of millions of families and serves as a continuous source of contamination and exposure via lead paint. Lead remains in some sources of drinking water in the home. It remains in soil and dust, caused potentially by both exterior and interior lead-based paint, as well as historical or ongoing deposition from mobile sources of nearby industry. Even the nation's food supply still contains some lead, albeit in small quantity. The aggregate effect from multiple sources, in a specific geographic area, may be sufficient to cause concern.

The major objective of this research is to examine environmental sources of lead that may be linked to chronic health effects in young children. In particular, such effects may be exacerbated by an aggregation of low-level environmental exposures to lead and lead compounds that result from multiple pathways of exposure. The research effort does not account for the direct effects of lead-based paint consumption. The methodology does take into account the indirect contribution to exposure from lead-based paint via lead-contaminated soil and dust. It is recognized, nevertheless, that lead-based paint provides the largest contribution to elevated blood-lead levels. This is particularly the case for acute lead-poisoning events. This effort, however, is to assess the extent to which low-level environmental sources of lead may also contribute to elevated blood-lead levels. It constitutes the first phase of Project LEAP: analysis of existing environmental data pursuant to a comparative risk analysis of childhood exposure to lead for the study cities. The goal is to discern a logical direction for future lead reduction efforts. Phases 2 and 3 will follow, to address lead testing and remediation, respectively.

This report documents the development of a management tool to identify and prioritize geographic areas having children with elevated environmental exposures to lead which may constitute a health risk to young children. The methodology explores the application of an Uptake Biokinetic Model, developed by the U.S. Environmental Protection Agency for site specific application, on a much larger scale than its original design and intent.

Methodology

The ultimate objective was to estimate the probability distribution of blood-lead in childhood populations, and then to compare geographic areas to judge the relative severity of the problem. For each metropolitan statistical central city area, environmental data was obtained for the major sources/routes of exposure, including point source air facilities, municipal waste combusters as a special case categorical air source, ambient air quality measurements, drinking water supplies, and operating as well as abandoned hazardous waste sites. Where available, the study used actual concentrations. Default values were established for each environmental medium where actual measurements had not been taken. Sensitivity analyses were conducted to assess the impact of assumed (default) values on the blood-lead uptake estimate. Air concentrations associated with major air sources were derived from modeling source emissions. This modeled data, however, was not used in the calculations, but rather was addressed in a qualitative analysis.

Demographic information was obtained from a geographic information systems application (derived and provided by the Geographic Information Systems Management Office, Region 5, U.S. EPA).

That office provided information at the census tract or community area (aggregation of census tract) levels for each city. In general, a census tract has a population of about 4,000 people. Environmental data (i.e., media concentrations) associated with each tract were provided in order to calculate blood-lead level distributions in affected populations.

Based upon environmental concentrations (ambient air, drinking water, soil, and dust) for each census tract/community area, the Uptake Biokinetic Model was run to calculate an expected percent exceedance for the pertinent area. The percentage, applied against the population data for the tract, provided an estimate of the relative number of children under seven years of age, potentially at risk. Further aggregations allowed for a community area total, from which a numerical ranking was derived.

The project selected data from a single geographical area, Minneapolis/St. Paul,Minnesota, to test the validity of the approach. That area had measured blood-lead levels available, along with pertinent demographic information. Two statistical procedures were performed. A simple correlation analysis was conducted to see whether there was a relationship between modeled blood-lead levels— based primarily upon the environmental data developed using the approach— and actual blood-lead levels. An association would indicate the viability of the approach in comparing cities.

Results

An analysis of environmental data indicates that we are still releasing a tremendous quantity of lead into the environment. Typically, a small (relative) number of sources contribute an overwhelming amount of the contaminant. Nevertheless, air quality, based upon measurements of the ambient air, is excellent. There are few exceedances of the primary air quality standard for lead. Point sources of emissions, although many in number, generally do not cause concerns (a measurable increase in the ambient air quality), except for a few high emitting industries. For those industries, increased ambient air concentration, as modeled, is expected close to the source. Drinking water supplies are also typically safe, although exposure does continue in some communities. Violations of the drinking water standard, in study area communities, are rare.

Exposure through soil and dust, associated with operating and abandoned hazardous waste sites, potentially occurs in a few cities. The majority of sites, however, are located beyond the boundaries of the central cities assessed and, consequently, do not generally pose a threat.

Environmental Data Qualitative Summary Results

Table I presents a qualitative summary of potential routes of exposure to lead from environmental sources, for the 83 MSA cities. A positive indication for a categorical source for a particular city does not imply violations of an environmental standard, or there is necessarily an urgent public health concern caused by sources via the indicated medium. It does mean that, based upon current information, the potential for a problem exists. One can only reach more definitive conclusions, in most instances, after on-site measurements are done.

TABLE I
Qualitative Summary of Environmental Exposures[2] to Lead for MSA Cities in 1988

City	Total No. of Area Concerns	No. of Air Point Sources	No. of RCRA Facilities	No. of Landfill Facilities	No. of Superfund Sites	Ambient Air > 0.2 μg/m³	Drinking Water > 4 μg/l
Rock Island							
Moline							
Chicago	1					✓	
Kankakee							
Peoria	1			✓			
Bloomington							
Normal							
Champaign							
Urbana							
Rantoul							
Springfield							
E. St. Louis	1	✓					
Granite City	7		✓✓✓✓	✓	✓	✓	
Rockford							
Total State of Illinois	10	1	4	2	1	2	
Gary	1			✓			
Hammond	1					✓	
E. Chicago	3	✓		✓		✓	
South Bend							
Mishawaka							
Elkhart							

[2] Air point source (in or proximate to city), RCRA facility, Landfill Facility, and Superfund facility numbers indicate facilities with potential to cause exposure to humans. Ambient air and drinking water exceedances pertain to the UBK model default values.

City	Total No. of Area Concerns	No. of Air Point Sources	No. of RCRA Facilities	No. of Landfill Facilities	No. of Superfund Sites	Ambient Air > 0.2 µg/m³	Drinking Water > 4 µg/l
Goshen							
Ft. Wayne							
LaFayette							
Kokomo							
Anderson							
Muncie							
Indianapolis	3	✓✓				✓	
Terre Haute							
Bloomington							
Evansville							
New Albany							
Total State of Indiana	8	3		2		3	
Saginaw							
Bay City							
Midland							
Muskegon							
Grand Rapids							
Lansing	1				✓		
East Lansing							
Flint							
Detroit	1	✓					
Ann Arbor							
Battle Creek							
Jackson							
Kalamazoo							
Benton Harbor							
Total State of Michigan	2	1			1		

City	Total No. of Area Concerns	No. of Air Point Sources	No. of RCRA Facilities	No. of Landfill Facilities	No. of Superfund Sites	Ambient Air > 0.2 µg/m³	Drinking Water > 4 µg/l
Moorhead							
Duluth							
St. Cloud							
Minneapolis	1	✓					
St. Paul	1	✓					
Rochester							
Total State of Minnesota	2	2					
Toledo							
Cleveland							
Akron	1						✓
Lorain							
Canton							
Steubenville							
Wheeling							
Marietta							
Youngstown	1						✓
Warren	1			✓			
Mansfield	2	✓					✓
Lima							
Dayton							
Springfield							
Columbus	1	✓					
Hamilton							
Middletown							
Cincinnati							
Total State of Ohio	6	2		1			3
Eau Claire							

City	Total No. of Area Concerns	No. of Air Point Sources	No. of RCRA Facilities	No. of Landfill Facilities	No. of Superfund Sites	Ambient Air > 0.2 μg/m³	Drinking Water > 4 μg/l
Wausau	1						✓
Green Bay							
Oshkosh							
Neenah							
Milwaukee	1						✓
Racine							
Kenosha							
Madison	1						✓
Janesville	1						✓
Beloit							
LaCrosse							
Sheboygan	1	✓					
Appleton							
Total State of Wisconsin	5	1					4
Total Six States	33	10	4	5	2	5	7

Uptake Biokinetic (UBK) Model City Results

Based upon all of the environmental data collected and the demographic information provided, the study derived the numbers of children expected to exceed 10 μg/dL by census tract or community area for each MSA city. The exceedance percentages were applied to the demographic information to estimate the numbers of children at risk in the census area. The project estimates the number of newborns based upon the birth rate for the city and the total population in the census area. Table II shows the results.

TABLE II
Numbers of Children Under 7 Years of Age in the Midwest
Expected to Exceed 10 µg/dL Blood-Lead Level in 1988

City	Childhood Population	Total No. Exceeding	African-American Exceeding	Hispanic Exceeding
Rock Island	4,910	461	103	17
Moline	4,379	434	5	37
Chicago	321,585	40,370	18,712	7,888
Kankakee	3,461	289	87	3
Peoria	13,368	1,306	354	24
Bloomington	4,362	330	21	5
Normal	2,430	26	2	0
Champaign	3,979	168	34	2
Urbana	2,359	154	10	3
Rantoul	N/A[3]			
Springfield	9,716	554	76	4
E. St. Louis	8,127	798	768	8
Granite City	3,726	273	4	5
Rockford	14,406	965	198	38
Total State of Illinois	396,809	46,129 (12 %)[4]	20,375	8,034
Gary	20,855	831	652	69
Hammond	10,522	1,059	92	100
E. Chicago	5,073	660	189	275
South Bend	11,441	1,084	207	26
Mishawaka	4,149	225	2	2
Elkhart	4,616	464	97	7

[3] **N/A not available. Data was not available for these cities.**

[4] **Percentage of total population. Numbers are based upon ambient air, drinking water, and derived soil and dust lead concentrations used in the Uptake Biokinetic Model.**

City	Childhood Population	Total No. Exceeding	African-American Exceeding	Hispanic Exceeding
Goshen				
Ft. Wayne	18,910	1,780	414	55
LaFayette	4,146	243	5	3
Kokomo	5,437	401	27	6
Anderson	6,707	502	110	3
Muncie	6,822	522	56	4
Indianapolis	73,868	5,223	1,740	52
Terre Haute	5,250	797	71	6
Bloomington	2,775	141	7	2
Evansville	12,444	1,248	135	7
New Albany	3,598	258	13	2
Total State of Indiana	196,612	15,439 (8 %)	3,817	619
Saginaw	9,943	935	348	92
Bay City	4,358	564	10	27
Midland	3,834	45	1	1
Muskegon	4,741	603	135	18
Grand Rapids	20,064	1,942	486	99
Lansing	15,251	955	128	75
East Lansing	2,531	115	7	2
Flint	19,923	1,446	581	38
Detroit	134,680	19,142	12,409	555
Ann Arbor	7,819	381	38	9
Battle Creek	4,150	569	129	12
Jackson	4,588	748	119	15
Kalamazoo	7,323	777	181	17
Benton Harbor	N/A			
Total State of Michigan	239,205	28,225 (12 %)	14,571	961

City	Childhood Population	Total No. Exceeding	African-American Exceeding	Hispanic Exceeding
Moorhead	2,401	61	0	1
Duluth	8,299	1,284	9	5
St. Cloud	3,577	206	1	1
Minneapolis	29,884	4,611	379	59
St. Paul	25,357	3,333	194	97
Rochester	5,774	237	1	2
Total State of Minnesota	75,292	9,732 (13 %)	584	165
Toledo	38,143	4,515	1,157	182
Cleveland	61,289	9,396	4,022	360
Akron	23,644	3,161	694	20
Lorain	8,962	465	53	70
Canton	9,739	1,342	264	18
Steubenville	2,002	160	25	1
Wheeling	N/A			
Marietta	N/A			
Youngstown	11,968	1,884	673	64
Warren	5,742	437	69	3
Mansfield	7,180	688	90	7
Lima	5,972	550	116	6
Dayton	22,426	2,206	688	17
Springfield	7,745	914	175	7
Columbus	2,968	432	110	5
Hamilton	7,217	728	77	6
Middletown	4,467	281	31	1
Cincinnati	38,829	5,415	1,939	41
Total State of Ohio	313,139	35,797 (11 %)	11,165	837
Eau Claire	4,250	247	1	1

City	Childhood Population	Total No. Exceeding	African-American Exceeding	Hispanic Exceeding
Wausau	3,017	284	0	1
Green Bay	9,058	483	1	4
Oshkosh	3,992	388	2	2
Neenah	N/A			
Milwaukee	67,871	13,878	4,225	781
Racine	9,626	819	130	56
Kenosha	7,927	494	19	22
Madison	12,294	759	21	11
Janesville	5,655	263	0	1
Beloit	3,982	421	63	5
LaCrosse	3,341	404	1	2
Sheboygan	4,810	443	1	8
Appleton	6,251	286	0	2
Total State of Wisconsin	138,773	18,767 (13.5 %)	4,465	894
Total Six States	1,359,830	154,089 (11.3 %)	55,247	11,513

The highest percentages of children exceeding 10 µg/dL Pb-B in Illinois were derived for Chicago, where the majority of census areas were in double digit percentages, with many in the 15 to 19 percent range. The maximum value was 19 percent. A majority of the total number of children exceeding 10 µg/dL in many of the communities were African-American and Hispanic, reflecting the racial makeup of the neighborhoods. This factor also gives rise to the large number of children under seven years of age at risk of exposure to lead. The high exposure potential reflects primarily soil and dust concentrations (based upon housing stock age). Drinking water and air concentration values in the city were low.

Two areas in East St. Louis also had high numbers of African-American children with expected exceedances, although the percentages were not high at 11 and 12 percent (597 and 100 African-American children, respectively). Granite City, an area with widespread soil and dust contamination resulting from industrial operations in the city, had an average of 7 percent exceedances using the methodology. The relative small numbers for African-American and Hispanic children reflect the low population concentrations of these two ethnic groups in Granite City. It is clear that the study approach underestimates the risk in Granite City, however, by not using the higher actual soil and dust concentrations that are currently being determined. One area in Peoria is notable, with a 15 percent exceedance estimate corresponding to 224 African-American and 13 Hispanic children. No other Illinois city was notable for large numbers of African-American or Hispanic children under seven years of age, expected to exceed 10 µg/dL Pb-B.

Compared to other states in the Midwest, the community areas of most cities in Indiana have low percentile values for expected exceedances, and low numbers of potentially exposed African-American and Hispanic childhood populations. This is due to not only generally low derived-exceedance-percentages, but also to smaller city populations and relatively low population density for both minority ethnic groups. Five cities, East Chicago, Evansville, Ft. Wayne, Indianapolis, and Terre Haute, had community areas in the 15 to 19 percent range. The largest numbers of African-American and Hispanic children with expected exceedances of 10 µg/dL Pb-B were in Indianapolis, with 1,740 and 52 children, respectively, followed in quantitative rank by Gary, with 652 and 69 children, respectively. This ranking is generally indicative of the relatively large population size of these two cities. It is noted, in particular, that the community area percentages for the City of Gary were all less than 10 percent.

Detroit closely resembles Chicago in having a number of areas with expected percentages ranging from 15 to 20 percent, with corresponding high numbers of African-American and Hispanic children reflecting the ethnic makeup of the communities. A total of 19,142 children, including 12,409 African-American and 556 Hispanic children, are the expected exceedance numbers. For other State of Michigan cities, aside from Detroit, community areas in Ann Arbor, Battle Creek, Flint, Jackson, and Kalamazoo had percentile values in the 15 to 19 percent range. None of these areas, however, had very high numbers of African-American or Hispanic children with expected exceedances of 10 µg/dL Pb-B.

As expected, for the State of Minnesota, both the highest percentages and the greatest number of African-American and Hispanic children with exceedances were derived for Minneapolis and St. Paul. The Twin Cities expected numbers of African-American and Hispanic children with exceedances were, respectively, 379 and 59 for Minneapolis, and 194 and 97 for St. Paul. For the State of Minnesota, only Duluth, aside from the Twin Cities, had community areas with percentile ranges of 15 to 18 percent.

The community area in Ohio with the largest expected exceedance percentile was located in the City of Toledo, with a value of 20 percent, corresponding to 431 African-American and 45 Hispanic children expected to exceed 10 µg/dL Pb-B. For the city as a whole, 1,157 African-American and 182 Hispanic children are expected to exceed 10 µg/dL Pb-B. Two cities in Ohio have higher numbers of children with exceedances. Cleveland's numbers are 4,022 African-American children and 360 Hispanic children, and Cincinnati's numbers are 1934 and 41, respectively. Although several other cities had community areas with percentage values in the 15 to 19 percent range, the only other city with more than 1,000 children potentially exceeding the criterion value was Columbus, with 1,094 African-American and 33 Hispanic children. For the State of Ohio, the highest percentile of 23 percent was derived for a low population density community area in Youngstown.

Wisconsin is set apart somewhat from the other states and community areas by having several communities with levels of lead in drinking water at measured levels, above the level of detection. This factor, combined with soil and dust concentrations associated with older housing stock, resulted in the higher estimates of exceedance for four Wisconsin cities.

On a community total basis, Milwaukee is high both in percentile (20 percent) and in numbers (13,878 total, including 4,225 African-American and 781 Hispanic children). Several areas were in the

28 to 30 percent range, making the city the highest overall of all cities assessed, and resulting in large estimated numbers of children with exceedances. Milwaukee's drinking water concentration also measured comparatively high, at 25 ppb for 1988. Aside from estimated percentages of 17 percent for areas in both La Crosse and Racine, neither the percentiles nor the numbers of African-American and Hispanic children exceedances were exceptional for all other communities in Wisconsin.

Seven cities are in the top 10 by virtue of both overall percent exceeding and number of children exceeding 10 µg/dL. Those cities are Milwaukee, Wisconsin; Detroit, Michigan; Minneapolis and St. Paul, Minnesota; and Cincinnati, Akron, and Cleveland, Ohio. The top 10 cities, by percentile and total number of children, are shown in TABLES III and IV, respectively.

TABLE III
Top Ranked Cities by Percentile
of Children Exceeding 10 µg/dL Pb-B

	City	%	Expected Total No. of Children < 7 Years Old	Expected No. of African-American Children < 7 Years Old	Expected No. of Hispanic Children < 7 Years Old
1	Milwaukee, WI	20.4	13,878	4,225	781
2	Jackson, MI	16.3	748	118	15
3	Duluth, MN	15.5	1,284	9	5
4	Minneapolis, MN	15.5	4,611	379	59
5	Cleveland, OH	15.3	9,396	4,022	360
6	Terre Haute, IN	15.2	797	71	6
7	Detroit, MI	14.2	19,142	12,409	556
8	Cincinnati, OH	13.9	5,415	1,934	41
9	Battle Creek, MI	13.7	569	129	11
10	Akron, OH	13.4	3,161	694	20

TABLE IV
Top Ranked Cities by Number of
Children Exceeding 10 μg/dL Pb-B

	City	%	Expected Total No. of Children < 7 Years Old	Expected No. of African-American Children < 7 Years Old	Expected No. of Hispanic Children < 7 Years Old
1	Chicago, IL	13	40,370	18,712	7,888
2	Detroit, MI	14	19,142	12,409	555
3	Milwaukee, WI	20	13,878	4,225	781
4	Cleveland, OH	15	9,396	4,022	360
5	Cincinnati, OH	13	5,415	1,939	41
6	Indianapolis, IN	7	5,223	1,740	52
7	Minneapolis, MN	15	4,611	379	59
8	Toledo, OH	12	4,515	1,157	182
9	St. Paul, MN	13	3,333	194	97
10	Akron, OH	85	3,161	694	20

The six Midwest states ranged from 8 percent exceedance estimates in Indiana to 13 percent in Minnesota, although it is noted that these percentages are not particularly meaningful at the state level. The States of Illinois and Michigan had the largest numbers of African-American and Hispanic children under seven years of age expected to exceed 10 μg/dL Pb-B, including 28,000 and 16,000 minority children, in the respective states. Every state has community areas where elevated blood-lead levels are of concern.

For the six states, all cities combined, the total childhood population (children under seven years of age) was 1,359,000 in 1988. The analysis indicates that 154,000 children, or 11 percent of the total, would have blood-lead levels exceeding 10 μg/dL. This includes 55,000 African-American and 12,000

Hispanic children. These numbers are presented for illustrative purposes, and are not a prediction of numbers of children. It is noted, however, that these numbers are conservative compared to other estimates.

Conclusions and Recommendations

Environmental Information

Soil and dust are the most important determinants of modeled Pb-B levels. There is minimal information, however, about the extent of lead contamination caused by operating and abandoned hazardous waste facilities that could cause such contamination. The EPA has not conducted off-site soil, dust, and air sampling for lead at most sites. Nonetheless, there should be a relatively small number of residents potentially exposed. Except for East St. Louis, Illinois, Granite City, Illinois, and Lansing, Michigan, this category of sources does not appear to warrant significant concern for most areas. Extensive sampling, however, around each site, would be required to make a definitive finding. Unless there is strong indication of contamination, however, such sampling is not generally thought to be prudent of cost effective.

Recommendation: Investigate further hazardous waste sites in Granite City, Illinois, East St. Louis, Illinois, Lansing, Michigan, and any city where a site falls within an area with large numbers of children expected to exceed 10 μg/dL blood-lead. Complete the remedial design work for the NL/Taracorp Corp. site in Granite City, Illinois, pursuant to on-site abatement and replacement of contaminated soil in a 55 square block residential area.

Major air sources are of concern only for residences close to the emission source. Municipal waste combusters do not constitute a serious concern, although more information is required for that judgment. Modeling of the air sources did not add value to the analysis, aside from confirming the lack of wide-spread impact.

Recommendation: Review major sources with (relatively) high modeled air values to ensure nearby residents are not exposed to excessive air-lead concentrations.

The ambient air, drinking water supply, and toxic release inventory data were useful in development of the approach and, for the former two data bases, for derivation of blood-lead values.

Statistical Analysis

One would expect to find a stronger relationship between distance and the actual blood-lead measurements only if there were a strong association between soil concentration and distance from a major highway. That association, although statistically significant, was weak. The conclusion is that, for the population, the distance from a major highway does not relate to actual blood-lead levels (or soil concentrations). Consequently, other factors (e.g., lead-based paint) appear to contribute more to the elevated Pb-B found in the survey. It is noted, however, that the average distance from the census tracts to an interstate is greater than one kilometer. The maximum distance exceeds five kilometers. Accordingly, most of the children are probably too far away, luckily, to be exposed to mobile source route lead emissions. We must note that this result is specific solely to the Minneapolis/St. Paul, Minnesota area, for which data were analyzed. Further, the analyzed data were not originally developed to assess the impact of mobile sources. Consequently, caution is necessary in the interpretation of the finding.

UBK City Results

Central city residents are subject to low-level exposure of environmental sources of lead, and exposure levels differ amongst the cities. The cities with the greatest number of children potentially at risk include the largest cities in the six-state area, including Chicago, Detroit, Milwaukee, and Cleveland. Although soil and dust predominate as sources of lead contamination, drinking water quality contributes in a handful of cities.

Recommendation: **Select areas within the top 10 cities with the highest numbers of children at risk. Conduct on-site sampling and investigation to determine the actual extent of residential lead contamination.**

Recommendation: Develop and implement a public outreach and awareness strategy, pertinent to African-American and Hispanic communities, in particular, but inclusive of any population at high risk of exposure, in selected cities.

Recommendation: Determine the current drinking water lead concentrations for Wausau, Eau Claire, Milwaukee, and Madison, Wisconsin, and Youngstown, Ohio. Evaluate the results to ensure compliance with the current drinking water supply standard for lead.

Recommendation: Start preliminary investigations in East St. Louis, Illinois.

Recommendation: Work with public health departments to coordinate outreach and education efforts to targeted communities.

Recommendation: Obtain results of stack test information, when available, for the Chicago, Illinois, North Montgomery County, Ohio, and South Montgomery County, Ohio, municipal waste incinerators. Evaluate the results to ensure that lead emissions do not pose an unacceptable risk to local residents.

Recommendation: Begin coordination with the newly created Regional Lead Center.

UBK Model and Algorithm Validity

An inability to account for ethnicity and socioeconomic status resulted in an underestimate of the at-risk population in lower socioeconomic minority communities. Nevertheless, the approach is considered to be valid, even though there was only a weak correlation between Pb-B modeled and Pb-B measured. A fundamental factor of the analysis is that the UBK model used to derive modeled blood-lead levels is not, nor was it intended to be, applicable and appropriate for use to discern a blood-lead level for an individual child. The model is appropriate for estimating the affects on populations of children. That is the precise use for which the algorithm uses the UBK model. Consequently, although not useful as a verification step of the approach using a correlation model, the model is useful in assessing population risk. Consequently, its use in this population comparative risk analysis is appropriate. Accordingly, the approach should prove to be useful in identifying "hot spot" locations where numbers of children are at higher relative risk.

Recommendation: Repeat the approach for other EPA regions and states, or in areas where targeting is desired to rank, prioritize, and better characterize the numbers and extent of at risk minority populations, due to exposure to lead. Account for abandoned and operating waste sites, municipal waste combusters, and stationary sources of air emissions by location. Follow-up facilities located within a high percentage exceedance area, as identified via the approach.

Recommendation: Include paint contribution (using procedures as derived for soil and dust based upon age of housing stock) in the model to better estimate expected blood-lead values. This would base derived values upon better knowledge of the association of lead-based paint contributions to daily intake, with housing age.