ORIGINAL COMMUNICATIONS

AN UPDATE ON BLOOD LEAD LEVELS IN PEDIATRIC PATIENTS OF A NEIGHBORHOOD HEALTH CENTER AND AN ANALYSIS OF SOURCES OF EXPOSURE

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This article continues the report of a study at the St Louis Comprehensive Neighborhood Health Center in which definitive blood lead levels were routinely determined in pediatric patients younger than 5 years of age. Data on changes during the 1980s in population, housing, and soil lead levels also are provided for possible correlation with changes in blood lead levels. From 1976 through 1993, there has been a progressive decline in annual mean blood lead levels and in the percentage of patients at several ranges indicative of different degrees of risk for brain damage. Comparisons of blood lead levels in residents of other neighborhoods in the city of St Louis show that most predominantly black neighborhoods and a single predominantly poor white neighborhood are particularly high-risk areas. In the study catchment area, the total population has decreased but the number of children younger than 5 years of age has increased. The latter has resulted in about a doubling of admissions to our health center in 1993. There also has been a decline in occupied housing units, an increase in unoccupied units (probably unfit for habitation), and the demolition of more than 6700 units. There also has been a remarkable citywide reduction in soil lead levels, somewhat more marked in the study catchment area than in some other areas of the city. The reduction in the lead burden in children in the study catchment area appears to be associated with the decline in housing units and the decline in soil lead levels. (*J Natl Med Assoc.* 1995;87:99-104.)

Key words • lead exposure • blood lead levels • toxicity • erythroprotoporphyrin

A previous report[1] described the characteristics of an almost 20-year-old program in which definitive blood lead levels were determined in children residing in a predominantly black well-defined neighborhood served by the St Louis Comprehensive Neighborhood Health Center (SLCNHC). Annual changes in mean blood lead levels, as well as changes in the percentage of children exhibiting ranges in lead levels with varying degrees of risk, were recorded. Comparisons were made with black and white children nationally, with children elsewhere in the city of St Louis, and with children residing in communities adjacent to a lead smelting operation located about 30 miles south of St Louis. In all of these comparisons, children residing in the study area showed the highest mean lead levels and the highest percentage of children with inordinately high lead levels.

In an attempt to identify the sources of exposure, we noted the high proportion of housing units built prior to 1940 containing lead-based paint, and we presented data from a 1976 citywide study of soil lead levels.

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TABLE 1. CHANGES IN SLCNHC BLOOD LEAD LEVELS, 1976 TO 1993

Years	No. of Cases	Mean μg/dL	Percent ≥10 μg/dL	Percent ≥25 μg/dL	Percent ≥50 μg/dL	Highest μg/dL
1976 to 1977	1809	34.2	99.9	80.0	8.1	101
1981 to 1984	2761	28.3	99.7	61.7	2.8	100
1985 to 1989	2035	22.0	94.3	40.4	1.6	82
1991 to 1993	2186	12.8	48.6	15.9	0.6	79
1990	349	15.9	54.7	26.1	1.4	65
1991	217	18.7	66.4	29.5	2.8	79
1992	976	12.8	49.0	17.9	0.2	68
1993	1509	9.3	39.6	3.1	0	48

Abbreviations: SLCNHC = St Louis Comprehensive Neighborhood Health Center.

However, neither of these sources appeared to account for the higher lead levels in the children.

Since about 1981, annual mean blood lead levels have progressively declined. As noted previously,[1] the only source of exposure that might account for at least some of this decline was the reduction in the use of leaded gasoline in motor vehicles, which began in 1974. By 1984, leaded gasoline consumption had declined nationally by 73%, and estimated lead levels in ambient air showed a comparable decline. However, these changes would not account for the continued decline after 1984.

Additional data on blood lead levels in the catchment study children have been obtained through 1993 as well as more definitive information on lead levels in children of other neighborhoods. More definitive data on changes in population and in housing also have been obtained, as well as more current data deriving from a 1990 citywide study of soil lead levels. This article attempts again to correlate sources of exposure with changes in blood lead levels. The elements of these correlations include changes in population, housing, and soil lead levels.

METHODS

Blood Lead Analyses

Blood lead analyses were carried out by the method previously described[1]; the annual number of cases is shown in Table 1. Without our knowledge, in 1990 and 1991 there was a departure from the established routine: blood samples were screened first by erythroprotoporphyrin (Ep) analyses, and as recommended at that time by the Centers for Disease Control (CDC), only samples with Ep levels ≥25 μg/dL were subjected to definitive lead analyses. This departure from earlier procedure accounts for the reduction in the number of samples with definitive lead analyses in those 2 years shown in Table 1.

Also available is a report from the St Louis Health Department that provides data on blood lead levels in children for 1993. These data were obtained from the city health department's mobile unit and lead clinic, and Head Start Program, as well as from other providers including health centers, private physicians, and a health maintenance organization. In large part, these data were derived from Ep screening with definitive blood lead analyses only in those samples with Ep levels ≥25. As shown in Table 2, these data have been divided into three compartments. One compartment includes the data from the mobile unit, the Head Start program, and the city's lead clinic. A second includes data from providers located in predominantly black neighborhoods, and a third includes data from those located in predominantly white neighborhoods. These are compared with data from the catchment study area.

Changes in Population and Housing

For changes in population and housing, the census tracts representing SLCNHC's catchment area were first recorded. The US Census Bureau Reports for SMSA St Louis for 1980 and 1990 then were used to determine changes in total population for each of these census tracts as well as changes in the population of children younger than 5 years of age, the latter representing the ages of the children in the lead program. These data are summarized in Tables 3 and 4. With respect to housing, the difference in total housing between 1980 and 1990 represents the number of housing units demolished during the 1980s. The census reports also provided the change in the percentage of African Americans residing in the catchment area.

Soil Lead Levels

In 1990, a citywide study of soil lead levels was carried out by the St Louis Health Department. This study contained an analysis of 322 soil samples

TABLE 2. COMPARISONS OF 1993 BLOOD LEAD LEVELS IN CHILDREN IN DIFFERENT ST LOUIS NEIGHBORHOODS

Source	No. of Units	No. of Samples	≥10 %	≥10 Range	≥20 %	≥20 Range
City mobile unit, Head Start Program, and city lead clinic	3	3452	42.7	21.9-58.6	8.9	2.5-10.8
Health facilities in predominantly black neighborhoods*	7	6006	25.7	2.2-42.5	4.1	0.7-10.4
Health facilities in predominantly white neighborhoods	5	2783	15.5	5.8-28.0	2.4	1.2-3.8
Above combined	15	12 241	28.1		5.1	
SLCNHC	1	1509	39.6		5.4	

Abbreviations: SLCNHC = St Louis Comprehensive Neighborhood Health Center.
*Does not include SLCNHC.

compared with only 44 in the 1978 study.[2] At each site, soil samples were obtained from two locations—the strip between the sidewalk and the curb and the center of the backyard. Fifty-eight of the 114 census tracts in the city (50.9%) were sampled. Of the 28 census tracts in the catchment area, 22 were sampled (78.6%); these 22 tracts represented 41.3% of all of the tracts sampled (Table 5).

RESULTS

Changes in Blood Lead Levels

The data in Table 1 illustrate that the progressive decline in annual mean blood lead level previously reported for the years 1976 to 1989 has continued through the years 1990 to 1993. The same trend holds for the percentage of cases with blood lead levels ≥10 and ≥25 μg/dL, with the most marked drop in the ≥25 category between 1992 and 1993. There also has been a progressive decline in the highest lead level among catchment area patients, with the greatest change again between 1992 and 1993. For the first time, there were no cases in 1993 with levels ≥50 μg/dL.

Nevertheless, if the data are examined with respect to the actual number of children with lead levels above the acceptable level <10 μg/dL as recommended by the CDC, it becomes evident that a significant abatement problem remains. During the period 1990 to 1993, there were 1275 cases with blood levels ≥10, 378 with levels ≥25 considered potential candidates for treatment, and 13 cases with levels of ≥50 μg/dL in whom treatment is regarded as mandatory. In the final year of this study alone (1993), there were 597 patients with levels ≥10 and 48 with levels ≥25 μg/dL.

Table 2 provides comparisons of the rates of two undesirable ranges of blood lead levels between several health-care facilities. The highest rates were present in programs conducted by the lead program of the St Louis Health Department. However, these data are selective in the sense that definitive lead determinations were carried out, in large part, on children first screened by Ep determinations. Moreover, information as to the racial distribution of these children was not available. The second highest rates were in children in the SLCNHC program, and the third highest rates were in facilities serving predominantly black populations. The lowest rates were in facilities serving predominantly white populations, including physicians in private practice and a health maintenance organization.

However, as indicated by the ranges in percentages, there is some overlap between these groupings. A ranking by individual facilities reveals that the highest rank is still in the population served by the lead program of the city's health department. Second in rank is a facility serving a predominantly black population, third in rank is the SLCNHC program, and fourth is a facility serving a predominantly (poor) white population. Last in rank is a facility serving a small predominantly black population.

Changes in Population

The catchment area is divided into two segments as shown in Table 3; patients were derived from both segments. The racial composition of the two segments is about the same (more than 80% black). As shown, the percentage of African Americans actually rose between 1980 and 1990. During this decade, the total population declined by 13.1%, but the population of children ≤5 increased by almost 8%. In 1993, the pediatric admissions to SLCNHC virtually doubled.

Changes in Housing

The housing changes are shown in Table 4. During

TABLE 3. SLCNHC CATCHMENT AREA POPULATION CHANGES, 1980 TO 1990

	1980	1990
Total population		
Service area	62 476	52 782
Contiguous area	60 006	53 714
Combined	122 482	106 496
Change		−15 986
Population younger than 5 years		
Service area	5567	5703
Contiguous area	4292	4922
Combined	9859	10625
Combined		+766
% African American	83.4	89.4
Pediatric admissions to SLCNHC	1708*	3585†

Abbreviations: SLCNHC = St Louis Comprehensive Neighborhood Health Center.
*Number represents 17.3% of all admissions in 1980.
†Number represents 33.7% of all admissions in 1990.

TABLE 4. SLCNHC CATCHMENT AREA HOUSING CHANGES, 1980 TO 1990

	1980	1990
Occupied housing		
Service area	19 687	17 252
Contiguous area	23 082	20 751
Combined	42 769	38 003
Change		−4767
Unoccupied housing		
Service area	2669	3203
Contiguous area	2443	3893
Combined	5112	7096
Change		−1984
Total housing		
Service area	22 356	20 455
Contiguous area	25 526	24 644
Combined	47 882	45 099
Change		−6751*
% African American	83.4	89.4

Abbreviations: SLCNHC = St Louis Comprehensive Neighborhood Health Center.
*Demolished housing units.

the 1980s, occupied housing declined by about 11%, unoccupied housing increased by almost 39%, and total housing declined by about 14%. Thus, more than 6700 housing units were demolished during this decade.

Soil Lead Levels

Table 5 presents data on soil lead levels. The 1990 study compared soil lead levels in the catchment area with those in the rest of the city by the two sites of sampling both separately and combined. From each site, as well as from the two sites combined, average levels in the catchment area were about 20% lower than in the rest of the city. Lead level ranges varied widely, indicating high soil lead levels in the catchment area, as well as elsewhere in the city. Of the 137 soil samples in the catchment area, 19.3% showed levels above 1000 ppm; of the 185 samples in the rest of the city, 23.2% were above this level. Table 5 also compares soil lead levels from the 1978 study with those from 1990. There were far fewer samples in the 1978 than in the 1990 study (44 versus 322), but samples from 1978 displayed average soil lead levels about four times higher than samples from 1990. In both studies, the average lead levels in the catchment area were lower than in the rest of the city.

DISCUSSION

The primary purpose of this study was to attempt to integrate changes in environmental components such as population, housing, and soil lead levels of a geographically defined area with blood lead levels in children residing in that area. Such an analysis is made possible because of a previously described[1] almost 20-year-old program in which definitive blood lead levels were determined routinely on pediatric admissions to a health center that is virtually the only source of health care in its catchment area. We have been unable to find any previous comparable study. A secondary purpose was to compare the risk level of children residing in the catchment area with that of children residing elsewhere in St Louis.

Changes in Blood Lead Levels

From the mid-1970s to the end of 1993, the children in the catchment area have exhibited a progressive decline in mean blood level from a high of 35.2 to a low of 9.3 μg/dL. There were comparable declines in the percentage of children with levels ≥10 and ≥25 μg/dL and in the maximum level from 101 to 48 μg/dL. Despite these remarkable improvements, a significant number of children still had blood lead levels ≥10 and ≥25 μg/dL.

In comparing these lead levels with those in children elsewhere in St Louis (excluding the lead program of the city's health department), a composite of predominantly black neighborhoods show a greater lead burden than those of predominantly white neighborhoods. However, of the 13 individual facilities for which data were available, one facility serving an almost totally

TABLE 5. SOIL LEAD LEVELS

	SLCNHC			St Louis		
	No. Samples	Average Lead Level (ppm)	Range (ppm)	No. Samples	Average Lead Level (ppm)	Range (ppm)
1978 study	12	2126.0	200-6300	32	2554.6	130-6200*
1990 study						
Strip between sidewalk and curb	70	492.2	20-3770	95	706.7	70-3060
Center of backyard	67	698.8	10-4360	90	845.5	20-4900
Combined	137	590.9	10-4360	185	774.2	20-4900

Abbreviations: SLCNHC = St Louis Comprehensive Neighborhood Health Center.
*One site with 15 000 ppm.

black population ranked first, the SLCHNC in the catchment area (almost 90% black) ranked second, and a facility serving a poor white community ranked third. Thus, as in many studies dealing with general health issues, both race and poverty appear to be significant risk factors.

Changes in Population and Housing

During the 1980s, the catchment area experienced a decline of about 13% in total population but an almost 8% increase in the population younger than 5 years of age. During the same period, there was an 11% decline in occupied housing, an almost 39% increase in unoccupied (probably uninhabitable) housing, and the demolition of more than 6700 housing units. These changes indicate both a significant movement of population out of the catchment area as well as a sharing of some housing units by more than one family—the latter suggested by the increase in the population younger then 5 years of age. This increase in the pediatric population also accounts for the doubling of pediatric admissions to the health center and for the sharp 1993 increase in the number of blood samples for lead analyses shown in Table 1.

Changes in Soil Lead Levels

A comparison of citywide 1978 soil lead levels with those of 1990 showed a remarkable average decline of about 75%. Moreover, the highest level in the 1978 study was 15 000 ppm compared with 4900 in the 1990 study even though the 1978 study included only 44 soil samples compared with 322 in the 1990 study. Because lead in the soil is stable, in the absence of a soil abatement program in this city, the decline can only be attributed to the washing away of the superficial layers of soil by rain and melting snow.

The standard by which these data should be measured is contained in a 1988 report of the Agency for Toxic Substances and Disease Registry,[3] which states that "lead in dust and soil above 500 to 1000 ppm begins to affect children." The average soil lead levels in the catchment area, as well as elsewhere in the city, were within this range. Moreover, more than 40% of the soil samples in the catchment area and almost 60% of those elsewhere in the city were >500 ppm; more than 15% of the soil samples in the catchment area and more than 23% of the samples elsewhere in the city exceeded 1000 ppm.

SUMMARY

The lead burden of children residing in catchment area has declined progressively between 1976 and 1993, although a significant number of children remain at risk for brain damage; some children even exhibit blood lead levels requiring treatment. Within the city of St Louis as a whole, most poor black children and the children in at least one poor white neighborhood are at greatest risk.

During the decade of the 1980s, there has been a significant decline in population as well as in available housing units in the catchment area, although the pediatric population has actually increased, indicating that some housing units are shared by more than one family. During the same decade, there has been a dramatic reduction in soil lead levels, although lead levels at many sites within our catchment area and elsewhere in the city remain at levels that put children at risk.

Thus, these data suggest that the decline in lead levels in the children of our catchment area may be due to reduced exposure resulting from an increase in unoccupied (probably unfit for habitation) housing and the demolition of more than 6700 housing units, as well as a dramatic reduction in soil lead levels.

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