Screening for Lead Poisoning: A Geospatial Approach to Determine Testing of Children in At-Risk Neighborhoods

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Objective To develop a spatial strategy to assess neighborhood risk for lead exposure and neighborhood-level blood lead testing of young children living in the city of Atlanta, Georgia.

Study design This ecologic study used existing blood lead results of children aged ≤36 months tested and living in one of Atlanta's 236 neighborhoods in 2005. Geographic information systems used Census, land parcel, and neighborhood spatial data to create a neighborhood priority testing index on the basis of proxies for poverty (Special Supplemental Nutrition Program for Women, Infants and Children [WIC] enrollment) and lead in house paint (year housing built).

Results In 2005, only 11.9% of Atlanta's 18 627 children aged ≤36 months living in the city had blood lead tests, despite a high prevalence of risk factors: 75 286 (89.6%) residential properties were built before 1978, and 44% of children were enrolled in WIC. Linear regression analysis indicated testing was significantly associated with WIC status ($P < .001$) but not with old housing.

Conclusions This neighborhood spatial approach provided smaller geographic areas to assign risk and assess testing in a city that has a high prevalence of risk factors for lead exposure. Testing may be improved by collaboration between pediatricians and public health practitioners. *(J Pediatr 2009;154:409-14)*

Elevated blood lead levels (BLLs) in young children have been associated with acute and long-term adverse health impacts.[1,2] Very elevated BLLs (>70 μg/dL) can result in encephalopathy, seizures, or death[2] but are not common in the United States today.[3] Elevated BLLs (≥10 μg/dL) in young children have been linked to learning disabilities and behavioral disorders; in addition, increasing evidence suggests that cognitive impairment occurs at BLLs < 10 μg/dL.[4-10] Importantly, no safe BLL has been established for children.

Childhood lead poisoning prevention and control efforts in the United States have focused on testing children.[11-14] Since 1997 the Centers for Disease Control and Prevention (CDC) has recommended testing children at highest risk for lead poisoning.[14] Children at high risk for lead poisoning are those whose families are poor and live in old housing.[15-17] Old housing often contains lead in paint, especially properties built before 1950. Beginning in the 1950s the paint industry began to reduce the amount of lead added to residential paint. Paint containing more than 0.06% (600 ppm) lead was banned for residential use in the United States in 1978.[18]

Because the risk for lead poisoning is not equally distributed across populations, CDC recommends that states develop targeted screening plans and assess screening levels among the groups targeted. Researchers and public health practitioners have developed targeted testing strategies using elevated blood lead levels and other risk factors for specific geographic areas, such as ZIP code,[19-23] census tract,[22,24] block group,[25] or tax parcel[19,22,23,26-27] and neighborhood.[28] Some have assessed testing of children enrolled in Medicaid,[19-20,29] a proxy for poverty and a group that should be tested at ages 12 and 24 months. Others have focused on areas with old housing.[19,22,23]

BLL	Blood level level	GIS	Geographic information system
CDC	Centers for Disease Control and Prevention	WIC	Special Supplemental Nutrition Program for Women, Infants, and Children
CMS	Centers for Medicare and Medicaid Services		
GACLPPP	Georgia Childhood Lead Poisoning Prevention Program		

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Defining high-risk areas by ZIP code has the advantage that residents know their ZIP code and if providers are told which ZIP codes are at high risk, they can test children who reside in those areas. However, ZIP codes can cover large areas that can be heterogeneous in levels of risk, and they can change over time. Defining high-risk areas by census tract, census block, or block group or tax parcel is not typically recognizable to parents. However, this strategy can be used to create software to tag patient addresses in high-risk areas or to provide outreach to those areas. A strategy to identify risk at the neighborhood level would have two advantages. First, neighborhoods are small areas and probably more homogenous. Second, children's parents and guardians can easily identify them. This project's goals were to develop a spatial strategy for categorizing risk for lead exposure by neighborhood and assess lead testing in neighborhoods with several categories of risk in the city of Atlanta, Georgia.

METHODS

This study focused on the city of Atlanta. To define neighborhood level categories of risk of lead exposure and to evaluate the extent of childhood blood lead testing in neighborhoods with varying levels of risk, the study integrated the following data: (1) childhood blood lead testing data, (2) residential land parcel data, (3) 2000 U.S. Census data within a geographic information system (GIS), and (4) neighborhood spatial data from the Georgia Department of Community Affairs.

Blood Lead Test Data

The Georgia Childhood Lead Poisoning Prevention Program (GACLPPP) recommends routine testing of all children (1) enrolled in Medicaid—a proxy measure for poverty—at ages 12 months and 24 months and (2) who are <6 years old and live in or visit properties built before 1978.[30] This ecological study did not fit the definition of human subjects research. CDC analyzed existing blood lead data that was aggregated, ie, not individually identifiable. GACLPPP provided aggregated neighborhood level blood lead testing information on all children aged ≤36 months who were tested in 2005 and had a residential address of Atlanta, Georgia. Blood lead tests for children <12 months and 24 to 36 months were included because many children are tested when they visit providers, which may not be at their first or second birthdays. With GIS, each child's street address obtained from the blood lead data was located as a point, which was grouped by the neighborhood in which they were located. The GACLPPP created a neighborhood dataset with derived fields, including the number of children (1) tested for lead poisoning, (2) with elevated BLLs (≥10 μg/dL), and (3) enrolled in Georgia's Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). Percentage of children tested was calculated using number of children aged ≤36 months tested for lead divided by the population of children aged ≤36 months.

Residential Land Parcel Data

The study obtained parcel-based data for Atlanta for 1999 from the Center for GIS at the Georgia Institute of Technology in Atlanta. The land parcel dataset had graphic and descriptive components. Each graphic parcel had an associated unique identifier label. The descriptive component contained 1 record for each parcel and the same unique identifier label as the graphic component. With GIS, the descriptive attributes of each parcel were related to the parcel's corresponding graphic feature. This process resulted in a spatial dataset of parcels with property type, such as residential, commercial, or industrial; date of structure construction; and appraised value of the structure. GIS allowed identification of the geographic center of all residential parcels and the corresponding neighborhood.

Census Data

The study used U.S. Census block group-level data because this level is the lowest resolution at which the Census releases disaggregated population data. However, the boundaries of the neighborhoods and the block groups in the study did not coincide. The demographic age data of children were transferred from the block groups to the neighborhoods in 2 steps with GIS. Geometric intersections between the neighborhoods and the block groups were created to enable boundary coincidence. The demographic age data of children aged ≤36 months were weighted by the area of the block group within each neighborhood and estimated the total number in each neighborhood. The demographic and land parcel data were then integrated with the child blood lead dataset created earlier at the neighborhood level.

Spatial Strategy

An index for risk of lead exposure was created for each neighborhood. The index was based on 2 surrogates for known risk factors: old housing and poverty. Housing units were categorized for 2 levels of risk: built before 1950 (pre-1950), and built before 1978 (pre-1978). Housing units built before 1950 (pre-1950) indicate the highest risk for containing lead paint and for having higher concentrations of lead in the paint. Housing units built before 1978 (pre-1978), the year more than 0.06% lead in residential paint was banned, indicate a risk for containing lead paint. The percentage of pre-1950 housing was calculated with number of residential land parcels with pre-1950 housing units divided by the total number of residential land parcels. Similarly, the percentage of pre-1978 housing was calculated with the number of residential land parcels with pre-1978 housing units divided by total number of residential land parcels. The percentage of children enrolled in WIC was calculated by use of the number of children aged ≤36 months enrolled in WIC divided by the population of children aged ≤36 months. The Medicaid enrollment data could not be obtained. Instead, WIC enrollment data were used as a proxy measure for poverty. In Georgia, it is estimated that nearly 100% of children eligible for WIC are enrolled before age