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Michigan Journal of Public Health

Volume 6 | Issue 1 Article 5

2012

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Recommended Citation

Kruger, Daniel; Shirey, Lauren; and Taylor, Sherry (2012) "Geographical Information Systems Facilitate Child Lead Screening Efforts," *Michigan Journal of Public Health*: Vol. 6 : Iss. 1 , Article 5.
Available at: http://scholarworks.gvsu.edu/mjph/vol6/iss1/5

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Geographical Information Systems Facilitate Child Lead Screening Efforts

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ABSTRACT

Background: Children at the highest risk for lead poisoning are African American, living in families with low incomes, or are living in housing built prior to 1946. The Greater Flint Lead Safe Children Program (GFLSCP) was designed to increase the proportion of African Americans under 6 years of age who are tested for lead in a State-designated high risk area for childhood lead poisoning.

Objective: We used Geographical Information Systems to create maps that facilitate program process and evaluation.

Methods: We created maps of neighborhood outreach coverage and lead screening results. We identified areas with higher concentrations of African American children under 6 years of age and housing units constructed prior to 1940.

Results: Digital maps organize program information and facilitate program process. Maps visually demonstrate the association between older housing stock and elevated blood lead levels, and assist GFLSCP staff in prioritizing areas at highest risk of lead poisoning. Analyses indicated that the proportion of houses built prior to 1940 predicted blood lead levels.

Conclusions: Geographic Information Systems provide an intuitive, visual means of tracking program progress and correspondence of intervention activities within the focus demographic and identified areas of concentrated risk.

Keywords: Geographical Information Systems, lead screening, children, Community Based Participatory Research

INTRODUCTION

Lead poisoning is a substantial health threat to individuals and communities. Once lead is ingested, it affects the absorption of iron – one of the building blocks of brain, nerve, and bone structures (Haner, 2000). Lead can produce adverse effects on virtually every system in the body; it can damage the kidneys, the nervous system, the reproductive system, and cause high blood pressure. Research has shown that lead poisoning and lead exposure are linked to aggression, learning problems, anemia, hearing loss, hyperactivity, developmental delays, as well as liver, kidney, and brain damage (for a review, see Michigan Department of Community Health, 2004). Extreme cases can result in coma and even in death (Michigan Department of Community Health, 2004). Treatment can reverse some damage; however, long-term exposure can cause lifelong problems (Haner, 2000).

Lead exposure in children under the age of 6 years is of particular concern because children absorb lead more readily than adults and are more likely to ingest lead from contaminated sources through normal hand-to-mouth activity (Michigan Department of Community Health, 2001; Centers for Disease Control and Prevention, 1997a). Lead-contaminated dust in the home from lead-based paint is a primary contributor to children's lead exposure (Centers for Disease Control and Prevention, 1997a). Although peeling, cracked, and/or chipped lead-based paint may be the most obvious source of ingestion, painted surfaces may produce lead dust even when they appear to be in good condition (Michigan Department of Community Health, 2001). Although progress has been made in reducing other sources of lead exposure, the Environmental Protection Agency (1995) reports that nearly 83% of homes built prior to 1978 still have a significant concentration of lead-based paint. Children living in homes built prior to 1946 are at greatest risk for exposure to lead-based paint as the likelihood of containing lead-based paint increases with age of the home (Michigan Department of Community Health, 2005).

Medicaid providers in Michigan are required by the Federal Centers for Medicare and Medicaid Services through Medical Services Administration to screen all Medicaid-enrolled children for lead as part of the Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) during their well-child visits. As stated in a May 2004 letter from the Michigan Surgeon General to local health care providers, the State of Michigan has consistently demonstrated lead testing rates that are considerably lower than currently required and recommended by the Michigan Department of Community Health (MDCH) and Centers for Disease Control and Prevention (CDC). As of December 2004, Medicaid blood lead testing data shows that only 39% of two year old children and 45% of three year old children who are enrolled in Medicaid had undergone a blood lead level test on or before their 2^{nd} birthday or on or before their 3^{rd} birthday, respectively (Michigan Department of Community Health, 2004). Thus, a significant gap in lead poisoning prevention services exists in that providers are not appropriately testing all Medicaid-enrolled children, as they are required to do.

Although provider compliance is problematic, there is also a lack of knowledge and skills of parents/guardians of at-risk children. Parents/guardians are often not aware that their child may be at risk for lead poisoning or that their child may meet MDCH criteria for recommended or required testing. Children with elevated blood lead levels (EBLL) are often asymptomatic, so it may not be outwardly obvious that a child is sick (Michigan Department of Community Health, 2001). Also, many parents believe paint chips to be the main source of lead exposure and poisoning, and so in the absence of any paint chips, do not realize the child is susceptible. However, as stated previously, lead dust is likely the major contributor to childhood lead poisoning present in homes today (Centers for Disease Control and Prevention, 1997a).

An additional issue is that parents/guardians may not be aware that their Medicaid-enrolled child is entitled to a lead test as part of the EPSDT portion of their well-child visit. Even if parents/guardians know that their child is potentially at risk for lead poisoning or is entitled to lead test through their provider, they may lack the confidence and skills to request a health care provider test the child's blood lead level. Therefore, parents/guardians are an important influence on whether or not children are appropriately tested for lead.

Lastly, health care access, particularly for uninsured children, is a major determinant of appropriate lead testing for children. In a 2003 population survey, 13.3% of Genesee County respondents reported that youth in their household age 17 years or under were without health insurance coverage at some time in the past year (Prevention Research Center of Michigan, 2003). Prior to the creation of the Greater Flint Lead Safe Children (GFLSC) program in spring 2005, the ongoing lead poisoning prevention program at the Genesee County Health Department (GCHD), the Childhood Lead Poisoning Prevention Program, provided a monthly lead-testing clinic for uninsured Genesee County children. However, in FY2003-2004, only six children were seen in this clinic, suggesting that there is a lack of awareness of the clinic or a lack of understanding of the important services it offers or barriers to access.

The Greater Flint Lead Safe Children Program: The Greater Flint Lead Safe Children Program (GFLSCP), funded through the Health Disparities Reduction Program at MDCH, conducted an outreach and education campaign to households and physician offices within the 48505 ZIP Code. In addition, the GFLSC involved the creation of a countywide coalition to raise awareness and increase collaboration in regards to childhood lead poisoning prevention. The 48505 ZIP Code is an MDCH designated high-risk area for childhood lead poisoning and is also home to the largest concentration of African American children in Flint. Although reliable data on lead poisoning and testing is difficult to ascertain by race, the Centers for Disease Control and Prevention (CDC) report that nationally the children at the highest risk for lead poisoning are African American, living in families with low incomes, or living in housing that was built prior to 1946 (Centers for Disease Control and Prevention, 1997a).

Genesee County has 10 MDCH-designated high-risk ZIP Codes for childhood lead poisoning (Michigan Department of Community Health, 2005). The 48505 ZIP Code area is one of those so designated and was chosen as the GFLSCP target area because it has the largest percentage (85.3%) and number (3,319) of African American children under the age of 6 years of all the designated high-risk ZIP Code areas (U.S. Census, 2001). The 48505 ZIP Code area is a very impoverished area of Flint, with 30.5% of families and 35.7% of individuals falling below the federal poverty level (U.S. Census, 2001). Additionally, the 48505 area is one of the most at risk ZIP Codes for childhood lead poisoning due to its high percentage (38.2%) of housing stock built before 1950 (U.S. Census, 2001).

According to the current MDCH Childhood Lead Poisoning Prevention Program Statewide Screening/Testing Plan (Michigan Department of Community Health, 2004), which is endorsed by the CDC, all Medicaid-eligible children in Michigan should be tested at 12 and 24 months of age, or between 36 and 72 months of age, if they were not previously tested. Also, all non-Medicaid children living in a geographic area with 27% or greater pre-1950 housing should be tested for lead poisoning (Michigan Department of Community Health, 2004). However, only 21.7% (270) of 1 and 2 year olds in 48505 and 14.6%, or 569, of all children under 6 years were tested in calendar year 2003 (Michigan Department of Community Health, 2004).

A review of the literature reveals that the majority of childhood lead poisoning interventions focus on reducing the blood lead levels of children already identified to have elevated blood lead levels (Schultz, Pawel, & Murphy, 1999; Aschengrau, Beiser, Bellinger, Copenhafer, & Weitzman, 1997). However, a significant proportion of children do not receive timely and appropriate blood lead level testing. Greater Flint Lead Safe Children Program (GFLSCP) utilized a multi-pronged approach to increasing lead testing rates for at-risk children. GFLSCP staff believe that addressing the knowledge, beliefs, and skills of parents/guardians in relation to lead poisoning prevention, in addition to increasing the knowledge of health care providers serving the geographic high-risk area, as well as the systems perspective of the proposed Genesee County Childhood Lead Poisoning Prevention Coalition, would result in increased testing rates in the 48505 ZIP Code area.

METHODS

The Greater Flint Lead Safe Children Program (GFLSCP) worked to increase the proportion of children under age 6 years in the 48505 ZIP Code who are tested for lead. The original program was been modified due to challenges in implementation and results of process evaluation. The GFLSCP distributed lead poisoning information door-to door to all occupied homes in 48505, as well as to pediatric and family practice physician offices located in the ZIP Code area. These information packets are educational and contain resources aimed at increasing the proportion of African American children under 6 years of age in 48505 who have their blood lead level tested. As part of the program, children covered by Medicaid or without health insurance were eligible for free blood lead level testing at the GCHD clinic located in the target area, Additional efforts identified other sites for conducting lead testing, such as local churches. As part of this testing initiative, parents/guardians participated in a curriculum based on the Health Belief Model (Strecher & Rosenstock, 1997), which was aimed at increasing parent/guardian knowledge, confidence, and skills in relation to lead poisoning prevention and lead testing.

GFLSCP partnered with University of Michigan School of Public Health faculty to facilitate and evaluate the implementation of the GFLSC Program. We followed the principles of Community-Based Participatory Research (CBPR; Israel, Schulz, Parker, & Becker, 1998) during these efforts. We used Geographical Information Systems (GIS) to aid and document GFLSC efforts. GIS is an effective tool for graphically portraying important information about health problems within a community. GIS is increasingly being utilized for detecting and monitoring public health issues (Cromley & McLafferty, 2002). One of the most popular public health applications of GIS is for environmental health issues, such as exposure to multiple environmental contaminants and breast cancer incidence (Gardner & Harrington, 2003; Elmes, 2004). GIS is also an effective planning tool for informing decision makers about the specific health care needs of population groups (Barnard & Hu, 2005).

The GLFSCP program used maps created with GIS to facilitate program process and evaluation. Stakeholders in Genesee County, including representatives from local community-based organizations, have been receptive to the use of GIS in mapping local health data in previous Genesee County projects (Kruger, Brady, & Shirey, 2008).We created digital maps to track the city blocks covered by neighborhood outreach efforts, the number of households reached, the distribution of informational packets, and lead screening results (See Figure 1). These maps displayed the number of informational packets distributed per street segment by month.With Census data, we identified areas with higher concentrations of African American children under 6 years of age and housing units constructed prior to 1940. We used Hierarchical Linear Modeling (Raudenbush & Bryk, 2002) to examine the relationship between the concentration of houses built prior to 1940 in a Census blockgroup and elevated blood lead levels in children in the 48505 ZIP Code area who have been tested for lead.

RESULTS

By June 30, 2006, 3,349 informational packets were distributed to homes in the 48505 ZIP Code area. A total of 419 African American children under age 6 years residing in this area had their blood lead level tested through the GLFSCP program from April 2005-June 2006, accounting for 33% of the tests conducted for children residing in 48505 during that time period. The percent of children age 6 years and under in 48505 who have been tested has increased from 21.2% from June 2004-June 2005 to 30% from June 2005-June 2006 (Michigan Department of Community Health, 2004). Sixty-five percent (*n* = 194) of parents/guardians of children tested through GFLSC have participated in the curriculum. Participant knowledge about symptoms, risk reduction, and rights regarding lead disclosure has increased dramatically from pre to post-test.

The creation of maps facilitated the documentation of program activities, encouraging precise and detailed record keeping of intervention events. As program staff often change during the course of an intervention, it is important to clearly document activities to prevent omission or duplication. GIS requires precise address information when mapping data. Program staff conducting outreach efforts knew which blocks were covered during neighborhood activities, however this information was not recorded in a manner suitable for mapping. For example, in the first iteration of maps, outreach staff provided only the name of streets covered. Thus, the entire street was mapped within the 48505 ZIP Code. Outreach staff then clarified that only certain blocks were covered, and were able to provide cross streets marking the boundaries of outreach efforts. Outreach staff and the evaluation researcher were able to work together to identify coverage information suitable for mapping; complete street addresses for starting and ending points, including street orientation (North, South, East, West) were provided. Thus, the institutional memory of outreach efforts was standardized and preserved for future reference (See Figure 1).

Maps created with Census data depicted the concentration of African American children under 6 years of age and housing units constructed prior to 1940 by Census blockgroup. Program staff used these maps to compare risk prevalence, concentration of the focus population, and locations of program outreach activities. African American children under 6 years of age were most concentrated in the central and south-central regions of the 48505 ZIP Code. The southern portion of the 48505 ZIP Code had the highest concentration of houses built prior to 1940 (See Figure 2). Maps of blood lead levels suggested clustering of lead poisoning cases in this area. HLM analyses indicated that the proportion of houses built prior to 1940 predicted blood lead levels, $t(30)=5.733$, $p<.001$. Program staff thus guided and prioritized outreach efforts towards the southern and south-central portions of the 48505 ZIP Code.

DISCUSSION

The use of Geographic Information Systems in presenting data has resulted in an intuitive, visual means of tracking program progress and has enhanced the correspondence of intervention activities with the concentration of at risk individuals in the focus demographic. GIS presentation of the data allow for precise, visual tracking of program efforts and program evaluation measures, such as lead testing and blood lead level. Maps combining blood lead level screening results with the prevalence of older housing stock visually demonstrate this association and assist GFLSC staff in prioritizing those areas within 48505 at highest risk of lead poisoning.

The intuitive nature of maps for presentation of quantitative data has enhanced accessibility by a broad audience, including community members, health care providers, and university researchers. Trends can be displayed visually for evaluating outcomes associated with community projects aimed at increasing blood lead level testing rates. This project demonstrates the utility of Geographic Information Systems in facilitating and assessing community based lead screening programs. Similar processes would be valuable in other communities and other types of interventions with a spatial component.

GIS is increasing adopted in public health efforts because of its broad utility of applications. For example, GIS can be used to locate clients or participants to assess spatial distribution; comparing health indicators across geographical areas; examining the health impact of neighborhood characteristics; assessing health needs, e.g., comparing the distribution of risk factors and screening coverage (Kruger, Brady, & Shirey, 2008); facilitating health education and promotion efforts (Kruger, Lewis, & Schlemmer, 2010); community outreach and data dissemination; informing local health policy (Kruger, Shirey, Morrel-Samuels, Skorcz, & Brady, 2009), and examining patterns of pollution and its impact on health (Mohai, Kweon, Lee, & Ard, 2011). Although considerable training is required for the use of professional GIS software, basic activities such as mapping locations and hyperlinking information to spatial coordinates is now possible with Google Maps and other freely available software. The notion that one picture is worth a thousand words of description rings true for those utilizing GIS in their health research and practice.

Acknowledgments

This work was made possible by funding from the Michigan Department of Community Health's Health Disparity Reduction Program. The authors also wish to extend their thanks to Kim Noble who was instrumental in early program efforts and evaluation.

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Figure 1. Example map for number of informational packets distributed per street segment by month

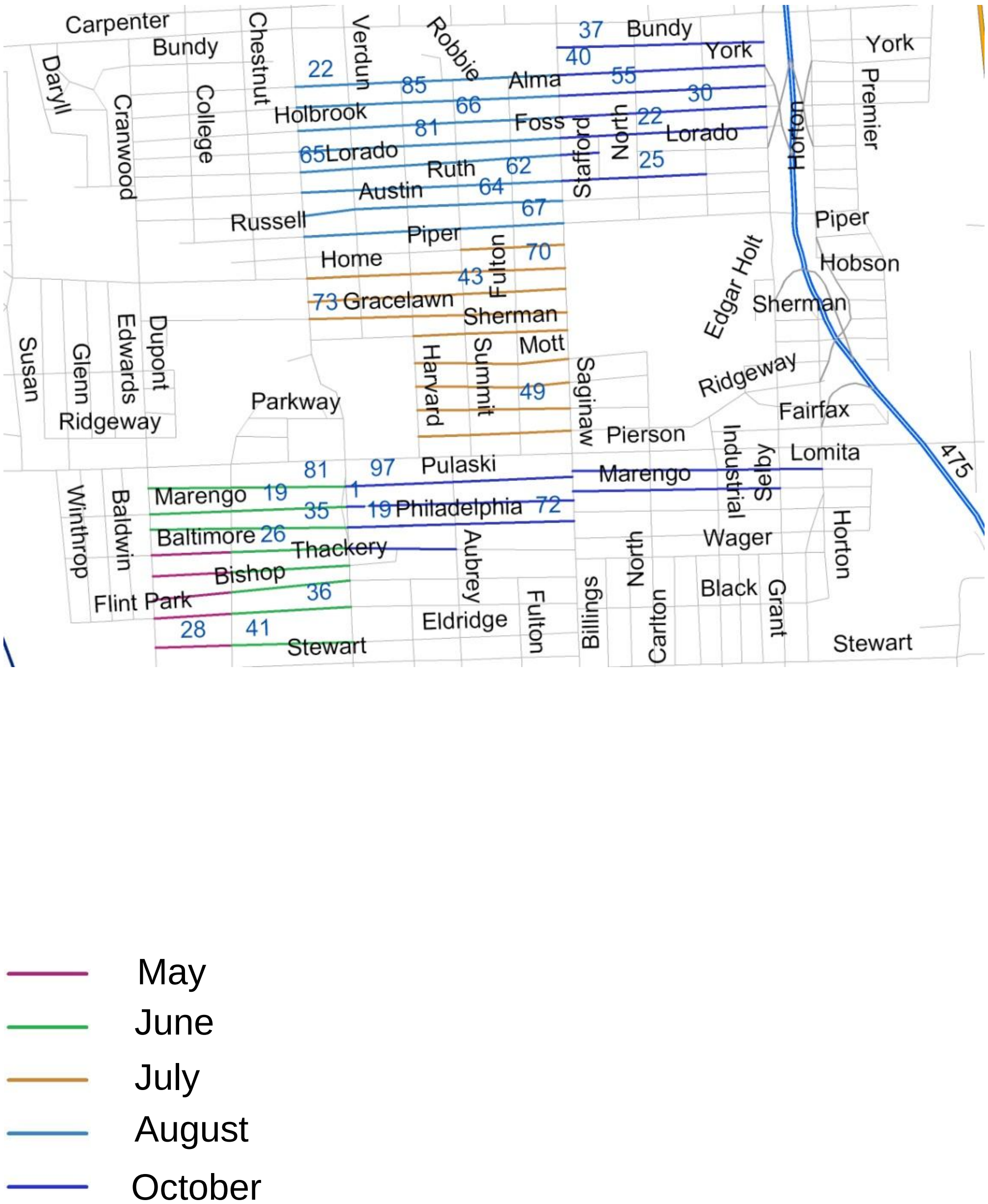

Figure 2. Proportion of housing units built pre-1940 and elevated blood lead levels