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Lead poisoning and asthma among low-income and African American children in Saginaw, Michigan ☆

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ABSTRACT

Objective: We sought to ascertain whether asthmatic children are more likely to have elevated blood lead levels (EBLLs), BLLs ≥ 10 μg/dL, than non-asthmatic children. Household risk factors associated with both lead and asthma were examined.
Method: We undertook a cross-sectional study involving children residing in mainly low-income and minority households in Michigan which were identified by the Statewide Systemic Tracking of Elevated Lead Levels and Remediation database (STELLAR) ($n=356$ children).
Results: Of the 356 index children, 19% had EBLLs and 15% were doctor-diagnosed asthmatic. After adjusting for confounders known to be related to lead poisoning and/or asthma, association remained between asthmatic children and EBLL children (AOR: 5.17; 95% CI (1.25–21.37)).
Conclusions: The results of our study show that asthmatic children are over 5 times more likely to have EBLLs than non-asthmatics (AOR: 5.17; 95% CI (1.25–21.37)). Intervention strategies designed to address lead poisoning prevention may be effective in reducing incidence of asthma. Further study is required.

1. Introduction

Health experts, academicians, and policy makers, alike, have recognized the high cost that both childhood lead poisoning and asthma exact on communities in this country. Three Healthy People 2010 goals which pertained to lead poisoning and asthma were: (1) to totally eradicate childhood lead poisoning by 2010; (2) to reduce the number of child deaths due to asthma by 2010; and (3) to reduce the number of hospitalizations due to asthma by 2010 (Department of Health and Human Services (HHS), 2000). Many communities found it a daunting task to reach these goals. This is especially due to the persistence of childhood lead poisoning and asthma in communities which are highly populated with minorities and low income persons (Lanphear et al., 1996; Malveaux and Fletcher-Vincent, 1995).

Childhood lead poisoning and asthma are two independent illnesses which have environmental mechanisms and pose greatest risk to urban, low-income, and minority children (Lanphear et al., 1996; Malveaux and Fletcher-Vincent, 1995). Residences with deteriorated lead-based paint are more likely to have elevated levels of lead in house dust and the surrounding soils (Jacobs et al., 2002), and a number of studies have confirmed that lead dust is the strongest predictor of childhood blood lead levels (Lanphear et al., 1998). Both house dust and fine-grained airborne particulates have likewise been identified as key risk factors for childhood asthma (Meyers and Binns, 2002).

In addition to housing-related linkages, the biological mechanisms of interaction have been discussed and the hypothesis that exposure to lead is a risk factor for childhood asthma has been considered (Rabinowitz et al., 1990). The suggestion is closely linked to the immunoregulatory effects of lead. Lead exposure enhances the level of IgE in mice and humans which diminishes host resistance to allergies and is associated with airways hypersensitivity (Gao et al., 2007; Lutz et al., 1999). Indeed, lead induced development of IgE-mediated allergy has been reported (Rabinowitz et al., 1990). Environmental lead exposure depresses the activities of several enzyme systems that influence cellular reducing capacity (glucose-6-phosphate dehydrogenase, nicotinamide adenine dinucleotide (NAD) synthetase, glutathione peroxidase, superoxide dismutase, catalase) and consequently may increase asthma risk (Greene, 1995). Besides the compromising effects on the immune system and oxidative processes, childhood asthma can further be influenced by lead poisoning in several other ways. For instance, impairments in neurobehavioral factors such as hearing, learning skills and self-regulatory ability can influence the likelihood that the child will seek early medical attention or self-manage his/her asthma.

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Some experimental studies have suggested that lead is a risk factor for stress through alterations in the interactions of glucocorticoids with the mesocorticolimbic dopamine system of the brain (White et al., 2007). Elevated stress levels, with corresponding elevated glucocorticoid levels, have been associated with asthma especially in low-income populations (Dowd et al., 2009).

The obvious questions raised by the intersection of these risk factors include the extent to which lead exposure and asthma interact and whether lead itself contributes as a risk factor to the increased incidence of asthma in low income and minority children. This paper presents the results of a study designed to address these question.

2. Methodology

2.1. Study site

The geographical areas included in this study were the 48601, 48602, and 48607 ZIP Code areas of Michigan, the ZIP Codes which make up the City of Saginaw and lies within Saginaw County. The City of Saginaw, Michigan, is listed as an one of fourteen Target Areas for the State of Michigan's Childhood Lead Poisoning Prevention efforts due to the age of the housing stock, incidence of EBL children, and other risk factors. The County of Saginaw is one of only two counties in Michigan with significantly higher hospitalization rates due to asthma, regardless of age, than those of the State (Wasilevich, 2005).

The City has long been one of Michigan's most dynamic industrial/manufacturing centers. However, with the closing of many facilities, the City is now plagued with many idle and abandoned former industrial and manufacturing sites; has an aging housing stock; a growing unemployed, uninsured/underinsured population; and has crime rates which are higher than those of major cities (Michigan Department of Labor & Economic Growth (DLEG), 2006; U.S. Census Bureau, 2000; US Department of Justice—Federal Bureau of Investigation, 2006).

2.2. Study population

The Statewide Systemic Tracking of Elevated Lead Levels and Remediation database (STELLAR) was used to find the names and addresses of homes where children who had received at least one blood lead test lived and the names of their parent/guardians. There were approximately 8500 names, some duplicates, of children on the STELLAR database who reside in the 48601, 48607, and 48602 ZIP Code areas of Saginaw, MI. Announcements, which explained the study and basic facts pertaining to lead and asthma, were mailed to 500 randomly chosen addresses listed on the STELLAR database. Three hundred fifty-three households with a total of 732 children 12 years old or younger enrolled in the study via a signed consent form. Once the household survey was completed the STELLAR Database was again queried to: (1) verify whether a blood lead level was available for the 732 children for which survey data was collected; (2) obtain the initial venous (confirmatory) blood lead levels of index children; and (3) obtain the dates blood lead levels were drawn. Children were matched by the child's first and last name, address and parent/guardian name. Three hundred fifty-six (356) of the 732 children residing in the households enrolled in the study were found to have blood lead level data listed on the database and were defined as *index children* in this study. Again, the measure of the amount of lead in an individual's blood was determined by the initial venous (confirmatory) listed on STELLAR. However, it should be noted that 3 index children who were counted as EBL children did not have a reported venous BLL listed on STELLAR. Therefore, the initial capillary (non-confirmatory) blood draw ≥ 10 μg/dL was used to determine their EBL status.

2.3. Residential questionnaire, home assessment, and database query

The study was approved by the University of Michigan Health Science Institutional Review Board prior to commencement of the study. Written consent, which explained the objectives, risks, and study procedure, was obtained from household respondents that were at least 18 years old and a parent/guardian of the children about whom questions were answered. The U.S. Department of Housing and Urban Development and National Institute of Environmental Health Sciences National Survey of Lead Hazards and Allergens in Housing Resident Questionnaire and Michigan Center for the Environment and Children's Health Screening Questionnaire were compiled, modified, and used as the surveying instrument. The determination of asthma morbidity prevalence, demographic characteristics including race and ethnicity, and environmental risk factors was based on answers provided by the adult respondent. ***Demographic information*** gathered included children's ages; race and ethnicity; gender and level of education; the number of persons living in the home; whether the homes were homeowner occupied; and families' income levels. ***Housing-unit information*** such as age of housing was collected from the respondent and then verified using the City of Saginaw Online Property Assessment System. Other housing information collected was: years of residency; heating system; pest problems (cockroach); pesticide use; moisture problems; bedding and sofa fabric; how often floors, bedding and furniture are cleaned; and condition of walls and ceiling (e.g., peeling paint, water stains, mold). ***Adult behavior*** questions included smokers present in the home; animals present in the home; and adult lead-related occupations/hobbies. ***Health outcome measures*** included asthma diagnosis; if children were currently taking asthma medications; activity limitations due to asthma; presence of respiratory illness symptoms of non-asthmatic children; number of children with elevated blood lead levels from previous tests. ***Observational findings*** noted while administering the survey included: (1) presence of strong smelling cleaners; (2) scented candles or burning incense; and (3) obvious evidence of smoking, food debris, moisture, mildew, mold, cockroaches, rodents, and clutter.

2.4. Data analysis

SPSS® was used to perform statistical analysis. Simple descriptive statistics were used to examine the population demographics and other numeric variables.

In a multivariate analysis, adjusted odds ratios (AORs) and 95% confidence intervals (CI) were derived in order to ascertain whether there is correlation between children with BLLs ≥ 10 μg/dL and those with asthma and whether the propensity for childhood lead poisoning and asthma is due to exposure to indoor environmental factors that are present within the dwellings. AORs were calculated with the variable "Children with BLLs ≥ 10 μg/dL" entered as the dependent variable and analyzed against predictor variables relevant to childhood lead poisoning. AORs were then calculated with "Children Diagnosed with Asthma within the Past 12 Months" evaluated against variables relevant to asthma/asthma exacerbation. Most risk factors were dichotomous with some being continuous and categorical.

3. Results

3.1. Demographic and housing unit characterization

According to 2000 U.S. Census data, there were 16,732 children aged 0–14 years old living in Saginaw, MI. Therefore, the study population, or the study's 356 index children, represented a little over 2% of the Saginaw population under the age of 12 years old. Children under the age of 6 years old made up 71% of the study population with 18% in the 7–9 year old age range and 10% being 10–12 years old. Males comprised 49% of the study population with the race and ethnic composition being 78% African American, 9.4% White, 4.3% Multi-race, and 8.3% non-African American and non-White Hispanic/Latino. Over 62% of the index children lived in homes where the household income was less than $20,000. The average length of residency for index children at the current address or within the current ZIP Code area which they resided was 5.9 years with an average of 4.4 persons living in each household. Forty-five percent of the index children resided in rental units and the rest in homeowner occupied units (Table 1).

Approximately 60% of the index children lived in housing units built in 1939 or before, 11% lived in housing units built between 1940 and 1960, and 24% in housing built post-1960. Of the households surveyed, 46% were cleaned daily and 42% were said to be cleaned weekly. Forty-one percent of index children lived in housing units where there was either a mildew or musty odor or water dampness within the past 12 months (Table 1).

3.2. Adult risk behaviors

Children living with a household member who smoked cigarettes comprised 43% of the index children; 14% had cats and 21% had dogs present within their homes. Where observations were allowed, trained recruits reported the use of candles and incense in 8.6% of the index children's homes, observed use of air fresheners in 24% of the homes, and observed clutter in 6.9% of the homes (Table 1).