Declines in Elevated Blood Lead Levels Among Children, 1997–2011

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Background: Early childhood lead exposure is associated with numerous adverse health effects. Eliminating blood lead poisoning is a national health objective for 2020.

Objective: To assess temporal trends in childhood elevated blood lead level (EBLL) rates.

Methods: Laboratory surveillance data were collected from 1997 to 2011 and analyzed in 2013 using linear regression to assess trends in confirmed EBLL rates among children aged <6 years in the U.S., New York State ([NYS], excluding New York City), and Monroe County NY. Monroe County was also examined as a case study of local public health efforts to reduce childhood lead exposures. Blood lead screening and home lead hazard inspection data were collected from 1990 to 2012 and analyzed in 2013.

Results: The prevalence of EBLL ≥ 10 μg/dL per 100 tested children decreased from 13.4 to 1.1 in Monroe County, 6.3 to 1.0 in NYS, and 7.6 to 0.6 in the U.S. between 1997 and 2011. The absolute yearly rate of decline in Monroe County (slope=−0.0083, $p<0.001$) occurred 2.4-fold faster than that in NYS (slope=−0.0034, $p<0.001$) and 1.8-fold faster than that in the U.S. (slope=−0.0046, $p<0.001$). The childhood blood lead testing rate was consistently higher in Monroe County than in NYS and the U.S.; however, testing increased for all three areas (all slopes >0, $p<0.05$), with greater improvements observed for U.S. children overall (slope=0.0075, $p<0.001$).

Conclusions: In addition to national and statewide policies, local efforts may be important drivers of population-based declines in childhood EBLL rates.
(Am J Prev Med 2014;46(3):259–264)

Background

Early childhood lead exposure has long been recognized as a risk factor for adverse health effects, including irreversible neurobehavioral deficits.[1–3] Public health efforts have therefore focused on reducing lead exposures as a prevention strategy. Between 1976 and 1991, blood lead levels declined substantially among U.S. children and adults, attributed mainly to the removal of lead from gasoline and soldered cans.[4] Subsequently, other sources of lead exposure have received more attention, such as lead-based paint, dust, and soil.[5] In 1992, federal legislation (Title X, the Residential Lead-Based Paint Hazard Reduction Act) was enacted, which emphasized the prevention and control of lead-based paint hazards in housing units, especially for children <6 years of age.[6]

Although average blood lead levels have declined among children in the past, so too has the threshold for concern regarding blood lead levels, given that no safe level has been demonstrated for children.[7] In 1991, the CDC lowered the elevated blood lead level (EBLL) of concern from 25 to 10 μg/dL and recommended universal screening.[8] Following this recommendation, New York State mandated health care providers to perform blood lead screenings in children and pregnant women in 1992. In 2012, the CDC adopted an even lower reference EBLL for children, 5 μg/dL, based on the 97.5th percentile of the blood lead level distribution among U.S. children aged 1–5 years.[9,10]

Despite the removal of lead from paint during the 1970s, lead-based paint in housing units has remained a major source of lead exposure, especially in many older homes. Historically, New York State has had the highest

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0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2013.11.007

concentration of older housing stock built before 1950 and among the greatest numbers of lead-poisoned children in the country.[11] Within New York State, Monroe County (including the City of Rochester) has had some of the highest rates of childhood lead poisoning, suggesting that lead exposure may vary widely across large geographic areas.[12,13] In 1992, New York State mandated public health action for children with an EBLL≥20 μg/dL; this threshold was lowered to 15 μg/dL in 2009.[14]

The elimination of childhood lead poisoning is a national objective for 2020.[15] A better understanding of recent trends in EBLL rates from the national to local levels may provide insights into effective public health strategies in reaching this goal. Accordingly, the purpose of this study was to examine the temporal EBLL trends for Monroe County, New York State, and the U.S. from 1997 to 2011. In addition, this study sought to describe local public health efforts aimed at reducing childhood lead exposures in the context of limited resources and policy changes over time, using Monroe County as a case study. For the latter study, data from 1990 to 2012 were examined.

Methods

Data Sources

In 1995, the CDC began collecting childhood blood lead surveillance data from state and local health departments.[16] Surveillance fields for this national database were extracted from the state child-specific databases, which vary in data collection methods. The laboratory-based data included tested and confirmed EBLLs by year and state for children aged <72 months (i.e., 6 years). A confirmed EBLL was defined as a child with one venous blood specimen ≥10 μg/dL or any combination of two capillary and/or unknown blood specimens ≥10 μg/dL drawn within 12 weeks of each other.[17] For any given year, a child was counted only once. For a child with a confirmed EBLL, if they had another elevated test result in subsequent years, regardless of the test type, then that value would be considered confirmed. In the present study, this CDC surveillance system was used for the U.S. and New York State (excluding New York City) data, whereas Monroe County data were obtained directly from the local health department. For the comparative analysis, the study period covered 1997–2011, the most recent year for which data were available.

Home lead inspection data for Monroe County were used to examine environmental lead exposure. The housing units of children with an EBLL were inspected for lead hazards using a risk assessment approach. Lead hazards included paint that was not intact or was on a friction-impact surface such as steps, windows, and doors in pre-1978 housing along with lead readings at or above the intervention level standard at the time of inspection (e.g., currently 0.5% lead by weight or 1.0 mg/cm^2) using a portable x-ray fluorescence (XRF) analyzer.[18] For this analysis, data from 1990 to 2012 were examined. Further, temporal patterns of childhood EBLL≥5 μg/dL were assessed for Monroe County.

Data Analysis

The main outcome for the present study was the case prevalence rate of childhood lead poisoning, which was defined as the number of children aged <6 years (i.e., 72 months) with a confirmed EBLL≥10 μg/dL per 100 tested children <6 years old. In addition, the screening rate was defined as the number of children <6 years old tested for blood lead per 100 children <6 years old. For both measures, the temporal trends were assessed using linear regression and by comparing the slopes for the U.S., New York State (excluding New York City), and Monroe County. Statistical analyses were performed using the data analysis module of Microsoft Office Excel 2010. Finally, trends in Monroe County home lead inspections conducted by the local health department were also examined using linear regression. All analyses were conducted in 2013.

Results

Summary characteristics of the U.S., New York State, and Monroe County populations are given in Table 1. Despite differences in size, the three geographic regions were similar in the proportion of children aged <5 years, gender distribution, persons per household, population below poverty level, and retail sales per capita. Compared to Monroe County and the U.S., New York State had higher percentages of racial/ethnic and cultural diversity but lower homeownership rates. High school graduation rates and population density were higher in Monroe County than in New York State and the U.S.

Between 1997 and 2011, the prevalence rate for confirmed EBLL≥10 μg/dL per 100 tested children decreased from 13.4 to 1.1 in Monroe County, 6.3 to 1.0 in New York State, and 7.6 to 0.6 in the U.S. (Figure 1). The absolute yearly rate of decline in Monroe County (slope=−0.0083, $p<0.001$) occurred 2.4-fold faster than that in New York State (slope=−0.0034, $p<0.001$) and 1.8-fold faster than that in the U.S. (slope=−0.0046, $p<0.001$) (Table 2). During the same time period, the blood lead testing rate for children was consistently higher in Monroe County than in New York State and the U.S. However, testing rates increased for all three areas (all slopes>0, $p<0.05$), with greater improvements showed by U.S. children overall (slope=0.0075, $p<0.001$) (Table 2).

Between 1990 and 2012, the prevalence rate of EBLL≥5 μg/dL for children in Monroe County peaked in 1995 (40%) (Figure 2), four years after the CDC lowered the blood lead level of concern from 25 to 10 μg/dL and recommended universal screening. On the other hand, the total number of EBLL cases peaked in 1994 (8106 children), 2 years after New York State mandated blood lead screening of children. Moreover, the blood lead testing rate sharply increased from 16% to 30% between 1993 and 1994 following New York State's

Table 1. Summary of population characteristics, % unless otherwise noted

Variable	Monroe County	New York State	United States
Population estimate, 2011 (*n*)	746,000	19,465,000	311,591,000
Age, <5 years	5.8	6.0	6.5
Girls/women	51.7	51.5	50.8
Race/ethnicity			
White	78.0	71.5	78.1
Black	16.0	17.5	13.1
Latino	7.5	18.0	16.7
Foreign-born individuals	8.4	21.7	12.7
High school graduate, age ≥25 years	88.4	84.4	85.0
Homeownership rate	66.7	55.2	66.6
Housing units in multiunit structures	30.8	50.6	25.9
Persons per household (*n*)	2.4	2.6	2.6
Population below poverty level	13.7	14.2	13.8
Population per square mile (*n*)	1133	411	87
Retail sales per capita ($)	$11,628	$11,879	$12,990

Source: U.S. Census Bureau, http://quickfacts.census.gov

enactment of mandated reporting of all blood lead tests regardless of blood lead level. Between 2000 and 2003, the EBLL rate declined relatively little, which may suggest a diminished impact of the previous intervention standard set by New York State (EBLL≥20 μg/dL) compared to the stricter standard later adopted by Monroe County in 2003 (EBLL≥15 μg/dL). Home lead inspections conducted by the local health department also peaked in 1994 (1050 housing units), with subsequent declines through 2012 (slope=−29.4, $p<0.001$). In any given year, the positive yield of identified lead hazards from these environmental lead inspections ranged from 70% to 91% (Figure 3).

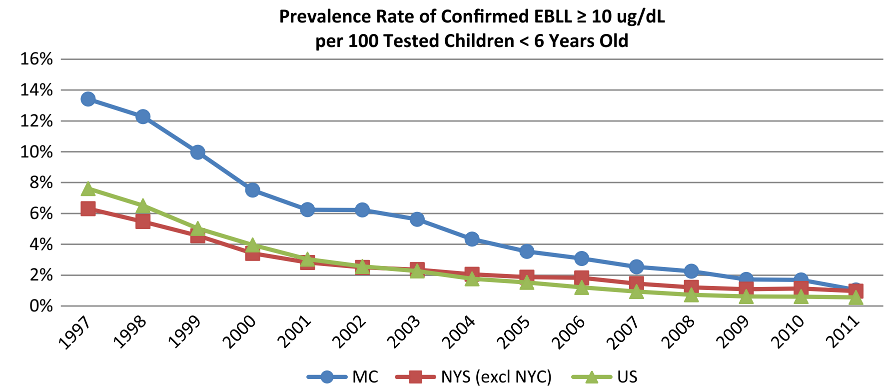

Figure 1. Trends in childhood elevated blood lead levels, 1997−2011
EBLL, elevated blood lead level; MC, Monroe County; NYS (excl NYC), New York State (excluding New York City)

Since the 1970s, the Monroe County Department of Public Health (MCDPH) has had a lead program. In the early 1990s, the program staff included approximately ten full-time equivalent (FTE) positions including sanitarians, nurses, health educators, and community health workers, which increased to about 20 in 1994, and then back down to ten by 2005. They performed home lead inspections; instructed property owners and managers about cost-efficient interim control measures (e.g., paint surface stabilization rather than paint removal); and educated families about in-home lead risk reduction and encouraged follow-up blood lead testing. With external grants such as those from the U.S. Department of Housing and Urban Development (HUD), the MCDPH provided direct support for targeted lead hazard remediation and interim housing assistance to temporarily relocate families during this process. The MCDPH also worked with a number of stakeholders, including community and academic physicians, housing and environmental health experts, educators, community advocates and civic leaders, as well as more peripheral technical experts—or "boundary networks"—who negotiate relationships between science and politics and producers and consumers of information, to achieve sustainable community impact, which has received national recognition.[19,20,21,22] A timeline of important events related to childhood lead hazard control efforts is summarized in Table 3.

Discussion

Using laboratory-based surveillance data reported to state and local health departments, the temporal trend analysis showed that rates of childhood EBLL decreased

Table 2. Analysis of trends in childhood elevated blood lead levels and testing, 1997–2011

Variable	Monroe County	New York State	United States
TRENDS IN THE RATE OF EBLL ≥ 10 μg/dL			
Linear regression model			
Intercept (*p*-value)	16.65 ($p<0.001$)	6.87 ($p<0.001$)	9.29 ($p<0.001$)
Slope (*p*-value)	−0.0083 ($p<0.001$)	−0.0034 ($p<0.001$)	−0.0046 ($p<0.001$)
R^2	0.90	0.85	0.85
Differences in slopes, *t* test *p*-value	ref	$p<0.001$	$p<0.001$
TRENDS IN THE RATE OF BLOOD LEAD TESTING			
Linear regression model			
Intercept (*p*-value)	−4.48 ($p=0.033$)	−5.71 ($p<0.001$)	−14.99 ($p<0.001$)
Slope (*p*-value)	0.0024 ($p=0.025$)	0.0029 ($p<0.001$)	0.0075 ($p<0.001$)
R^2	0.33	0.64	0.86
Differences in slopes, *t* test *p*-value	ref	$p=0.633$	$p<0.001$

Note: New York State data exclude New York City.
EBLL, elevated blood lead level

significantly between 1997 and 2011 in the U.S., New York State, and Monroe County. These trends are consistent with prior reports using National Health and Nutrition Examination Surveys (NHANES) data. These data are based on a nationally representative sample and provide estimates of the blood lead levels for the U.S. population but cannot provide estimates for smaller geographic areas or high-risk subpopulations.[23] Notably, this study found that in Monroe County, the absolute rate of decline in childhood lead poisoning, defined as EBLL ≥ 10 μg/dL, occurred much faster than those in the U.S. and New York State (Figure 1).

While affirming that no safe blood lead level in children has been identified, in May 2012, the CDC lowered the childhood EBLL threshold for triggering public health intervention from 10 to 5 μg/dL. As these updated recommendations are implemented nationwide, there will likely be an increase in both the number of children identified with lead poisoning and the number of housing units inspected for lead hazards. With this anticipated demand, it seems reasonable to suggest that additional resources will be needed, especially at the local level, where much of the groundwork occurs. The experience of Monroe County suggests that this newer, stricter threshold is appropriate and that investing in prevention efforts will yield favorable and cost-efficient outcomes over time.

When interpreting the results of this study, several important limitations should be kept in mind. First, the laboratory-based surveillance data were not directly linked with sociodemographic information. Therefore, examining trends by factors such as race/ethnicity, education, and poverty status was not possible. The CDC and the Center for Medicare and Medicaid Services have recommended that states link blood surveillance and claims data to better identify high-risk subgroups.[24] To date, these linked data sources are not available for many states, including New York. Second, this analysis did not account for smaller geographic areas such as zip codes or census tracts, which may capture more homogeneous subpopulations and communities.

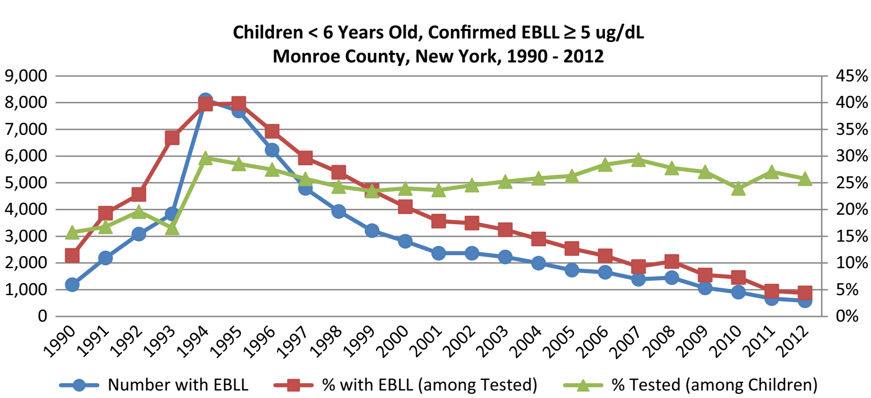

Figure 2. Trends in childhood elevated blood lead levels, 1990–2012
EBLL, elevated blood lead level (confirmed)

Table 3. Timeline of important events related to childhood lead hazard control efforts

Year	Comments
1991	CDC recommends universal lead screening and lowers EBLL of concern for children from 25 to 10 μg/dL.
1992	Congress passes the Residential Lead-Based Paint Hazard Reduction Act (Title X) to protect young children and families from harmful exposure to lead in paint, dust, and soil.
	NYS mandates blood screening for all children at least once before entering school and public health action for those with EBLL ≥ 20 μg/dL.
1994	NYS mandates reporting of all blood lead tests regardless of blood lead level.
1997	MCDPH awarded initial HUD grant for lead-based paint hazard control efforts (e.g., training local contractors in EPA-certified lead-safe work practices; recruiting unemployed adults from community for training and/or apprenticeships).
2000	The Coalition to Prevent Lead Poisoning (formerly the Rochester Lead-Free Coalition) is established, in partnership with MCDPH, as an education and advocacy organization.
2003	MCDPH lowers EBLL threshold for children from 20 to 15 μg/dL for triggering public health action.
2005	City of Rochester adopts a local lead ordinance that incorporates lead inspections into the Certificate of Occupancy process, receiving national recognition.
2008	MCDPH awarded initial NYSDOH grant for childhood lead primary prevention efforts (e.g., providing lead risk assessment to identify lead hazards in homes of children with EBLL < 15 μg/dL, pregnant women or those with infants, and newly arriving refugees).
2009	NYS lowers EBLL threshold for children from 20 to 15 μg/dL for triggering public health action.
	MCDPH subsequently lowers this EBLL threshold to 10 μg/dL.
2012	CDC lowers EBLL threshold for children from 10 to 5 μg/dL for triggering public health action.
2013	MCDPH lowers EBLL threshold for children from 10 to 8 μg/dL for triggering public health action, rendering it one of the strictest standards in NYS.

EBLL, elevated blood lead level; EPA, U.S. Environmental Protection Agency; HUD, U.S. Department of Housing and Urban Development; MCDPH, Monroe County Department of Public Health; NYS, New York State; NYSDOH, New York State Department of Health

Third, childhood blood lead testing rates were suboptimal from the national to local levels; consequently, these findings may not be generalizable to all children.

In conclusion, using recent data, this study found that the rates of childhood lead poisoning, as defined, decreased significantly nationwide. These declines were greater for Monroe County, which had higher baseline rates of EBLL and an older housing stock, than the U.S. overall. The experience of Monroe County demonstrates the role of local health department capacity and community-based efforts in reducing sources of environmental lead exposure for children beyond national and statewide policies. Childhood lead poisoning remains a public health issue, and having effective strategies to mitigate lead hazards will be critical to reaching the national goal of eliminating childhood lead poisoning by 2020.

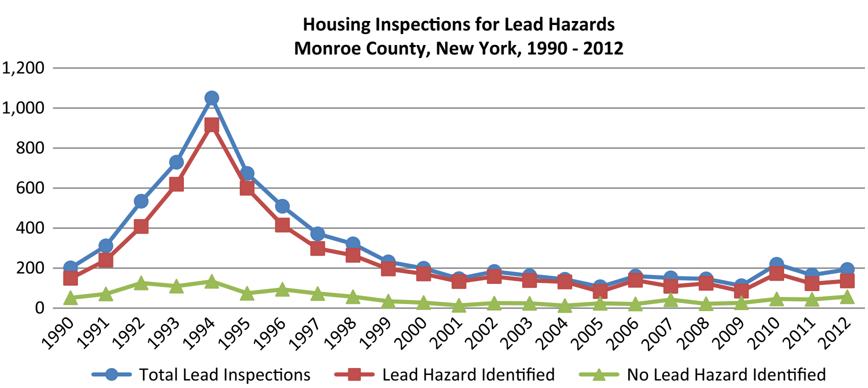

Figure 3. Trends in housing inspections for lead hazards, 1990–2012
Note: Lead Hazard Identified, lead level in paint at or above intervention level standard and paint is not intact or is on a friction impact surface such as steps, windows, doors; No Lead Hazard Identified, lead level below intervention level standard or paint is intact and not on a friction impact surface.

The authors thank John Ricci, MS, Anne Kern, and Susette Langston for reviewing earlier drafts of this work.

No financial disclosures were reported by the authors of this paper.

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