	FINANCE – HEALTH AND MEDICAID SUBCOMMITTEE
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Today's Date May 22, 2017

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Testifying on Bill Number: Sub. H.B. No. 49

Testimony: ____ Verbal ____ Written x Both

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OHIO SENATE
FINANCE — HEALTH AND MEDICAID SUBCOMMITTEE
May 24, 2017

Testimony by Danielle Gadomski Littleton, Esq., The Legal Aid Society of Cleveland

Good morning, Chairman Hackett, Vice Chair Tavares, and members of the subcommittee. Thank you for this opportunity and to Senator Brown for inviting our comments regarding the importance of Ohio cities maintaining their ability to prevent lead poisoning.

My name is Danielle Gadomski Littleton. I am an attorney with the Legal Aid Society of Cleveland, a non-profit law firm serving the civil legal needs of low-income clients in Northeast Ohio. Our firm represents clients affected by lead primarily as tenants and students in need of special education services.

Although we serve many rural and urban areas, the lead problem in Cleveland is unique among our service area, the state, and the country. **Although Flint, Michigan's lead-poisoning crisis grabbed national headlines, the lead-poisoning rate in Cleveland is double that in Flint.**[i] In 2015, 12.21% of the children tested for lead exposure in Cleveland had lead levels above 5 μg/dl , the current level of concern adopted by the Centers for Disease Control.[ii] Statewide 2.81% of children tested had levels above 5 μg/dl.[iii] The next highest city was Lakewood at 6.98%.[iv] An April 2016 study by the Case Western Reserve University Center on Urban Poverty and Community Development considered the impact of substandard housing on Cleveland Metropolitan School District (CMSD) students found 40% of CMSD kindergartners have tested positive for elevated blood lead levels at some point prior to entering school.[v] The distribution of the elevated blood levels suggests that the effect is not evenly distributed among the residents of Cleveland, but instead falls more heavily on our African American and Latino communities.[vi] Finally, it is important to remember these staggering rates of lead poisoning are based on incomplete screening data.

There is no safe level of lead in a child's bloodstream.[vii] At even low levels lead poisoning is correlated with aggression, attention, and learning issues.[viii] Our clients come to the Legal Aid Society of Cleveland with children who are struggling to learn and focus in school without explanation: an aggressive six year old with speech delays; an eight year old who cannot focus or read at grade level; a fifteen year old who has completely disengaged from school because no one recognized his IQ was twenty points below the cut off for an intellectual disability. Through reviewing records, we learned all of these children had lead levels at or in one case six times the Centers for

Disease Control's level of concern. **We were able to secure special education services for each of these children, but we cannot reverse the damage done to their potential.**

In order to prevent another generation of poisoned children, the Legal Aid Society of Cleveland has pressured the Cleveland Department of Health to comply with Ohio law by following up with landlords when children have elevated blood lead levels and their home is confirmed to have lead hazards. We recently filed a mandamus action on behalf of a two year old child against the City of Cleveland asking that the Eighth Circuit Court of Appeals order the City to notify landlords and tenants of lead hazards in compliance with the mandated timelines and timely order the property to be vacated, where appropriate.

Even full compliance with Ohio law would still use children as lead detectors. Ohio law is reactive and only requires a home to become lead-safe after a child has already been poisoned.

The Legal Aid Society of Cleveland is partnering with the City of Cleveland and many other local community organizations to seek a more proactive approach. Beginning on July 1, 2017, the City of Cleveland will inspect every rented home for lead hazards and many other healthy home factors. This program was inspired by other community based proactive approaches. Rochester, New York implemented a local lead inspection program and their lead poisoning rate was cut in half in four years.[ix] Toledo has the local will to make similar gains.

The provision of the budget bill that would give the state of Ohio sole authority to regulate lead would halt the Cleveland community's progress toward addressing lead in our city. The State's reactive program would preempt any local effort to prevent poisoning. The budget provision specifically takes education, job training, and data collection regarding lead away from the control of the cities it affects the most.

Regulating housing conditions is a crucial local issue and cities must retain the ability to protect our children by taking affirmative action to meet this crisis.

Thank you again for the opportunity to provide comments on behalf of the Legal Aid Society of Cleveland. I am happy to answer questions and provide follow up if necessary.

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[i] Wines, Michael, *Flint is in the News, but Lead Poisoning Is Even Worse in Cleveland*, N. Y. TIMES, March 3, 2016

[ii] City Break Down Table of Elevated Blood Levels for 2015, Ohio Department of Health (2016)

[iii] *Id.*

[iv] *Id.*

[v] Coulton, Claudia et al., *Briefly Stated: Housing Deterioration Contributes to Elevated Lead Levels and Lower Kindergarten Readiness Scores in Cleveland*, No. 16-02, April 2016

[vi] Dissell, Rachel and Brie Zeltner, *Race, racism and lead poisoning: Toxic Neglect*, CLEVELAND PLAIN DEALER, October 22, 2015

[vii] American Academy of Pediatrics, *Policy Statement: Lead Exposure in Children: Prevention, Detection, and Management*, PEDIATRICS Vol. 116, No. 4, October 2005

[viii] *Id.*

[ix] Korfmacher, Katrina Smith et al., *Rochester's Lead Law: Evaluation of a Local Environmental Health Policy Innovation*, ENVIRONMENTAL HEALTH PERSPECTIVES Vol. 120. No. 2, February 2012, 313

The New York Times | http://nyti.ms/24DRx6U

U.S.

Flint Is in the News, but Lead Poisoning Is Even Worse in Cleveland

By MICHAEL WINES MARCH 3, 2016

CLEVELAND — One hundred fifty miles northwest of here, the residents of Flint, Mich., are still reeling from the drinking water debacle that more than doubled the share of children with elevated levels of lead in their blood — to a peak, in mid-2014, of 7 percent of all children tested.

Clevelanders can only sympathize. The comparable number here is 14.2 percent.

The poisoning of Flint's children outraged the nation. But too much lead in children's blood has long been an everyday fact in Cleveland and scores of other cities — not because of bungled decisions about drinking water, but largely because a decades-long attack on lead in household paint has faltered. It is a tragic reminder that one of the great public health crusades of the 20th century remains unfinished.

"Unless there is some sort of concerted national effort to do something about this problem, it's going to persist for years to come," said Philip J. Landrigan, a leading expert on lead and professor of preventive medicine and pediatrics at the Mount Sinai School of Medicine.

"Lead is a big problem in this country, and it frustrates me to no end that except in rare cases, it passes unnoticed."

Four decades ago, political leaders declared war on lead, citing evidence that even vanishingly small amounts of it have a pernicious impact on young brains, stunting intellectual growth and affecting cardiovascular, immune and hormone systems. The federal government began phasing out leaded gasoline in 1975, and banned lead-based household paints in 1978. In 2000, a cabinet-level task force proposed to end lead poisoning in children within a decade.

By 2006, blood lead levels in children under 6 had fallen to close to a tenth of their 1970s levels.

But progress since has slowed. By the most recent estimate, about 37 million homes and apartments still have some lead paint on walls and woodwork, 23 million with potentially hazardous levels of lead in soil, paint chips or household dust.

The Centers for Disease Control and Prevention estimate that four million of those most dangerous households have children. A half-million children — in Atlantic City, Philadelphia and Allentown, Pa., where a remarkable 23.1 percent of children tested had excessive lead — are believed to have enough lead in their blood to merit a doctor's attention.

That need not happen. New York City has a vast and aged housing stock and one of the nation's strictest laws on lead testing and removing lead hazards. In 2014, only 2.1 percent of children tested were flagged for excessive lead.

But in most cities, the lead threat is confined largely to poor neighborhoods with scant political clout. There is little official urgency — and increasingly, little money — to address it.

Charm Warren-Celestine, 64, replaced the windows and porch of her century-old home in east Cleveland's Glenville neighborhood after her toddler grandson Zy'aire developed high blood lead levels after spending the summer of 2011 with her.

"It took me three years and two applications to get the city to do what was needed to make my dwelling lead-free," she said. "I had to apply twice because funding was exhausted. You had to be relentless to make it happen."

Almost five years later, Zy'aire shows no physical effects from the lead, but its effect on his mental development remains unclear.

Researchers argue that failing to attack lead paint hazards is a costly mistake. A 2009 study calculated that every dollar spent on that would generate up to $221 in benefits — in increased productivity, greater tax receipts and lower health care and education costs.

And not the least, in reduced crime. Researchers have long linked high blood lead levels to impulsiveness and violence.

The C.D.C. has consistently lowered its definition of an elevated blood lead level: 60 micrograms per deciliter, then 10, and, as of 2012, five — less than a millionth of an ounce in a little more than a pint of blood.

Yet experts say that is still too much. A 2005 study concluded that increasing a child's blood lead level to 10 micrograms from 2.4 translated to a 3.9-point drop in I.Q. A 2015 study of Chicago elementary school students concluded that blood lead concentrations of five to nine micrograms explained up to 15 percent of failing grades in reading and math.

Even tiny increases, below five micrograms, "are associated with significant decrements in performance on standardized tests," the researchers said.

The 2000 cabinet task force found that the lead danger to children then could be substantially eliminated for what, in federal terms, was a pittance: $2.1 billion, over 10 years, to eliminate lead hazards in old homes that posed the greatest threat.

Congress never allotted the full amount, and since 2003, funding for lead-abatement programs has fallen by 43 percent.

"We know how to fix it," said David Jacobs, a chief contributor to the task force who ran the federal lead program from 1995 to 2004. "The technology is there. It's just a matter of political will to properly appropriate the money."

Money for screening children has also fallen. The C.D.C. has cut state grants for lead poisoning prevention by more than half since 2009, and the share of children younger than 6 who are tested has fallen by more than 40 percent. Sixteen states do not even forward the results of lead tests to the federal authorities.

The Ohio Legislature established a Lead Poisoning Prevention Fund in 2003 to attack the lead-paint problem in older homes and to pay for blood tests of children without medical insurance — but never gave it even a dollar.

On Cleveland's east side, the Glenville neighborhood embodies the neglect of the lead problem and the hope that it might be erased.

At the turn of the 20th century, Glenville was called Cleveland's Gold Coast, a mansion-studded enclave where John D. Rockefeller had donated land for the city's largest park. By the 1960s, the wealthy had fled to the suburbs and Glenville was part of the inner city, poor and almost entirely black.

In 1967, Thajuan Perry was 5 years old, living in a Glenville apartment with her parents, when it became clear that something was wrong with Eric, her baby brother. Eric once crawled around the rooms; suddenly, he was neither moving nor making noises.

"He would just gaze for long periods," Ms. Perry said. "It went from gazing to seizures, and from seizures to a coma."

Eric was hospitalized with lead poisoning, sickened by dust and paint chips on the apartment floor. At age 50 today, he can speak only simple sentences, takes anti-seizure medication and works at a center for the disabled.

Ms. Perry is his full-time caretaker. "The thing about lead poisoning," she said, "is that you don't know you've been affected until you have symptoms. At the time, most parents didn't realize that apartments had lead-based paint."

In Cleveland, many still do not.

In 2010, researchers estimated that 7.7 percent of the nation's black children younger than 6 had blood lead levels above five micrograms per deciliter. But in Glenville, 26.5 percent of children tested in 2014 — 286 children in all — exceeded that standard. Two registered more than 45 micrograms, the threshold for hospitalization to remove lead from the body.

Cleveland tested less than half its under-6 population. How many other children are at risk is unknown, but an Ohio State University analysis suggests that in some census tracts, it could be more than four in 10.

Dr. Dorr Dearborn, a retired pediatrician and chairman emeritus of Case Western Reserve University's department of environmental health sciences, said widely elevated lead levels "give these children an abnormal base to which all the other determinants of school failure and aggressive behavior are added."

Dr. Dearborn has long campaigned for Cleveland to erase lead-based paint from its homes — nearly nine in 10 of the city's houses were built before the 1978 ban — but Clevelanders were oblivious.

That changed last October, after a series of articles in The Plain Dealer reported that the city's Department of Public Health had failed to investigate more than 2,100 cases of lead poisoning during the previous five years. Until 2015, the city had but one employee to inspect homes where lead poisoning occurred.

City officials contest some of those numbers, but in an interview conceded that the city's lead safety efforts were a mess. The main reason, they said, was a lack of money.

When the C.D.C. began cutting lead poisoning prevention grants in 2010, the officials said, the Health Department had to curtail lead tests and lay off inspectors. In 2012, federal officials withdrew Cleveland's multimillion-dollar grant for addressing lead in homes because the city's track record was so poor.

Some critics are less sympathetic, noting that the city has found money for other projects — including $30 million for a 2013 renovation of its National Football League stadium — while lead abatement languished.

"A lot of folks failed," said Kim Foreman, the director of Environmental Health Watch, a local group that works to ease lead and other health threats in homes. "The layperson, they thought we dealt with lead. But you also have a lot of folks affected who are people of color or low-income people. And honestly, people are not as concerned about them."

The city vows to do better. The Health Department is to get new leadership; officials have committed to hire more lead inspectors. A new data system will better track lead cases and integrate with other departments that inspect or repair homes. The lost federal grant was reinstated last fall.

Perhaps most important, community leaders have started to face the problem and work on ways to solve it. University Hospital's network, the Cleveland Clinic and others are devising a program to address lead poisoning and infant mortality in neighborhoods near Case Western.

Glenville is at the head of the list.

A version of this article appears in print on March 4, 2016, on page A1 of the New York edition with the headline: Beyond Flint, Lead Poisoning Persists Despite Decades-Old Fight .

Ohio Department of Health

Ohio Healthy Homes

Notes:

1. The table below demonstrates the number of children, less than 72 months of age, tested and determined to have blood lead levels (BLLs) in each result range.
2. BLLs reflect the highest confirmed test during the year if a confirmed test exists for the child, or the highest test for the year, otherwise.
3. Units are µg/dL or micrograms per deciliter of blood.
4. Unconfirmed BLLs are defined as tests for children who had an elevated capillary test and did not receive an confirmatory test within 90 days.
5. Only cities with 500 or more children tested in 2015 are listed.
6. Table may be updated as corrected laboratory test data are shared with the Healthy Homes and Lead Poisoning Prevention Program.

		Confirmed BLLs Only											
City	0-4 µg/dL	5-9 µg/dL	10-14 µg/dL	15-19 µg/dL	20-24 µg/dL	≥25 µg/dL	Total ≥5 µg/dL	% Tested with ≥5 µg/dL	Total ≥10 µg/dL	% Tested with ≥10 µg/dL	Unconfirmed 5-9 µg/dL	Unconfirmed ≥10 µg/dL	Total
COLUMBUS	15,300	157	27	10	7	7	208	1.31%	51	0.32%	362	63	**15,933**
CINCINNATI	14,654	326	64	31	5	18	444	2.88%	118	0.77%	243	57	**15,398**
CLEVELAND	10,958	1,122	257	95	36	64	1,574	12.21%	452	3.51%	305	54	**12,891**
TOLEDO	4,625	190	59	15	10	8	282	5.52%	92	1.80%	160	40	**5,107**
DAYTON	4,516	53	9	2	1	7	72	1.54%	19	0.41%	78	14	**4,680**
AKRON	3,887	74	13	2	1	1	91	2.22%	17	0.42%	104	14	**4,096**
CANTON	1,973	36	7	2	0	3	48	2.21%	12	0.55%	132	18	**2,171**
HAMILTON	1,889	35	10	3	1	2	51	2.56%	16	0.80%	39	11	**1,990**
SPRINGFIELD	1,832	57	12	9	3	3	84	4.26%	27	1.37%	47	7	**1,970**
YOUNGSTOWN	1,607	53	10	2	1	2	68	3.82%	15	0.84%	88	17	**1,780**
LORAIN	1,247	27	5	1	0	0	33	2.54%	6	0.46%	14	3	**1,297**
NEWARK	1,196	11	1	1	0	0	13	1.03%	2	0.16%	52	4	**1,265**
LIMA	1,048	33	3	1	0	2	39	3.58%	6	0.55%	1	0	**1,088**
MANSFIELD	980	30	10	5	0	2	47	4.42%	17	1.60%	32	5	**1,064**
EUCLID	975	37	3	1	2	1	44	4.28%	7	0.68%	8	1	**1,028**
ZANESVILLE	988	7	5	2	1	1	16	1.56%	9	0.88%	17	2	**1,023**
ELYRIA	968	10	2	1	0	1	14	1.39%	4	0.40%	17	6	**1,005**
REYNOLDSBURG	966	1	0	0	0	2	3	0.31%	2	0.20%	10	3	**982**
WARREN	919	16	0	0	0	0	16	1.64%	0	0.00%	36	3	**974**
LANCASTER	893	7	3	0	1	1	12	1.29%	5	0.54%	23	3	**931**
MIDDLETOWN	885	18	2	1	0	2	23	2.51%	5	0.54%	9	1	**918**

GROVE CITY	898	2	0	0	1	0	3	0.33%	1	0.11%	9	3	**913**
FAIRFIELD	789	1	0	0	0	0	1	0.13%	0	0.00%	7	0	**797**
PARMA	775	8	3	0	0	0	11	1.39%	3	0.38%	5	1	**792**
WEST CHESTER	765	0	0	0	0	0	0	0.00%	0	0.00%	9	2	**776**
HILLIARD	761	0	0	0	0	0	0	0.00%	0	0.00%	8	2	**771**
MARION	696	19	4	1	0	0	24	3.31%	5	0.69%	5	1	**726**
ALLIANCE	634	21	9	2	1	1	34	4.70%	13	1.80%	46	9	**723**
LAKEWOOD	605	36	7	3	1	0	47	6.98%	11	1.63%	18	3	**673**
MASSILLON	596	5	2	1	1	1	10	1.56%	5	0.78%	23	10	**639**
PERRYSBURG	605	4	0	0	0	0	4	0.65%	0	0.00%	2	0	**611**
GALLOWAY	592	1	0	0	0	0	1	0.17%	0	0.00%	3	1	**597**
PICKERINGTON	581	0	0	1	0	0	1	0.17%	1	0.17%	8	0	**590**
CANAL WINCHESTER	566	0	0	0	0	0	0	0.00%	0	0.00%	15	2	**583**
CHILLICOTHE	558	4	0	0	0	0	4	0.69%	0	0.00%	12	3	**577**
FAIRBORN	560	3	0	2	0	0	5	0.87%	2	0.35%	10	1	**576**
WESTERVILLE	544	2	0	0	0	0	2	0.36%	0	0.00%	8	1	**555**
NEW PHILADELPHIA	520	11	1	0	0	0	12	2.20%	1	0.18%	11	3	**546**
RAVENNA	536	3	4	0	0	0	7	1.29%	4	0.74%	1	0	**544**
PAINESVILLE	529	3	3	2	1	0	9	1.67%	6	1.12%	0	0	**538**
FINDLAY	527	5	0	1	0	0	6	1.13%	1	0.19%	0	0	**533**

Last Reviewed 10/7/2016

briefly STATED

Research Summary

April 2016

No. 16-02

Housing Deterioration Contributes to Elevated Lead Levels and Lower Kindergarten Readiness Scores in Cleveland[1]

Claudia J. Coulton, PhD, Francisca García-Cobián Richter, PhD, Robert L. Fischer, PhD, and Youngmin Cho, MA

A retrospective analysis of the housing histories of more 13,000 entering kindergartners in 2007-10 in Cleveland demonstrates the role that housing plays in early childhood development. Children who spent more time living in or near properties that had signs of deterioration and disinvestment were more likely to have elevated lead levels and to have low scores on a kindergarten readiness assessment. Nearly 40 percent of the entering kindergartners tested above the public health threshold for lead exposure (i.e. blood lead level >5mg/DL). Each year from birth to kindergarten approximately one-third of the children spent time either in or near properties that were in poor condition or showed signs of disinvestment.

Children in many big cities in the US are already at an educational disadvantage when they enter kindergarten, presenting a major challenge for public education systems. In fact, socio-economic inequalities in children's cognitive skills at school entry are significantly higher in the US than in the UK, Canada or Australia[2]. Though it is generally acknowledged that the environment in which children spend their early years is crucial, little is known specifically about how housing conditions, both in children's own family homes and the immediately surrounding areas, factor into disparities in early development and kindergarten readiness. This housing context for children can be a major influence on early development and requires coordinated efforts to address potential risks.

HOW HOUSING PROBLEMS MIGHT AFFECT SCHOOL READINESS

Poor housing conditions can undermine children's early school success by contributing to a number of negative factors, such as parental stress[3], triggering unplanned residential moves[4] or by increasing the chances that the young child will be exposed to harmful substances in the home environment[5]. Housing that has been vacant or subject to disinvestment tends to have serious maintenance deficiencies that can pose significant risk for such hazards[6].

Lead exposure is one of the consequences of housing deterioration that has shown clearly negative effects on early cognitive development. Studies show that young children with elevated blood lead levels consistently score lower on school readiness and developmental assessments compared to their unexposed peers[7]. Prolonged disinvestment and lack of maintenance in the affordable housing stock are key factors that persist in explaining economic disparities in lead exposure among young children[8].

In Cleveland, housing vacancy and disinvestment have been on the rise since the city was hit by the foreclosure crisis more than 10 years ago. In the ensuing years, the city experienced exponential growth in properties that were mired in the foreclosure process, remained vacant for extended periods, were sold at low prices through bulk sales, and suffered serious deterioration[9]. These trends raise concerns about the possible impact of deteriorating properties and lead exposure on the school readiness of Cleveland kindergartners.

JACK, JOSEPH AND MORTON MANDEL SCHOOL OF APPLIED SOCIAL SCIENCES
CASE WESTERN RESERVE UNIVERSITY

Center on Urban Poverty and Community Development

THE STUDY DESIGN

We undertook a study of Cleveland kindergartners to examine how the housing conditions that they were exposed to during their early childhood may have contributed to their kindergarten readiness. In particular, we evaluated a variety of markers of disinvestment in the children's residences as predictors of low scores on the kindergarten readiness assessment and of the risk of elevated blood lead levels. We used rigorous research methods to control for bias due to endogenous selection over time and assess the cumulative influence of housing problems at crucial stages of child development.

The study population included all children that entered kindergarten for the first time in the Cleveland Metropolitan School District (CMSD) during the 2007-2010 academic years (N=13,762). The study drew on two integrated data systems maintained by the Center on Urban Poverty and Community Development. The ChildHood Integrated Longitudinal Data (CHILD) system is a secure computing environment that links administrative records on children from multiple agencies that are de-identified for research purposes. NEO CANDO links together historical and current property records from numerous public data sources[10]. We compiled monthly address histories for the children in the study from a combination of administrative records, which allowed for the assessment of the timing and duration of numerous measures related to their housing conditions (**see table 1**), the conditions of the properties within the surrounding 500 feet, the socio-economic composition of their neighborhoods and their levels of residential mobility. Other records supplied data on maternal and child characteristics, any child maltreatment investigations, and the results of blood lead screening tests. The outcome, kindergarten readiness, was measured by the KRA-L test administered by CMSD[11].

STUDY FINDINGS

The kindergartners in this study had a mean KRA-L score of 15.8 out of 29, well below state averages. Only 18 percent had scores in the top band (24-29) width which is considered indicative of not in needing special supports for language and literacy development. Thirty-nine percent of the kindergartners tested positive for lead (>5mg/DL) at some point in early childhood. Prior to entering kindergarten, the children in this study were cumulatively exposed to a number of adverse economic, neighborhood and housing conditions. On average, they spent about three-quarters of their early childhood months in poverty and 66 percent of their time in disadvantaged neighborhoods. However, there was much more variation in housing experiences. The typical child in this study relocated approximately 3 times between birth and kindergarten. Each year, from birth to entering kindergarten, approximately one-quarter of the children lived in units with one or more signs of disinvestment such as foreclosure, tax delinquency or in housing owned by speculators. The average yearly occupancy of houses in poor condition was 18 percent and of low market value was 31 percent.

Housing predictors of lead exposure and kindergarten readiness

The statistical analysis evaluated the cumulative effects of housing problems on the chances that children would have elevated blood lead levels and do poorly on kindergarten readiness assessments, controlling for time-varying housing and neighborhood selection and other childhood risk factors such as poverty and child maltreatment. We focused on estimating the effects of housing attributes that could be found in public records to develop these predictive models (**see table 2** on page 3). We found that the cumulative number of months children lived in housing classified as in poor condition and with estimated market value below $30,000 (in 2010 dollars) were predictive of an elevated lead test. Moreover, time spent in properties that had markers of disinvestment was an even stronger predictor of lead exposure. These markers included properties that were in the process of foreclosure, had prolonged tax delinquency or had been purchased at very low prices by speculators. Even after accounting for neighborhood and housing selection, these housing market distress factors also had direct negative effects on kindergarten readiness scores and indirect

Table 1. Housing measure and source

Concept	Measure (Unit)	Source
Neighborhood quality		
Concentrated disadvantage	Factor score of six items[a] (Rank, 0-100)	N
Housing characteristics		
Housing condition	Poor condition	H1
Low market value	Market value below $30,000 (in 2010 dollars)	H1
Public/subsidized housing	Public housing or project based Section 8	H4,H5
Housing market distress		
Tax delinquency	Parcel with tax delinquency	H1
Foreclosure	Parcel in foreclosure	H2
Speculator owned	Parcel owned by speculator[b]	H3

Source:
H1: Cuyahoga County tax assessor H2: Cuyahoga County Sheriff's department
H3: Cuyahoga County recorder deed transfers H4: Cuyahoga Metropolitan Housing Authority (CMHA)
H5: Department of Housing and Urban Development (HUD)
N: 2000 Decennial Census and 2009 American Community Survey (ACS)-5 year estimates (www.census.gov)
[a] Variables were interpolated between 2000 and 2010. Six items are comprise of individual poverty, unemployment, children, African-American, single-householder, and welfare receipt
[b] Real estate owned (REO) sales deeds applied text recognition to identify individuals, companies and LLCs with pattern of buying REO at low values including bulk and individual purchases.

Table 2. Marginal Structural models (MSM) predicting KRA-L and elevated lead levels

	KRA-L model						Lead model		
	Model I			Model II					
Variable	b	se		b	se		b*	se	
Neighborhood quality [a]									
Concentrated disadvantage [b]	-0.71	0.20	***	-0.74	0.22	***	0.09	0.01	***
Housing characteristics [a]									
Poor condition housing	-0.43	0.23	†	-0.13	0.24		0.04	0.01	**
Low value housing [c]	-0.13	0.20		-0.25	0.20		0.05	0.01	***
Public housing or project based Section 8				-0.15	0.29		-0.01	0.02	
Housing market distress [a]									
Parcel with tax delinquency				-0.52	0.29	†	0.06	0.01	***
Parcel in foreclosure				-1.01	0.44	*	0.05	0.02	*
Parcel owned by speculator				-1.25	0.39	**	0.05	0.03	†
Buffer 500ft- Avg. number of parcels									
With tax delinquency				0.05	0.02	*	0.00	0.00	***
In foreclosure				-0.11	0.05	*	0.01	0.00	**
Owned by speculator				0.03	0.05		0.00	0.00	
Mediators									
Child neglect/abuse investigation [a]				-2.21	0.34	***			
Residential moves (average per year)				-0.45	0.17	*			
Lead level in blood >5µg/dL(Ref: Negative)									
(Positive)				-0.84	0.14	***			
(Not tested)				-0.78	0.20	***			

Note †p<.10, *p<.05, **p<.01, ***p<.001. Multiple imputation (m=30). [a] Share of years up to k entry exposed to each condition. [b] Score>70th percentile. [c]<$30,000 inflation adjusted.
MSM are weighted by the inverse probability of treatment.
KRA-L models (N=13,689) are linear specifications including dummy variable for the year of entry into kindergarten and controlling for family and child background characteristics (not shown). Lead model (N=13,681) is a multinomial logit specification on a three-leveled variable (not tested, tested negative, tested positive) including dummy for year of birth. We present the marginal effects for testing positive. Coefficients b represent the change in the KRA-L score due to a change in the independent variables. Coefficients b* represent the change in the probability of testing positive due to a change in the independent variables.

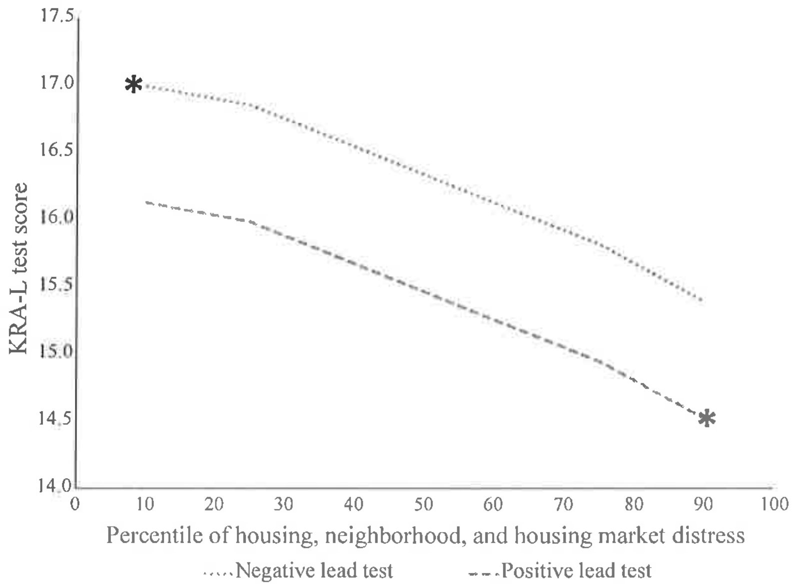
effects on KRA-L through lead exposure. Additionally, we found that the markers of housing distress in properties within a 500-foot buffer around children's own homes had spillover effects on increasing children's risk of lead exposure and poor performance on KRA-L. Living in a neighborhood that was socio-economically disadvantaged was also predictive of lead exposure and low scores on the kindergarten readiness test. However, our analysis shows that the housing problems within these neighborhoods are arguably proximate triggers for some of these apparent neighborhood effects.

To illustrate the level of educational disadvantage that is likely to occur in children due to living in distressed housing and neighborhood conditions and being exposed to lead, we display estimates from our model in the **figure 1** (on page 4). The figure shows the predicted KRA-L score for children that experience a continuum of housing and neighborhood conditions from the least disadvantage (10[th] percentile) to the most disadvantaged (90[th] percentile). These estimates are shown separately for children that experience an elevated blood lead level (>5mg/DL) and those who tested negative for lead. Comparing the two ends of the continuum, we see that children living in the most deteriorated housing and displaying elevated blood lead levels score 15 percentage points lower on the kindergarten readiness test than do children that live in housing that is not distressed and avoid exposure to lead, all else being equal. This is an educationally meaningful difference that can persist without compensatory intervention.

Geography of lead exposure risk for young children

If housing related lead exposure is to be prevented, we need to focus on the youngest children, prior to their environmental exposure to risk. Lead screening tests, however, are performed

Figure 1. Average predicted test scores for levels of housing and neighborhood distress



raise risk of exposure to toxic substances and family distress. Young children are particularly at risk of lead exposure due to developmentally appropriate behaviors that increase their contact with lead and likelihood of ingesting it (e.g., crawling on tainted surfaces, placing fingers in mouth). Deterioration in housing units where young children reside, such as that resulting in elevated lead levels, set the stage for future development. Numerous studies have suggested the deleterious effects of neighborhood socio-economic disadvantage on early development, but this research shows that the state of repair of families' housing units within neighborhoods are a proximal influence that further impacts kindergarten readiness. We also demonstrate that housing market forces play a role in exacerbating housing problems and their effects on children, and that there are spillover effects on children from housing disinvestment in properties in the immediate area.

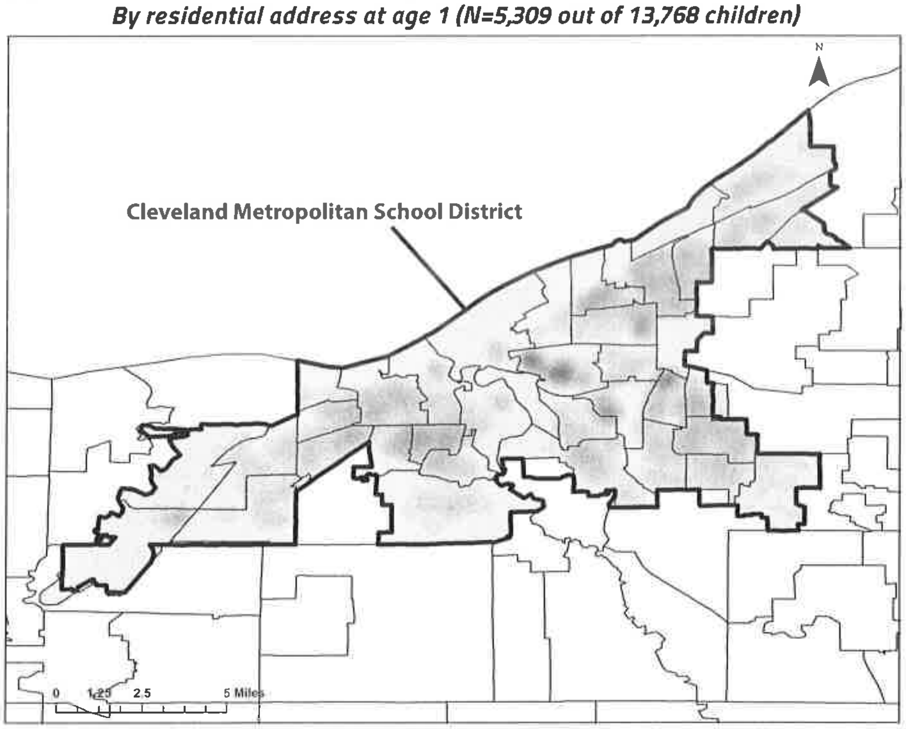
at various ages even though it is now recommended that they be done at ages 1 and 2, and are required for children on Medicaid at these intervals. Although the average age of testing for children in this population who tested positive for lead was 2, we present a map (**see figure 2**) that focuses on the residential location of the children at age 1, a peak period for lead exposure. It can be seen that there are clear areas of density of positive lead test in particular sections of the city. It should be noted that the children in this study were age 1 in the years 2003-2006. The areas of geographic concentration of lead exposure are likely to vary over time related to changes in the levels of housing and neighborhood conditions in particular locales. Nevertheless, this study points to the importance of tracking linked housing and child-related data continually in order to plan prevention that is effectively targeted on the housing units that are occupied by young children and have markers of disinvestment.

POLICY IMPLICATIONS

Young children are unique in the vital role that housing quality can play because they spend much of their time in the home setting and are quite vulnerable to housing problems that

The findings of this study are pertinent to stimulating policy discussions that fully connect housing and neighborhood conditions to the well-being of young children in urban areas. In particular, current policies that address housing market stabilization and housing quality do not take into account children's housing experiences in their investment

Figure 2. Density map of ever tested positive blood lead levels (>5 µg/dL): By residential address at age 1 (N=5,309 out of 13,768 children)



strategies or allocation of resources. Similarly, policies directed at early childhood education and risk reduction do not incorporate neighborhood and housing conditions into their planning and implementation. Greater attention to the role of housing in educational success could lead to policies and programs to promote school readiness that involve school districts, municipal building and environmental health departments, early childhood programs, housing providers, and community development agencies. Lead exposure, which is exacerbated by housing problems, could be a target for early detection and prevention. Early care and education providers could potentially be a source of information to parents on the importance of housing quality and stability for their young children. Health and human service providers could also play a role in screening for housing problems and in referring at risk families for assistance.

Additionally, communities would benefit from establishing early warning data systems that track properties with characteristics that are high risk for children. Community-based organizations could use such information to prioritize outreach to families in these housing units, facilitating screening for very young children and information to help families evaluate the risk that they face. Working in collaboration with local government, community-based workers could update housing information, lead prevention efforts and the activities of other community development agencies. Supported by a collaborative data tool and an integrated property information system such as the one that was used in this research, community organizations could coordinate their efforts with health department and housing department responsibilities. Together they can reduce the negative impact of housing problems on young children and mitigate the resulting educational disparities.

A full report on this study can be found at povertycenter.case.edu.

[1] This research was supported by the John D. and Catherine T. MacArthur Foundation as part of the *How Housing Matters program*. The authors are grateful to Michael Schramm for his assistance with data preparation, and to all of the partner agencies that provide data and support to the Integrated Data Systems used for this study.

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Race, racism and lead poisoning: Toxic Neglect

A long history of discrimination in housing laws and racial segregation has concentrated the poorest minority families in the worst housing in the city. The same neighborhoods have the highest lead poisoning rates due to deteriorating lead-based paint in homes, poor code enforcement, and proximity to industrial areas and highways. (Andrea Levy, The Plain Dealer)

By **Rachel Dissell, Brie Zeltner, The Plain Dealer**
Email the author
on October 22, 2015 at 12:00 PM, updated October 22, 2015 at 12:17 PM

TOXIC NEGLECT

CLEVELAND, Ohio--Kim Foreman has watched the effects of lead poisoning on Cleveland children for over 17 years. She's seen more than one generation of a single family poisoned by the same homes.

She knows which pockets of the city have been hardest hit, and she knows why.

A long history of discrimination and racial segregation has concentrated the poorest minority families in the worst housing in the city, she says. As a result, they're living in mostly aging, badly maintained rental units.

"This is about equity and disparities," says Foreman, executive director of Environmental Health Watch, a nonprofit that works with city and county officials to address lead and other environmental health hazards in Cleveland. "It's not about emotion. This is our history."

From 1999 to 2004, black children nationally were 1.6 times more likely to test positive for lead in their blood than were white children, according to the Centers for Disease Control and

Prevention. Black children were nearly three times more likely to have highly elevated blood-lead levels. In Cuyahoga County, it's neighborhoods with majority black populations that have the highest rates of lead poisoning.

It's a history many people would prefer to ignore, but Foreman is past caring about that.

"That's the real story," she says. "That's what we need to talk about."

Poor families locked in to poor housing

In Cleveland and many other big cities, some housing experts argue the lead-poisoning story begins with **federal "redlining" policy in the 1930s**. The policy, which outlined areas deemed unsafe for home loans because of their high population of foreign-born or black residents, effectively barred these residents from home-ownership and the ability to build wealth, concentrating poor people in specific neighborhoods.

Those neighborhoods are still the poorest in the city, with the highest levels of exposure to air pollution and environmental toxins. Chronic asthma, a disease that is twice as common among black children as the rest of the population, is rampant here. So are childhood obesity, high blood pressure and diabetes.

One common denominator for kids in these neighborhoods is the substandard housing they live in, Foreman says: "You can look at maps of the city and see these connections to health and housing."

Kids who live in these neighborhoods are more likely to live near highways and industrial areas, which increase their risk of exposure to pollutants.

There's no question that poorer, minority children have levels of lead in their blood, said **Dr. Bruce Lanphear**, a professor of children's environmental health at Simon Fraser University in Vancouver and former director of Cincinnati Children's Hospital's Environmental Health Center.

Anyone who lives in a home built before 1978, when lead paint was banned, is at risk for lead poisoning. Low-income families who rent, though, often have no recourse when that paint is deteriorating. They can't move, fear eviction if they complain, and don't know who to turn to for help.

"You can't just pick up and move when you have no resources and no one to fall back on," Foreman says.

Minority children appear to be at higher risk of lead poisoning independent of income level, though, according to some research.

Cleveland provides searchable online database of city homes with known lead hazards

Cleveland lead hazard database: Search for homes on the list

Legal Aid Society sues Cleveland on behalf of toddler, asks court to make city follow lead poisoning laws

Elderly Glenville resident upset by lead hazard placard on home after repairs made

Cleveland begins complying with state law on warning signs for lead hazard properties, city says in Tweet

Cleveland City Council expresses unanimous opposition to budget amendment that would curtail planned inspections for lead hazards

Landlords want state to control lead poisoning laws; local approaches have proven more effective

Outside Cleveland, health officials placard most lead hazard properties, some offer help relocating

Ohio Department of Health publishes list of 540 lead hazard homes that should be vacant

Cleveland ignores state law requiring warning signs on homes with unaddressed lead hazards

All Stories

Black kids have blood lead levels 50 percent higher than other races, regardless of age and family income, Lanphear said. While it's unclear why, it may be a result of genetic differences in the way lead is absorbed in the body.

Concentrating the poison

County public health officials boast of a near 90 percent drop in the level of lead poisoning since the late 1990s.

It's true; lead levels have dropped substantially across the nation over the same period, largely thanks to the EPA's complete ban of leaded gasoline for cars in 1996 and efforts to reduce lead exposure in homes.

But as children's lead levels have dropped everywhere, lead poisoning has been concentrated further among those who cannot escape the hazardous homes and tainted soils of their neighborhoods.

In Cleveland, parents who find out their kids are poisoned by lead don't even have the option of looking for another safe place to live; the city has no registry of lead-safe homes.

In cities such as Beachwood, Pepper Pike and Avon Lake, it's hard to find any children with lead poisoning.

The stark disparity has contributed to the myth that the problem isn't that big, experts say.

"It's our society mindset to put it into the category that it doesn't affect me, and it's just [the inner city] and they have so many problems, what's one more?" says Dr. Dorr Dearborn, a pediatric lung specialist and former director of the Mary Ann Swetland Center for Environmental Health at Case Western Reserve University.

"If this was a different group of children, we wouldn't tolerate this as a society, community or a city," says Bob Cole, an attorney working on lead-poisoning advocacy in Toledo.

Instead, national policy for decades has been to use primarily poor, minority children as household lead detectors, only cleaning up hazards after a child is exposed and irreversibly harmed.

A history of marginalization

David Rosner, co-director of the Center for the History & Ethics of Public Health at Columbia University, says that racism and classism are deeply rooted in the nation's response to lead poisoning.

Trade associations for the lead-pigment industry as far back as the 1950s tried to shift the blame by portraying poisoning victims as diseased children with irresponsible parents, to ease the fears of middle-class America.

"They literally said that 'negro and Puerto Rican' children were the problem and middle-class parents had nothing to worry about," said Rosner, co-author of "Lead Wars: The Politics of Science and the Fate of America's Children."

In the late 1950s, The Plain Dealer referred to the children being lead poisoned in Cleveland neighborhoods as "paint nibblers" who would eat anything they can, "be it bugs, dirt, crayons, pebbles -- or paint." Doctors believed children got sicker in the summer because in the warmer months they could more easily peel and eat paint off the outside of buildings. It's more likely children became ill because they were playing in soil that was highly contaminated with lead from ground-up paint chips and leaded-gasoline emissions.

In the 1970s, when it became clear that even low-level exposure to lead could cause behavioral and learning issues for children, the same trade associations insinuated that losing a little ground in school was not so important to the largely poor, minority children being poisoned, Rosner said.

"The prevailing racism of those eras said that these were unimportant questions for these groups of children," he said. "They continue to be used more subtly than before as explanations for why it's not really a big deal."

But the implications of marginalizing the victims of lead poisoning are immense, Rosner said.

"We end up allowing children's lives to be destroyed."

AMERICAN ACADEMY OF PEDIATRICS

POLICY STATEMENT

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of All Children

Committee on Environmental Health

Lead Exposure in Children: Prevention, Detection, and Management

ABSTRACT. Fatal lead encephalopathy has disappeared and blood lead concentrations have decreased in US children, but approximately 25% still live in housing with deteriorated lead-based paint and are at risk of lead exposure with resulting cognitive impairment and other sequelae. Evidence continues to accrue that commonly encountered blood lead concentrations, even those less than 10 μg/dL, may impair cognition, and there is no threshold yet identified for this effect. Most US children are at sufficient risk that they should have their blood lead concentration measured at least once. There is now evidence-based guidance available for managing children with increased lead exposure. Housing stabilization and repair can interrupt exposure in most cases. The focus in childhood lead-poisoning policy, however, should shift from case identification and management to primary prevention, with a goal of safe housing for all children. *Pediatrics* 2005;116:1036–1046; *child, lead, environmental exposure, chelation therapy, succimer, cognition, clinical trials, housing, prevention, behavior.*

ABBREVIATIONS. CDC, Centers for Disease Control and Prevention; AAP, American Academy of Pediatrics; EPA, Environmental Protection Agency; CNS, central nervous system; EP, erythrocyte protoporphyrin; EDTA, ethylenediaminetetraacetic acid; TLC, Treatment of Lead-Exposed Children; HUD, Department of Housing and Urban Development.

BACKGROUND

In 1991, when 1 in 11 US children had a blood lead concentration greater than 10 μg/dL, both the Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) recommended that all US children have their blood lead concentration measured at around 1 and 2 years of age, when concentrations increase and then peak. By 1997, the median blood lead concentration in the United States had decreased, and screening in some areas with newer housing turned up few cases of elevated blood lead concentration. The CDC and AAP then began to recommend screening only those children with a greater chance of having an elevated blood lead concentration—those in older housing, those who had a sibling or playmate with an elevated blood lead concentration, or those who had lived in or visited a structure that might contain deteriorated, damaged, or recently remodeled lead-painted surfaces. Screening of all children eligible for Medicaid, among whom were found 80% of those with increased blood lead concentration,[1] continued to be recommended and had been required by Health Care Financing Administration (now the Centers for Medicare and Medicaid Services) regulation since 1989.

This new policy statement replaces the 1998 statement and includes discussion of new data, including:

- Reliable estimates of the percentage of the US homes containing lead hazards[2];
- Results from a large clinical trial showing that chelation in children with moderately elevated blood lead concentrations does not improve cognitive or neuropsychologic test scores[3];
- Documentation of unacceptably low screening rates among Medicaid-eligible children[4];
- Further confirmation of the link between lead exposure in early childhood and delinquent behavior during adolescence[5,6]; and
- New data showing inverse associations between blood lead concentrations less than 10 μg/dL and IQ.[7,8]

The best approach to lead poisoning is to prevent exposure in the first place, but it will be years before that goal is realized. In the meantime, case finding, case management, and prevention of additional exposure will still be required. This document considers relevant aspects of the epidemiology, clinical toxicology, prevention, and treatment of lead exposure in young children and provides recommendations for pediatricians as well as public health authorities.

DECLINE OF LEAD POISONING IN THE UNITED STATES

Lead is an element and occurs naturally, but blood lead concentrations are quite low in the absence of industrial activities.[9] In the United States, there were historically 2 major sources of industrially derived lead for children: airborne lead, mostly from the combustion of gasoline containing tetraethyl lead; and leaded chips and dust, mostly from deteriorating lead paint. Both contribute to soil lead. A steep decrease in exposure to airborne lead in the United States has occurred since 1980. Federal legislation in the 1970s removed lead from gasoline and decreased smokestack emissions from smelters and other sources, causing blood lead concentrations in children to decrease. From 1976 to 1980, before the regulations had their full effect, US children 1 to 5 years

doi:10.1542/peds.2005-1947
PEDIATRICS (ISSN 0031 4005).

of age had a median blood lead concentration of 15 μg/dL.[10] In 1988–1991, the median was 3.6 μg/dL[11]; in 1999, the median was 1.9 μg/dL.[12] Although concentrations have decreased in all children, black children and poor children continue to have higher blood lead concentrations. Airborne lead should no longer be a source of community exposure in the United States, but individual counties sometimes still exceed airborne lead regulations, and continued vigilance is warranted. Individual children may still be exposed to airborne lead in fumes or respirable dust resulting from sanding or heating old paint, burning or melting automobile batteries, or melting lead for use in a hobby or craft.

SOURCES OF LEAD EXPOSURE

Lead Paint, Dust, and Soil

The source of most lead poisoning in children now is dust and chips from deteriorating lead paint on interior surfaces.[13] Children who developed lead encephalopathy with blood lead concentrations more than 100 μg/dL often had chips of lead paint visible on abdominal plain films. Children who live in homes with deteriorating lead paint, however, can achieve blood lead concentrations of 20 μg/dL or greater without frank pica.[14] The use of leaded paint on interior surfaces ceased in the United States by the mid-1970s. However, in 1998, of the 16.4 million US homes with ≥1 child younger than 6 years, 25% still had significant amounts of lead-contaminated deteriorated paint, dust, or adjacent bare soil ("lead hazard").[2] Dust and soil are also a final resting place for airborne lead from gasoline and dust from paint. Lead in dust and soil can recontaminate cleaned houses[15] and contribute to elevating blood lead concentrations in children who play on bare, contaminated soil.[16]

Transplacental Exposure and Lead in Human Milk

Lead crosses the placenta, and the blood lead concentration of the infant is similar to that of the mother.[17] The source of lead in the infant's blood seems to be a mixture of approximately two thirds dietary and one third skeletal lead, as shown by studies that exploited the differences in lead isotopes stored in the bones of women migrating from Europe to Australia.[18] Although lead appears in human milk, the concentration is closer to plasma lead and much lower than blood lead, so little is transferred. Because infant formula and other foods for infants also contain lead, women with commonly encountered blood lead concentrations who breastfeed their infants expose them to slightly less lead than if they do not breastfeed.[19] In Mexico, giving women supplemental calcium during lactation resulted in a small (less than 2 μg/dL) decrease in the mother's blood lead concentration, presumably by decreasing skeletal resorption.[20] Theoretically, this could diminish transfer of lead through breast milk even further. In the United States, however, where calcium intake may be higher, calcium supplementation does not prevent bone loss during lactation[21] and, thus, might not affect lead transfer at all.

Other Sources

Lead plumbing (in Latin, "plumbus" = lead) has contaminated drinking water for centuries, and lead in water can contribute to elevated blood lead concentrations in children.[13] In 2003–2004, some tap water in Washington, DC, was found to exceed Environmental Protection Agency (EPA) regulations. This was thought to be caused by a change in water disinfection procedures, which increased the water's ability to leach lead from connector pipes between the water mains and interior plumbing in old houses. The extent of this problem in Washington and other cities is not yet known. Affected families are drinking filtered or bottled water until the pipes can be replaced. (Most bottled water is not fluoridated; its consumption may lead to marginal fluoride intakes in children.) Much more about lead in drinking water is available on the EPA Web site (www.epa.gov/safewater/lead/index.html).

Table 1 includes questions about less common sources of lead exposure, which include hobbies, contaminated work clothes, ceramics, cosmetics, imported canned foods, etc. Such questions may be useful if a child has an elevated blood lead concentration but no exposure to leaded dust or soil. They have not been validated for the purpose of deciding whether to screen.

The lead concentration of blood for transfusion is not routinely measured. After exchange transfusion in the extremely low birth weight infant, 90% of the infant's blood is donor blood. Bearer et al[22] recommended that only units with lead concentrations of less than 0.09 μmol/L be used in these patients, on the basis of their adaptation of the World Health Organization tolerable weekly intake from ingestion to intravenous injection. Approximately one third of the units of blood that they measured were above this concentration. The effect of lead in transfused blood used in older children has not been considered.

TOXICITY OF LEAD

Subclinical Effects

At the levels of lead exposure now seen in the United States, subclinical effects on the central nervous system (CNS) are the most common effects. The best-studied effect is cognitive impairment, measured by IQ tests. The strength of this association and its time course have been observed to be similar in multiple studies in several countries.[23] In most countries, including the United States, blood lead concentrations peak at approximately 2 years of age and then decrease without intervention. Blood lead concentration is associated with lower IQ scores as IQ becomes testable reliably, which is at approximately 5 years of age.[23] The strength of the association is similar from study to study; as blood lead concentrations increase by 10 μg/dL, the IQ at 5 years of age and later decreases by 2 to 3 points. Canfield et al[7] recently extended the relationship between blood lead concentration and IQ to blood lead concentrations less than 10 μg/dL. They observed a decrease in IQ of more than 7 points over the first 10 μg/dL of

TABLE 1. Suggested Clinical Evaluation for Lead Exposure

- Medical history
  - Ask about
    - Symptoms
    - Developmental history
    - Mouthing activities
    - Pica
    - Previous blood lead concentration measurements
    - Family history of lead poisoning
  - Environmental history
  - Paint and soil exposure
    - What is the age and general condition of the residence or other structure in which the child spends time?
    - Is there evidence of chewed or peeling paint on woodwork, furniture, or toys?
    - How long has the family lived at that residence?
    - Have there been recent renovations or repairs to the house?
    - Are the windows new?
    - Are there other sites at which the child spends significant amounts of time?
    - What is the condition/make-up of indoor play areas?
    - Do outdoor play areas contain bare soil that may be contaminated?
    - How does the family attempt to control dust and dirt?
  - Relevant behavioral characteristics of the child
    - To what degree does the child exhibit hand-to-mouth activity?
    - Does the child exhibit pica?
    - Are the child's hands washed before meals and snacks?
  - Exposures to and behaviors of household members
    - What are the occupations of adult household members?
    - What are the hobbies of household members? (Fishing, working with ceramics or stained glass, and hunting are examples of hobbies that involve risk for lead exposure.)
    - Are painted materials or unusual materials burned in household fireplaces?
  - Miscellaneous
    - Does the home contain vinyl miniblinds made overseas and purchased before 1997?
    - Does the child receive or have access to imported food, cosmetics, or folk remedies?
    - Is food prepared or stored in imported pottery or metal vessels?
    - Does the family use imported foods in soldered cans?
- Nutritional history
  - Take a dietary history
  - Evaluate the child's iron status by using the appropriate laboratory tests
  - Ask about history of food stamps or participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)
- Physical examination
  - Pay particular attention to the neurologic examination and the child's psychosocial and language development

lifetime average blood lead concentration. Bellinger and Needleman[8] subsequently reported a similarly steep slope in a reanalysis of data from their study of children with blood lead concentrations similar to those in the Canfield et al study. To confirm the adverse effects of lead on IQ at these concentrations, however, more children whose blood lead concentration has never been more than 10 μg/dL should be studied. A reanalysis of the primary data from several of the prospective studies is underway to help resolve this issue. At the moment, however, these data have not yet been incorporated into policy, and the CDC[16] and AAP[24] both currently use 10 μg/dL (Table 2) as the blood lead concentration of concern.

Other aspects of brain or nerve function, especially behavior, also may be affected. Teachers reported that students with elevated tooth lead concentrations were more inattentive, hyperactive, disorganized, and less able to follow directions.[25,26] Additional follow-up of some of those children[25] showed higher rates of failure to graduate from high school, reading disabilities, and greater absenteeism in the final year of high school.[27] Elevated bone lead concentrations are associated with increased attentional dysfunction, aggression, and delinquency.[28] In children followed from infancy with blood lead measurements, self-reported delinquent behavior at 15 to 17 years of age increased with both prenatal and postnatal lead exposure,[5] and bone lead, thought to represent cumulative dose, is higher in adjudicated delinquents.[6] These data imply that the effects of lead exposure are long lasting and perhaps permanent. Subclinical effects on both hearing[29] and balance[30] may occur at commonly encountered blood lead concentrations.

Although there are reasonable animal models of low-dose lead exposure and cognition and behavior,[31] the mechanisms by which lead affects CNS function are not known. Lead alters very basic nervous system functions, such as calcium-modulated signaling, at very low concentrations in vitro,[32] but it is not yet clear whether this process or some other one yet to be examined is the crucial one. Lead interferes detectably with heme synthesis beginning at blood lead concentrations of approximately 25 μg/dL.[33] Both aminolevulinate dehydratase, an early step enzyme, and ferrochelatase, which completes the heme ring, are inhibited. Ferrochelatase inhibition is the basis of an erstwhile screening test for lead poisoning that measures erythrocyte protoporphyrin (EP), the immediate heme precursor. Because it is insensitive to the lower concentrations of

TABLE 2. Summary of Recommendations for Children With Confirmed (Venous) Elevated Blood Lead Concentrations[16]

Blood Lead Concentration	Recommendations
10–14 μg/dL	Lead education Dietary Environmental Follow-up blood lead monitoring
15–19 μg/dL	Lead education Dietary Environmental Follow-up blood lead monitoring Proceed according to actions for 20–44 μg/dL if A follow-up blood lead concentration is in this range at least 3 months after initial venous test; or Blood lead concentration increases
20–44 μg/dL	Lead education Dietary Environmental Follow-up blood lead monitoring Complete history and physical examination Lab work Hemoglobin or hematocrit Iron status Environmental investigation Lead hazard reduction Neurodevelopmental monitoring Abdominal radiography (if particulate lead ingestion is suspected) with bowel decontamination if indicated
45–69 μg/dL	Lead education Dietary Environmental Follow-up blood lead monitoring Complete history and physical examination Lab work Hemoglobin or hematocrit Iron status Free EP or ZPP Environmental investigation Lead hazard reduction Neurodevelopmental monitoring Abdominal radiography with bowel decontamination if indicated Chelation therapy
≥70 μg/dL	Hospitalize and commence chelation therapy Proceed according to actions for 45–69 μg/dL

Not Recommended at Any Blood Lead Concentration
Searching for gingival lead lines
Evaluation of renal function (except during chelation with EDTA)
Testing of hair, teeth, or fingernails for lead
Radiographic imaging of long bones
X-ray fluorescence of long bones

ZPP indicates zinc protoporphyrin.

blood lead that are of concern now, the test is obsolete for that use; however, EP measurement is still used clinically in managing children with higher blood lead concentrations.

Clinical Effects

Children with blood lead concentrations greater than 60 μg/dL may complain of headaches, abdominal pain, loss of appetite, and constipation and display clumsiness, agitation, and/or decreased activity and somnolence. These are premonitory symptoms of CNS involvement and may rapidly proceed to vomiting, stupor, and convulsions.[34] Symptomatic lead toxicity should be treated as an emergency. Although lead can cause clinically important colic, peripheral neuropathy, and chronic renal disease in adults with occupational exposures, these symptoms are rare in children.

Reversibility

In an influential 1994 study, 154 children who were 13 to 87 months old and had blood lead concentrations between 25 and 55 μg/dL were given chelation with ethylenediaminetetraacetic acid (EDTA) and therapeutic iron when clinically indicated and then followed for 6 months. Those whose blood lead concentrations decreased the most had improved cognitive test scores independent of whether they had been given iron or chelation therapy.[35] An Australian study[36] of 375 children with longer follow-up, however, found only small and inconsistent improvement in the IQs of children whose blood lead concentrations decreased the most. A large (780-children) randomized trial of the use of succimer in children with blood lead concentrations of 20 to 44 μg/dL, the Treatment of Lead-Exposed Children (TLC)[3] Trial, showed no benefit on cognitive or neuropsychologic testing despite an abrupt but transient decrease in the treated children's blood lead concentrations. The children were randomly assigned at approximately 2 years of age and followed with cognitive, neuropsychologic, and behavioral tests until they were approximately 5 years of age. The large size of the trial permits confident exclusion of a drug-related improvement of 2 IQ points or more. Additional follow-up at 7 years of age with more sophisticated testing still showed no advantage for the succimer-treated children.[37]

Because blood lead concentrations decreased as the children in the TLC Trial got older regardless of whether they had chelation, Liu et al[38] used the TLC data to attempt to replicate the reported relationship between decreasing blood lead concentrations and improved cognitive test scores. Test scores were unrelated to decreasing blood lead concentrations at 6 months' follow-up, but results from following the children for 36 months, when they were approximately 5 years of age, showed improved test scores with greater decreases in blood lead concentration but only in the placebo group. Additional research on whether some effective intervention can be isolated to account for this phenomenon is needed. There remains no evidence that chelation will reverse cognitive impairment, and the predominance of data is consistent with a noncausal association between decreasing blood lead concentrations and improved cognitive test scores.

COSTS OF CHILDHOOD LEAD POISONING AND BENEFITS OF PREVENTION

Cost-Benefit Analyses

The removal of lead from gasoline cost money, and it will cost more money to remove lead from housing. If childhood lead exposure, however, affects cognitive function and its consequences, such as graduating from high school, then it is plausible that it will affect social function, employment, and earnings. Several groups have estimated the long-term dollar costs of childhood lead exposure, assuming that the effect of lead on IQ is linear and permanent; they also assume a specific economic value of increased IQs. Grosse et al[39] estimated the economic benefit of the 25-year secular downward trend in childhood lead exposure in the cohort of children 2 years of age in 2000. The estimated increase in earnings for the 3.8 million children would be between $110 billion and $319 billion over their lifetimes, compared with what they would have earned if they had been exposed to 1975 lead levels. Landrigan et al[40] estimated the lifetime costs for each year's cohort of children currently exposed to lead to be $43 billion. On the cost side, Needleman[41] estimated a $10 billion cost for deleading the estimated 2 million lead-contaminated houses that existed in 1990. In 2002, a more reliable estimate is that there are 4 million such lead-contaminated houses,[2] and when adjusting for inflation (with the Consumer Price Index inflation calculator [www.bls.gov/cpi]), Needleman's estimate becomes approximately $28 billion in 2002. Combining these estimates leads to the conclusion that removing lead paint is cost-effective if it prevents even two thirds of lead exposure for any single year's cohort of 2-year-olds. Similarly, a presidential task force estimated that the net nationwide benefit of interim control of lead hazards in the nation's pre-1960 housing would be $1 billion to $9 billion over 10 years. The benefit of abating the hazards permanently would be $21 billion to $38 billion. Such quantitation allows planning and setting priorities to be done more transparently and allows comparisons to estimates of the cost for lead-abatement programs and other preventive activities. Although these are exemplary numbers in simplified analyses, all parts of which could be challenged, they illustrate the rationale for viewing lead exposure as a problem that should be solved, even on economic grounds.

Federal Strategy to Prevent Lead Poisoning

The President's Task Force on Environmental Health Risks and Safety Risks to Children was formed in 1997 by executive order. It consists of government officials from the EPA, the Department of Health and Human Services, the Consumer Product Safety Commission, the Department of Housing and Urban Development (HUD), and others. One of its first projects was to formulate a plan to eliminate childhood lead poisoning,[42] a goal that was incorporated into the Healthy People 2010 goals for the nation(www.healthypeople.gov/Document/HTML/Volume1/08Environmental.htm#_Toc490564710). For the first time, the strategy concentrated on primary prevention and was directed at housing. It did not require that a lead-poisoned child first be identified before a house was considered eligible for participation (the principle of primary prevention). The core of the strategy is a grant-based program administered by the HUD that would accelerate the pace at which in-place management of lead hazards would occur in US homes. The strategy projected that more than 20 million houses could be remediated in the decade from 2000–2010, making lead-safe housing available to a large majority of US children. The strategy also included continued screening, especially among Medicaid-eligible children, enforcement of existing statutes and regulations, and research, especially on the effectiveness of in-place management of lead hazards. The HUD plans periodic evaluations and progress reports, which can be tracked on its Web site (www.hud.gov/offices/lead).

DIAGNOSTIC MEASURES

The diagnosis of lead poisoning or increased lead absorption depends on the measurement of blood lead concentration. This is best performed by using a venous sample, but a carefully collected finger-stick sample can be used. Most blood lead measurements are now performed because the child meets some general eligibility criteria (screening) and not because they are at especially high risk of exposure or have symptoms suggestive of lead poisoning (diagnosis).

Screening

Between 1991 and 1997, both the AAP and CDC recommended universal screening, that is, that all children have their blood lead concentration measured, preferably when they are 1 and 2 years of age. Because the prevalence of elevated blood lead concentrations has decreased so much, a shift toward targeted screening has begun,[43] and the criteria for and implementation of targeted screening continues to develop. As of early 2005, the situation is as follows. All Medicaid-eligible children must be screened.[4] Medicaid will reimburse 2 screenings, one at 1 year of age and one at 2 years of age. Most children with elevated blood lead concentrations are Medicaid eligible, and most Medicaid-eligible children have not been screened.[4] The Advisory Committee on Childhood Lead Poisoning Prevention has proposed criteria by which a state could acquire an exemption from this requirement, and the proposal is under consideration in the Secretary of Health and Human Services' office. Until such exemptions are granted, both the CDC[4] and AAP support universal screening of Medicaid-eligible children. The thinking behind the availability of exemptions is not primarily to decrease the number of screenings performed but rather to increase it among groups in which increased lead absorption will be found. Children whose families participate in any assistance program but who, for whatever reason, are not eligible for Medicaid should also be screened.

For children not eligible for Medicaid, several states and some municipalities have developed targeted screening recommendations or policies using suggestions made by the CDC,[43] their own data, or some combination of the 2. All practitioners should determine if such recommendations are in place where they practice. Appropriate contacts at state and city health departments with CDC-funded programs are listed on the CDC Web site (www.cdc.gov/nceh/lead/grants/contacts/CLPPP%20Map.htm).

The approach to screening children who are not eligible for Medicaid and who live in areas in which health authorities have not made locale-specific recommendations is less clear. Although targeted screening may be desirable, well-validated tools with which to achieve it are not yet in place.[44] In the absence of policy, current recommendations support screening all children who are not enrolled in Medicaid and who live in areas in which local authorities have not issued specific guidance.

There are now many case reports of children who are recent immigrants, refugees, or international adoptees who have elevated (sometimes very elevated) blood lead concentrations.[45] Such children should be screened on arrival in the United States.

Diagnostic Testing

Some experienced clinicians measure the blood lead concentration in children with growth retardation, speech or language dysfunction, anemia, and attentional or behavioral disorders, especially if the parents have a specific interest in lead or in health effects from environmental chemicals. However, a persistent elevation of blood lead concentration into school age is unusual, even if peak blood lead concentration at 2 years of age was high and the child's housing has not been abated. This is probably because hand-to-mouth activity decreases and the child's body mass increases. Thus, a low blood lead concentration in a school-aged child does not rule out earlier lead poisoning. If the question of current lead poisoning arises, however, the only reliable way to make a diagnosis is with a blood lead measurement. Hair lead concentration gives no useful information and should not be performed.[46] Radiograph fluorescence measurement of lead in bone is available in a few research centers and has been used in children as young as 11 years with acceptable validity for research purposes,[47] but it has no clinical utility as yet.

MANAGEMENT OF CHILDREN WITH ELEVATED BLOOD LEAD CONCENTRATIONS

In 2002, the national Advisory Committee on Childhood Lead Poisoning Prevention published a monograph, "Managing Elevated Blood Lead Levels Among Young Children."[16] The goal of the monograph was to provide an evidence-based, standard approach to management usable throughout the United States. Anyone involved with the management of children with elevated blood lead concentrations needs access to it. This section is consistent with the monograph.

The management of children with elevated blood lead concentrations is determined primarily by how high the concentration is (Table 2). Children with concentrations less than 10 μg/dL are not currently considered to have excess lead exposure. Children with concentrations 10 μg/dL or greater should have their concentrations rechecked; if many children in a community have concentrations greater than 10 μg/dL, the situation requires investigation for some controllable source of lead exposure. Children who ever have a concentration greater than 20 μg/dL or persistently (for more than 3 months) have a concentration greater than 15 μg/dL require environmental and medical evaluation.

Residential Lead Exposure

Most children with elevated blood lead concentrations live in or regularly visit a home with deteriorating lead paint on interior surfaces. Some children eat paint chips, but pica is not necessary to achieve blood lead concentrations of 20 μg/dL or greater.[14] Children can ingest lead-laden dust through normal mouthing behaviors by simply placing their hand or an object in their mouth. This also happens when children handle food during eating.[48–50] There is increasing evidence that professional cleaning, paint stabilization, and removal and replacement of building components can interrupt exposure. Cooperation with the health department in investigating and decreasing the source is necessary. Although some authorities insist that moving children to unleaded housing or removal of all lead paint from their current housing is the only acceptable solution,[51] alternative housing is rarely available and extensive on-site removal of leaded paint can raise the concentration in house dust and resident children.[52]

Lead in soil is higher around houses with exterior lead paint and in places where there has been a smokestack or other point source or heavy traffic. Soil concentrations are related to blood lead concentrations but not as closely as are interior dust lead concentrations.[13] Soil can be tested for lead content, and the EPA has guidelines for testing on its Web site (www.epa.gov/lead/leadtest.pdf). Lead should no longer be a problem in municipal water supplies, but wells, old pipes from the municipal supply to the house (as has been the case in Washington, DC), or soldered joints may add lead to water (see www.epa.gov/safewater/lead/index.html).

Other Sources

Some children will have persistently elevated blood lead concentrations without access to lead paint, bare soil, or lead in their drinking water. Their exposure may come from any of the sources listed in Table 3. Blood lead concentrations should decrease as the child passes approximately 2 years of age, and a stable or increasing blood lead concentration beyond that age is likely to be caused by ongoing exposure.

The recommended approach to environmental investigation of a child with an elevated blood lead concentration consists of (1) an environmental history, such as the one shown in Table 1, (2) an inspection of the child's primary residence and any building in which they spend time regularly, (3) measurement of lead in deteriorated paint, dust, bare soil, or water as appropriate, (4) control of any immediate hazard, and (5) remediation of the house, which may require temporary relocation of the child. If new or lead-safe housing is an option for the family, it offers a simple and permanent solution. These situations can be frightening for the families. Involving the family and providing them with information as it is obtained is the right thing to do and may help lessen anxiety.

Although intense regimens of professional cleaning decrease children's blood lead concentrations, providing families with instructions and cleaning materials does not. Washing children's hands has intuitive appeal, but no data support its role in decreasing exposure. Suggested prevention strategies are listed in Table 3.

Medical Management

If the blood lead concentration is greater than 45 $\mu g/dL$ and the exposure has been controlled, treatment with succimer should begin. A pediatrician experienced in managing children with lead poisoning should be consulted; these pediatricians can be found through state health department lead programs, through pediatric environmental health specialty units (www.aoec.org/pehsu.htm), at hospitals that participated in the largest clinical trial of succimer,[3] or by calling the local poison control center or the AAP Committee on Environmental Health. The most common adverse effects of succimer listed on the label are abdominal distress, transient rash, elevated hepatocellular enzyme concentrations, and neutropenia. The drug is unpleasant to administer because of a strong "rotten-egg" odor, and 40% of the families on active drug compared with 26% on placebo found the drug difficult to administer.[53] The succimer label provides dosages calculated both by body surface area and by weight, but the equivalent dose by both methods would occur in a child approximately 5 years of age. For the younger children

TABLE 3. Sources of Lead Exposure and Prevention Strategies[59]

Source	Prevention Strategy
Environmental	
Paint	Identify and abate
Dust	Wet mop (assuming abatement)
Soil	Restrict play in area, plant ground cover, wash hands frequently
Drinking water	Flush cold-water pipes by running the water until it becomes as cold as it will get (a few seconds to 2 minutes or more; use cold water for cooking and drinking
Folk remedies	Avoid use
Cosmetics containing additives such as kohl or surma	Avoid use
Old ceramic or pewter cookware, old urns/kettles	Avoid use
Some imported cosmetics, toys, crayons	Avoid use
Contaminated mineral supplements	Avoid use
Parental occupations	Remove work clothing at work; wash work clothes separately
Hobbies	Proper use, storage, and ventilation
Home renovation	Proper containment, ventilation
Buying or renting a new home	Inquire about lead hazards
Lead dust in carpet	Cover or discard
Host	
Hand-to-mouth activity (or pica)	Frequent hand washing; minimize food on floor
Inadequate nutrition	Adequate intake of calcium, iron, vitamin C
Developmental disabilities	Enrichment programs

typically given the drug, body surface area calculations give higher doses, which are those that are recommended.[54]

Although chelation therapy for children with blood lead concentrations of 20 to 44 μg/dL can be expected to lower blood lead concentrations, it does not reverse or diminish cognitive impairment or other behavioral or neuropsychologic effects of lead.[3] There are no data supporting the use of succimer in children whose blood lead concentrations are less than 45 μg/dL if the goal is to improve cognitive test scores.

Children with symptoms of lead poisoning, with blood lead concentrations higher than 70 μg/dL, or who are allergic or react to succimer will need parenteral therapy with EDTA and hospitalization. Guidelines for these circumstances are beyond the scope of this statement, but the same consultation as described above is recommended. There are academic centers that use D-penicillamine, another oral chelator used in Wilson disease, for lead poisoning. Its safety and efficacy, however, have not been established,[55] and the AAP Committee on Drugs considers it to be a third-line drug for lead poisoning.[56]

Dietary Intervention

The Advisory Committee on Childhood Lead Poisoning Prevention reviewed the evidence for dietary intervention in lead-exposed children.[16] They concluded that there are no trial data supporting dietary interventions aimed specifically at preventing lead absorption or modulating the effects of lead. However, there are laboratory and clinical data suggesting that adequate intake of iron, calcium, and vitamin C are especially important for these children. Adequate iron and calcium stores may decrease lead absorption, and vitamin C may increase renal excretion. Although there is epidemiologic evidence that diets higher in fat and total calories are associated with higher blood lead concentrations at 1 year of age,[57] the absence of trial data showing benefits and the caloric requirements of children at this age preclude recommending low-fat diets for them.

Psychological Assessment

The Advisory Committee on Childhood Lead Poisoning Prevention reviewed the evidence for psychological assessment and intervention in lead-exposed children.[16] Despite data from several large epidemiologic studies suggesting that moderate exposure to lead produces specific deficits in attention or executive functions, visual-spatial skills, fine-motor coordination, balance, and social-behavioral modulation,[58] there is no specific "signature" syndrome yet identified. In addition, although 2-year-olds tend to have the highest blood lead concentrations, they will usually not have detectable cognitive damage, which can be expected to become more apparent at 4 years of age and later. It seems reasonable to manage children whose blood lead concentration is 20 μg/dL or greater at its peak as having a higher risk of developmental delay and behavior abnormalities.[16] Because the effects emerge later, after the child's blood lead concentration will have decreased, the child's record must be kept open even after the blood lead concentration has decreased.

Although there is not specific literature supporting the use of enrichment programs in lead-poisoned children, programs aimed at children with delay from another cause should be effective in lead-poisoned children.

RECOMMENDATIONS FOR PEDIATRICIANS

1. Provide anticipatory guidance to parents of all infants and toddlers about preventing lead poisoning in their children. In particular, parents of children 6 months to 3 years of age should be made aware of normal mouthing behavior and should ascertain whether their homes, work, or hobbies present a lead hazard to their toddler. Inform parents that lead can be invisibly present in dust and can be ingested by children when they put hands and toys in their mouths.
2. Inquire about lead hazards in housing and child care settings, as is done for fire and safety hazards or allergens. If suspicion arises about the existence of a lead hazard, the child's home should be inspected. Generally, health departments are capable of inspecting housing for lead hazards. Expert training is needed for safe repair of lead hazards, and pediatricians should discourage families from undertaking repairs on their own. Children should be kept away from remediation activities, and the house should be tested for lead content before the child returns.
3. Know state Medicaid regulations and measure blood lead concentration in Medicaid-eligible children. If Medicaid-eligible children are a significant part of a pediatrician's practice or if a pediatrician has an interest in lead poisoning, he or she should consider participating in any deliberations at the state and local levels concerning an exemption from the universal screening requirement.
4. Find out if there is relevant guidance from the city or state health department about screening children not eligible for Medicaid. If there is none, consider screening all children. Children should be tested at least once when they are 2 years of age or, ideally, twice, at 1 and 2 years of age, unless lead exposure can be confidently excluded. Pediatricians should recognize that measuring blood lead concentration only at 2 years of age, when blood lead concentration usually peaks, may be too late to prevent peak exposure. Earlier screening, usually at 1 year of age, should be considered where exposure is likely. A low blood concentration in a 1-year-old, however, does not preclude elevation later, so the test should be repeated at 2 years of age. Managed health care organizations and third-party payers should fully cover the costs of screening and follow-up. Local practitioners should work with state, county, or local health authorities to develop sensitive, customized questions appropriate to the housing and hazards encountered locally.
5. Be aware of any special risk groups that are prevalent locally, such as immigrants, foreign-born

adoptees, refugees, or children whose parents work with lead or lead dust in their occupation or hobby and, of course, those who live in, visit, or work on old houses.

6. In areas with old housing and lead hazards, encourage application for HUD or other moneys available for remediation.
7. Keep current with the work of the national Advisory Committee on Childhood Lead Poisoning Prevention and any relevant local committees. Although there is now evidence that even lower blood lead concentrations may pose adverse effects to children, there is little experience in the management of excess lead exposure in these children. Although most of the recommendations concerning case management of children with blood lead concentrations of 15 μg/dL should be appropriate for children with lower concentrations, tactics that decrease blood lead concentrations might be expected to be less and less effective as they are applied to children with lower and lower blood lead concentrations.

RECOMMENDATIONS FOR GOVERNMENT

1. Identify all children with excess lead exposure, and prevent further exposure to them. The AAP supports the efforts of individual states to design targeted screening programs, even for Medicaid children. However, the goal must be to find all children with excess exposure and interrupt that exposure, not simply to screen less. To do this, state and local government activities must focus on the children who are most at risk, which requires more and better data about the prevalence of elevated blood lead concentrations in specific communities. Prevalence estimates based on convenience samples or clinic attendees are not reliable and should not be used as the basis of policy.
2. Realize that case-finding per se will not decrease the risk of lead poisoning. It must be coupled with public health programs including environmental investigation, transitional lead-safe housing assistance, and follow-up for individual cases. Lead-screening programs in high-risk areas should be integrated with other housing and public health activities and with facilities for medical management and treatment.
3. Continue commitment to the Healthy People 2010 goal of eliminating lead poisoning by 2010. The AAP supports the current plan with emphasis on lead-safe housing. Continued monitoring and commitment will be necessary. Research findings on low-cost methods of remediating housing have become controversial. The federal government should support impartial scientific and ethical inquiry into the best way to carry out the needed research.
4. Minimize the further entry of lead into the environment. Regulations concerning airborne lead should be enforced, use of lead in consumer products should be minimized, and consideration should always be given to whether a child might come into contact with such a product.
5. Encourage scientific testing of the many simple, low-cost strategies that might decrease lead exposure. Examples include hand-washing and use of high chairs. Exploration of innovative, low-technology tactics should be encouraged, perhaps through the use of special study sections or review groups. Educational resources for parents and landlords need to be developed and tested.
6. Require coverage of lead testing for at-risk children by all third-party payers by statute or regulation.
7. Fund studies to confirm or refute the finding that blood lead concentrations of less than 10 μg/dL are associated with lower IQ. The next important step in lead research is conducting of studies in which confounding by socioeconomic factors is not so strong. Funding of studies in this area needs to be given high priority, as was done in the early 1980s when the question of effects of blood lead concentrations less than 20 μg/dL was raised.
8. Gather the nationally representative data necessary for a rational public health response to the problem of childhood lead poisoning. The federal government should continue measuring children's blood lead concentrations in the National Health and Nutrition Surveys to allow national estimates of exposure and should periodically resurvey housing to measure progress in the reduction of lead-paint hazards. In addition, state governments can improve monitoring of trends among screened children by supporting electronic reporting of blood lead test results to the CDC.

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Lead Exposure in Children: Prevention, Detection, and Management

Committee on Environmental Health

Pediatrics 2005;116;1036
DOI: 10.1542/peds.2005-1947

Rochester's Lead Law: Evaluation of a Local Environmental Health Policy Innovation

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Background: Significant progress has been made in reducing the incidence of childhood lead poisoning in the United States in the past three decades. However, the prevalence of elevated blood lead in children (≥ 10 μg/dL) remains high in some communities, particularly those with high proportions of pre-1978 housing in poor condition. Increasingly, municipalities are using local policy tools to reduce lead poisoning in high-risk areas, but little is known about the effectiveness of such policies.

Objectives: In this article, we evaluated the effectiveness of a comprehensive rental housing–based lead law adopted in Rochester, New York, in 2005.

Methods: This policy evaluation integrates analyses of city inspections data, a survey of landlords, landlord focus groups, and health department data on children's blood lead levels from the first 4 years of implementation of the 2005 law.

Results: Implementation has proceeded consistent with projected numbers of inspections with nearly all target units inspected in the first 4 years. Higher than expected inspection passage rates suggest that landlords have reduced lead hazards in rental housing affected by the law. Implementation of the lead law does not appear to have had a significant impact on the housing market.

Conclusions: Although many uncertainties remain, our analysis suggests that the lead law has had a positive impact on children's health. Strong enforcement, support for community-based lead programs, and ongoing intergovernmental coordination will be necessary to maintain lead-safe housing in Rochester. Lessons learned from the Rochester experience may inform future local lead poisoning prevention policies in other communities.

Key words: childhood lead poisoning prevention, environmental health policy, healthy housing, local government. *Environ Health Perspect* 120:309–315 (2012). http://dx.doi.org/10.1289/ehp.1103606 [Online 14 October 2011]

Federal policies to reduce childhood lead poisoning, particularly bans on lead in paint and gasoline in the 1970s, resulted in drastic declines in the proportion of children with elevated blood lead (EBL; ≥ 10 μg/dL) from nearly 20% in 1990 to 1.6% in 2000 (Levin et al. 2008). Despite this progress, lead remains a critical environmental health hazard for many low-income children who live in housing built before 1978, when lead paint was banned for residential use in the United States. To address these remaining problems, some states have adopted additional policies to reduce lead poisoning. Most state policies focus on screening and management of children with EBL, but several promote housing-based primary prevention (Breysse et al. 2007; Brown et al. 2001). In addition to these state laws, a small number of cities have longstanding local lead laws aimed at housing-based primary prevention; in fact, several local laws preceded federal lead legislation (Freudenberg and Golub 1987).

Recognition that some communities continue to suffer disproportionately from lead and increased appreciation for the negative health effects of low-level lead poisoning sparked renewed interest in local lead policies in recent years. Rochester, New York, is one such community. In 2000, the proportion of children with EBL was substantially higher among screened children in high-risk neighborhoods in Rochester than in the state of New York or the United States as a whole; in 12 extreme-risk census tracts, > 35% of screened children were identified as having EBL (Boyce and Hood 2002).

Rochester is typical of cities in which the proportion of screened children with EBL far exceeds the national average. The vast majority of Rochester's housing stock was built before 1978, with 87% constructed before 1950, when the highest amounts of lead in paint were used (Boyce and Hood 2002). Because of economic conditions in the city, many of these properties are now low-income rental units. Citywide, most housing units are rentals; in some neighborhoods, rental rates exceed 85%. National housing research has established that rental units are more likely to contain lead hazards than are owner-occupied units (Jacobs et al. 2002; Lanphear et al. 1998a).

Research conducted in Rochester in the 1990s highlighted both the high prevalence of EBL children and the developmental effects of even low levels of lead (Jones et al. 2009). The implications of the high prevalence of childhood EBL for children's education and welfare caught the attention of child advocates in Rochester. These advocates, including educators, researchers, community groups, health care providers, and many others, formed the Coalition to Prevent Lead Poisoning (CPLP) in 2000 (Korfmacher 2008; Stoss 2005). CPLP quickly focused on the goal of passing a local policy to reduce lead hazards in high-risk housing. Although a wide range of stakeholders agreed on the importance of protecting children from lead hazards, many concerns were raised about the costs of lead hazard control, the most effective ways to protect children, the city's financial and technical ability to implement lead hazard inspections, and the potential impact on Rochester's already weak housing market. After several years of analysis, public debate, and policy advocacy, in December 2005, the Rochester city council passed an amendment to its housing code that requires lead inspections of rental properties built before 1978 (City of Rochester 2005a).

More than a dozen municipalities in the United States have recently enacted or amended local lead laws. Local lead laws are widely viewed as a promising approach to targeting the remaining gaps in childhood lead poisoning. However, no comprehensive evaluation has been conducted of the impacts of these laws. In this paper, we analyzed the impacts of Rochester's lead law, using several existing sources of health and housing information, and provide recommendations for future local lead policies and research.

Housing-based lead hazards are the primary—but not the only—source of lead exposure among children in Rochester. Although the purpose of the lead law was to decrease the number of children with EBL in Rochester, local housing policy is only one of

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We gratefully acknowledge the contributions of S. Dixon (National Center for Healthy Housing), S. Boyce, R. Ruffer, the Rochester Coalition to Prevent Lead Poisoning, the City of Rochester, and the Monroe County Department of Public Health.

Much of the analysis reported in this paper was conducted by the Center for Governmental Research in partnership with the National Center for Healthy Housing and the University of Rochester with funding from the Greater Rochester Health Foundation. K.S.K. was supported, in part, by the National Institute of Environmental Health Sciences (grant P30 ES01247) and by the Public Health Law Research Program of the Robert Wood Johnson Foundation.

The authors declare they have no actual or potential competing financial interests.

Received 23 Febraury 2011; accepted 14 October 2011.

many factors affecting the number of children identified as having EBL, including housing markets, landlord and tenant knowledge, nonhousing lead sources, screening rates, and population dynamics. In addition, Rochester's lead law targets only pre-1978 rental (not owner-occupied) housing. Therefore, rather than simply analyzing changes in EBL data since passage of the lead law, we evaluated the potential impacts of the lead law on factors identified by stakeholders in the policy process as key to determining the lead safety of rental housing. These factors include the effectiveness of the city's inspections, the effects of the law on landlords' maintenance practices, and impacts on the housing market.

Rochester's Lead Law

Rochester's lead law targets high-risk housing to cost-effectively control lead hazards before children are poisoned (Korfmacher 2008). The policy integrates a visual inspection for deteriorated paint into the existing certificate of occupancy inspection system for pre-1978 rental housing. Properties found to have deteriorated paint in excess of HUD's *de minimis* level or bare soil within 3 ft of the house fail the visual inspection. HUD standards allow for deteriorated paint below a *de minimis* level of 20 ft^2 on any exterior surface, 2 ft^2 in any interior room, or 10% of any component (such as a window sill) (City of Rochester 2005a). The soil provision was focused on the dripline area close to the house where lead paint scraped from the siding was most likely to result in elevated soil lead levels. In areas the city designates as high-risk based on past EBL data, units that pass the visual inspection must also pass a dust-wipe test based on federal standards. This provision was included as a quality control check on the city's visual inspections and also because research has shown that units that pass visual tests for intact paint frequently contain invisible lead dust hazards (Breysse et al. 2007).

Under the lead law, property owners must correct any identified lead hazard violations before receiving a certificate of occupancy. To reduce compliance costs, the law allows owners or workers who have training in lead-safe work practices to complete repair work, rather than requiring U.S. Environmental Protection Agency (EPA)–certified abatement workers. The law allows the use of interim controls to address hazards. Interim controls such as repainting are less expensive than full lead abatement (permanent encapsulation or removal of lead). Although housing research has found interim controls to be effective in protecting children, homes treated in this way must be monitored so that the temporary controls remain intact (Dixon et al. 2005). In Rochester, this ongoing monitoring is accomplished through required periodic inspections of rental property. When the repair work is completed, those properties that were cited for an interior violation must pass a third-party clearance test to confirm that the lead hazards were addressed. These clearance tests must be conducted by U.S. EPA–certified inspectors using U.S. Department of Housing and Urban Development (HUD) clearance protocols (HUD 2004b).

The Rochester city council passed three accompanying resolutions to the lead law prioritizing inspections in target areas (Resolution 2005-23; City of Rochester 2005b), encouraging public education and establishing a citizen advisory group to inform implementation (Resolution 2005-24; City of Rochester 2005c), and requesting that the city establish a voluntary program for owner occupants (Resolution 2005-25; City of Rochester 2005d).

Key community goals were to inspect all rental properties by 2010 (the federally adopted target date for ending childhood lead poisoning) and to target initial inspections at the riskiest properties. Several features of the law target properties that are most likely to have lead hazards. First, a tenant complaint provision allows residents to request a free inspection by the city at any time. Second, homes of many families on public housing assistance from the county Temporary Assistance for Needy Families received more frequent inspections through the Quality Home Inspection program. Third, high-risk areas are targeted first. These areas were identified based on historical health department blood lead screening data. The lead law defined the high-risk area as those census block groups that cumulatively encompass an area in which no fewer than 90% of the units identified by the county health department for inspections in conjunction with its elevated blood lead–level inspections for the period of the preceding 5 years are located. These targeting strategies were implemented because research in other cities had suggested that lead poisoning can be efficiently prevented by focusing resources on the highest-risk neighborhoods (Haley and Talbot 2004; Meyer et al. 2005; Sargent et al. 1997).

Methods

This analysis builds on an evaluation of the first 2 years of implementation of Rochester's lead law that was conducted by the Center for Governmental Research (CGR) (Boyce et al. 2008). Resources for policy evaluation are generally scarce, particularly at the local level. In this case, however, the widespread community involvement in getting the lead law passed resulted in a commitment by Greater Rochester Health Foundation to support the analysis by CGR. CGR partnered with the City of Rochester, the Monroe County Department of Public Health (health department), the National Center for Healthy Housing (NCHH), and the Environmental Health Sciences Center of the University of Rochester to synthesize city inspection data, survey and conduct focus groups with landlords affected by the law, and analyze health department data on children's blood lead levels. The University of Rochester Research Subjects Review Board (RSRB00033720) reviewed the use of human subjects data for this article and determined it to be exempt.

The CGR report and additional analyses conducted for this manuscript relied on three primary sources of data. The first was publicly available city housing inspections data, including the number and results of visual inspections, dust-wipe inspections, and exterior inspections. City housing inspectors trained in using the HUD Visual Assessment protocol (24 CFR Part 35; HUD 2004a) conducted visual assessments (City of Rochester 2005a). U.S. EPA–certified city lead inspectors took dust-wipe samples using HUD clearance protocols and analysis standards (HUD 2004b).

Second, we obtained blood lead data under a memorandum of agreement with the Monroe County Department of Public Health. The blood lead database of the county health department comprises blood lead results from all children tested under the lead screening law of New York State, which requires blood lead testing of all children at ages 1 and 2 years. Although the county health department does not calculate testing rates for the city, the number of children tested in Monroe County between 2004 and 2009 fluctuated by around 10% (between 13,624 and 14,917; no consistent trend). For the purpose of its analysis, CGR geocoded blood lead results to determine the number of EBL children who lived in the city during 12-month periods before and after implementation.

Third, CGR conducted two landlord focus groups and a telephone survey of 200 landlords. CGR surveyed by telephone a random sample of landlords drawn from the city's list of all owners of two-unit (duplex) pre-1978 rental properties that were inspected during the first year after the law was implemented. Duplexes were chosen to maximize comparability of landlords' experiences. The sample was restricted to owners of two-unit properties to limit variation in the size, housing characteristics, and value of the properties owned by the landlords included in the sample. Of the 373 landlords who were reached by phone, 200 completed the survey, for a response rate of 54% (landlords on the list were called in random order until 200 responses were obtained). City and county staff involved in lead programs also provided qualitative information about implementation. CGR recruited six landlords for the focus groups through local housing agencies. These focus groups explored landlords' experiences with and perceptions about implementation of the lead law. Results were recorded, transcribed, and coded for common themes, which were integrated with survey results in the CGR analysis. Further information on methodology is provided in the CGR report (Boyce et al. 2008).

Publicly available inspection data from the City of Rochester and a data-sharing agreement with the health department made it possible to extend parts of this analysis through the third and fourth years of implementation (2008–2009 and 2009–2010). Where appropriate, we derived *p*-values for differences between time periods using chi-square tests. We used the Breslow–Day test for homogeneity of odds ratios using SAS version 9.2 (SAS Institute Inc., Cary, NC).

In 2010, the New York State comptroller's office completed an audit of local lead control programs that provided additional evaluation of the lead law and its interactions with other local lead poisoning prevention efforts (Office of the New York State Comptroller 2010). Finally, the roles of the authors as participant observers (K.S.K. as a member of CPLP, M.A. as a member of CGR staff, and R.M. as Executive Director of the NCHH) provided ongoing access to the community, private, and government groups involved in the policy development and implementation process. Our findings are based on analysis of health department blood lead and city inspection databases and observational, qualitative (focus group), and quantitative (survey) data.

Our analysis focuses on the three major areas of concern that were debated before the law was passed: the inspection process of the city, the effectiveness of the law in protecting children from housing-based lead hazards, and the impacts on the housing market. We conclude with recommendations for future research and lessons learned for other communities interested in developing lead policies.

Results

Implementation of the law: city housing inspections. Before the law was passed, debate about the proposed inspection process centered around two key issues: the cost of the lead inspections, and whether the city inspectors had the capacity to inspect all high-risk rental properties by 2010. To implement the lead law, the city hired and trained four new lead inspectors whose primary responsibility was to perform dust-wipe tests in high-risk units that passed a visual inspection for deteriorated paint. These inspectors, additional administrative needs, and analysis of lead dust wipes cost approximately $600,000 per year.

During discussions of the impacts of the lead law, city staff had estimated that they would inspect approximately 16,500 units each year. A total of 58,177 interior visual inspections were conducted in the first 4 years (Table 1)—within 15% of the number predicted by city staff before the law was adopted. As a result, the city was able to inspect nearly all pre-1978 rental units during the first 4 years of implementation.

During the first 4 years of implementation, 94% of inspected properties passed the interior visual inspections (Table 1). This passing rate was much higher than had been anticipated based on prior lead assessments in high-risk areas. For example, in 2004, a community-based project that conducted full risk assessments in 70 homes in a high-risk neighborhood in Rochester found deteriorated leaded paint, lead in soil, or lead dust hazards in 95% of units (Korfmacher 2008; O'Fallon and Dearry 2002). As a result of this survey, as well as observations by city and county inspectors, CPLP members expected that Rochester would have much higher rates of housing with deteriorated paint than the national average. The National Survey of Lead and Allergens in Housing, a nationally representative, random sample of 831 housing units surveyed between 1998 and 2000, found only 14% had significantly deteriorated paint (Jacobs et al. 2002). Given the prior expectations, CPLP members were surprised that the actual visual inspection passing rate was higher than those in the national survey.

The national survey also indicated that lead in dust or soil lead hazards may exist in a significant number of units that pass a visual inspection (Jacobs et al. 2002). To address this risk, the Rochester law requires that units in high-risk areas that pass an interior visual inspection for deteriorated paint also pass a dust-wipe test. During the first 4 years, 20,555 units were referred for dust-wipe inspections (Table 2). A lower percentage of referred units received dust-wipe inspections in the first 2 years than in the second 2 years of implementation (77% vs. 88%; $p < 0.001$). According to city officials, the initially slow rate of dust testing was due to administrative challenges in scheduling follow-up visits with landlords. The increased proportion of referred units receiving dust-wipe testing in later years reflects increased efficiency of implementation as city inspectors and landlords adjusted to the requirements of the new law. Because of phased-in implementation (to keep the inspectors' workload manageable, the city defined a smaller initial high-risk area in year 1), the total number of properties eligible for dust-wipe referrals increased in year 2 when the high-risk area was expanded to its full extent. This explains why the total number of units referred for dust wipes increased (from 3,850 to 5,778) in the second year.

Of the 17,050 units that actually received dust-wipe tests during the first 4 years of implementation, 89% passed. This passage rate exceeded predictions based on the National Survey of Lead and Allergens in Housing, in

Table 1. Interior inspections for deteriorated paint (visual inspections).

Inspection results	Year 1 1 July 2006–30 June 2007	Year 2 1 July 2007–30 June 2008	Year 3 1 July 2008–30 June 2009	Year 4 1 July 2009–30 June 2010	Total
No. of units inspected for deteriorated interior paint	16,449	11,607	13,355	16,766	58,177
No. (%) of units failing deteriorated interior paint inspection	958 (6)	1,380 (12)	699 (5)	684 (4)	3,721 (6)
No. (%) of units passing interior paint inspection	15,491 (94)	10,227 (88)	12,656 (95)	16,082 (96)	54,456 (94)

Years 1 through 4 after lead law implementation (1 July 2006–30 June 2010). Data from City of Rochester annual Lead Paint Poisoning Prevention Ordinance Inspection Review reports (City of Rochester 2005a).

Table 2. Dust-wipe tests in units passing visual inspections in high-risk areas.

Inspection results	Year 1 1 July 2006– 30 June 2007	Year 2 1 July 2007– 30 June 2008	Total for Years 1 and 2	Year 3 1 July 2008– 30 June 2009	Year 4 1 July 2009– 30 June 2010	Total for Years 3 and 4	Total
No. of units referred for dust-wipe test[a]	3,850	5,778	9,628	5,320	5,607	10,927	20,555
No. (%) of referred units that received dust-wipe test	2,850 (74)	4,606 (80)	7,456 (77)	4,654 (87)	4,940 (88)	9,594 (88)	17,050 (83)
No. (%) of units that passed dust-wipe test	2,420 (85)	3,936 (85)	6,356 (85)	4,242 (91)	4,518 (91)	8,760 (91)	15,116 (89)
No. of units cleared after failing dust-wipe test[b]	251	683	934	446	541	987	1,921

[a]Units located in high-risk areas that pass an interior inspection for deteriorated paint were referred for dust-wipe testing. [b]After failing the initial dust-wipe test, some units do not clear (complete required repairs and pass subsequent dust-wipe test) until a later year.

which only 67% of units with intact paint had no interior dust hazards (Clickner et al. 2001). Dust-wipe test passing rates significantly increased from years 1 and 2 to years 3 and 4 (85% vs. 91%; $p < 0.001$), which may indicate, as suggested by landlord survey and focus group participants, that property owners learned how to repair hazards effectively and to do these repairs before inspections as they gained experience complying with the law. Nonetheless, the dust-wipe testing identified almost 500 units each year (1,921 over the first 4 years of implementation) (Table 2) that had hazardous levels of lead in household dust, despite passing a visual inspection.

Because the city records exterior inspections by property (each of which may consist of multiple units), exterior violations data were reported separately from interior violations (Table 3). A total of 40,889 exterior inspections were conducted in the first 4 years; these inspections resulted in 5,637 citations (86% passing rate) for deteriorated paint or bare soil within 3 ft of the house. No clear pattern of change was observed in passing rates of exterior inspections over time.

Effectiveness of the law: impacts on children's blood lead levels. Evaluating the impact of the law on children's lead levels is complex. One approach is to track changes in the extent of lead hazards in children's homes. Ideally, one might conduct independent risk assessments in homes that had passed the city inspection to determine whether the environments were indeed lead safe. Because past research has correlated dust lead levels with blood lead levels, low dust lead levels in homes that passed the city inspection would suggest that the law is effectively protecting children's health (Lanphear et al. 1996, 1998b). However, conducting independent risk assessments of inspected units was prohibitively expensive and logistically challenging—landlords were unlikely to grant access to their properties for a nonmandatory inspection. Instead, CGR compared results of city lead inspections with the results of subsequent inspections conducted by the county health department as part of case management for an EBL child. Although this was uncommon, in several cases county inspectors found hazards in properties that recently had passed city inspections. City and county staff reviewed the specific lead hazards in these cases and found that many of the hazards identified by county inspections were below the *de minimis* standard of the city lead law for lead violations. Nonetheless, city staff plan to use these findings for ongoing training of city inspectors. Both the CGR report and the state comptroller's audit recommend that the city inspections office conduct annual cross-comparisons with health department inspections to identify any patterns of hazards in the homes of EBL children that were not detected during city lead inspections, or treatments that failed to eliminate hazards to children who were subsequently identified as having EBL.

A second approach to assess the effect of the lead law on children's health is to examine trends in blood lead levels before and after implementation of the law. Before the passage of the law, some CPLP members speculated that a flurry of home renovations (not using lead-safe work practices) would be conducted in an attempt to comply with the law and would generate additional lead-laden dust. Thus, there were concerns that initial implementation

Table 3. Visual inspections for exterior lead hazards (deteriorated paint or bare soil).

Inspection results	Year 1 1 July 2006–30 June 2007	Year 2 1 July 2007–30 June 2008	Year 3 1 July 2008–30 June 2009	Year 4 1 July 2009–30 June 2010	Total
No. of buildings inspected for exterior lead hazards	10,548	10,619	8,612	11,110	40,889
No. (%) of buildings that passed exterior lead hazards inspection	8,588 (81)	9,391 (88)	7,339 (85)	9,934 (89)	35,252 (86)

Table 4. Children's blood lead results, City of Rochester, July 2004–June 2008.[a]

	Preimplementation of lead law		Postimplementation of lead law	
Level of blood lead	Year −2 1 July 2004–30 June 2005	Year −1 1 July 2005–30 June 2006	Year 1 1 July 2006–30 June 2007	Year 2 1 July 2007–30 June 2008
No. of children screened	7,256	7,420	7,146	6,528
Mean BLL (µg/dL)	4.73	4.21	4.00	3.73
Median BLL (µg/dL)	4.00	3.00	3.00	3.00
No. of children with BLL ≥ 10 µg/dL	604	490	403	284
Percentage of children with BLL ≥ 10 µg/dL	8.3	6.6	5.6	4.4

BLL, blood lead level.
[a]These results are based on health department BLL data from the 2 years before and 2 years after implementation of the lead law (see Boyce et al. 2008).

Table 5. Positive properties in City of Rochester, by ownership status, July 2004–June 2009 [*n* (%)].[a]

Property type	Year −2 1 July 2004– 30 June 2005	Year −1 1 July 2005– 30 June 2006	Total for Years −2 and −1	Year 1 1 July 2006– 30 June 2007	Year 2 1 July 2007– 30 June 2008	Year 3 1 July 2008– 30 June 2009	Total for Years 1 to 3
Positive[a]	114	89	203	132	114	110	356
Positive and ownership status could be determined	108	88	196	129	104	97	330
Owner occupied	23 (21)	25 (28)	48 (24)	21 (16)	27 (26)	24 (25)	72 (21)
Investor owned[b]	85 (79)	63 (71)	148 (76)	108 (84)	77 (74)	73 (75)	258 (79)

[a]Units found to have lead hazards in the course of the health department's environmental investigation of lead in the home environment of a child with a blood lead level ≥ 15 µg/dL.
[b]Rental properties.

Table 6. Odds ratios of EBL children residing in rental property versus EBL children living in owned-occupied property, City of Rochester, July 2004–June 2009.

	Preimplementation of lead law			Postimplementation of lead law			
	Year −2 1 July 2004– 30 June 2005	Year −1 1 July 2005– 30 June 2006	Total for Years −1 and −2	Year 1 1 July 2006– 30 June 2007	Year 2 1 July 2007– 30 June 2008	Year 3 1 July 2008– 30 June 2009	Total for Years 1 to 3
Odds ratio (95% CI)	3.00 (1.43, 6.29)	3.93 (1.93, 8.00)	3.45 (2.07, 5.75)	3.49 (1.85, 6.59)	1.92 (1.05, 3.51)	2.15 (1.34, 4.08)	2.42 (1.69, 3.48)

might increase children's lead exposures. It is reassuring to note that the prevalence of EBL among children tested in Rochester declined from 8.3% 2 years before implementation to 4.4% 2 years after implementation ($p = 0.027$) (Table 4). Although it is possible that renovation-related exposures increased during this time period, but were masked by background declines in EBL, such an effect was not reflected in the overall proportion of children with EBL.

CGR pursued a third approach based on the fact that Rochester's lead law applied only to pre-1978 rental housing. In the 2 years before the law's implementation, 79% (year –2, 1 July 2004–30 June 2005) and 71% (year –1, 1 July 2005–30 June 2005) of positive properties (those the county found to have lead hazards in the course of investigating the housing of an EBL child with blood lead levels > 15 µg/dL) were rentals (Table 5), higher than the proportion of homes citywide that were rentals (56% in 2006). This is consistent with research findings that rental housing tends to have more lead hazards than owner-occupied housing (Jacobs et al. 2002). Because the lead law affects only rental housing, it was expected that the proportion of positive properties that were owner-occupied properties would increase after passage of the lead law. However, the proportion of positive properties that were owner occupied did not change significantly when comparing the 2 years before implementation with the 3 years after (24% vs. 21%; $p = 0.480$).

Another way to examine this effect is to see whether the proportion of EBL children who lived in rental housing declined relative to the proportion of EBL children who lived in owner-occupied homes after implementation of the lead law. Because of data limitations of the county health department's screening database, CGR was unable to determine the ownership status of all units in which a child with an EBL resides. Therefore, we used a case–control approach to compare a random sample, taken from screening data, of 100 EBL cases and 100 non-EBL cases for each year of implementation. We calculated odds ratios comparing EBL among children living in a rental unit versus an owner-occupied unit. The resulting analysis showed that odds ratios after implementation were lower than in the 2 years before implementation. However, this change was not statistically significant [2.42, 95% confidence interval (CI): 1.69, 3.48 vs. 3.45, 95% CI: 2.07, 5.75; $p = 0.276$] (Table 6).

Costs of compliance: impacts on rental housing market. During discussions leading up to passage of the lead law, one of the most significant areas of concern was the predicted economic impact of the lead law on the housing market in Rochester. Because of low property values and narrow profit margins in Rochester's rental housing, landlord groups asserted that the additional costs of complying with the lead law would cause widespread abandonment of rental properties. Although it is difficult to separate the impacts of the lead law from other ongoing changes in the housing market, the CGR landlord survey and focus group results suggest that the lead law has not resulted in significant additional costs to landlords nor disruption of the rental housing market.

Results from the CGR telephone survey of landlords of duplex properties contributed to understanding of the law's impacts on Rochester's rental housing market. Among the 183 respondents who provided cost of compliance information, 34% said they spent nothing, 37% spent < $1,000, and 30% spent > $1,000 (Table 7). The mean per unit cost of repairs was $1,726 (median, $300). Notably, owners of higher-value duplex properties (> $40,000) spent less on repairs than did owners of lower-value duplex properties; over half of the higher-value properties required no or minimal repairs to comply with the new law (55% spent < $250; median, $120).

Respondents were not asked to distinguish whether they made repairs in anticipation of an inspection or to comply with a citation under the law. However, the fact that so many properties passed visual inspections suggests that most owners undertook necessary repairs before their inspection took place. Although this may have contributed to the higher-than-expected passing rates, one possible drawback to property owners prepping their units before inspection is that workers performing repairs may not have been trained in lead-safe work practices, as required when a unit is cited under the lead law. The U.S. EPA Renovation, Repair and Painting rule (RRP), implemented in April 2010, requires training of all paid workers (including landlords) who disturb paint in pre-1978 dwellings (U.S. EPA 2008). Before implementation of the RRP, there was concern that repair work conducted without lead-safe work practices would result in units that would appear safe, yet have extremely high levels of lead in remaining dust (Breysse et al. 2007). However, the 88% passing rate for dust-wipe tests conducted in units that passed the visual inspection suggests that preinspection renovation work generally resulted in lead-safe units. Both of these factors suggest that landlords used lead-safe work practices when making repairs.

CGR's landlord focus groups affirmed that property owners did not find complying with the law prohibitively costly. Most violations were addressed by paint repair and cleaning, although some owners chose to conduct more extensive repairs, like window replacement. City inspectors provided property owners cited under the lead law with information on the city and county HUD-funded Lead Hazard Control grant programs in Rochester. Between 2003 and 2009, these and other local grant programs allocated $45 million to make > 1,200 units in Rochester lead safe (Office of the New York State Comptroller 2010). Although this was a small percentage of all the pre-1978 housing units in the city, these grant programs provided a resource to owners who needed financial assistance to undertake major repairs.

Before passage of the lead law, property owners also expressed concern about the cost of clearance testing. Under the lead law, owners must hire a private firm to conduct visual and dust-wipe testing after repairs are completed to clear the violation in a cited property. Initial estimates were that clearance testing would cost around $300 per unit. However, city staff reported that the average costs for clearance dropped to < $150 after implementation of the law as more firms became certified to conduct this testing and competition increased.

A separate concern raised by officials from the county Department of Human Services (DHS) was the impact that the law might have on demand for emergency housing. DHS provides emergency housing for a variety of crisis situations, including health and safety hazards. To examine this issue, CGR requested emergency placement data from DHS for 1 year before the law went into effect and for 2 years after. The number of

Table 7. Cost of repairs to comply with lead law [*n* (%)].

Repair costs	All respondents	Properties valued < $40,000	Properties valued ≥ $40,000
No. of duplex units	183 (100)	89 (100)	94 (100)
Total cost of repairs			
$0	63 (34)	21 (24)	42 (45)
$1–$250	25 (14)	16 (18)	9 (10)
$251–$1,000	42 (23)	24 (27)	18 (19)
$1,001–$2,500	25 (14)	15 (17)	10 (11)
$2,501–$5,000	16 (9)	7 (8)	9 (10)
> $5,001	12 (7)	6 (7)	6 (6)
Median cost	$300	$400	$120
Mean cost	$1,726	$2,265	$1,211

Data from Boyce et al. (2008). Data were taken from survey of owners of duplexes inspected in the prior year; respondents were asked to estimate costs for just those repairs made because of the lead law. These responses include both anticipatory repairs (prior to the inspection) and those conducted to correct a violation cited under the lead law.

emergency placements for lead contamination remained very low (between 3 and 13 of the approximately 9,000 annual emergency housing requests). According to city and county staff, the impacts of the law on demand for emergency placement may have been limited because *a*) many units are inspected and repaired while vacant; *b*) the majority of cited units can be repaired without relocating residents; and *c*) tenants and landlords prefer private relocation to emergency placement (i.e., staying with friends or relatives or going to a hotel). Overall, it appears that the lead law has not had the negative effects that some landlords predicted it would have on rental housing in Rochester. Indeed, the CGR focus group participants were "enthusiastic about the law and felt that it will help children in the City" (Boyce et al. 2008).

Discussion

Rochester used the best available medical and housing research, combined with local data, to design a cost-effective, targeted lead law. However, because many of the law's features were novel, there were many uncertainties about its potential consequences. Using diverse sources of available information, we explored a variety of perspectives on the law's impacts. Our analysis was limited by the nature, extent, and quality of available data, including the health department blood lead screening database and the city inspections records. The new data collection efforts conducted by CGR (the landlord survey and focus groups) were limited by their small sample size. Nonetheless, our analysis of the available data suggests several lessons for other communities considering local lead laws.

First, it appears that Rochester's system is reducing lead hazards in rental housing. Although the lead law protocol does not result in elimination of lead hazards, it does raise the bar for lead safety in the city's highest risk housing. Because landlords can opt to use interim lead hazard controls instead of permanent lead hazard abatement, it is essential to continue regular inspections to monitor lead safety over time. The existence of higher-standard lead hazard control programs, such as the health department's system of environmental investigations for EBL children and HUD lead hazard control grants for houses needing major repairs, provides the opportunity for ongoing quality control.

Second, the law contained several built-in provisions to monitor its effectiveness. For example, the requirement for dust-wipe testing in units that pass a visual inspection provides an objective source of quality control for the visual inspections. Because the law requires an annual implementation report, both city council and the public can track the number of inspections and passing rates over time.

Third, the design of the Rochester law requires ongoing collaboration among stakeholders. For example, as emphasized by City Council Resolution 2005-24 (City of Rochester 2005c), community education efforts are essential to make sure that tenants know *a*) their roles in maintaining lead-safe housing (e.g., cleaning, reporting damaged paint), *b*) their right to request inspection on demand, and *c*) ways to protect themselves from landlord retaliation. The availability of free lead-safe work training is also important to ensure that owners who do work on their properties do so safely. Financial resources to help landlords make repairs, to subsidize clearance costs, and to support the inspection program also support effective implementation. Continued community advocacy and commitment by local government leaders can help ensure that these resources remain available.

Many questions remain about the impacts of Rochester's lead law, including

- Effectiveness of inspection protocols: The fact that only 6% of Rochester properties failed visual inspections suggests that either property owners were making sure paint was in good repair before their inspections or that visual inspections were not identifying all deteriorated paint. The high dust-wipe passing rate suggests that the visual inspections were effective in identifying lead hazards; otherwise, more units would have failed the dust-wipe tests. Alternatively, the higher-than-expected dust-wipe passing rate calls into question the effectiveness of the dust-wipe tests themselves. Dust-wipe protocols are standardized; however, they may miss hazards. For example, dust-wipe results may be skewed by taking samples only in well-cleaned areas. Rochester's high dust-wipe test passage rate suggests that either landlords were successfully addressing lead dust hazards before inspection or that the inspections were not fully effective in identifying hazards. A systematic study of the city's dust-wipe tests could determine whether they are conducted effectively and consistently.
- Long-term costs and effectiveness: The lead law allows interim controls of lead hazards, which by definition do not permanently address lead hazards without ongoing maintenance. As properties come up for reinspection, it is important to monitor whether interim controls have been maintained and whether landlords have found it cost effective to implement more permanent measures. Comparing inspection results on properties with their prior inspection records and repeating the landlord survey could shed light on these questions.
- Impacts on high-risk families: This evaluation did not directly address how the lead law has affected families at risk of lead poisoning. Although there are no data suggesting that the law is causing homelessness (as indicated by the low rate of lead-related emergency housing placements), it is possible the law has made it more difficult for families to find housing. It is also not known how well tenants understand their rights under the law and their role in maintaining lead safety over time.
- Long-term effects on blood lead levels: Inspection results, landlord feedback, and qualitative observations from staff at implementing agencies suggest that the lead law has contributed to declining blood lead levels among children living in rental housing, but other factors (e.g., ongoing demolition of high-risk housing, grant programs, public education) have likely contributed also. It is important to continue to monitor inspection results, blood lead levels, and the ownership status of units where EBL children reside. It might also be revealing to compare EBL rates over time in high-risk census tracts in Rochester with those in similar cities that do not have a lead law.

Rochester's lead law embodies several new approaches to reducing lead hazards in housing that were designed to be cost effective. Many other promising proposals were considered and rejected during the policy debate that may be adopted in other cities. As other communities experiment with lead policy innovations, they should evaluate and share their experiences to contribute to our national understanding of how to design effective local lead policies.

Conclusions

Evaluation is a critical part of the policy process (Hu and Brown 2003). However, evaluation of local policy impacts is often neglected because of financial limitations, available staff time, data constraints, and technical complexity. In the case of the Rochester lead law, the support of a local foundation and a partnership of private consultants, academics, government, and community groups provided valuable insights into the initial impacts of this groundbreaking local law.

Implementation has proceeded much as predicted, with nearly all pre-1978 rental units inspected by the end of 2010. The resources required for implementation have been similar to what was anticipated by the city. Although city government has strongly supported this program, there are concerns that implementation costs may not be sustainable because of anticipated future budget constraints.

Despite assertions by landlord advocates that adopting the lead law would result in massive abandonment of rental properties, the lead law does not appear to have had a significant impact on the rental housing market. Although a comprehensive analysis of changes in the housing market attributable to the lead law was beyond the scope of our study, publicly available housing data did not indicate a marked change.

The evaluation also suggests that the lead law has contributed to continued declines in children's blood lead levels by decreasing the extent of lead hazards in pre-1978 rental housing; however, additional information on the proportion of EBL children living in targeted housing is needed to confirm this finding. The fact that 94% of units passed visual inspections and that 89% of tested units passed dust-wipe inspections during the first 4 years—both much higher passing rates than predicted based on prior local and national studies—is perhaps the strongest indicator that the lead safety of rental housing has improved since passage of the Rochester lead law. The high visual inspection passing rate may indicate that landlords are performing repairs to reduce lead hazards before inspections. In addition, the unexpectedly high passing rates for dust wipes suggest that these repairs are being done using lead-safe work practices. Alternatively, the dust-wipe tests may not be identifying all hazards. Therefore, it is essential to conduct ongoing quality assurance inspections to make sure dust-wipes tests are being carried out effectively. The trends in children's blood lead levels do not suggest that the law has created new hazards; additional analysis would be needed to confirm that the lead law is protecting children from being exposed to lead hazards over time.

Government, academic, private-sector, and community groups continue to communicate regularly about the lead law. These conversations allow stakeholders to jointly identify weaknesses, develop solutions, and prioritize approaches to new challenges. The implementation environment of state and federal policies, the housing market shifts, and implementation resources are constantly changing. Over time, therefore, Rochester's collaborative process of evaluation may be a key to the long-term success of its new lead policy.

Local lead laws can help protect children from the lead that will remain in U.S. housing for decades to come. They are an important complement to federal and state programs and policies currently in place, particularly in high lead risk communities. However, our understanding of the most effective local approaches is in its infancy. Therefore, efforts to evaluate local policy innovations may be a key to sustaining declines in lead poisoning. Local governments and communities need pragmatic, sustainable systems to track progress over time, identify unintended consequences, and suggest opportunities for improvement in their policy innovations.

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