

# Primary Prevention of Childhood Lead Poisoning Through Community Outreach

Thomas L. Schlenker, MD, MPH, Renee Baxmann, RN, Peter McAvoy, MS, JD;  
John Bartkowski, RN, PhD, Amy Murphy, MPH

## ABSTRACT

**Background:** The prevalence of childhood lead poisoning has substantially decreased in Milwaukee, Wisconsin over the past decade. Nevertheless, by the mid 1990s, 30% of children were still found to have elevated blood levels.

**Objective:** To extend the reach of the Milwaukee Health Department (MHD) to previously underserved families in 1 inner city neighborhood with extremely old housing, the Sixteenth Street Community Health Center (SSCHC) implemented, in 1995, the Community Lead Outreach Project (CLOP). Going door-to-door, CLOP attempted to identify children 6 months to 6 years old with elevated blood lead levels (BLL), referring those  $\geq 20$   $\mu\text{g}/\text{dL}$  to MHD and enrolling those with BLLs 10-19  $\mu\text{g}/\text{dL}$  in a program of prevention education and environmental clean-up with the specific aim of preventing BLLs increasing to 20  $\mu\text{g}/\text{dL}$  and above.

**Methods:** A team of community outreach workers led by a nurse-coordinator visited, over a 4-year period, families in their homes in 13 census tracts surrounding the SSCHC. During the home visits, capillary blood samples for BLLs were drawn, environmental assessments and scoring were conducted, lead poisoning prevention education provided and repair and cleaning of household lead hazards demonstrated. For control and comparison, BLL data for the entire city by ZIP Code and provider were obtained from the Milwaukee Health Department. Odds ratios for changes in the proportions of children screened  $\geq 10$   $\mu\text{g}/\text{dL}$  were

calculated and compared for the years 1996 through 1999. The odds ratios of changes for various populations were compared for significant differences using tests of homogeneity. To control for age confounding, proportions of elevated BLLs for all groups and for all years were age-standardized, using the direct method.

**Results:** Over the entire study, 20.9% of the children screened had BLLs  $\geq 10$   $\mu\text{g}/\text{dL}$  and 3.0% were  $\geq 20$   $\mu\text{g}/\text{dL}$ . For 395 children with BLLs 10-19  $\mu\text{g}/\text{dL}$  enrolled in the CLOP follow-up program, the mean BLL was 12.9  $\mu\text{g}/\text{dL}$ . Mean levels at the first, second and third follow-up visits were 10.8, 10.3 and 9.8  $\mu\text{g}/\text{dL}$  respectively, showing an overall decline of 3.1  $\mu\text{g}/\text{dL}$  or 24%. At the first follow-up visit, 97% of the children tested were  $< 20$   $\mu\text{g}/\text{dL}$  while 76% were  $< 10$   $\mu\text{g}/\text{dL}$ . By the second follow-up visit, 100% were  $< 20$   $\mu\text{g}/\text{dL}$ . Initial environmental scores averaged 24.7, declining to 19.0 at first, 17.8 at second and 14.8 at third follow-up visits. For the entire CLOP population, the proportion of children testing  $> 10$   $\mu\text{g}/\text{dL}$  declined each year from 46.3% in 1996 to 22.5% in 1999. The geographic area in which CLOP operated recorded the highest screening penetration rate in the city: 61%. The odds ratio for CLOP clients to have elevated blood lead levels at the end of the study period, in contrast with the beginning, was 0.34 compared to 0.55 for the entire city and 0.75 for private physicians serving the same general population. Comparison of odds ratios showed the CLOP target population enjoyed a decrease in rate of elevated BLL 1.6 times that of the city-wide average,  $p$ -value = 0.016 and more than double that of the patients of area private providers.

**Conclusions:** We conclude that the Sixteenth Street Community Health Center Childhood Lead Outreach Project has successfully accessed populations of children with high rates of lead poisoning who had escaped more traditional screening venues and effectively intervened to reduce their BLLs to

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<10 µg/dL. Moreover, CLOP produced impressive and unanticipated primary prevention benefits in the community at large. The demonstrated ability of community outreach workers to access high-risk populations and reduce exposure to lead hazards suggests the potential of this strategy for extension to other geographic areas, to the patients of private physicians and to address other prevalent, urban health problems like asthma, injuries and violence.

## BACKGROUND

Lead poisoning has been called the most common and devastating environmental disease of young children in the United States. Levels as low as 10 µg/dL are associated with harmful effects on learning and behavior.<sup>1,2,3</sup> As late as the 1980s, it was estimated that more than 4 million US children had blood lead levels (BLL) greater than 15 µg/dL.<sup>4</sup> In more recent years, substantial nation-wide improvement has been achieved. Geometric mean BLLs for children ages 1-5 years old declined from 15.0 µg/dL during 1976-1980<sup>5</sup> to 2.7 µg/dL during 1991-1994.<sup>6</sup> Nevertheless, data from the early 1990s estimated that there remain 900,000 children with BLLs at or above 10 µg/dL and 85,000 at or above 20 µg/dL. Most of these are poor, inner-city, pre-school age children who exhibit no acute symptoms of poisoning and often go undiagnosed during routine medical care.

Milwaukee, WI is a Midwestern city with considerable poverty, a large stock of older, lead paint contaminated housing and a proportion of children with elevated lead levels that is much greater than the US national average. Over the years, the nationally recognized Milwaukee Health Department Lead Poisoning Prevention Program has significantly reduced local lead poisoning rates. Yet, by the mid 1990s, 30% of all children screened were still found to have blood lead levels at or above 10 µg/dL, more than 6 times the US national average of 4.4%.<sup>7</sup> Annually, over 1000 children tested at or above 20 µg/dL, requiring medical follow up and environmental remediation. Sixty to 70 tested at or above 45 µg/dL, requiring chelation, a painful and time consuming process of in-hospital infusions and injections. The persistence of childhood lead poisoning in inner-city Milwaukee demanded new and innovative strategies.

In 1995, the Sixteenth Street Community Health Center (SSCHC) began the Community Lead Outreach Project (CLOP) in conjunction with and in order to extend the reach of the Milwaukee Health Department. CLOP's goal was to reduce, through early intervention, lead poisoning rates in children in

one South Side Milwaukee neighborhood where a poor and ethnically diverse population inhabits the city's oldest housing. CLOP trained and fielded a core of community-based, bilingual, outreach workers to visit the homes of families with young children. During the home visits, the outreach workers performed blood lead testing, conducted visual environmental assessments, demonstrated lead hazard clean-up and provided culturally sensitive lead poisoning prevention education in the primary languages spoken by the families. Children with BLLs 10-19 µg/dL, considered the primary target population, were enrolled in the CLOP program of follow-up home visits for repeat blood lead testing, environmental assessments and education. The project's goal was to prevent these children from rising to BLLs 20 µg/dL and above, levels which are incontrovertibly associated with long-term cognitive and behavioral impairments.<sup>7,8,9,10</sup> The following study reports the results of the first 4 years of the CLOP intervention and compares the decline of lead poisoning rates among children served by CLOP, SSCHC primary care, private physicians in the same geographical area and all providers city-wide.

## METHODS

### *Study population*

From July of 1995 through June of 1999, families living in 13 contiguous census tracts (155, 156, 157, 158, 163, 164, 165, 166, 167, 168, 169, 174, 175) on the near South Side of Milwaukee, all within the service area of the Sixteenth Street Community Health Center, were targeted for home visits. The study population included children 6 through 71 months of age. Adjusted Milwaukee Public School system data for 1997 showed the total population of children of these ages for the targeted census tracts was 5062. According to the 1990 US Census, ZIP Code 53204, which roughly encloses the targeted census tracts, contains a population 47.2% White, 2.7% Black, 2.9% Indian, 5.3% Asian, 41.7% Hispanic and 0.2% other. Fifty percent of adults lack high school diplomas, 49.1% have annual family incomes below \$15,000 and 70.7% below \$25,000. Based on Milwaukee Master Property File data, 97.2% of the housing in the 53204 ZIP Code was built before 1950 while 56.2% was built before 1900. Seventy-three percent of units are rentals. Average value for duplexes in 1994 was \$35,772.

### *Intervention*

The Sixteenth Street Community Health Center is a federally qualified community health center serving Milwaukee's near South Side with special attention to

**Table 1. Proportions of Blood Lead Levels >10 µg/dL by Age, 1996-1999.**

Age in months	Year	CLOP	SSCHC	Privates	City	No. Screened
0-11	1996	28	16	26	15	1431
	1997	00	08	24	12	1493
	1998	14	14	15	09	1754
	1999	.00	.03	.11	.06	2227
12-23	1996	53	40	33	32	3542
	1997	54	44	33	28	3951
	1998	31	35	30	22	4622
	1999	.26	.17	.26	.19	5254
24-35	1996	66	45	39	43	2149
	1997	50	42	43	42	2252
	1998	49	41	37	34	2127
	1999	.31	.21	.32	.32	2222
36-47	1996	48	35	30	38	2007
	1997	35	30	32	39	2053
	1998	43	27	33	33	1607
	1999	.22	.12	.32	.28	1530
48-59	1996	41	31	24	30	1666
	1997	13	22	26	33	1605
	1998	41	38	22	28	1252
	1999	.29	.19	.20	.25	1079
60-71	1996	37	28	27	25	1292
	1997	17	34	28	25	1156
	1998	12	14	16	21	854
	1999	19	00	12	20	721

Latino and Asian populations and a steadfast commitment to understanding and taking into account the factors that influence the everyday lives of families. For the Community Lead Outreach Project, the SSCHC assembled staff that consisted of a nurse-coordinator and up to five outreach workers at any one time. The nurse, previously experienced in lead poisoning, received further training in childhood lead poisoning prevention from MHD nursing and environmental personnel and SSCHC clinical and laboratory staff. The nurse hired culturally sensitive, bilingual (English/Spanish and English/Hmong) outreach workers from the targeted community who generally had no previous technical training or background. The outreach workers were trained in phlebotomy with the help of an MHD video and their technique supervised by the nurse-coordinator. The workers, while not formally trained or certified as lead inspectors or risk assessors, did receive training from MHD lead inspectors on how to conduct a visual assessment of household interior and exterior painted surfaces in order to identify probable lead-based paint hazards. They were equipped with various clean-up supplies (buckets, rags, detergent, tape, etc.) as well as high-energy particulate accumulator (HEPA) vacuum cleaners for in-home demonstration. Some of the outreach workers were also trained

in community capacity building by the Wisconsin Action Coalition and spent some of their time organizing the South Side Parents Against Lead (PAI) coalition.

CLOP outreach workers attempted to visit each home within the targeted census tracts and made repeated visits, including during evenings and weekends, to homes noted to contain children. Blood samples for lead measurement were obtained (with written, signed, parental consent) from as many age appropriate children as possible who, by parental report, had not previously been tested. Previous tests reported were confirmed by record checks of the Milwaukee Health Department (MHD) database. In agreement with the Milwaukee Health Department, CLOP referred children with BLLs of 20 µg/dL or above to MHD for medical management, public health nursing and environmental intervention. Children with BLLs 10-19 µg/dL were enrolled in the CLOP follow-up program and visited, on average, 2-3 times during the subsequent 12-month period for repeat blood tests, environmental assessments and education. Children who had moved or were otherwise unavailable for follow-up were lost from the study.

The environmental survey that was employed by the outreach workers at first and subsequent visits

**Table 2.** Proportions of Blood Lead Levels > 10 µg/dL by Provider, 1996-1999

Category	1996	1997	1998	1999	OR	OR Ratio	95% CI	P-value
<b>City</b>								
BLL ≥ 10 µg/dL	3829	3864	2978	2642				
Number tested	12087	12510	12216	13033				
Proportion elevated	.32	.31	.24	.20	0.55	NA	NA	NA
Age-standardized	NA	NA	NA	NA				
<b>CLOP</b>								
BLL ≥ 10 µg/dL	99	42	74	52				
Number tested	214	126	228	231				
Proportion elevated	.46	.33	.33	.23	0.34	1.62	1.09-2.49	0.016
Age-standardized	.48	.35	.33	.22				
<b>SSCHC</b>								
BLL ≥ 10 µg/dL	130	137	115	82				
Number tested	383	410	372	677				
Proportion elevated	.34	.33	.31	.12	0.27	2.04	1.51-2.86	<0.0001
Age-standardized	.34	.33	.31	.14				
<b>Private providers</b>								
BLL ≥ 10 µg/dL	261	242	212	182				
Number tested	857	766	764	734				
Proportion elevated	.31	.32	.28	.25	0.75	0.73	0.59-0.94	0.012
Age-standardized	.31	.32	.28	.24				

was developed by SSCHC in collaboration with MHD.<sup>12</sup> Each household was assessed by numerical score for housing unit age, exterior paint condition, interior paint condition, window condition and exposed soil in the yard. Environmental lead sampling was not performed. Composite environmental survey scores of <16 were considered low risk, 16-32 moderate risk and > 32 high risk.

### Laboratory methods

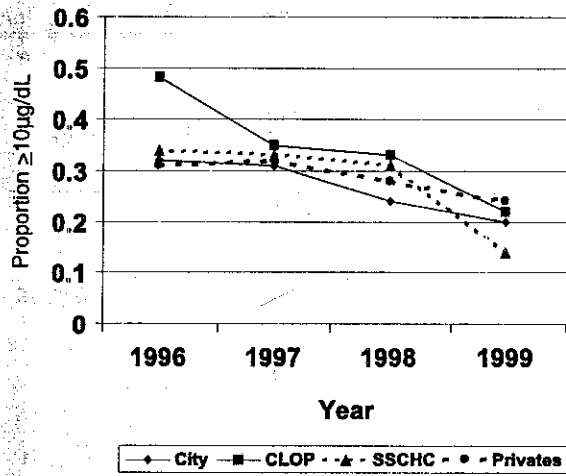
Community outreach workers, under the ongoing supervision of the nurse-coordinator, obtained micro blood samples (approximately 0.5 milliliters) from children in their homes, using capillary sampling techniques and supplies developed and tested by the MHD.<sup>13</sup> All blood lead measurements were performed by the MHD chemistry laboratory (a participant in the Blood Lead Proficiency Testing Program of the Centers for Disease Control and Prevention, Wisconsin State Laboratory of Hygiene and the US Health Resources and Services Administration) using graphite furnace atomic-absorption spectrophotometry.<sup>14,15</sup>

### Statistical methods

Demographic, BLL and environmental data were compiled over the years of the study for all children enrolled in CLOP. BLLs and environmental scores for children and their households were tracked over time to establish trends. For practical and ethical rea-

sons, no control population was enrolled. Instead, changes in proportions of CLOP children with elevated lead levels were compared for reference to city-wide averages and populations in the same geographic area served by other providers. From the Milwaukee Health Department, the repository for all local blood lead screening data, BLLs, stratified by age, from calendar years 1996 through 1999, city-wide, by ZIP Code, by medical provider were obtained. Proportions of children with BLLs ≥ 10 µg for the city as a whole, by ZIP Code and by provider, including CLOP, were calculated for each year 1996 through 1999. Within ZIP Code 53204, children, for whom provider identification was submitted with their blood samples, were sorted by groups: CLOP (those who were first sampled during home outreach visits), SSCHC (those attending the SSCHC primary care clinic and first tested there), and children from the ZIP Code 53204 served by private medical providers. Odds ratios for change in proportions from 1996 to 1999 were calculated for each population and comparisons between odds ratios (ratios of odds ratios) to establish relative risk were calculated using the Breslow-Day test for homogeneity.<sup>16</sup> To control for age confounding, proportions of elevated BLLs by provider and by year were standardized for age using the direct standardization method.<sup>17</sup> The distributions of ages among all children screened city-wide for each year 1996

Figure 1. Lead Poisoning Trends, Milwaukee 1996-1999



through 1999 were used as the standard reference populations. Screening penetration rates, based on adjusted Milwaukee Public School estimates for 1997 for children 0-71 months of age, were calculated for Community Development Block Grant (CBDG) Planning Areas for the entire city for 1998, with Planning Area 16 roughly corresponding to the CLOP target area.

**RESULTS**

From July 1995 through June 1999, CLOP determined blood lead levels on 1850 children 6-71 months of age living in the 13 census tracts of the target area. The children sampled were 81% Hispanic, 9% Caucasian, 6% Asian, 3.5% African American and <1% American Indian. Forty-one percent of their parents had eighth grade education or less and 95% earned annual incomes less than \$25,000. The large majority were renters (85%) and 62% had moved within the previous year. The housing units in which they lived were very old: 98% built before 1950, 66% built before 1900.

The mean age of the 1850 children tested was 2.2 years old (Interquartile range = 1.0-3.6). Median BLL was 5.3 µg/dL (Interquartile range = 2.9-9.0). For all 4 years of the study, the mean proportion of children who tested ≥10 µg/dL was 20.9% including 3.0% ≥20 µg/dL. For the 395 children with BLLs 10-19 µg/dL (331 identified through CLOP door-to-door home visits and 64 referred to CLOP for follow-up by the Sixteenth Street Community Health Center) the mean BLL was 12.9 µg/dL. Their subsequent BLLs obtained at 3-6 month intervals were: first follow-up (232 children) 10.8 µg/dL, second follow-up (116 children) 10.3 µg/dL and third follow-up (55

children) 9.8 µg/dL. Overall the decline in BLLs from initial to 3rd follow-up visit was 3.1 µg/dL (24%). For the 143 children 10-19 µg/dL enrolled in CLOP during the fourth year of the program, the only year in which such rates were calculated, 76% of those who received the first follow-up BLL had dropped below 10 µg/dL and 97% were below 20 µg/dL. At second-follow up visits, 100% were below 20 µg/dL.

The environmental surveys of the households of the children with BLLs 10-19 µg/dL showed somewhat higher risk scores than those for children 0-9 µg/dL: 24.7 (SD 12.2) vs 21.8 (SD 12.3). After the first visit, during which lead poisoning prevention education and lead hazard clean-up demonstration were provided, follow-up visits to the households of children in the 10-19 µg/dL group demonstrated risk scores at first follow-up 19.0, second follow-up 17.8, third follow-up 14.8. Based on the CLOP scoring system, the average environmental risk for all CLOP households decreased from moderate risk to low risk.

Milwaukee Health Department city-wide BLL data by provider for children 0-71 months uniformly excludes cases without an identified provider. Because of missing provider identification, the MHD file for 1996 through 1999 contained smaller numbers of CLOP children tested and registered somewhat different proportions of elevated lead levels than CLOP's own data file. Over the 4-year period, the MHD data showed progressive city-wide improvement, as measured by proportion of children tested for the first time with BLLs at or above 10 µg/dL. City-wide, and in all subgroups, the median ages of all children tested tended to decrease over the 4 years of the study, presumably because the backlog of older, never been tested children, was progressively eliminated. The proportions of blood lead levels > 10 µg/dL by age for each of the categories in each of the years plus the total number of children 0-71 months old screened city-wide (the standard reference populations for each year) are listed in Table 1. The number of children tested yearly, numbers and proportions at or above 10 µg/dL for each category, odds ratios comparing total improvement in risk over four years, comparisons of odds ratios for relative risk between subgroups and the city as a whole and age-standardized proportions are listed in Table 2. Over the 4 years of the study, the proportion of children tested with BLLs ≥10µg/dL for the entire city of Milwaukee declined by 38%. Within the 53204 ZIP Code area, declines among age-adjusted children served by CLOP, SSCHC and private

providers were 54%, 59% and 23% respectively. The trends in elevated blood lead levels among age-standardized clients served by the 3 providers in ZIP Code 53204 and city-wide are represented graphically. Combining first-time BLLs from all providers, MHD calculated the screening penetration for children 0-71 months old in 1998 for city-wide, NSP planning areas. Penetration rates ranged from 34% to 61% for all 17 planning areas with a mean of 45%. Planning area 16, roughly corresponding to the CLOP target area, had the highest penetration rate of 61%.

## DISCUSSION

Various lead hazard abatement and interim control strategies have been found to reduce blood lead levels in children. However, in a recent review, the Environmental Protection Agency found that, although blood lead levels can be reduced, none of the 19 intervention strategies studied consistently brought concentrations below the level of concern: 10 µg/dL.<sup>11</sup> The EPA suggested that primary prevention, "preventing lead exposure before it occurs in the first place," may be the more effective approach.

Properly done, lead hazard abatement produces lead safe housing but it is costly, administratively complex and takes years to be fully carried out. Conversely, interim control strategies, based on screening, family education and assistance with environmental clean-up are cheaper, easier and can be rapidly implemented. Unfortunately, interim control strategies have not always been successful.<sup>18,19,20</sup> In randomized controlled studies, Rhoads' group in New Jersey reported a 17% reduction in blood lead levels over 1 year<sup>21</sup> while Lanphear's group in Rochester, NY, reported no improvement.<sup>22,23</sup> In Milwaukee, a pilot study in the early 1990s employing community outreach workers lowered average BLL by 21%.<sup>24</sup>

Community outreach workers have long played key roles in some public health efforts, such as tuberculosis control.<sup>25</sup> Recruited from and reflecting the racial, linguistic and cultural characteristics of the communities they serve, they excel at gaining access to and the trust of high-risk populations.<sup>26</sup> Through the SSCHC Community Lead Outreach Project, community outreach workers, working in a neighborhood containing Milwaukee's oldest housing (average age approximately 100 years) and interacting with a poor, educationally limited, highly mobile, multi-cultural and multi-lingual population, helped produce the highest blood lead screening penetration rates in the city. CLOP workers reached high risk children who, for whatever reason, had not accessed

physician office-based or Health Department screening programs. A significant proportion of these children (46% in the first year of the project) were found to have elevated blood lead levels. For the 395 children with BLLs 10-19 who were enrolled in CLOP follow-up, their home environments improved and their BLLs decreased, with the large majority dropping below 10 µg/dL within a few months of enrollment.

Based on comparison of uniform health department data sets, it is clear that CLOP also obtained significant success in the primary prevention of childhood lead poisoning. From 1996 to 1999, the proportion of CLOP children tested for the first time with BLLs  $\geq 10$  µg/dL decreased from 46% to 23%, bettering city-wide improvement by 1.6 times and more than doubling the improvement seen among children from the same neighborhoods served by private physicians. The success of SSCHC primary care is also remarkable. Despite the fact that "primary prevention of lead ingestion through the provision of anticipatory guidance is a major role of pediatricians," private practitioners in ZIP Code 53204 lagged behind CLOP and SSCHC and were below average compared to city-wide improvement for the 4 years of the study.<sup>27</sup>

CLOP's success at primary prevention suggests that younger children coming of age, older children who had missed previous screenings and new arrivals to the neighborhood benefited from prior household risk reduction and parental education. The magnitude of the decline in lead poisoning rates suggests extensive diffusion of effective prevention activities beyond nuclear families to relatives and neighbors in the community. New tenants, a large group in an area where 85% of residences are rentals and 62% of all families move each year, may have especially benefited by efforts to motivate and enable families and landlords to improve the physical state of residential properties. Finally, a large part of CLOP's success must be ascribed to its base of operations, the Sixteenth Street Community Health Center and its doctors, nurses and allied staff who have built, over 30 years, a trusting and productive relationship with the community they serve.

In cities where levels of childhood lead poisoning remain high, renovation, abatement and replacement of lead contaminated housing is a slow and costly process while quicker and cheaper approaches to prevention based on screening and mass education may not be effective. To achieve the goal of eliminating childhood lead poisoning in the United States in this decade, we must address the remaining pockets

of at-risk children found in low income, inner-city, rental properties containing deteriorating, lead-based paint. In Milwaukee, community-based outreach, linked to a high-quality, community health center and working in collaboration with the local health department proved to be a rapidly effective and low cost strategy for primary and secondary prevention of childhood lead poisoning. With investment of resources, community outreach strategies could be duplicated in other inner-city areas and even extended to serve the large number of children seen by private practitioners. Also, community outreach interventions should be considered for other serious problems of in urban communities such as asthma, injuries and violence.

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