Evaluation of the Invest in Children Primary Lead Prevention Project

Leila W. Jackson

Despite extensive interventions to reduce lead exposures over the past several decades, lead poisoning remains a major environmental health threat to children in the United States. In Cleveland and Cuyahoga County, the prevalence of elevated blood lead levels far exceeds that of the United States; among children 0 to 72 months of age who were screened in 2009, 21% and 16% respectively, had blood lead levels ≥5 µg/dL.

Older housing stock is a significant risk factor for lead poisoning among children as the use of lead-based paint in houses was not banned in the United States until 1978. Children living in older homes within low-income neighborhoods are affected disproportionately as their residences are more likely to contain chipping, peeling, or water damaged paint that has not been properly addressed. These conditions combined with the normal hand-to-mouth behaviors of small children can result in ingestion and inhalation of lead dust, flakes, and contaminated soil.

Despite being an established and well-studied public health problem, the majority of lead poisoning intervention occurs at the level of secondary, rather than primary prevention; that is, efforts are aimed at screening children for lead poisoning between 1 and 6 years of age. We therefore designed a primary lead prevention study to evaluate the effectiveness of low cost, minor lead repairs and caregiver education in homes of newborn infants to prevent lead poisoning in these children. The lead repairs performed as part of this study were not meant to remove lead completely from the home, nor were the repairs meant to be permanent; however, they were meant to reduce the risk of elevated blood lead levels among young children when they are at the greatest risk. If low cost repairs are effective in preventing elevated blood lead levels in young children, more homes can be addressed in the near-term thereby decreasing the incidence of lead poisoning in children.

METHODS

Two designs were employed to evaluate this primary lead prevention program. First, a program-no program design was used to compare blood lead levels of study infants (target infants) to blood lead levels of a random sample of community-based infants. Second, a before-after design was used to determine the program effectiveness in 1) decreasing dust lead loadings in the home, 2) maintaining or decreasing blood lead levels of children who were 6-72 months of age at enrollment (resident children), and 3) increasing caregiver knowledge and practices related to lead hazards.

Families and property owners were consented for participation in the study before the newborn infant was approximately four months old. During this in-home visit, a visual inspection for lead hazards was completed, lead dust wipes were collected, blood lead levels of resident children were determined, and demographic characteristics of the mother were obtained.

Low cost lead repairs were completed on the home before the target infant's 6-month birthday. Repairs included paint stabilization, window trough treatment, and mulching of bare soil, followed by a standardized cleaning method. After the repairs were completed, dust lead loadings were confirmed to be below HUD (Department of Housing and Urban Development)/EPA (Environmental Protection Agency) clearance standards. The family was notified that not all lead was removed from the home, and remaining known lead hazards were discussed with the family. At the initiation of
the study, the estimated cost of repairs per home was $2300 (maximum $3,000), which was paid for by the study.

An education visit was completed approximately one month after repairs. At 6 and 12 months after the repairs, follow-up visits were carried out to obtain blood lead levels on the target infant and resident children, dust lead loadings in the home, and caregiver knowledge and practices related to lead hazards; knowledge of lead reduction activities was also reinforced during these visits. Families received a $40 gift card to a local food store at the education visit and the 6- and 12-month visits. This study was approved by the University Hospitals Case Medical Center Institutional Review Board for human subjects research.

**STUDY POPULATION**

This study was carried out in ZIP codes in Cleveland and its first ring suburbs in which children are known to be at high risk for lead poisoning. Women in the 3rd trimester of pregnancy or with infants less than 4 months of age were identified primarily through prenatal and newborn outreach programs. Primary eligibility criteria included infant less than 6 months of age at the time of repairs; home built before 1960; confirmed presence of lead hazard in the home; and all children between 6 and 72 months of age living in the home had blood lead levels <10 µg/dL.

Community-matched infants were selected from the STELLAR (CDC Systematic Tracking of Lead Levels and Remediation) database for the comparison of target infant blood lead levels. Target and community infants were matched on sex, age, year and quarter of blood lead test, and census tract with additional attempts made to match on type of blood draw (i.e. capillary or venous) when possible.

**BLOOD LEAD LEVELS**

Blood lead levels were obtained on resident children at baseline, and the target infant and resident children at 6 and 12 months post repairs. Blood lead tests were done on capillary blood samples, unless the parent requested a venous test or a recent venous test was available from STELLAR. All samples were analyzed by graphite furnace atomic absorption spectroscopy.

**DUST LEAD LOADINGS**

An Ohio-licensed lead risk assessor obtained dust lead loadings at four times during the study, including: consent, immediately after repairs, 6 months after repairs, and 12 months after repairs. All dust wipes were taken in accordance with HUD guidelines and standard practices outlined by the American Society for Testing and Materials; lead was quantified by flame atomic absorption spectrophotometry. EPA/HUD clearance standards were used to determine whether the dust lead loadings met clearance levels (floors: 40 µg/ft²; sills: 250 µg/ft²; troughs: 400 µg/ft²).

**LEAD EDUCATION**

A trained health educator provided an initial health education visit approximately one month after repairs with reinforcement at the 6- and 12-month visits. At the education visit, the caregiver was provided with and taught to use a HEPA vacuum, a doormat, and a cleaning kit to reduce lead hazards. At the start of the education and 6- and 12-month visits, a brief interviewer-administered survey evaluated the caregiver’s knowledge of how to reduce lead hazards and the frequency these activities were carried out. At the 6- and 12-month visits, the interview also included questions on the perceived importance of various lead
reduction activities and the difficulty of completing the activities.

RESULTS

Recruitment began in April 2006 and continued through December 2009 with follow-up through December 2010. A total of 196 houses, 200 target infants including 4 sets of twins, and 92 resident children were enrolled in the study. Lead repairs were completed on 129 homes with the average cost of repairs per home being $1931 (standard deviation [SD]: $714) compared to the projected cost per home of $2300. The education visit was completed by 99 families; the 6-month visit by 53 families, and the 12-month visit by 27 families. A large percentage of families were lost to follow-up or withdrew over the course of the study; the primary reasons for withdrawing from the study included families moving (31%) and the inability to contact a family (33%).

Among enrolled families, the mean maternal age was 24 years (SD: 8.2). The majority of mothers indicated they were non-Hispanic Black, unmarried, and had a high school degree or less. The mean age of target infants at consent was 2.5 months (SD: 1.4) and the mean age of resident children was 37.5 months (SD: 17.8). The majority (64%) of houses included in the study were built before 1920.

Blood lead levels: Among target infants, the season-adjusted geometric mean blood lead levels at 6 and 12 months were 2.2 µg/dL (95% confidence interval [CI]: 1.4, 3.5) and 2.7 µg/dL (95% CI: 1.5, 5.1), respectively; levels did not differ significantly by visit. Approximately, 15% and 21% of target infants had blood lead levels ≥5 µg/dL at 6 and 12 months post repairs as compared to 23% and 46% among community-matched infants (see Figure 1 on the prior page). As compared to community-matched infants, target infants were 41% and 76% less likely to have a blood lead level ≥5 µg/dL at 6 and 12 months post repairs, respectively.

Geometric mean blood lead levels of resident children were 3.8 µg/dL (95% CI: 3.2, 4.5), 2.6 µg/dL (95% CI: 1.5, 4.4), and 4.5 µg/dL (95% CI: 2.6, 7.5) at baseline, 6 months and 12 months, respectively; levels did not differ significantly over time. Forty-four percent of resident children had blood lead levels ≥5 µg/dL at baseline, dropping to 18% at 6 months and 20% at 12 months after repairs. The percent of resident children with blood lead levels ≥5 µg/dL at 6 months after repairs was lower than that observed for the City of Cleveland over the same period, while the percent at 12 months was similar to that observed for Cleveland between 2007 and 2010.

Dust lead loadings: Season-adjusted geometric mean dust lead loadings were significantly lower after repairs as compared to baseline levels (see Figure 2 to the right). While mean levels increased at 6 and 12 months after repairs, they remained significantly lower than baseline levels.

Examining specific surface areas, 45% of homes had one or more floor wipes exceeding HUD/EPA limits at the baseline assessment, decreasing to 15% at 6 months and 12% at 12 months after repairs. Sixty percent of homes had one or more sill wipes that exceeded HUD/EPA limits at baseline, decreasing to 31% at 6 months and 24% at 12 months after repairs. One or more trough samples failed in 88% of homes at baseline, decreasing to 63% at 6 months and 62% at 12 months after repairs. Trough wipes, followed by sill wipes were the most common reason for a house failing. Among the homes assessed at 6 and 12 months, 25% and 38%, respectively, failed solely due to trough wipes that exceeded HUD/EPA limits. Overall, 69% of homes had one or more dust wipes exceeding clearance limits at 12 months after repairs.
Lead education: Knowledge of specific activities to reduce lead exposure was low at the education visit, but increased over the course of the study with caregivers able to report significantly more activities over time (see Figure 3 to the right). Significant increases in the percent of caregivers reporting specific activities to reduce lead exposure were observed between the education visit and 12-month visit, respectively, for hand washing (8% vs. 44%), toy washing (6% vs. 48%), removing shoes (3% vs. 22%), mopping (7% vs. 26%), vacuuming (14% vs. 41%), and washing window troughs (21% vs. 52%).

There was also a significant increase in the reported frequency (often/always doing activity) of hand washing (67% vs. 93%), toy washing (60% vs. 70%), and vacuuming (61% vs. 89%) between the education and 12-month visits, respectively. The use of indoor doormats at some or all doors increased significantly between the education visit (54%) and 12-month visit (74%); however, there was only a slight and non-significant increase in the use of doormats outside.

At the 6-month visit, the majority of caregivers indicated that various lead reduction activities were somewhat or very easy to carry out; this did not change greatly at the 12-month visit. The primary reasons given for having difficulty completing activities was not having enough time or just forgetting. Some indicated they were unable to use doormats or to ask individuals to remove their shoes because it was not their home, and that individuals often would not listen to requests to remove shoes. The lack of enough doormats for all doors or concerns of doormats being stolen were also barriers to doormat use; however, a number of participants indicated the benefit of receiving a doormat from the project. In relation to cleaning window troughs, some indicated they did not open the windows or that windows were sealed for winter.

**DISCUSSION**

Over the 12 month follow-up of this primary lead prevention project, we observed a decreased probability of elevated blood lead levels among target infants as compared to community-matched controls, a decrease in blood lead levels among resident children, a significant decrease in dust lead loadings among homes receiving minor repairs, and an increase in knowledge and frequency of lead reduction activities among caregivers. These results are similar to those observed in other primary lead prevention programs carried out in the United States.

A primary prevention study in St. Louis that included lead repairs to homes observed significantly lower blood lead levels among intervention children (2.70 µg/dL; 0% ≥10 µg/dL; n=60) at 12 months of age as compared to community controls (3.73 µg/dL; 4.2% ≥10 µg/dL) matched on age and census tract. Though not statistically significant, we observed a substantial difference in the proportion of target and community-matched infants with blood lead levels ≥10 µg/dL at 12-months post repairs (5% vs. 21%, respectively). This was despite the minor repairs employed in our study as compared to the more extensive repairs in the St. Louis study. Furthermore, our results are less likely to be confounded by other factors given our more extensive matching criteria.

The minor repairs employed in this study resulted in dust lead loadings 12 months post-repairs that were similar to or better than a national study examining the long term effects of low-level treatment interventions. Furthermore, we observed a similar percent reduction in the number of homes failing EPA clearance limits between baseline and 12 months later as observed in a primary prevention program among families of newborns in Philadelphia that provided education and repairs. The Philadelphia study found an increase in overall knowledge; however, a direct comparison to our project cannot be made. Another primary prevention program that provided lead hazard education to pregnant mothers reported no effect on infant blood lead levels during follow-up as compared to controls. While we were unable to examine the association between education and blood lead levels within our study due to
small numbers, target infants were less likely to have elevated blood lead levels than community-matched controls at 6 and 12 months after repairs, and resident children were less likely to have blood lead levels ≥5 µg/dL at 6 and 12 months after repairs as compared to baseline. These differences may be due in part to increased knowledge.

Inferences made from this study should consider both the study strengths and limitations as discussed in the full report. Of greatest concern are the small sample size and the low retention rate over the course of the study. Despite having limited statistical power, we did observe significant changes in dust lead loadings; however, we were limited in our analysis of blood lead levels. The high mobility of our study population was expected with retention rates comparable to those observed in other similar studies. We did not observe significant differences between those who participated in follow-up visits and those who did not; however, some non-significant differences were observed; these differences should be considered when interpreting and generalizing the study results to a larger population.

Finally, it should be noted that while this study was designed to prevent lead poisoning among infants by reducing lead hazards in the home before their 6-month birthday, it did not address prenatal or breast milk lead exposures which have been associated with adverse health effects among infants. Prenatal exposure can be limited through removal of existing exposures prior to pregnancy, and proper maternal nutrition during pregnancy and breastfeeding; however, the former may not be an effective primary prevention strategy given the large proportion of unplanned pregnancies. By limiting childhood lead exposures in this project and with low cost repairs in general, we hopefully will decrease the risk of neurodevelopmental deficits and other adverse health effects among children, and limit bone lead stores in these children which could be mobilized later in life.

**CONCLUSIONS**

This project resulted in significantly lower dust lead loadings 6 and 12 months after minor repairs were made to the home as compared to before repairs; however, the majority of homes had one or more dust wipes exceeding HUD/EPA clearance limits 12 months after repairs. Evaluation of blood lead levels was limited by the small number of children with measured levels during follow-up; however, target infants were 76% less likely to have blood lead levels ≥5 µg/dL 12 months after repairs as compared to community-matched infants. Furthermore, the percent of resident children with levels ≥5 µg/dL decreased between baseline and 12 months after repairs. Overall, knowledge and frequency of lead reduction activities increased between the education visit and 12-month visit. Given the limitations of the study, results should be interpreted cautiously; however, it appears that minor lead repairs and caregiver education in homes of newborns may be moderately successful in decreasing dust lead loadings, increasing knowledge, preventing elevated blood lead levels in target infants, and reducing blood lead levels in other children living in the home over a 12 month period.

**Acknowledgements**

We would like to acknowledge the many individuals who made this evaluation project possible. The evaluation study was supported by Invest in Children and Cuyahoga County with funding support from the George Gund Foundation. The study was carried out in collaboration with the Cleveland Department of Public Health, Cuyahoga County Board of Health, and Environmental Health Watch. This study could not have been completed without the many efforts of employees from MomsFirst and Help Me Grow who helped recruit mothers for the study. Finally, we thank all the families who participated in the study.

**References**

Leila W. Jackson, PhD, MPH is currently Principal and Senior Epidemiologist at Applied Public Health Research and Evaluation in Cleveland, OH. In addition, she is an Adjunct Assistant Professor in the Department of Epidemiology and Biostatistics, Case Western Reserve University School of Medicine, where she was fulltime faculty from 2005-2012. Most of Dr. Jackson's research examines the impact of environmental exposures on reproductive, perinatal, and childhood health.

The Center on Urban Poverty and Community Development seeks to address the problems of persistent and concentrated urban poverty and is dedicated to understanding how social and economic changes affect low-income communities and their residents. Based in Cleveland at Case Western Reserve University’s Mandel School of Applied Social Sciences, the Center views the city as both a laboratory for building communities and producing change locally, and as a representative urban center from which nationally relevant research and policy implications can be drawn.

A community resource for expertise and data analysis for over 20 years, the Center on Urban Poverty and Community Development created the groundbreaking community data system NEO CANDO (Northeast Ohio Community and Neighborhood Data for Organizing), a web-based tool that centralizes a broad array of indicators, making it easier to overlay and analyze disparate data. Community development corporations, foundation program officers, local governments, neighborhood activists and residents, students at the Mandel School and other institutions, the media, community reinvestment professionals and academic researchers are among those who have found NEO CANDO invaluable in their work. The Center conducts extensive training and maintains a listserv so NEO CANDO users can get the most out of its vast data collection. You can visit the NEO CANDO webpage at http://neocando.case.edu.