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LEAD-BASED PAINT ABATEMENT AND REPAIR AND MAINTENANCE STUDY IN BALTIMORE:

FINDINGS BASED ON TWO YEARS OF FOLLOW-UP

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EXECUTIVE SUMMARY

In recent years, there has been growing interest in the use of interim measures to temporarily control the problem of extensive residential lead-based paint hazards in U.S. housing in a cost-effective manner. Title X of the Housing and Community Development Act of 1992 (P.L. 102-550) defined interim controls as "a set of measures designed to reduce temporarily human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards and the establishment of management and resident education programs." The 1995 *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* issued by the U.S. Department of Housing and Urban Development (HUD) provide detailed information on interim control practices. However, little is known about the short- and long-term effectiveness of these approaches in terms of reducing lead in dust and in children's blood.

This report presents two years of follow-up of the Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study in Baltimore. An earlier report presented results for the first year of follow-up (EPA, 1997). The study was designed to characterize and compare the short-term (two months to six months) and longer-term (12 months to 24 months) effectiveness of three levels of interim control interventions (R&M I-III) in structurally sound housing where children were at risk of exposure to lead in settled house dust and paint. At the time of this study, owners were not required to reduce lead exposure in their rental properties prior to children becoming poisoned. Thus, study houses received R&M interventions that they were not likely to have gotten otherwise. Funds for R&M work provided by the Maryland Department of Housing and Community Development were capped at $1,650 for R&M I, $3,500 for R&M II, and $7,000 for R&M III.

R&M I included wet scraping of peeling and flaking lead-based paint on interior surfaces; limited repainting of scraped surfaces; wet cleaning with a trisodium phosphate (TSP) detergent and vacuuming with a high efficiency particulate air (HEPA) vacuum to the extent possible in an occupied house; the provision of an entryway mat and information to occupants; and stabilization of lead-based paint on exterior surfaces to the extent possible, given the budget cap. R&M II included two key additional elements: use of sealants and paints to

make floors smoother and more easily cleanable and in-place window and door treatments to reduce abrasion of lead-painted surfaces. R&M III added window replacement and encapsulation of exterior window trim with aluminum coverings as the primary window treatment, encapsulation of exterior door trim with aluminum, and the use of coverings (*e.g.*, vinyl tile) on some floors and stairs to make them smooth and more easily cleanable. Additionally, all R&M households received cleaning kits for their own cleaning efforts. During follow-up, families were informed by letter of the results of dust lead and blood lead tests from each campaign (Appendix A).

For this reason, the study intervention was a combination of R&M work and the provision of information to families on a periodic basis. Further, as required by Maryland law, all blood lead results were reported to the Maryland Childhood Blood Lead Registry which in turn reported the results to the Baltimore City Health Department for follow-up and case management. Thus, this study add to, but did not replace usual medical care.

The study had two control groups: urban houses built after 1979, and presumably free of lead-based paint, and previously abated houses which had received comprehensive abatement between May 1988 and February 1991. For ethical reasons, the study did not include a non-intervention control group of houses that contained lead-based paint hazards.

The study population consisted of Baltimore households with at least one participating child that occupied or moved into study houses owned by collaborating rental property owners and a non-profit housing organization. All households were African-American and reflected the demographic composition of neighborhoods where collaborating owners managed their properties. At the outset, mean ages of study children ranged from 25 to 34 months across groups, and their geometric mean blood lead concentrations were 9 µg/dL in R&M I, 13 µg/dL in R&M II, 14 µg/dL in R&M III, and 12 µg/dL in the previously abated houses. Based on reported housing histories, children in these four groups had spent most or all of their lives in older low-income rental housing and thus had been at risk of exposure to lead in dust and paint. By contrast, most children in the modern urban group had lived in the same house since birth, and all of them had baseline blood lead concentrations less than or equal to the CDC's blood level of concern (10 µg/dL). Their baseline geometric mean blood lead concentration was 3 µg/dL, a value similar to that estimated for U.S. children in this age range (2.7 µg/dL) but lower than the estimate for U.S. non-Hispanic black children 12 months to 60 months of age (4.3 µg/dL) (CDC, 1997b).

Study objectives related to enrollment, laboratory performance,

data quality and data completeness were met. The main findings based on dust lead loadings and concentrations, dust loadings, and children's blood lead concentrations from the five study groups collected before and immediately after intervention, as well as during the two-, six-, 12-, 18-, and 24-month post-intervention data collection campaigns are summarized below.

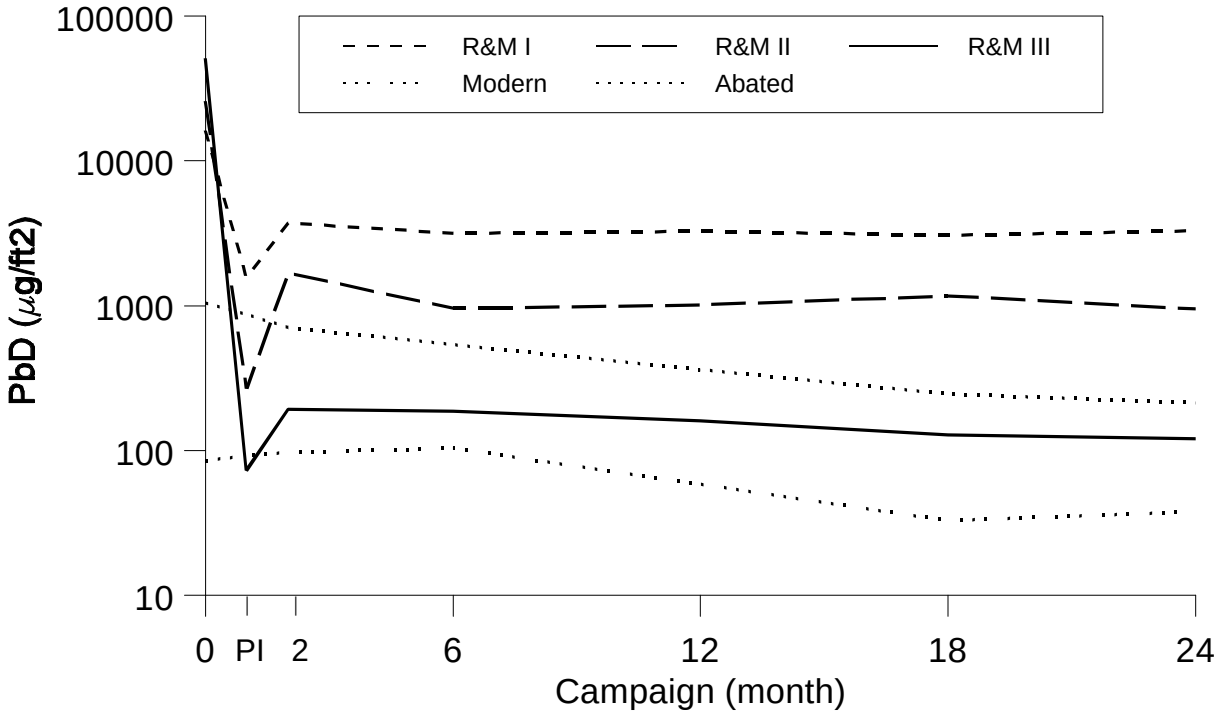
Main Findings Related to Dust Lead Loadings and Concentrations and Dust Loadings

Median dust lead loadings and concentrations based on floor, window sill and window well surfaces are displayed in Figure ES-1 and Table ES-1 to provide a sense of the overall magnitude of house dust lead levels over time within and between groups. Among R&M groups, pre-intervention dust lead loadings tended to be highest in vacant R&M III houses, lowest in occupied R&M I houses, and intermediate in R&M II, which was a mix of vacant and occupied houses.

- All three levels of R&M intervention were associated with statistically significant reductions in house dust lead loadings and total dust loadings that were sustained below pre-intervention levels during two years of follow-up. Dust lead concentrations were significantly reduced following intervention in the middle level (R&M II) and high level (R&M III) intervention houses, but not in the low level intervention houses (R&M I). Further, the three levels of R&M interventions did not reduce lead loadings, lead concentrations, and dust loadings to the same extent.

*
Overall median values are summary measures based on combined R&M cyclone dust data across floors, window sills, and window wells within a house, weighted by surface area sampled. (Month O=Baseline; PI=Immediately Post Intervention; Abated=Previously Abated between 5/1988 and 2/1991).

Figure ES-1: Overall Median Dust Lead Loading (PbD) by Group*



When interpreting Figures ES-1 to ES-4 some caveats should be noted. First, the overall summary measure plotted in Figure ES-1 is not directly comparable to HUD interim clearance standards and EPA clearance standard guidance for lead in house dust, both of which are surface specific (floors: 100 µg/ft^2; window sills: 500 µg/ft^2; window wells: 800 µg/ft^2) and based on wipe samples. The median values in Figures ES-2 to ES-4 are also not directly comparable to clearance standards for lead in house dust due to the sampling method used. Data at immediately post-intervention (PI) and at two-months post-intervention are relevant to the three R&M groups only. The median values presented in Figures ES-1 to ES-4 are not adjusted for season or other covariates or potential effect modifiers.

Table ES-1: Overall Median Dust Lead Loadings ($\mu g/ft^2$), Lead Concentrations ($\mu g/g$) and Dust Loadings (mg/ft^2) by Group for Selected Campaigns *

Measure and Group	Baseline	Post-Intervention	2 Months	12 Months	24 Months
Lead Loading:					
R&M I	16,150	1,580	3,760	3,300	3,320
R&M II	25,930	270	1700	1,020	960
R&M III	51,210	70	200	160	120
Prev.	1,050	n/a	n/a	370	210
Modern	90	n/a	n/a	60	40
Lead Conc.:					
R&M I	18,790	7,990	16,800	16,150	8,700
R&M II	16,830	6,910	10,970	5,600	6,340
R&M III	22,010	2,650	1,530	1,080	890
Prev.	2,430	n/a	n/a	3,010	1,130
Modern	210	n/a	n/a	310	290
Dust Loading:					
R&M I	940	140	260	250	260
R&M II	1,610	40	160	220	200
R&M III	2,510	30	130	140	130
Prev.	290	n/a	n/a	220	190
Modern	400	n/a	n/a	140	140

* Overall median values are summary measures based on combined R&M cyclone dust data across floors, window sills, and window wells within a house, weighted by surface area sampled.

n/a = not applicable

Main Dust Findings (cont.)

- Immediately after intervention and during two-years of follow-up, dust lead loadings, lead concentrations and dust loadings were lowest in R&M III houses, intermediate in R&M II houses, and highest in R&M I houses (Figure ES-1; Table ES-1). For example, at 24 months, overall median lead loading estimates were 27 times higher in R&M I houses than in R&M III houses, and eight times higher in R&M I houses than in R&M II houses. Statistically significant differences were found between R&M groups on the two dust lead measures over time. Differences in lead loadings between R&M groups were primarily due to differences in lead concentrations and secondarily to differences in dust loadings.

- Surface-specific data for lead loadings and concentrations show that the differences between R&M groups after intervention were most pronounced for window wells and window sills as compared to floors (Figures ES-2 - ES-4; Tables ES-2 - ES-3). Moreover, across groups and time, window wells had the highest lead loadings, floors the lowest, and window sills were intermediate.

- Reaccumulation of dust and dust lead loadings in all three R&M groups was the greatest during the first two months after intervention, while there was relatively little reaccumulation between two months and 24 months post-intervention (Figures ES-1-ES-4).

- The modern urban control group had significantly lower dust lead loadings and concentrations across time than the other four groups (Figures ES-1 - ES-4, Tables ES-1 and ES-2). These houses, located in clusters of urban houses built after 1979, were expected to reflect the lowest residential and ambient lead levels in the urban environment. Low dust lead concentrations (overall medians <400 µg/g, equivalent to ≤ 0.04 percent) and drip-line soil lead concentrations (geometric means ≤ 70 µg/g) support the assumption that these houses were free of lead-based paints. Dust lead levels in the previously abated control houses four years to six years post-abatement were generally similar to those in R&M III houses at the end of the second year of follow-up (Figure ES-1).

- No evidence was found for selection bias when R&M study houses were compared to houses that were considered for study but later rejected, mainly due to lack of timely cooperation with the loan process, family moves and safety concerns.

Figure ES-2: Median Floor Dust Lead Loading by Group

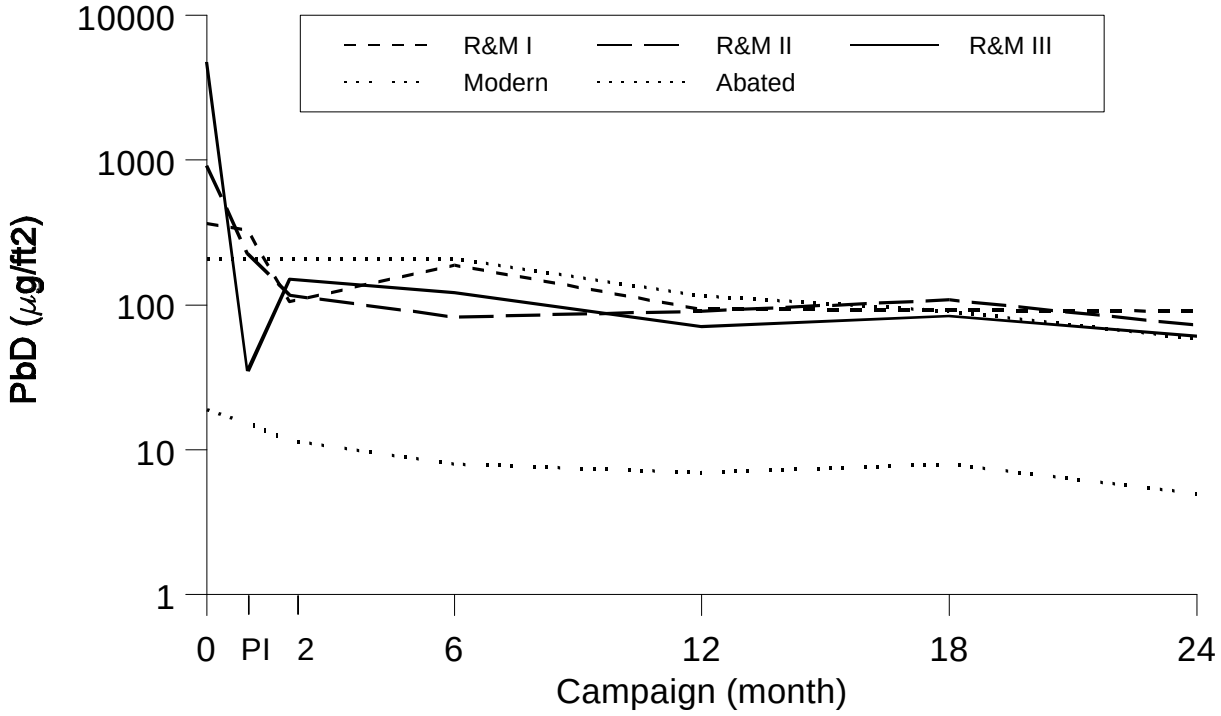


Figure ES-4: Median Window Well Dust Lead Loading by Group

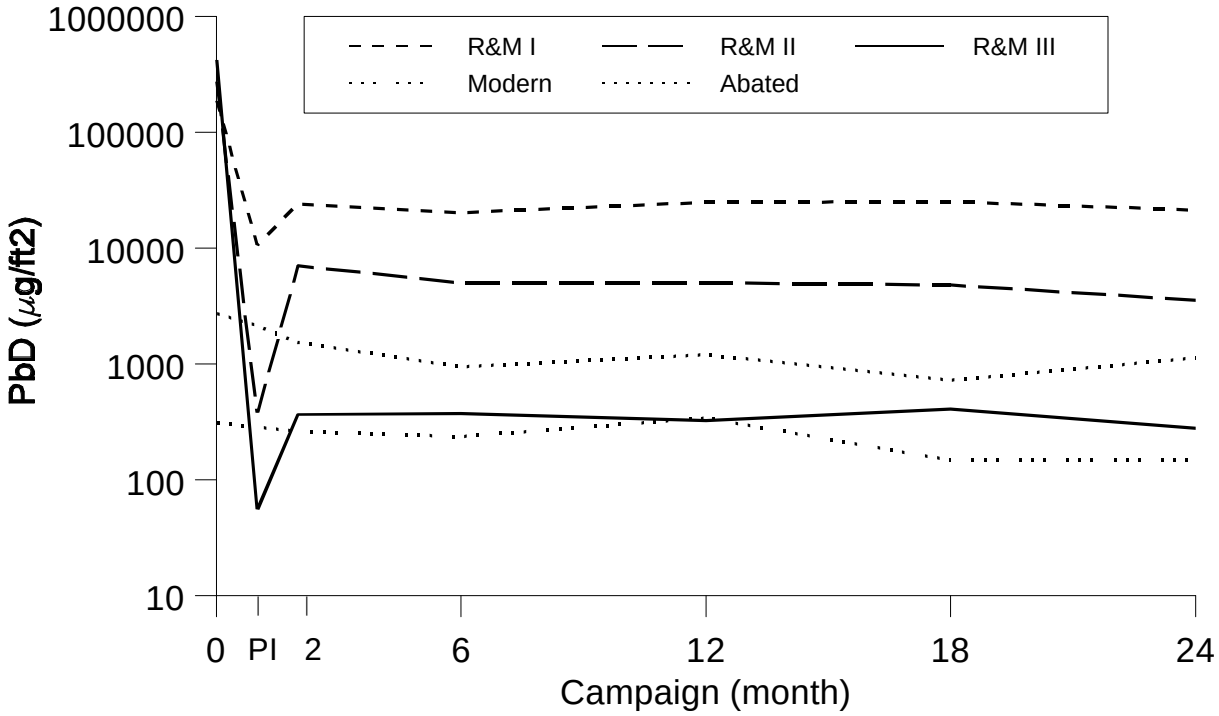
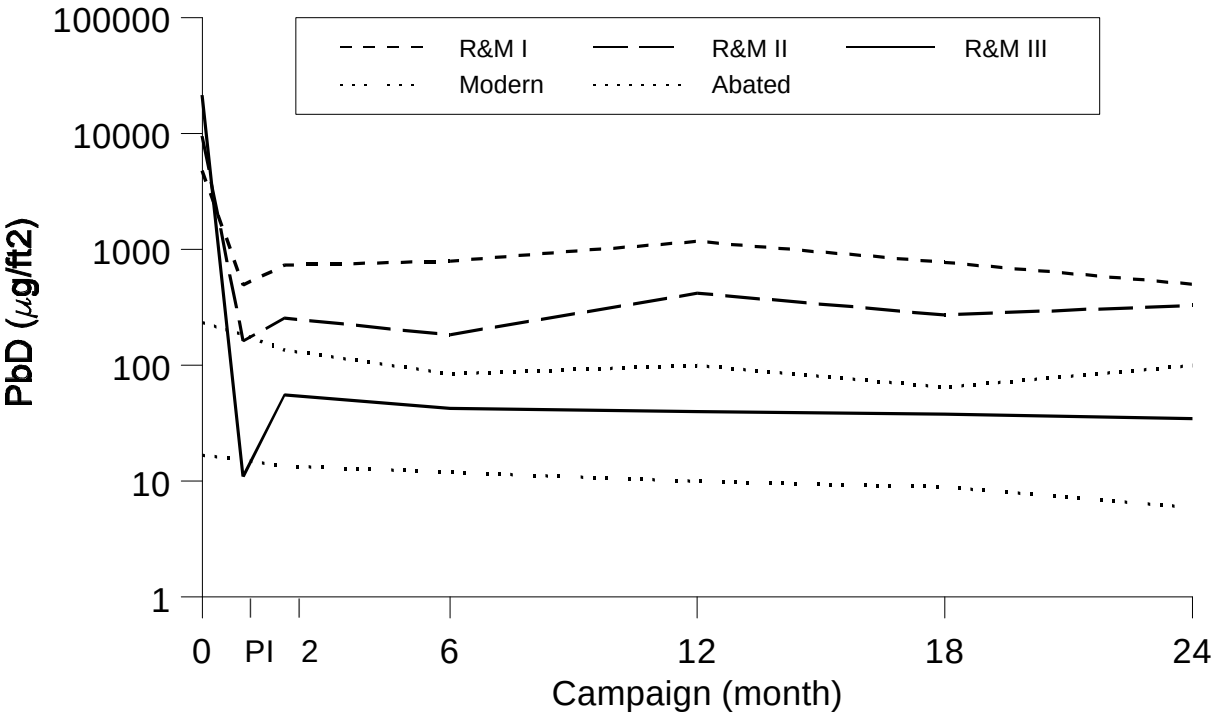


Figure ES-3: Median Window Sill Dust Lead Loading by Group



Main Findings Related to Children's Blood Lead Concentrations

- Using all five study groups in the longitudinal data analysis, a statistically significant relationship was found between a composite measure of house dust lead in an entire house (both concentration and loading) and children's blood lead concentration, controlling for age and season.

- Children in the modern urban group had significantly lower blood lead concentrations than children in each of the other four groups (Table 22); their blood lead concentrations were <10 μg/dL, the Center for Disease Control's level of concern (Figure 17).

- Children with baseline blood lead concentrations $\geq$15/dL in each of the three R&M groups and the previously abated group had statistically significant reductions in blood lead concentration during follow-up, after controlling for age, gender and season (Table 23).

Table ES-2: Median Dust Lead Loadings (μg/ft^2) by Surface Type and by R&M Group for Selected Campaigns

Surface Type	Group	Pre-Intervention	Post-Intervention	2 Months	12 Months	24 Months
Floor	R&M	370	330	110	90	90
	R&M	910	230	120	90	70
	R&M	4,780	35	150	70	60
Window Sill	R&M	4,800	500	740	1,180	510
	R&M	9,560	160	260	420	330
	R&M	21,670	10	60	40	40
Window Well	R&M	187,170	10,760	24,250	24,970	21,530
	R&M	273,980	380	7,150	5,080	3,590
	R&M	420,970	60	370	330	280

Table ES-3: Median Dust Lead Concentrations (μg/g) by Surface Type and by R&M Group for Selected Campaigns

Surface Type	Group	Pre-Intervention	Post-Intervention	2 Months	12 Months	24 Months
Floor	R&M	2,050	1,460	770	750	740
	R&M	2,850	3,250	1,200	720	700
	R&M	4,070	1,840	850	560	600
Window Sill	R&M	16,890	16,620	8,740	10,100	9,940
	R&M	15,260	8,030	6,600	4,500	3,260
	R&M	14,860	617	1,020	630	830
Window Well	R&M	27,960	25,624	32,190	26,840	23,330
	R&M	22,430	13,390	12,750	7,450	8,970
	R&M	21,680	2,040	1,560	1,220	1,250

Main Blood Lead Findings (cont).

- Overall, children in the three R&M groups with baseline blood lead concentrations <15 µg/dL had a statistically significant reduction in blood lead concentration over time, when controlling for age, gender and season (*e.g.,* the predicted blood lead concentration at 24 months was on average 20 percent lower than the baseline level). However, no statistically significant differences in predicted blood lead concentration were found between and within individual R&M groups during the two years of follow-up, controlling for age, gender and season (Table 22). Cumulative body lead burden, neighborhood housing characteristics and age at start of study are discussed as factors that may have mediated children's blood lead responses to the R&M interventions and contributed to the differences in blood lead concentrations observed between children in the modern urban group and those in the other four groups.

- Across groups, most children who reached the age of six months during follow-up had blood lead concentrations <10μg/dL, the CDC level of concern, despite increases in blood lead concentration over time (Figure 19). The small number (n=16) of such children precluded further data analysis, however they add to our understanding of the potential role of R&M interventions in the primary prevention of lead poisoning.

It should be emphasized that the R&M interventions under investigation are interim control or partial abatement approaches to reducing lead-based paint hazards. As such, they are not expected to be as long-lasting as lead-based paint abatement work. During the first two years of follow-up, none of the interventions in individual houses failed, that is, all or most of the dust samples showed lead loadings at, or below, pre-intervention levels. Thus, a major study objective with important policy implications remains the documentation of the longevity of the R&M interventions. Toward this end, the study has been extended to five years of follow-up with funding from HUD. Lastly, it is important to recognize that the costs of the interventions in this study may not be generalizable to other settings and time periods.