EPA 747-S-00-001
January 2000

LEAD EXPOSURE ASSOCIATED WITH RENOVATION AND REMODELING ACTIVITIES

FINAL SUMMARY REPORT

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for

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1.0 INTRODUCTION

The phased elimination of lead additives from motor fuels during the 1970s and 1980s and restrictions on the use of lead in paint and solder have resulted in large declines in blood-lead levels over the past decade. Childhood lead poisoning, however, continues to be a serious environmental health problem in the United States. Chief among the remaining sources of public lead exposures is lead-based paint on the interior surfaces of older buildings, including dwellings, public buildings, and commercial structures.

In 1978, maximum allowable content limits were placed on the use of lead in paint used for toys, residences, and most furniture by the Consumer Product Safety Commission (CPSC). Nevertheless, substantial quantities of lead-based paint, some of it covered with more than one layer of newer paint or other wall covering, remain in the older building stock, particularly dwellings and public buildings constructed before 1950. Lead-based paint that is chipping, peeling, or otherwise deteriorating is widely recognized as a source of lead exposure for toddlers and young children in older neighborhoods. Increasingly, environmental and public health researchers have become concerned that disturbing intact lead-based paint or otherwise mobilizing lead dust behind woodwork, window frames, in walls, etc., during renovation and remodeling (R&R) of older buildings can expose construction workers and building occupants to high lead levels.

To address this concern, Congress directed the U.S. Environmental Protection Agency (EPA) as part of the 1992 Residential Lead-Based Paint Hazard Reduction Act (Title X of HR 5334) to conduct a study of lead exposure associated with R&R. Specifically, Title IV of the Toxic Substances Control Act, Section 402 (c), paragraph (2), states:

> *"The Administrator shall conduct a study of the extent to which persons engaged in various types of renovation and remodeling activities in target housing[1], public buildings constructed before 1978, and commercial buildings are exposed to lead in the conduct of such activities or disturb lead and create a lead-based paint hazard on a regular or occasional basis."*

Accordingly, EPA undertook research to examine lead exposures for different categories of:

- *Persons*— R&R workers, occupants of buildings where lead-based paint is present and R&R activities are carried out, particularly children and other potentially exposed persons (i.e., persons who renovate or remodel their own old or historic houses ["do-it-yourselfers"]).

- *Activities*— R&R activities deemed to entail potential lead exposure (e.g., paint removal, surface preparation, interior demolition). Eleven such ***target activities*** were identified through consultation with other government agencies, lead poisoning prevention experts, industry representatives, labor unions, and other concerned groups.

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[1] "Target housing" is defined by the Act as housing constructed before 1978.

The study had two objectives:

1. Determine the extent to which persons engaged in various types of R&R activities are exposed to lead.

2. Determine the extent to which persons engaged in various types of R&R activities disturb lead and create a lead-based paint hazard, on a regular or occasional basis, to building occupants or other exposed individuals.

An optimal study design would involve measuring worker and occupant blood-lead concentrations and environmental-lead levels before, during, and after R&R activities. Unfortunately, this design was not feasible due to substantial ethical and legal reasons. Therefore, the study was conducted in a series of four independent data collection efforts (phases) undertaken from 1993 to 1998.

The first two data collection efforts were conducted to characterize the environmental lead disturbance resulting from R&R activities (Phase I) and to focus on the effect of R&R activity on worker blood-lead concentrations through a retrospective study (Phase II). After the completion of these data collection efforts, additional studies (Phase III and Phase IV) were completed to address two remaining, significant data gaps. Phase III was designed to move beyond Phase I to assess the relationship between the incidence of R&R activity and elevated blood-lead concentrations in children. Phase IV was designed to assess whether there exists a subset of R&R workers or homeowners, performing R&R work in high-risk homes, that have an increased risk of elevated blood-lead concentrations.

Although some design aspects were employed in multiple phases, each of these four phases was a distinct data collection effort and all phases were conducted in different locations, at different times, and with different sample populations. The next four chapters present the specific study design and results for each phase of the R&R Study.

2.0 PHASE I: ENVIRONMENTAL FIELD SAMPLING STUDY

2.1 PHASE I: DESIGN

The first data collection effort of the R&R Study was the Environmental Field Sampling Study (EFSS), which assessed the relative distribution of exposure to lead created by selected R&R activities. The EFSS focused on monitoring six specific R&R ***activities*** rather than specific ***worker groups***. The activities included: removal of large structures (demolition), window replacement, carpet removal, heating, ventilating, and air conditioning (HVAC) repair or replacement, surface preparation, and repairs with small surface disruption. Exposures from exterior siding, wallpaper removal, and exterior soil disruption were not evaluated because they were considered of secondary importance by the study design team and the individuals consulted in the information-gathering phase.

For each monitored R&R activity, buildings containing lead-based paint suitable for typical application of the activity were selected. Environmental measurements of lead were

taken before, during, and after conducting the target activity. The measurements taken in the EFSS included:

- **Personal Air Samples.** Measures of airborne lead concentrations at a fixed flow rate within each worker's personal breathing zone were collected by taking air samples through a cassette filter mounted to the worker's lapel. These samples were used to provide a measure of the potential inhalation exposure for workers.

- **Room (Ambient) Air Samples.** Ambient air samples were collected for selected activities in areas adjacent to the activity. Adjacent areas were used to address the levels at which occupants might be exposed to airborne lead in other parts of the building while the activity was being conducted.

- **Settled Dust Samples.** Settled dust samples were taken either from stainless steel dustfall collectors or from selected areas such as floors, window sills, window wells, and carpets. Samples were collected at varying distances from the surfaces disturbed by the activity. Lead loadings from settled dust samples were measured as indicators of the amount of lead disturbed by the activity and available as a potential exposure to occupants.

The EFSS was supplemented by an extensive search for other sources of data that could be used either to fulfill data requirements for a specific activity or to confirm results obtained in the Environmental Study.

2.2 PHASE I: RESULTS

Airborne lead levels in a worker's breathing zone, representing an average exposure over the duration that R&R activity was performed, were often very high during many R&R activities (see Table 1). These levels averaged greater than 100 $\mu g/m^3$ (micrograms of lead per cubic meter of air) for paint removal, interior demolition, and sawing activities, and greater than 49 $\mu g/m^3$ for interior surface preparation and disturbance of the central heating system ductwork. Average levels were considerably lower (< 20 $\mu g/m^3$) for drilling, carpet removal, window replacement, and exterior surface preparation. These personal exposure measurements reflect only the period of conducting the specific R&R activity and do not represent average exposures over an 8-hour day for a worker. In addition, results were based on selected case studies and small sample sizes. Nevertheless, a number of personal exposure measurements in the R&R Study were high enough to imply that conducting the activity for even a short period of time, with no exposure during the rest of the work day, would result in an 8-hour time-weighted-average (TWA) above the OSHA personal exposure limit (PEL). For each activity, Figure 1 presents the minimum duration of activity that, on average, would be necessary to achieve an 8-hour TWA of 50 $\mu g/m^3$, based on the limited personal exposure data collected in this study.

Occupant exposure to lead in buildings was assessed by analyzing samples of dust deposited as a result of R&R activities. With the exception of carpet removal and drilling into plaster, all monitored activities deposited considerable amounts of lead, well over the current EPA guidance of 100 $\mu g/ft^2$ for floors (see Table 2, Figure 2). Paint removal, demolition, sawing, and disturbing central heating system ductwork were more likely to cause airborne lead

to scatter and settle over a widespread area, while window replacement and drilling confined the disturbed lead to a smaller area. Simple broom and shop-vacuum cleanup resulted in substantial reduction in the total amount of lead available to occupants. However, as the distance from the activity increased, the cleanup left more lead in the remaining dust. In addition, the average amount of lead remaining after cleanup often stayed above EPA's current guidance on bare floor dust levels (100 $\mu g/ft^2$).

3.0 PHASE II: WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY

3.1 PHASE II: DESIGN

The second data collection effort of the R&R Study was the Worker Characterization and Blood-Lead Study (WCBS). The WCBS involved collecting questionnaire information and blood-lead measurements from 585 R&R workers in two cities to (1) characterize blood-lead concentrations in specific worker groups, (2) determine if specific worker groups or specific R&R activities are associated with increases in blood-lead concentrations, and (3) collect information to be used to develop worker profiles. The WCBS was intended to obtain information independent from the Environmental Field Sampling Study that would provide a direct measure of health effects on worker exposure to lead and to validate the results of the Environmental Field Sampling Study. Target R&R activities examined in the WCBS included removal of large structures (demolition), window replacement, carpet removal, HVAC repair or replacement, and paint removal/surface preparation. Post-activity cleanup was also assessed.

3.2 PHASE II: RESULTS

The questionnaire employed in Phase II captured data on how often each worker conducted specific target activities in any home, including pre-1950 homes, during the past 30 days. The questionnaire results indicated that the sampled workers spent an average of 17 days during the previous month on general renovation and remodeling. The workers spent an average of 11 of these 17 days in pre-1950 homes. The questionnaire results also indicated that:

1. The R&R workers performed a wide variety of R&R activities, and spent considerable time removing large structures, removing paint, and preparing surfaces, activities with potential for creating high dust-lead exposure.

2. Ninety percent of the workers did not use a respirator.

3. Eighty-eight percent of the workers who performed cleanup activities did not use cleanup methods recommended for use in a lead-contaminated environment, and 99 percent used dry sweeping.

4. Of workers who performed paint removal, 97 percent used dry methods.

5. Sixty-seven percent of the workers had not received any materials on lead hazards, and 87 percent had received no lead exposure training.

Blood samples were collected from 581 of the 585 workers. Worker blood-lead concentrations were generally low: 9.1 percent were above 10 μg/dL, 1.2 percent were above 25 μg/dL, and only one worker had a blood-lead concentration greater than 40 μg/dL. The geometric mean blood-lead concentration for all workers was 4.5 μg/dL (see Figure 3). However, there were significant differences among the worker groups that differentiate the groups with the high mean blood-lead concentrations from those with the low mean blood-lead concentrations. Drywall workers (6.1 μg/dL), painters (5.9 μg/dL), and window installers (5.8 μg/dL) had the highest blood-lead concentrations, and floor layers (2.8 μg/dL) had the lowest (see Table 3).

The results of statistical models developed and fit to the data indicated that, with the exception of carpet removal, there was a statistically significant positive relationship between worker blood-lead concentration and short-term conduct (days in the last 30 days) in pre-1950 houses for each target activity. The relationships between worker blood-lead concentration and mid-term (weeks in the last year) and long-term exposure (years in career) associated with target activities were also generally positive. After adjusting for other variables potentially related to lead exposure — such as education level, smoking status, or age of worker's home — the data suggested that activities such as general R&R, cleanup, and paint removal would result in significant increases in worker blood-lead concentrations. However, in either the adjusted or unadjusted models the estimated increases, while statistically significant, were generally so small as to be of little practical consequence (see Table 4).

4.0 PHASE III: WISCONSIN CHILDHOOD BLOOD-LEAD STUDY

4.1 PHASE III: DESIGN

The third data collection effort of the R&R Study was the Wisconsin Childhood Blood-Lead Study (Wisconsin R&R). The Wisconsin R&R Study was designed as a retrospective case-control study to examine the association between incidence of R&R activities and elevated childhood blood-lead levels (EBLs). The Wisconsin Bureau of Public Health's Blood-Lead Registry was used to identify children with elevated blood-lead concentrations (cases) and children that did not have elevated blood-lead concentrations (controls). Children, both cases and controls, were selected from the registry, and questionnaire information was obtained from a guardian of each selected child. The questionnaire obtained information on: the child's residence, duration of residence, R&R activities in the past 12 months, blood sampling, household information, adult occupations and hobbies, and household income. Target R&R activities examined in the study included interior and exterior painting, paint removal and surface preparation, window repair, carpet removal, and wall repair.

4.2 PHASE III: RESULTS

Analyses of the questionnaire and blood information collected indicated that general residential R&R is associated with an increased risk of elevated blood-lead levels in children. Specifically, children living in a residence where R&R was conducted in the last 12 months were 1.3 times more likely to have elevated blood-lead levels than children who did not live in a residence where R&R was conducted.

Specific R&R activities were also found to be associated with an increase in the risk of elevated blood-lead concentrations among child occupants. In particular, removing paint (using open flame torches, heat guns, chemical paint removers, and/or wet scraping/sanding) and preparing surfaces by sanding or scraping significantly increased the risk of an elevated blood-lead level (see Table 5). For example, when paint removal using a heat gun was performed at a residence, the odds of an elevated blood-lead concentration were highly significant (4.6 times greater) than if the work was not performed. (The odds were over 4 times greater when compared to the case when some other type of surface preparation was carried out and to the case when the effects of other R&R factors were taken into account).

Several other factors were also found to increase the risk of an elevated blood-lead level in children. These factors included: increasing the number of rooms in which surface preparation was carried out for inside painting, having a relative or friend not in the household perform the R&R, living in the home while R&R was being conducted, and performing R&R in the kitchen (see Table 5).

The questionnaire responses were also used to characterize the exposure of residents to R&R activities. At least one R&R activity such as inside painting, outside painting, carpet and floor repair or replacement, or other repairs (e.g., window repair) were conducted in 67.2 percent of the study residences in the previous 12 months. Some form of surface preparation was involved in 42.3 percent of R&R activities. Most surface preparation involved hand scraping or sanding. Heat guns were used for surface preparation 7 percent of the time, and chemical paint removers were used 13.6 percent of the time.

5.0 PHASE IV: WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY OF WORKERS AND HOMEOWNERS PERFORMING R&R IN HISTORIC HOMES

5.1 PHASE IV: DESIGN

The final data collection effort of the R&R Study was the Worker Characterization and Blood-Lead Study of Workers and Homeowners Performing R&R in Historic Homes (WCBS-HH). This study was designed as a follow-on study to Phase II of the R&R Study (the WCBS). Like the WCBS, it involved collecting questionnaire and blood-lead measurements from professional R&R workers to (1) characterize blood-lead concentrations in specific worker groups, (2) determine if specific worker groups or specific R&R activities are associated with increases in blood-lead concentrations, and (3) collect information to be used to develop worker profiles. However, the WCBS-HH also collected similar information from homeowners performing R&R themselves. Another difference from the Phase II study was that in either case (homeowners or workers), information was obtained from populations believed to be at a high-risk for lead-exposure because they routinely disturb lead-based paint; the data collection was targeted to workers and homeowners performing R&R in older homes that are likely to contain lead-based paint. Target R&R activities examined in the WCBS-HH included removal of large structures (demolition), window replacement, carpet removal, paint removal/surface preparation, and post-activity cleanup.

5.2 PHASE IV: RESULTS

In all, questionnaires were collected from 246 participants (163 workers and 83 homeowners). The Phase IV questionnaire collected information on how often each participant performed general R&R as well as specific target activities in historic homes. Workers in Phase IV spent, on average, 21 days performing general R&R in historic homes during the last 30 days. Homeowners spent, on average, 14 days performing general R&R in their own historic or pre-1940 home. The responses to the questionnaires also indicate that:

1. Workers spent more time performing R&R than did homeowners.

2. Both workers and homeowners spent time performing a variety of R&R activities. In particular, a large amount of time was spent performing large structure removal and paint removal/surface preparation.

3. Sixty-three percent of workers and 43 percent of homeowners had used, at some time in their career, a dust mask or respirator. However, on average, respirators were used among homeowners or workers for only about half of the time spent performing R&R during the last 30 days.

4. The majority of workers had not been trained (76%) nor received educational information (67%) on lead exposure due to R&R work. Similarly, 62 percent of homeowners had not received information on lead.

5. Over 75 percent of workers and homeowners who performed surface preparation reported using dry sanding/scraping to remove paint. About one-third of homeowners and workers reported using chemical stripping or burning/torching/ heat gun methods to remove paint.

Blood samples were collected from 161 workers and 82 homeowners. Overall, the geometric mean blood-lead concentrations were well below 10 μg/dL: 5.7 μg/dL for workers and 4.5 μg/dL for homeowners. Approximately 20 percent of the study participants had blood-lead concentrations above 10 μg/dL. Also, 2.9 percent had blood-lead concentrations above 25 μg/dL, and three study participants had blood-lead levels above 40 μg/dL (see Figures 4 and 5). The adjusted geometric mean blood-lead concentrations among the worker groups ranged from 4.2 μg/dL for Laborers to 6.3 μg/dL for Painters but were not found to be significantly different (see Table 3). However, the adjusted geometric mean blood-lead concentrations for workers were significantly greater than those for homeowners. Further, the geometric mean blood-lead concentrations among high-risk workers (Phase IV) were significantly higher than the geometric mean blood-lead concentrations of general workers (Phase II) (see Table 3).

The results of statistical models developed and fit to the data indicated that there was a significant relationship between the conduct of certain R&R activities and blood-lead concentrations. Specifically, based upon covariate adjusted models, the number of days a worker spent performing general R&R, paint removal/surface preparation, and cleanup were significantly related to increases in worker blood-lead concentrations (see Table 6). Similarly,

the number of hours that homeowners spent performing general R&R and paint removal/surface preparation was found to be significantly related to increases in blood-lead concentrations (see Table 7). However, as in Phase II, the estimated increases for workers or homeowners were small.

6.0 CONCLUSIONS

The results of this study indicate that R&R workers may be exposed to high levels of environmental lead while conducting certain activities in certain environments. However, there was little evidence of elevated blood-lead concentrations[2] in a population of general R&R workers who conduct a wide variety of activities. Phase II of the R&R Study included workers in cities with documented lead problems who were conducting a significant amount of work in older buildings. In this regard, the results were weighted toward highly exposed general R&R workers. However, only one out of 581 participating workers had a blood-lead concentration greater than 40 μg/dL. Only seven out of 581 participating workers had a blood-lead concentration greater than 25 μg/dL. There was evidence (Phase IV) that R&R workers who may be even more highly exposed (i.e., workers specializing in historic renovations) had higher blood-lead concentrations than workers surveyed in Phase II. However, Phase IV found that even among these high-risk workers, only three out of 161 had blood-lead concentrations above 40 μg/dL. Further, out of 82 homeowners who performed R&R while residing in their own historic/pre-1940 home, none had blood-lead levels above 40 μg/dL and only four had blood-lead concentrations above 25 μg/dL.

Because low blood-lead concentrations were observed among R&R workers, long-term occupant exposure should be stressed when determining the need for worker training, certification, or educational materials. In this study, occupant exposure was characterized by measuring lead levels in environmental dust and through a retrospective survey. Results from Phase I of the study indicate that there is a potential for disturbing significant amounts of lead during R&R activities which could result in occupant exposure if appropriate cleanup and contamination practices are not conducted. The results of Phase III indicate that children residing in homes where R&R activities were conducted are more likely to have elevated blood-lead concentrations[3] than children residing in homes where R&R was not conducted.

7.0 REFERENCES

U.S. Environmental Protection Agency (1997a) "Lead Exposure Associated With Renovation and Remodeling Activities: Summary Report." Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, EPA 747-R-96-005, May 1997.

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[2] Elevated blood-lead concentrations among workers are defined for this study as concentrations above 40 μg/dL, the current Occupational Safety and Health Administration (OSHA) level at which full medical surveillance of a worker is required.

[3] Elevated blood-lead concentrations among children are defined as concentrations equal to or greater than 10 μg/dL.

U.S. Environmental Protection Agency (1997b) “Lead Exposure Associated with Renovation and Remodeling Activities: Environmental Field Sampling Study.” Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, EPA 747-R-96-007, May 1997.

U.S. Environmental Protection Agency (1997c) “Lead Exposure Associated with Renovation and Remodeling Activities: Worker Characterization and Blood-Lead Study.” Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, EPA 747-R-96-006, May 1997.

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U.S. Environmental Protection Agency (1998b) “Lead Exposure Associated with Renovation and Remodeling Activities: Phase IV, Worker Characterization and Blood-Lead Study of R&R Workers Who Specialize in Renovation of Old or Historic Homes.” Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, EPA 747-R-99-001, March 1999.

Table 1. Summary Measures of Worker Exposure to Airborne Lead (Phase I)

	Number of Workers Monitored	Estimated Geometric Mean Exposure[1] ($\mu g/m^3$)	95% Confidence Interval for Geometric Mean	Estimated Percentage of Workers With Exposures Expected to Exceed 50 $\mu g/m^3$[1]	95% Confidence Interval for the Estimated Percentage of Workers
R&R Target Activities					
Carpet Removal	14	7.54	(1.74, 32.6)	14%	(3%, 43%)
Window Replacement	8	7.48	(1.13, 49.3)	6.5%	(0%, 50%)
Paint Removal[2] (Hand)	6	254.00	(23.7, 2720)	94%	(41%, 100%)
(Power)	3	571.00	(42.9, 7600)	99%	(48%, 100%)
Large Structure Removal (Interior Demolition)	20	108.00	(26.6 435)	83%	(40%, 99%)
HVAC Work	4	49.60	(11.4, 216)	48%	(10%, 90%)
Surface Preparation[3] (Interior)	31	58.20	(2.27, 1490)	52%	(23%, 80%
(Exterior)	38	4.33	(0.408, 46.0)	11%	(0%, 49%)
Generic R&R Tasks[4]					
Drilling into Wood	7	15.10	(4.57, 50.2)	18%	(4%, 51%)
Drilling into Plaster	6	6.76	(3.00, 15.3)	0%	(0%, 21%)
Sawing into Wood	6	546.00	(366, 813)	99%	(99%, 100%)
Sawing into Plaster	2	110.00	(0, 2.32×10^6)	76%	(15%, 99%)

[1] Exposures represent the average lead exposure over the period in which the activity was conducted.
[2] Consists of continuous dry sanding activities (using hand or power methods).
[3] Based on data from other sources. Surface preparation consisted of a wide variety of activities including wet and dry scraping, feathering of edges, and wet and dry sanding to prepare a surface for repainting.
[4] It could not be determined from this study how much of the difference between wood and plaster substrates was due to differences in paint lead loading versus differences in substrate.

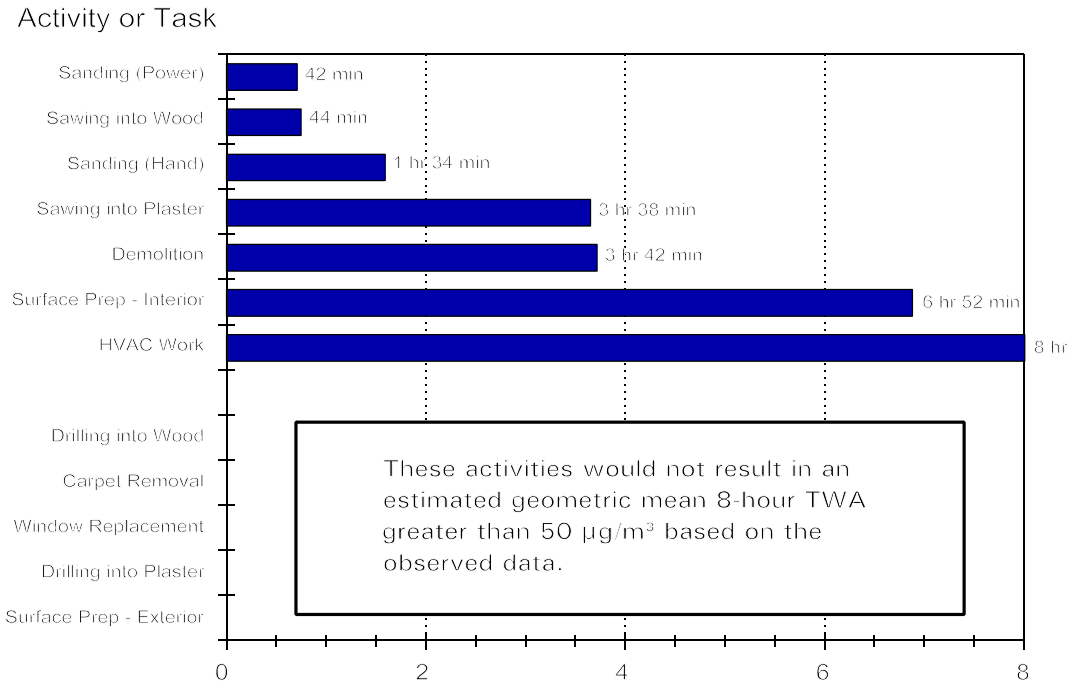
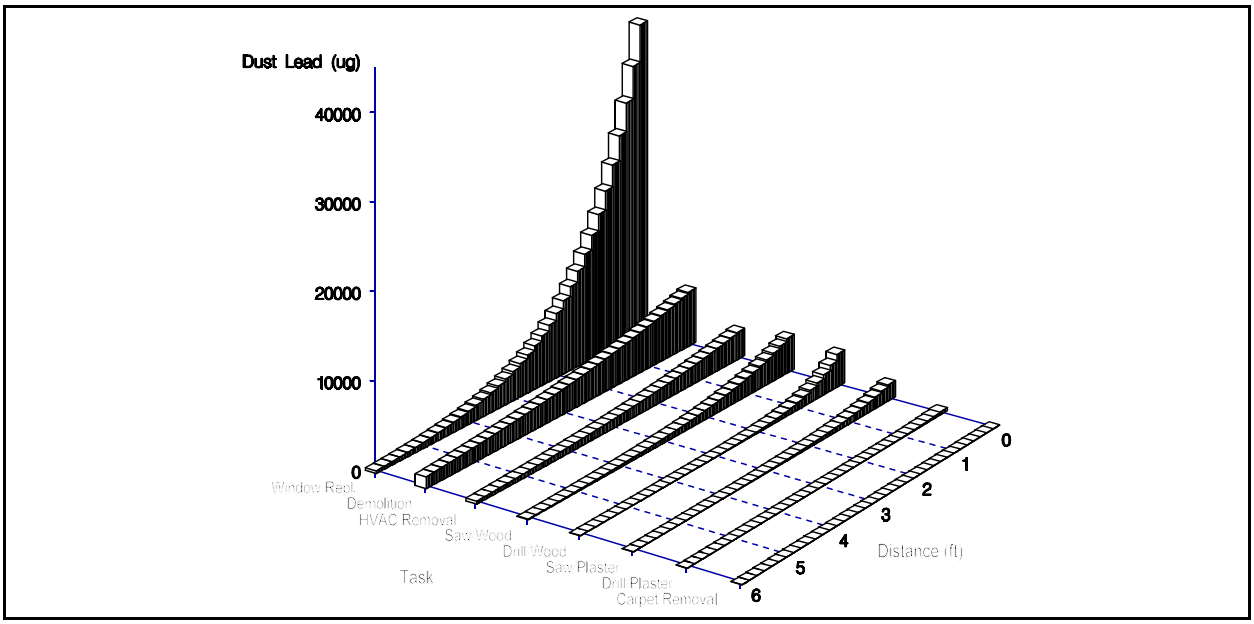


Figure 1. Hours of Activity That Would Result in an Estimated Geometric Mean 8-Hour TWA of 50 µg/m³ (Phase I)

Table 2. Summary Measures of Potential Occupant Lead Exposures that Can Result from Conducting Target and Generic R&R Activities (Phase I)

	Average Lead Loading (µg/ft²) in Settled Dust (Measured Post-Activity, Before Cleanup)		
	Estimated Loading in a 6'x1' Region Extending from the Activity	Estimated Loading at 6 Feet from Activity	Standard Unit of Activity
Target Activity			
Carpet Removal	16.9	[1]	100 ft²
Window Replacement	7,710.0	482	1 window
Paint Removal	42,900.0	15,500	no standard unit of activity
HVAC Work	1,290.0	414	1 room
Large Structure Removal (Interior Demolition)	3,250.0	1,530	1 room
Generic Activity			
Drilling into Wood	432.0	1.27	10 holes
Drilling into Plaster	34.5	0.04	10 holes
Sawing into Wood	999.0	105.00	1 linear ft
Sawing into Plaster	328.0	10.60	1 linear ft

[1] No samples were collected at six feet from the activity.



Note: Results are based on conducting a standard unit of activity (see Table 6).

Figure 2. Estimated Distribution of Dust Lead in a 6' x 1' Region Extending from the Activity Area for Various Activities (Phase I)

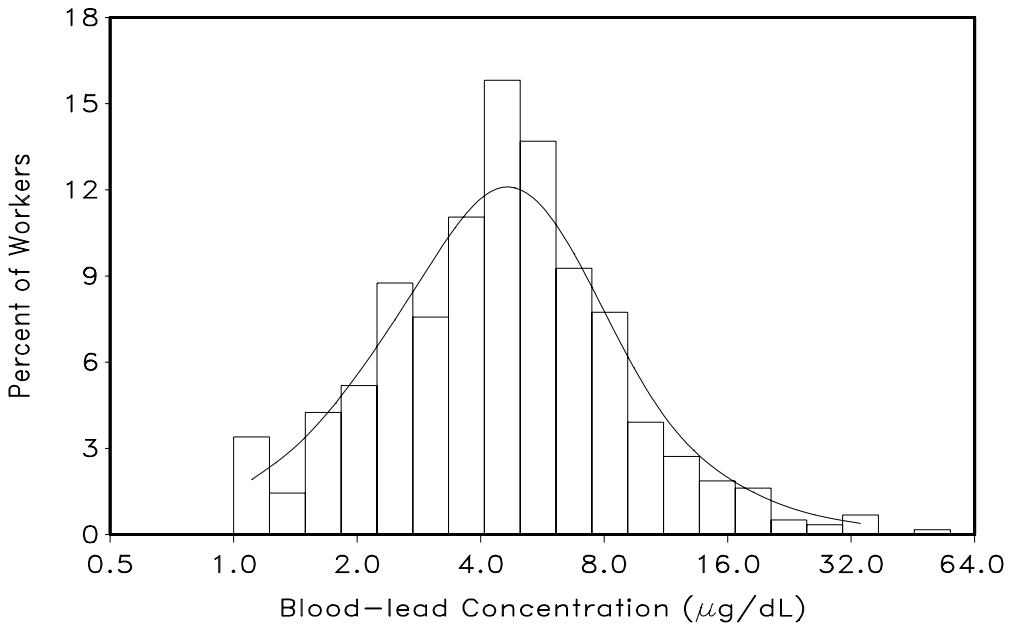


Figure 3. Histogram of Blood-Lead Concentration (Semi-Logarithmic Scale) for Workers in the WCBS (Phase II)

Table 3. Information for an Assessment of Worker Exposures Associated with Different R&R Worker Groups (Phases II and IV)

Study	Worker Group	# Workers Monitored	MEASURES OF WORKER EXPOSURES			
			Geometric Mean Blood-Lead Conc. (µg/dL)	95% Confidence Interval on Geometric Mean	Percentage That Used a Respirator[(1)]	Percentage That Received Some Lead Training
WCBS (Phase II)	Union Carpenters	159	4.5	(4.1, 5.0)	4	9
	Non-Union Carpenters	105	4.8	(4.3, 5.4)	12	16
	Floor Layers	82	2.8	(2.5, 3.2)	7	9
	Laborers	56	4.1	(3.5, 4.9)	23	16
	Supervisors	57	4.1	(3.5, 4.8)	5	23
	Painters	34	5.9	(4.8, 7.3)	21	21
	Drywall Workers	64	6.1	(5.3, 7.1)	2	6
	Window Replacement Workers	14	5.8	(4.3, 7.9)	14	14
WCBS-HH (Phase IV)	Carpenters	47	6.1	(5.1, 7.4)	28	30
	Laborers	42	4.2	(3.5, 5.1)	16	9
	Painters	44	6.3	(5.1, 7.7)	30	32
	Other Workers	26	5.0	(3.9, 6.4)	16	18
	Homeowners That Perform R&R	82	4.4	(3.7, 5.2)	16	N/A

[(1)] Does not include wearing dust masks.

Table 4. Predicted Changes in General Worker Blood-Lead Concentrations Associated with 10 Days of Work in Pre-1950 Buildings (Phase II)

Target Activity	Based on Model Unadjusted for Covariates		Based on Covariate Adjusted Model	
	Base Level ➜	Level When Worker Conducts an Additional 10 Days per Month of Activity	Base Level ➜	Level When Worker Conducts an Additional 10 Days per Month of Activity
Carpet Removal	4.4	4.9	4.5	4.1
Window Replacement	4.2	5.1*	4.4	4.8
Paint Removal	4.1	5.2*	4.3	4.8*
HVAC Work	4.4	5.6*	4.4	4.7
Large Structure Removal	4.2	4.8*	4.3	4.7
Cleanup	4.1	4.7*	4.3	4.6*
General R&R	3.7	4.4*	3.9	4.4*

* Slope parameter estimate was significant at an alpha = 0.05 level.

Table 5. Unconditional Odds Ratios from Logistic Regression with Single R&R Variables (Phase III)

Variable [a]	Higher Risk	Lower Risk	P-Value	Odds Ratio[b]	Confidence Interval
Any R&R Work	Yes	No	0.0220*	1.309	(1.035,1.656)
Inside Painting	Yes	No	0.9267	1.010	(0.814,1.252)
Window Repair or Replacement	Yes	No	0.4652	1.095	(0.855,1.402)
Inside or Outside Painting	Yes	No	0.0116*	1.322	(1.060,1.649)
Prepared Surface	Yes	No	0.0038*	1.430	(1.117,1.830)
Prepared Surface for Inside Painting	Yes	No	0.0645	1.325	(0.977,1.796)
Hand Sanding or Scraping	Yes	No	0.1158	1.226	(0.946,1.588)
Power Sanding, Grinding, Sandblasting	Yes	No	0.1035	1.372	(0.930,2.025)
Open Flame Torch	Yes	No	0.01018*	4.883	(1.423,16.759)
Heat Gun	Yes	No	< 0.0001*	4.597	(2.715,7.782)
Washing, Wetscraping, Water Blasting	Yes	No	0.0092*	1.625	(1.119,2.360)
Chemical Paint Removers	Yes	No	0.0046*	1.969	(1.220,3.176)
Who Did the Work?					
Head of the Household or Spouse	Yes	No	0.1696	1.214	(0.915,1.611)
Other in Household	No	Yes	0.0355*	3.000	(1.055,8.531)
Relative or Friend Not in Household	Yes	No	0.0015*	2.231	(1.344,3.705)
Owner or Apartment Staff	Yes	No	0.4787	1.244	(0.672,2.305)
Professional	Yes	No	0.1195	1.490	(0.893,2.486)
Lived in Home While R&R Was Done	Yes	No	0.01638*	1.365	(1.054,1.769)
Number of Rooms	1 [c]	0 [c]	0.0007*	1.119	(1.047,1.197)
R&R Work in Kitchen	Yes	No	0.0243*	1.569	(1.052,2.340)

Note: Shaded area (and asterisk) indicates statistically significant results

(a) If the answer to any of the following questions was "Yes", this indicator variable was set to 1.
(b) The odds ratio compare the odds of a child having elevated blood-lead concentrations when a particular R&R activity occurred against the odds of a child having elevated blood-lead concentrations when the particular R&R activity did not occur.
(c) "Number of Rooms" was included as an ordinal variable. The risk groups were chosen for illustration. More generally, the odds ratio between $n + k$ and n rooms is 1.119^k.

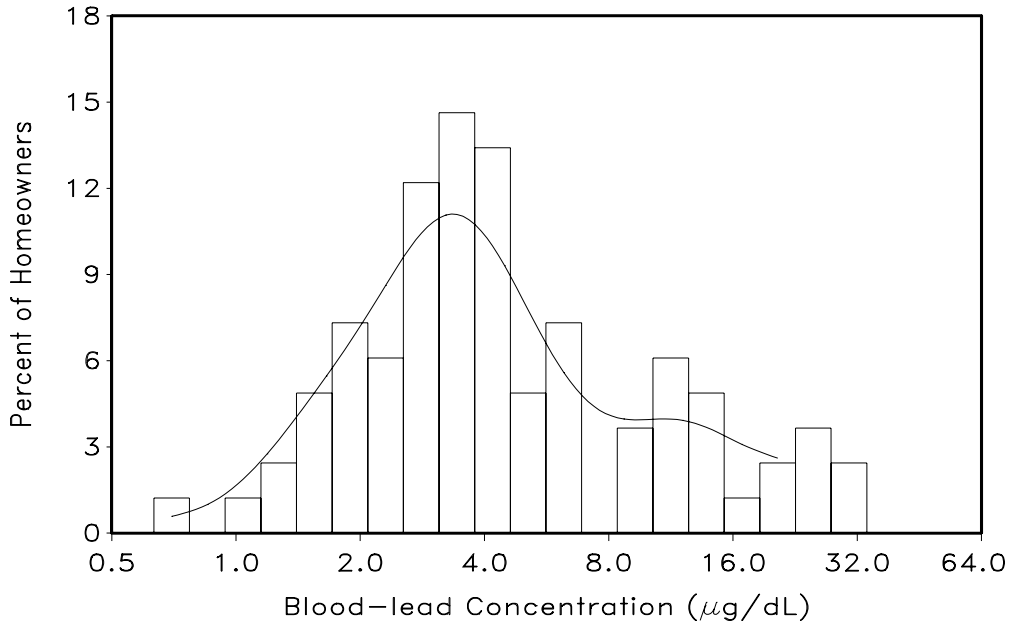


Figure 4. Histogram of Homeowner Blood-Lead Concentration (Semi-Logarithmic Scale) (Phase IV)

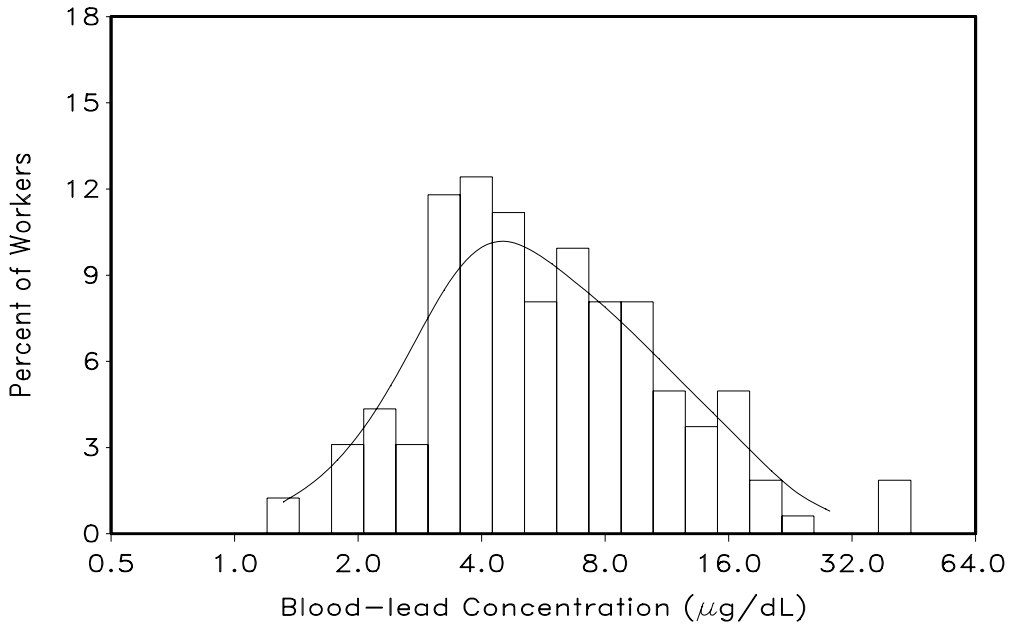


Figure 5. Histogram of Blood-Lead Concentration (Semi-Logarithmic Scale) for Workers Specializing in R&R of Historic/Old Homes (Phase IV)

Table 6. Predicted Changes in High-Risk Worker Blood-Lead Concentrations (µg/dL) Associated with 10 Days of Work in Pre-1940 Homes (Phase IV)

Target Activity	Based on Model Unadjusted for Covariates		Based on Covariate Adjusted Model	
	Base Level[a]	Level When Worker Conducts an Additional 10 Days per Month of Activity	Base Level[a]	Level When Worker Conducts an Additional 10 Days per Month of Activity
Large Structure Removal	5.6	5.7	5.7	5.7
Paint Removal/ Prepare Surface	4.8	5.5*	4.7	5.4*
Window/ Door Casement Removal	5.2	6.1*	5.3	6.0
Carpet Removal	5.9	5.3	5.8	5.4
Cleanup	4.5	5.3*	4.4	5.2*
General R&R[a]	3.8	5.5*	4.0	5.5*

(a) The Base Level for General R&R is 10 days, for all other activities the Base Level is zero days.

* Slope parameter estimate for days per month of activity was significant at the alpha = 0.05 level.

Table 7. Predicted Changes in Homeowner Blood-Lead Concentrations (µg/dL) Associated With Changes in the Number of Hours Spent Performing a Target Activity in Their Pre-1940 Home (Phase IV).

Target Activity	Additional Number of Hours**	Based on Model Unadjusted for Covariates		Based on Covariate Adjusted Model	
		Base Level[a]	Level When Homeowner Conducts Additional Hours per Month of Activity	Base Level[a]	Level When Homeowner Conducts Additional Hours per Month of Activity
General R&R	80	3.0	4.5*	3.1	4.5*
Large Structure Removal	14	4.6	4.5	4.3	4.4
Paint Removal/ Prepare Surface	36	3.4	4.5*	3.5	4.4*
Window/ Door Casement Removal	6	4.5	4.5	4.3	4.4
Carpet Removal	2	4.5	4.5	4.4	4.4
Cleanup	25	4.7	4.5	4.2	4.4

(a) The Base Level is zero hours for all comparisons.

* Slope parameter estimate for days per month of activity was significant at the alpha = 0.05 level.

** The number of hours is based upon the average number of hours homeowners spent performing the target activity in their home during the last 30 days.

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