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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

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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

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Battelle Memorial Institute (Battelle)

Battelle was responsible for designing the study, recruiting participants, collecting worker and homeowner questionnaire data and blood samples, creating and maintaining data bases, conducting statistical analysis, and producing the final report.

U.S. Environmental Protection Agency (EPA)

The U. S. Environmental Protection Agency was responsible for oversight in developing the study plan, managing and coordinating the study, and reviewing and editing this report. The EPA Work Assignment Manager was Dan Reinhart. The EPA Project Officers were Jill Hacker and Sineta Wooten.

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EXECUTIVE SUMMARY

The Residential Lead-Based Paint Hazard Reduction Act (Title X) required the U.S. Environmental Protection Agency (EPA) to conduct a study of lead exposure associated with renovation and remodeling activities (R&R Study). Information obtained from the R&R Study will be used to help determine which groups of workers require training, certification, or educational materials because of the potential lead exposure to themselves or to others resulting from the R&R activities that they perform. Three phases of the R&R Study, each comprising a separate and distinct data collection effort, have been completed. They include:

- Phase I, Environmental Field Sampling Study (EFSS). The EFSS was conducted to measure the airborne (breathing zone) lead levels and lead levels in settled dust resulting from several renovation and remodeling work activities.

- Phase II, Worker Characterization and Blood-Lead Study (WCBS). The WCBS was designed to assess the relationship between the conduct of R&R activities and lead exposure to the R&R workers who engaged in those activities. The WCBS collected questionnaire information and a blood sample for analysis from each of 581 R&R professionals.

- Phase III, Wisconsin Childhood Blood-Lead Study. The Wisconsin Childhood Blood-Lead Study was a retrospective case-control study designed to systematically examine the association between R&R activities and elevated blood-lead levels ($\geq$10 µg/dL) among children.

This report presents the fourth Phase in this series of data collection activities. Phase IV closely resembles Phase II (WCBS) in design and functions as an extension of the earlier study. Whereas Phase II explored lead exposure among general R&R workers, Phase IV focused on individuals who worked extensively in older (pre-1940) or historic homes where the risk of lead exposure associated with R&R work is considered to be especially high. In addition to R&R professionals, homeowners of older or historic homes who reside in their homes while performing R&R activities themselves were included in Phase IV.

Study participants were recruited using several approaches. Newspaper advertising produced the greatest number of study subjects. In-person recruitment and personal referrals were also effective methods for identifying participants. In total, questionnaire information and blood samples were collected from 243 participants (161 workers and 82 homeowners) in three cities: Charleston, SC; Savannah, GA; and Baltimore, MD.

As was the case with Phase II, environmental samples were not collected as part of Phase IV. There were several reasons for this decision. Both phases were designed to be minimally intrusive to potential participants. Collection of environmental samples would have reduced the participation rates for these two studies, and clearly would have substantially increased the time and cost of conducting them.

The questionnaire results indicated that

1. Workers spent more time performing R&R than homeowners (on average 24 days and 14 days in the past 30 days respectively).

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

3. Despite the OSHA Lead in Construction Standard, only 23.7 percent of workers reported using a respirator in the last 30 days. Similarly, only 16 percent of homeowners used a respirator in the last 30 days. Homeowners and workers in every work group used a dust mask more frequently than any type of respirator (44.9 percent of workers and 29.6 percent of homeowners reported using dust masks).

4. Seventy-six percent of workers had not received any lead exposure training, and 67 percent of workers and 62 percent of homeowners had not received any educational materials on lead hazards (homeowners were not asked about training).

5. Over 75 percent of workers and homeowners reported using dry sanding/scraping to remove paint. Roughly 41 percent of workers reported using chemical stripping (37 percent of homeowners) and 32 percent of workers (31 percent of homeowners) reported using burning/torching/heat gun to remove paint.

The geometric mean blood-lead concentrations of study participants were 5.73 μg/dL for workers and 4.45 μg/dL for homeowners. Forty-nine out of the 243 study participants (20.2 percent) had blood-lead concentrations greater than 10 μg/dL. Several participants (2.9 percent) had blood-lead concentrations greater than 25 μg/dL, and three participants (all workers) had blood-lead concentrations above 40 μg/dL.

Overall, the blood-lead data indicate that Phase IV study participants were more highly exposed to lead than the general R&R workers from Phase II (i.e., workers not necessarily working in historic or older homes). The geometric mean blood-lead concentration for workers in this study (Phase IV) was significantly higher than the geometric mean blood-lead concentration of workers in the WCBS (Phase II). On the other hand, the geometric mean blood-lead level for homeowners in Phase IV was not significantly different from that of workers in the WCBS. Perhaps most important, a significantly larger percentage of all participants (workers and homeowners) in Phase IV had elevated blood-lead levels than did workers in the WCBS. In general, the percentage of Phase IV participants with blood-lead levels above 10 μg/dL, 15 μg/dL, and 25 μg/dL was about twice as high as the corresponding percentages for workers in the WCBS.

Statistical models were developed and fitted to the worker and homeowner data. These models were used to investigate the relationship between blood-lead concentrations and potential lead exposure associated with specific R&R activities. These models indicate that there is a significant relationship between the conduct of certain R&R activities and blood-lead

concentrations. For homeowners, paint removal/surface preparation was the single target activity that explained the most variability in blood-lead concentrations. For workers, the models indicated that worker blood-lead concentrations were most strongly associated with the combined effects of the following: the number of days spent performing cleanup, the number of weeks spent performing paint removal/surface preparation, the number of weeks spent performing carpet removal, and the number of years in the R&R career where some time was spent replacing window or door casements. The total number of hours in the last 30 days and the number of weeks in the last 12 months that the homeowner spent performing paint removal/surface preparation were related to increased blood-lead concentrations. The number of hours and weeks spent performing general R&R were also related to increased blood-lead levels in homeowners.

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1.0 INTRODUCTION AND BACKGROUND

To address potential lead exposure associated with R&R, the U.S. Congress directed the U.S. Environmental Protection Agency (EPA) Administrator to conduct a study of lead exposure associated with R&R activities (R&R Study). The R&R Study is required by paragraph (2) of Section 402 (c) of Title IV of the Toxic Substances Control Act, contained in the Residential Lead-Based Paint Hazard Reduction Act (Title X of HR 5334). Paragraph (2) of Section 402 (c) 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, 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."*

The overall objectives of the R&R study were to

- Determine the extent to which persons engaged in various types of R&R activities are exposed to lead; and

- 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.

Previous results of the R&R Study were derived from three principal data collection efforts: Phase I: Environmental Field Sampling Study[1] (EFSS); Phase II: Worker Characterization and Blood-Lead Study[2] (WCBS); and Phase III: Wisconsin Childhood Blood-Lead Study[3]. The EFSS was conducted to measure the airborne lead levels and lead levels in settled dust resulting from various renovation and remodeling work. The WCBS was designed to collect data and information that could be used to assess the relationship between R&R activities (termed "Target Activities") and lead exposure to the R&R workers conducting these activities. Questionnaire information on work history, work habits, specific work activities, etc., was obtained for 585 workers in the WCBS, and blood samples were collected from 581 of the 585 workers. Because children may be the population most sensitive to lead exposures from R&R activities, additional data were needed to assess the impact of the conduct of R&R activities on household occupants. Phase III was added to the overall R&R study with the

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[1] U.S. Environmental Protection Agency, "Lead Exposure Associated with Renovation and Remodeling Activities: Environmental Field Sampling Study, Volume I: Technical Report; Volume II Appendices," EPA Report No. EPA 747-R-96-007, May 1997.

[2] U.S. Environmental Protection Agency, "Lead Exposure Associated with Renovation and Remodeling Activities: Worker Characterization and Blood-Lead Study," EPA Report No. EPA 747-R-96-006, May 1997.

[3] U.S. Environmental Protection Agency, "Lead Exposure Associated with Renovation and Remodeling Activities: Wisconsin Childhood Blood-Lead Study," EPA Report No. EPA 747-R-99-002, 1999.

objective of determining the impact of residential R&R work on child occupant's blood-lead levels.

Although there were significant differences among worker groups identified in the WCBS, the average blood-lead concentrations for the sampled workers were well below 10 μg/dL (the geometric mean blood-lead concentration among all workers was 4.5 μg/dL). However, because such a diverse group of R&R workers was sampled, it is possible that one or more subgroups of high-risk R&R workers were not well represented in the WCBS. This study, Worker Characterization and Blood-Lead Study of R&R Workers Who Specialize in Renovation of Historic Homes (WCBS-HH), is a follow-up to the WCBS. It is a focused examination of those workers who routinely perform R&R activities in homes where there is likely to be a high risk of exposure to lead. In particular, this study focused on workers who conduct R&R activities in historic/older[4] homes likely to contain lead-based paint. In addition, homeowners of older or historic homes that reside in their homes while performing R&R activities themselves may also be at high risk for lead exposure. Information on the renovation activities conducted by homeowners was also collected.

1.1 STUDY OBJECTIVES

The overall objective of this study was to conduct a focused study of workers and homeowners who are believed to have the greatest potential for exposure to lead-based paint because they routinely perform R&R activities in older homes. These homes are considered high-risk because they are likely to contain large amounts of lead-based paint which is often disturbed by R&R. Additionally, because these are older homes, fine dust and debris containing lead may have accumulated behind woodwork, plaster, and other architectural components and may be released as a result of the R&R activities.

The specific objectives of this study were to

1. Determine the relationship between blood-lead concentrations and work practices or activities performed by workers or homeowners in old or historic homes, after controlling for potential confounding factors.

2. Determine if the blood-lead concentrations of workers in specific worker groups differ after adjusting for potential confounding factors.

3. Determine if the blood-lead concentrations of homeowners differ from those of workers.

4. Gather additional information on the types of work activities and work practices that workers and homeowners performing R&R conduct.

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[4] Throughout the remainder of this report, the term "old" or "older" will be used to indicate homes built prior to 1940.

5. Compare the blood-lead results of workers and homeowners specializing in R&R in high-risk homes with those observed among general R&R workers (WCBS).

6. Determine if the blood-lead concentrations of persons routinely performing R&R activities in high-risk homes differ from those of the general U.S. population.

1.2 LIMITATIONS OF THE STUDY

There are several limitations to this study, all of which may have an impact on the analyses and conclusions presented in this report. First, though attempts were made to recruit specific workers, this study is predominantly a "volunteer" study. That is, workers and homeowners were not selected with fixed probabilities from a pre-determined sampling frame. Thus, the respondents participating in this study may have characteristics that differ from those that are not apt to volunteer. For example, if respondents that volunteer are more conscientious workers or have an increased awareness of the dangers of lead paint, they may take precautions that non-respondents do not.

Another limitation of this study is that the information collected is based upon recall of selected activities performed at various times throughout the last month, year, or throughout the lifetime of the respondent. Therefore, there is some inherent degree of recall error. However, every attempt was made to design questionnaires that would facilitate accurate recall and minimize the associated recall errors.

Finally, this study was conducted in cities where the majority of the housing stock is known to contain lead-based paint. However, since environmental samples were not collected in this study, there is no guarantee that workers or homeowners were actually performing tasks on surfaces that contained lead-based paint. This lack of knowledge is a potential confounding component to the analysis in that the inclusion of information from respondents that are not exposed to lead-paint could result in the distortion of the relationships between blood-lead levels and R&R activities. For example, consider a homeowner who reported performing extensive R&R in a historic home that, unbeknownst to the homeowner, has been previously abated. In this case, the blood-lead levels of this homeowner may not be related in any way to the amount or nature of the R&R activities performed. Thus, including this homeowner's blood and questionnaire information would cause the positive relationship between R&R and blood-lead levels to be underestimated.

1.3 PEER REVIEW

This report was reviewed independently by members of a peer review panel. Comments which are important for interpreting the study results or which resulted in important modifications to the report are discussed below.

Several comments were made on the sampling methodology and statistical analysis of the data. No changes were made to the methodology or analysis as a result of these comments but in many instances additional text or tables were added to clarify the interpretation of the results. For example, one reviewer expressed concern with the eligibility criteria for workers and

homeowners. As a result of comments from the reviewers, Section 2.1.4 was added to discuss the rationale for requiring study participants to have a history of routinely performing R&R activities in older homes over an extended period so as to focus the study on chronically exposed workers rather than workers engaged in intense activities of short duration. Additional text was added to Section 2.1.4 in response to a comment to clarify differences in selection criteria for professional workers and homeowners. Another reviewer commented on the lack of discussion on specific methods of clean-up and the ramifications that this has on the analysis. As a result, additional text was added to discuss these limitations in the study design and the ramifications on the study results. In response to one reviewer's comment, text was added to discuss the impact of not sampling the worker's environment to confirm that participants were actually working with lead-based paint.

In a few cases, suggested changes or recommendations by reviewers did not ultimately result in substantial changes to the interpretation or the discussion contained in this report. However, these recommendations and suggestions were carefully investigated, and served to improve the report through innumerable small changes in either the methodology or in the phrasing of the discussion. One reviewer suggested changes to the methods used to fit the statistical models. However, it was determined that the suggested changes would result in comparisons that were less statistically powerful and therefore, the suggestion was not implemented. Other concerns included the appropriateness of modeling job/task predictors of historical exposure based on blood-lead concentrations, the lack of specific questions related to time indices for performing the R&R activities, and the classification of workers into groups.

Several responses were received that just commented upon the findings, compared them to previous studies, or suggested areas where language or tables could be clarified or emphasis added. Two reviewers commented upon the negative association between carpet removal and blood-lead concentrations. Additional text was added in Section 3.6.3.1 discussing the various interpretations of this result. Two reviewers also felt that more detailed data should be given concerning the type of respirator used by the participants; additional discussion was included and the number of categories in Table 11 was expanded to provide more information relative to this topic. Discussion of the relationship between clean-up method and R&R activities and its implications for the results presented in this report was also included in Section 3.6.3.1. Additional text was added to further highlight the differences in paint removal work practices between homeowners and workers at the suggestion of a reviewer. Table 14 was expanded to provide more information on respirator use, work practices and education. At the suggestion of a reviewer, Table 20, and corresponding text, was changed to include odds ratios comparing the odds of a blood-lead concentration greater than 25 μg/dL for study participants to the general population.

EPA has established a public record for the peer review under administrative record AR-210. The record is available in the TSCA Nonconfidential Information Center, which is open from noon to 4 PM Monday through Friday, except legal holidays. The TSCA Nonconfidential Information Center is located in Room NE-B607, Northeast Mall, 401 M Street SW, Washington, D.C.

2.0 STUDY DESIGN AND METHODS

This study (WCBS-HH) was a focused follow-up to the WCBS. As expected in a follow-up study, the study design was based upon the experiences acquired in the WCBS, and the design for this follow-up study is similar to that used in the WCBS. However, several modifications were made to the design of the WCBS to reflect field experiences and so that resource and schedule limitations could be met.

This study involved a targeted survey of two groups of persons engaged in renovation and remodeling activities (professional workers and homeowners who were renovating their own home) in three cities (Charleston, South Carolina; Savannah, Georgia; and Baltimore, Maryland). The data collected included:

1. Questionnaire data that were used to characterize the workers and homeowners and to understand differences in blood-lead concentrations

2. Blood samples that were analyzed for lead.

Information for this study was collected in two stages. In the first stage, workers and homeowners from each city were recruited into the study. Brief screening questionnaires (separate questionnaires for workers and homeowners) were administered to potential participants over the telephone to determine eligibility and collect preliminary information on targeted work activities. The second stage involved collecting blood samples and questionnaire data from the eligible participants recruited in the first stage.

This section presents the overall design of the study including the survey design, sample collection, data management, and statistical methods.

2.1 SURVEY DESIGN

Components of the WCBS-HH study design included defining the target population, selecting the sampling locations, sample size determinations, and recruiting the targeted number of workers and homeowners in the survey.

2.1.1 Target Population

The target population for this study consisted of two different groups of persons engaged in renovation and remodeling in historic homes or homes built before 1940:

- Professional R&R workers

- Homeowners that perform a large amount of R&R in their home.

Homeowners were included in this study because it was believed that they perform a wide variety of renovation and remodeling activities in their historic or older homes and are potentially exposed to lead as a result of these activities.

Similarly, professional R&R workers, both union and non-union, who perform R&R in historic or older homes were included in the study. However, initial investigations indicated that a large portion of commercial R&R work performed in historic homes is being conducted by employees of independent, non-union contractors. Therefore, unlike Phase II of the R&R Study (WCBS), this study did not specifically target workers based upon union membership.

Workers and homeowners were targeted in three cities: Charleston, SC; Savannah, GA; and Baltimore, MD. These cities were selected because they fulfilled several key criteria including:

- Potential Respondent Base: In order to fulfill the sample size requirements, each city area needed to have a sufficient number of workers and homeowners that perform R&R activities in historic or older homes on a routine basis. Therefore, each city needed to have a large number of historic or older homes. Local historic preservation societies and other local organizations in several cities were contacted in an effort to determine cities that have a large population of historic homes.

- Presence of Local Organizations: The presence of local organizations, such as a local historic preservation society, was considered to be a key component in identifying potential respondents.

- Geographic Location: In order for the study to be cost effective, it was desirable to have on-site data collection support in or near the sampled city.

Several other cities including: Boston, Chicago, New Orleans, San Francisco, and Cleveland were considered for this study, but were eliminated because they did not fulfill all three of the above criteria.

2.1.2 Sample Size Determinations

The targeted sample sizes were developed to allow an assessment of whether workers (or homeowners) that perform R&R activities in historic homes have elevated blood-lead levels as a result of their R&R activities. Moreover, the resulting sample size represents the minimum sample size necessary to detect a 2.5-fold difference between the geometric mean blood-lead levels observed in the general U.S. population and blood-lead levels of workers that routinely perform R&R activities in historic homes or homeowners that perform R&R activities in their historic home while retaining residency.

The following assumptions were made to derive the minimum sample size required:

- Statistical hypothesis tests were assumed to be conducted at the 5 percent significance level to examine whether the blood-lead levels of workers and homeowners were significantly higher than the national average. Also, these tests were assumed to be conducted with at least 90 percent power. That is, the Type I and II error rates were assumed fixed at 0.05 and ≤ 0.10, respectively.

- The analysis was assumed to consist of a general linear model with the log-transformed blood-lead as the response variable since blood-lead data are generally assumed to follow a log-normal distribution.

- The log standard deviation of the blood-lead levels was assumed to be twice that observed in the WCBS. These respondents were expected to have higher blood-lead levels than workers in the WCBS. Since blood-lead is assumed to follow a log-normal distribution, higher expected mean levels would also result in more variability.

Based upon these assumptions, the minimum sample size was calculated to be 40 professional R&R workers, and 40 R&R homeowners in each city area. For the purposes of determining sample size estimates, Charleston, SC, and Savannah, GA, were considered as one city area while Baltimore, MD, was considered to be a second city area. Therefore, the total target sample size of 160 individuals was set for the study (80 professional R&R workers and 80 R&R homeowners).

2.1.3 Recruitment

With professional workers, many contractors who have listings or advertisements indicating that they specialize in R&R of historic homes spend only a small fraction of their time actually working in historic homes. Similarly, much of the hands-on work may be completed by subcontractors who spend a large portion of time working in newer construction. Also, as was experienced in the WCBS, large contracting companies are reluctant to allow their workers to participate in a study of this type. Homeowners often do not want to participate in this type of study because they are performing R&R work without a permit.

A similar, multi-pronged approach was used to recruit both workers and homeowners. Section 2.1.3.1 presents the recruitment approach used for workers and Section 2.1.3.2 presents the recruitment approach for homeowners.

2.1.3.1 Recruitment of Workers. Initial investigations indicated that a large portion of the work performed in historic homes is done by employees of independent, non-union contractors. Therefore, membership lists in unions such as the United Brotherhood of Carpenters that were employed in the WCBS, were not used as a sampling frame. Instead, a three-pronged approach that consisted of (1) newspaper, magazine, and radio advertisements; (2) development of contractor lists; and (3) referrals and other networking activities, was used to identify potential respondents. The following activities were conducted to recruit workers:

- Advertisements. Newspaper advertisements were the most successful method for recruitment of eligible workers; both as a primary and as a secondary recruitment method (i.e., a worker was referred to the study by someone who saw an advertisement). Advertisements were placed in wide circulation daily newspapers and smaller community-based newspapers in each city. Examples of the newspaper advertisements are presented in Appendix E.

Approximately 60 15-second radio advertisements were also run on local stations in Charleston, SC, and Savannah, GA, to recruit potential study subjects. These advertisements identified the project as a study on renovation and remodeling and provided a phone number that interested persons could call.

- Media Coverage. A written press release was prepared and sent to all media in each city (see Appendix E). A video press release was prepared and sent along with the written press release to all television stations in each city's broadcast area. Two television stations in Savannah, GA, covered the study.

- Networking and Outreach. Posters were put in local hardware stores and lumberyards (see Appendix E). Local neighborhood associations were contacted, and posters about the study were distributed to their members. Other local associations such as historical societies were contacted and asked to recruit workers into the study.

  In each city, several in-person visits were made to neighborhoods where there was observable renovation and remodeling being performed. During these visits, preprinted fliers were distributed to the workers and they were encouraged to participate in the study.

- Referrals. Referrals were also highly effective in recruiting additional participants. To encourage eligible participants to provide referrals, a $10 cash incentive was given to participants for each R&R worker (or homeowner) they referred to the study. This incentive was only given if the person referred was subsequently determined to be eligible and participated in the study. Eligible participants were asked to provide referrals during a telephone interview (screener) and were again reminded while participating in their data collection session.

- Contact List. Lists of non-union contractors were developed through listings in local phone books, advertisements, and by contacting local organizations, such as historic preservation societies, landmark commissions, and architectural firms. An attempt was then made to contact and enroll all workers on the list. Although this method was more time consuming and only a handful of participants were identified through this approach, it allowed for the inclusion of participants that might otherwise have been omitted from the study (e.g., persons who work by themselves and do not read the paper).

Of these activities, newspaper advertisements, word-of-mouth referrals, and in-person recruitment were the three most successful methods for obtaining eligible worker participants.

2.1.3.2 Recruitment of Homeowners. Recruitment of homeowners that perform R&R work in their own historic/older home while retaining residency was conducted in a fashion similar to that described in Section 2.1.3.1. Again, a multi-pronged approach was used. Newspaper advertisements were the primary method for recruitment of eligible participants and separate, targeted advertisements were developed to recruit this group of participants (see Appendix E).

Although news advertisements and identification of R&R homeowners through local organizations (e.g., neighborhood associations, historical societies, etc.) were successful in recruiting a number of homeowners, other recruitment activities were conducted to ensure that the target sample size was reached. For example, fliers and posters were prepared and distributed to local hardware stores and supermarkets and radio advertisements were developed and aired on various media. However, these recruitment activities were labor intensive and were used only after it appeared that newspaper advertisements alone would not be successful in reaching the target sample size.

2.1.4 Eligibility Criteria

As in any study, the eligibility criteria are a function of both the study objectives and restraints on resources available to conduct the study. Further, the eligibility criteria needed to account for differences in the nature of exposure from R&R activities. For example, workers can perform activities for a brief (less than 10 days) but intense period, which may result in an elevated blood-lead level due to the intense exposure. This situation, however, could be investigated using data from the WCBS data (where days spent performing R&R were not used as an eligibility criterion). What could not be investigated using the WCBS data was the relationship between routinely (over many days) performing R&R activities in high-risk residences and blood-lead levels (only 41 percent of the respondents performed R&R work in pre-1950 homes and on-average WCBS respondents only spent approximately 10 days working in homes built before 1950[5]). Therefore, this study was focused on examining the relationship between performing R&R activities in "worst-case" exposure scenarios where workers routinely day-after-day, spend the majority of their time performing R&R activities in high-risk, older homes. Given this focus, the information that was already collected in the WCBS, and the resource constraints for the study, the eligibility criteria were established so that we focused on the chronically exposed workers.

The eligibility criteria were different for homeowners and workers because the type of exposure for homeowners due to conducting R&R differs from that of professional R&R workers. First, R&R workers tend to work for 8-hour periods during the business week while homeowners tend to perform R&R as a "second job" on nights and weekends. Second, homeowners have the potential for additional exposure because they are living in the home while they are performing R&R. Thus, we utilized different eligibility criteria for homeowners because we wanted to capture both types of exposure. A criterion based solely on the number of days in the last 30 days that the homeowner performed the activity may account for secondary exposure due to living in the home, but may not account for the intensity of the activities being performed. Conversely, using criteria based solely on the intensity of the activity (hours in the last 30 days) may not account for exposure due to living in the home. We established the specific eligibility criteria for homeowners based upon the results of a pilot test of the questionnaire.

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[5] The WCBS only collected detailed information on the number of days worked in all residences and in pre-1950 residences.

Ideally, we hoped to measure worker's exposure in the same fashion as homeowners (i.e., in terms of both days and hours). However, it proved unrealistic to have R&R workers determine, even in a general sense, how many hours they spent performing a particular R&R activity.

2.2 SAMPLE COLLECTION

2.2.1 Questionnaires

One set of questionnaires was used to obtain information such as detailed work history, personal characteristics, and general work practices from professional R&R workers and another set was used to obtain similar information from homeowners that conduct R&R activities in their own historic/older home. Each set of questionnaires consisted of a telephone administered screener and a main self-administered questionnaire (SAQ). All four questionnaires are presented in Appendix A.

The worker questionnaires were modifications of those used in the WCBS and had essentially been pre-tested. However, the homeowner questionnaires were necessarily more complex. A pre-test of the homeowner questionnaires was conducted with homeowners to determine whether the flow of the questionnaire caused confusion or item non-response and to estimate the amount of time needed to complete the screener and main questionnaire.

In all four questionnaires, most questions were worded with pre-coded responses to avoid ambiguous answers to open-ended questions. This also minimizes the potential for information bias, ensures consistency in the respondents' answers, and facilitates data editing, cleaning, coding, and analysis. The few questions that were not amendable to closed-ended responses were left open and categorized retroactively.

2.2.1.1 Telephone Screener Questionnaires. Questionnaire information was collected on all potential participants using a telephone interview (screener) as part of the recruitment process. Specifically, the telephone interview was used to:

1. Determine Eligibility. To be eligible for the study, a R&R worker had to meet four criteria: (a) perform R&R for a living, (b) conduct "hands-on" R&R work, (c) have worked more than 10 days (in the last 30 days) in historic homes or homes built before 1940, and (d) have worked more than 9 weeks (in the last 12 months) in historic homes or homes built before 1940.

   Homeowners were considered to be eligible for the study if they met all of the following seven criteria: (a) did not perform R&R for a living, (b) had made room additions or renovations to their home in the last 12 months, (c) lived in the house while the R&R was being performed, (d) lived in a home built before 1940, (e) did a large portion of the "hands-on" R&R work themselves, (f) did more that 20 hours of R&R work in their home in the last 30 days, and (g) did some R&R work in their home in at least 9 weeks (in the last 12 months).

2. Assess Potential Selection Bias. Information from the screener allowed for a comparison between basic demographic characteristics and targeted activities for those workers and homeowners that participated in the study and those that refused to participate.

3. Schedule Appointments and Collect Referral Information. Once the eligibility of a participant had been determined, an appointment for further data collection was scheduled for eligible participants. Both eligible and ineligible participants were asked at the end of the telephone screener to provide referrals for the study.

Each telephone interview took approximately five minutes to complete.

In some cases, the respondent did not complete a telephone screener prior to arrival at the data collection facility. In these cases, a screener, identical to the telephone screener, was administered in-person to determine eligibility of these "walk-in" participants.

2.2.1.2 Main Study Questionnaires. Among participants that were eligible for the study, detailed information on work history, personal characteristics, and general work practices was obtained during a data collection session at a collection facility. A central location (either a hospital or health department building) was used in each city as the data collection facility. Three, one-night data collection sessions were held in Charleston, SC, at Roper Hospital on 4/21/97, 5/12/97, and 5/28/97. Two one-night data collection sessions were held in Savannah, GA, at the Public Health Department on 5/14/97 and 5/29/97. Three data collection sessions were held in Baltimore, MD, at Johns Hopkins University (Bayview Campus) on 6/26/97 and 7/15/97-7/16/97. During the data collection sessions, detailed work history, personal characteristics, and information on general work practices were collected using a self-administered questionnaire (SAQ), which took approximately 30 minutes to complete. A trained interviewer was present during all of the data collection sessions to answer questions concerning specific questions in the questionnaire or to administer the entire questionnaire, if necessary.

A field review of this questionnaire was performed before the respondent left the facility in an effort to minimize item non-response. Respondents that satisfactorily completed the SAQ received $25.

2.2.2 Blood Samples

Two trained and licensed phlebotomists collected a venous blood sample from eligible study participants immediately following the completion of the SAQ. A duplicate blood draw was collected from approximately 15 percent of the respondents for quality assurance purposes. Respondents for whom a successful blood sample was collected received an additional $25.

The protocol for collecting, storing, and shipping the blood samples is described in "Quality Assurance Project Plan (QAPjP) for the R&R Worker Characterization and Blood-Lead Study," July 8, 1994.

2.3 DATA MANAGEMENT

Carefully designed data control procedures were employed to ensure that all data collected were accurate, consistent, and complete. During all the steps of data management, measures were taken to ensure confidentiality of personal information obtained from study participants. Locked file cabinets were assigned in which all hard copies were kept. Access to these file cabinets was limited to those directly involved in data collection, editing, and cleaning of data for this study.

There were four components to the data control procedures:

1. Data Receipt and Control System Update. Data receipt and control procedures served as a link between data collection and data preparation. The data receipt and control system ensured that all documents required for each case were received and logged. Routine reports were produced on the number of cases collected at each stage of processing. These reports allowed for timely identification of any documents not received from the field.

2. Data Editing and Coding. All data were subject to a series of steps to ensure that they were maximally error-free prior to electronic storage. When a data collection form was completed it was edited for missed, inconsistent, or illegible responses. Any problems were checked with the respondent while he/she was still present at the data collection site. Completed data collection forms were logged in and sent to the data preparation department to be thoroughly edited for completeness, accuracy, and consistency. Editors conducted a question-by-question review of the data collection form. During this step the data were checked again for inappropriate skips of questions, double coding, inconsistencies, and illegible responses. Any inconsistencies or unusual situations were referred to the Data Preparation Manager who was responsible for handling all editing and coding decisions. Missed questions or inconsistent responses were retrieved from the respondent whenever possible.

3. Data Entry and Verification. Once data passed the manual edit, they were transferred to data entry. Data sets were keyed in-house using double entry to verify correct keying of the data. Any discrepancies in keying were corrected before computer editing of data.

4. Computer Edits. Computer edits of the data took place after data were entered into the computer. A set of edit specifications were created by the Data Preparation Manager to check out-of-range values (e.g., more than 30 days worked in last month), inconsistencies across variables, and skip patterns. The data set was then checked against these specifications, and a computer printout was produced to list all errors found in the data. Errors identified by this procedure were corrected by the editing staff, and the corrections were made to both the hard copy and the data disk. The data set was run against these specifications a second time to ensure that all corrections were made. This procedure was repeated until no errors were found in the data.

2.4 STATISTICAL ANALYSIS

The statistical analysis included several preliminary steps, including constructing variables, calculating descriptive statistics, and exploratory data analysis. Statistical models were then fit to the data to meet the study objectives listed in Section 1.1. The statistical models were used to assess relationships between blood-lead concentrations and potential lead exposure associated with the target activities. These relationships were investigated for three time periods for workers: exposure during the previous 30 days, exposure during the past 12 months, and historical exposure. For homeowners, only two time periods were investigated: exposure during the previous 30 days and exposure during the past 12 months. All statistical analyses were performed using the SAS® computing system (Version 6.12).

2.4.1 Construction of Variables

Questionnaire responses and measured blood-lead concentrations were used to construct variables for statistical analysis. The primary response variable for statistical analyses was blood-lead concentration. Histograms, probability plots, and descriptive statistics were examined to determine the distribution that best approximates the realized sample of blood-lead concentrations.

The following two sections discuss the two types of variables constructed prior to performing the statistical analyses: variables related to potential lead exposure from conducting R&R work (Section 2.4.1.1), and variables related to demographic characteristics and other sources of exposure (Section 2.4.1.2). The constructed variables were used to assess the effects of target activities on blood-lead concentration.

2.4.1.1 Construction of Exposure Variables. Measures of potential lead exposure to professional workers resulting from conducting R&R work were constructed for three exposure periods: last 30 days, last 12 months, and the entire career. The exposure measures were constructed for each target activity (large structure removal, paint removal and surface preparation, window replacement, carpet removal, and cleanup) and for conducting R&R work in general.

For each specific target activity, the potential lead exposure variables for workers were constructed from the following questions:

Short-term: (last 30 days)	In the last 30 days, how many days did you work on the target activity?
	In the last 30 days, how many days did you work on the target activity in homes or buildings built before 1940?

Mid-term: (last 12 months)	Altogether in the past 12 months, how many weeks did you work on the target activity? (0) None (1) < 1 Week (2) 1-4 Weeks (3) 5-8 Weeks (4) 9-12 Weeks (5) 13-26 Weeks (6) > 26 Weeks
Long-term: (entire career)	Think about all the years you have done renovation and remodeling. In how many of these years did you work on the target activity at least some of the time?

In addition, one objective of this study was to determine if specific groups of workers are more exposed than others due to the nature of their work. Therefore, each worker was assigned to a specific worker group based on their response to the following question: What is your current job title and what are your main activities at work? The main activities were used to define the worker groups, independent of blood-lead concentrations and target activities. When the subject's main activity response was insufficient for defining an appropriate worker group, both job title and main activity were taken into consideration. In all, four worker groups were defined: Carpenter, Laborer, Painter, and Other. Table B-1 in Appendix B contains a listing of the main activities and job titles for each worker group.

There were two questions related to short-term exposure of workers: (1) In the last 30 days, how many days did you spend doing any kind of R&R work? and (2) In the last 30 days, how many days did you spend doing any kind of R&R work in historic homes or homes built before 1940? Therefore, an effort was made to determine which was most strongly related to worker blood-lead concentration. For each target activity, relationships were examined between worker blood-lead concentration and the number of days the target activity was conducted, and the number of days conducted in pre-1940 houses. Based on plots and univariate regressions, the number of days an activity was performed in homes built before 1940 was selected as the measure of short-term exposure.

Measures of potential lead exposure to homeowners resulting from conducting R&R were constructed for two exposure periods: last 30 days and the last 12 months[6]. As with the workers, exposure measures were constructed for each target activity and for conducting R&R work in general.

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[6] Information corresponding to the third exposure period (entire career) was not collected for homeowners because of the intermittent nature of renovation performed by homeowners and difficulties of recall.

For each specific target activity, four potential lead exposure variables for homeowners were constructed from the following questions:

Short-term: (last 30 days)	In the last 30 days, how many days did you work on the target activity in your historic or pre-1940 home?
	On a typical day within the last 30 days, when you performed the activity, about how many hours did you perform the work?
Mid-term: (last 12 months)	During the past 12 months, in how many weeks did you spend any time performing the activity?
	In a typical week in the past 12 months when you performed the activity, about how many days did you perform the work?

The two questions related to short-term exposure of homeowners as a result of conducting R&R activities were used to determine which type of exposure was most strongly related to blood-lead concentration (duration of R&R project or hours of exposure). For each target activity, relationships were examined between homeowner blood-lead concentration and the number of days the target activity was conducted by the homeowner in their home, and the total number of hours spent by the homeowner conducting the activity in the last 30 days (calculated by multiplying the number of days by the hours spent on a typical day). This distinction is important because it is believed that homeowners are thought to be exposed not only by the actual work, but also by living in the home while the work is being performed. The number of days in the last 30 days the homeowner performed the activity may account for secondary exposure due to living in the home but may not account for the intensity of the activities being performed. Conversely, the total number of hours spent performing the activity may account for exposure due to performing the activity but may not account for the duration of the R&R project. For example, consider two homeowners: the first performing some R&R every day in the last 30 days but for only one hour a day (total of 30 hours), the second performing R&R eight hours a day for one consecutive week (total of 56 hours). Univariate regressions and plots did not provide insight into which measure was more related to homeowner blood-lead concentrations. Therefore, the statistical analyses were conducted twice, once for each measure.

There were also two questions related to mid-term exposure of homeowners performing R&R activities in their home: weeks in the last 12 months or days in the last 12 months (calculated by multiplying weeks in the last 12 months by the number of days in an average week where the R&R activity was performed). Again, an effort was made to determine which of the two measures was the most related to homeowner blood-lead concentration. As with the measures associated with short-term exposure, univariate regressions and plots did not provide insight into determining which measure was more related to homeowner blood-lead concentrations and the statistical analyses were performed once for each measure.

2.4.1.2 Construction of Other Variables. Demographic variables such as age, gender, race/ethnicity, and level of education were constructed from the questionnaire responses. The questionnaires also provided information on potential lead exposure that occurred outside of R&R work. An indicator (zero or one) variable was constructed from the responses to questions on other activities (Appendix A). If a worker or homeowner responded positively to one or more of those questions then they were assigned a value of one for the variable "Other Occupations," indicating potential occupational exposure outside of R&R. A similar variable for potential lead exposure was defined based on the responses to questions on non-work related activities. Variables were also constructed for the use of specific work practices and work habits.

2.4.2 Descriptive Statistics

Descriptive statistics were calculated for each variable constructed in Section 2.4.1. For continuous variables such as age, means and percentiles were calculated. For categorical variables such as gender, the percentage of respondents in each category was calculated.

Geometric means and standard errors of blood-lead concentrations for each study group and city were calculated. Additional tables were prepared to assess the variability in measured blood-lead concentrations between duplicate blood samples and among duplicate chemical analyses.

2.4.3 Exploratory Data Analysis for Ancillary Variables

Exploratory data analyses were performed to assess the relationships between blood-lead concentration and various ancillary variables describing demographics, work practices, and work site characteristics. The purpose of these analyses was to select ancillary covariates for modeling the relationships between blood-lead concentration and target activities. For each ancillary variable, the analyses included a plot against blood-lead concentration and a statistical test to assess the significance of any functional relationship revealed in the plot. Analyses of variance (ANOVA) were carried out for categorical variables and significance of slopes of linear regressions were examined for continuous variables. These analyses were conducted separately for workers and homeowners and for each sampling frame.

2.4.4 Statistical Models

2.4.4.1 Blood-Lead Concentrations. The July 8, 1994, WCBS QAPjP (also used for this study) specified that at least one set of CDC blood-lead quality control reference (CDC QC) samples be included in each shipment of blood samples. Nominal blood-lead concentrations of the low, middle, and high CDC QC samples were 4.5, 10.6, and 20.8 µg/dL, respectively. An ANOVA model appropriate for random effects was fit to the CDC QC samples to assess the variability between replicate samples at same blood-lead concentration and to estimate recovery rates at each concentration.

At least two chemical analyses were performed on each blood sample. Approximately 15 percent of the workers were selected for duplicate blood draws. An ANOVA model appropriate for random effects was fitted to the subset of workers possessing two blood samples

to assess the variability in blood-lead concentrations between duplicate blood draws. The following random effects were included in this model: (1) worker, (2) blood sample nested within worker, and (3) analysis nested within blood sample.

2.4.4.2 Relationships Between Target Activities and Blood-Lead Concentrations. Although the questionnaire for homeowners was based in part upon the worker questionnaire, responses to similar questions may have different meanings as they relate to the two groups of study participants. For example, most homeowners did not perform R&R activities all day long while most professional workers did. Thus, responses to similar questions like: "How many days did you perform the R&R activity?" may measure vastly different periods of exposure between workers and homeowners. Therefore, the statistical analyses conducted for this study were performed separately for workers and homeowners. However, a similar approach was used to assess the relationships between the target activities and the blood-lead concentrations for workers and homeowners. This approach is discussed below.

For each study group (workers and homeowners) a series of statistical models were fit to the data to determine if there were any significant associations between blood-lead concentrations and various types of work or target activities. For workers, the relationship between blood-lead concentrations and potential lead exposure associated with R&R target activities was investigated for exposure during the previous 30 days, exposure during the past 12 months, and historical exposure (years in career). For homeowners, the relationship between blood-lead concentrations and potential lead exposure associated with performing the target R&R activities was investigated for exposure during the previous 30 days and exposure during the past 12 months. Multiple regression models were employed for both study groups to examine these relationships. To simplify the regression models, results of multiple chemical analyses and duplicate blood samples were averaged for each participant to provide a single blood-lead concentration for each study participant.

Figure 1 displays the paradigm utilized for fitting the models to worker blood-lead concentrations. Figure 2 shows the paradigm utilized for fitting the models to homeowner blood-lead concentrations. The first step in the model fitting for both workers and homeowners (as shown in the top box of both figures) was to conduct preliminary analyses to

1. Define the measures of exposure,

2. Verify the use of log-normal distribution for blood-lead concentrations, and

3. Select covariates for the statistical models.

The second step, presented on the left branches of Figure 1 and Figure 2, shows that separate models were fit to the data for each target activity. Initially, linear regression models were fit to the log transformed blood-lead concentrations using each of the exposure measures as the independent variable. Next, the analyses were repeated incorporating the previously selected ancillary variables (age, gender, ethnicity, smoking status, and room additions or renovation in own home) as covariates. Finally, a linear regression model that incorporated the ancillary

covariates and simultaneously investigated the potential for lead exposures within the past month, the past year, and historically was fit to the data for each target activity.

The above analyses helped characterize the strength of the relationship between each target activity and blood-lead concentrations for workers and homeowners. The final goal, however, was to develop models (one for workers and one for homeowners) that explain how each of the target activities interacted in their association with blood-lead concentrations while accounting for the effect of potentially confounding ancillary covariates. Therefore, as illustrated by the right branches of Figure 1 and Figure 2, regression models that examined all of the target activities simultaneously, were fit to the data. The initial models included effects for all five target activities for each exposure period (short-term, mid-term, and long-term for workers; short-term and mid-term for homeowners). For workers, these models were repeated with worker group added to the model. Finally, an attempt was made to construct models for workers and homeowners that would assess the effects of the exposure periods simultaneously for all of the explanatory variables. However, correlations among the target activities and between the exposure periods within a target activity were high for both workers and homeowners. Therefore, as shown in Figures 1 and 2, only a subset of the variables for the various exposure period and target activity combinations were included in the final models.

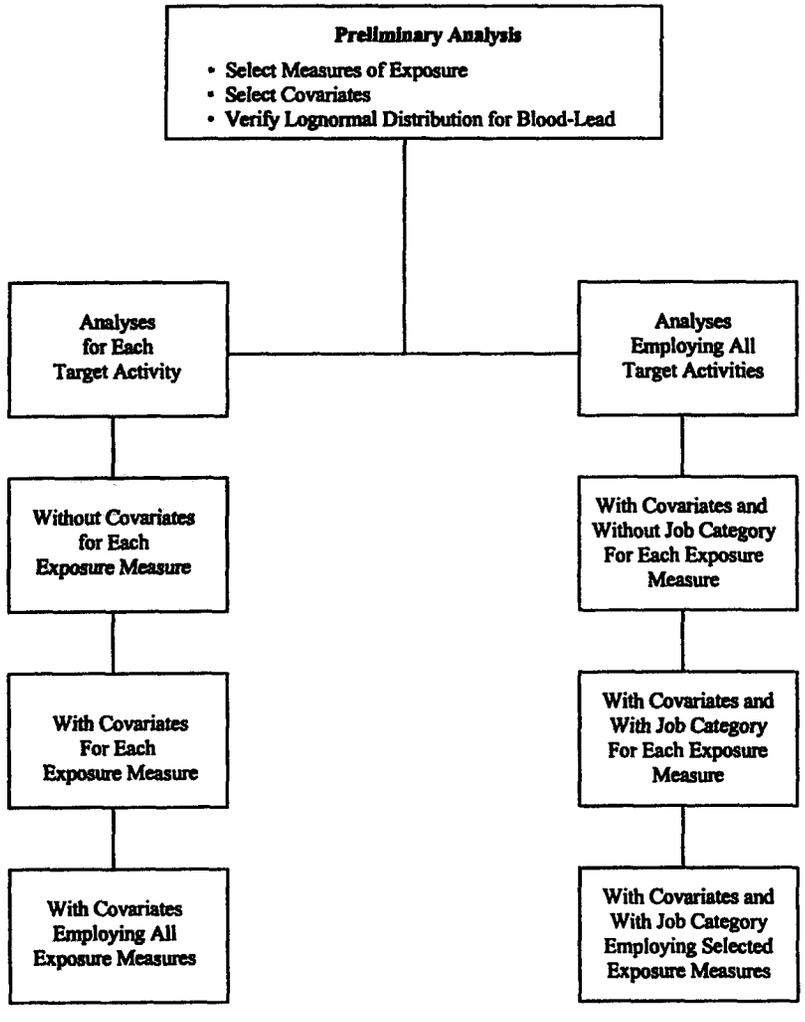

Figure 1. Paradigm for Fitting Statistical Models to Worker Blood-Lead Concentrations

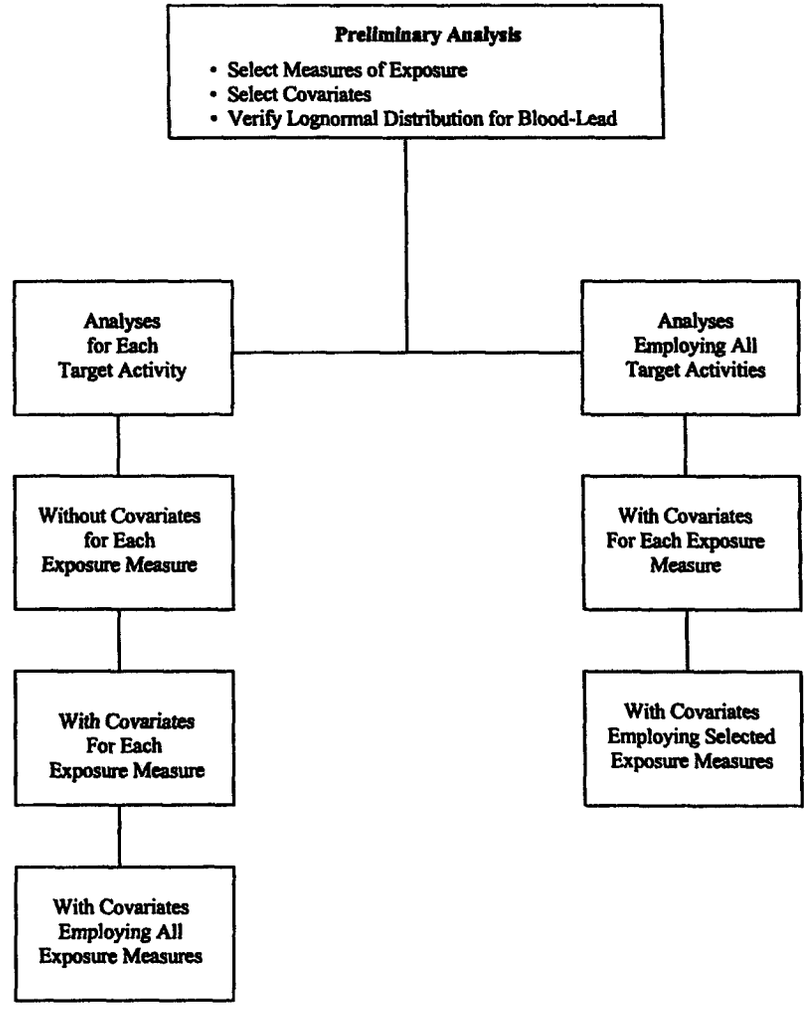

Figure 2. Paradigm for Fitting Statistical Models to Homeowner Blood-Lead Concentrations

3.0 RESULTS

The sections in this chapter discuss the results of recruitment, data collection, and statistical analysis. It should be noted that the results presented in this chapter are based upon questionnaires and venous blood-samples collected from professional R&R workers and homeowners performing R&R in their own historic or older home. The recruitment approach and the study cities were selected to maximize the likelihood that the study participants disturb lead-based paint through their R&R activities. However, environmental samples were not collected to examine the assumption that the participants actually did disturb lead-based paint.

3.1 RECRUITMENT RESULTS AND FIELD EXPERIENCES

3.1.1 Recruitment of Respondents

Recruitment activities were conducted in Charleston, SC, on April 7, 1997, through May 28, 1997, in Savannah, GA, on April 27, 1997, through May 29, 1997, and in Baltimore, MD, on June 11, 1997, through July 16, 1997. As a result of the recruitment activities, 498 participants were screened for participation in the study. Through the screening process, each participant was classified into one of the following four categories:

- Eligible — Eligible participants were defined to be those participants who were screened as eligible and scheduled for future data collection.
- Eligible Refused — These participants completed the screener and were eligible for the study but refused to complete the main questionnaire.
- Refused Screener — These are potential respondents who called in to the study line but refused to participate in the screening/recruiting interview.
- Ineligible — These respondents participated in the screening/recruitment but were not eligible for the study (see Section 2.2.1.1).

As shown in Table 1, of the 498 respondents who were screened, 55 percent (274) were determined to be eligible for the study. Approximately 74 percent (181) of the workers who were screened were classified as eligible for the study while 37 percent (93) of the screened homeowners were eligible for the study. This difference is likely due to the more restrictive eligibility criteria for homeowners.

Although a majority of the 269 participants who were screened and scheduled for further data collection completed the study, there was a small subset (31) who did not. Furthermore, 17 of the participants who were originally screened as eligible and completed the main questionnaire actually were ineligible for the study at the time that the main questionnaire was administered. One possible explanation for this is that for a few of these respondents, during the delay between the time of the telephone screener and the time that the respondent completed the questionnaire, a change occurred in the number of days worked in pre-1940 homes in the last 30 days. Another, more likely explanation for misclassifying workers as eligible who were

screened on-site is that the responses to the screener may not be as accurate as responses to the main questionnaire (see Section 3.1.2). Eligible participants who completed the questionnaire and the blood draw were classified as **Complete**. Questionnaire and blood results for the 17 participants who were originally screened as eligible but were later found to be ineligible were not included in the statistical analyses.

Table 1. Summary of Recruitment Results by Study Group and City

Study Group	City	Total Screened	Eligible	Eligible Refused	Ineligible	Refused Screener	Total Number Completed	Response Rate[a]
Workers	Baltimore	132	101	0	31	0	92	91%
	Charleston	70	47	0	23	0	41	87%
	Savannah	42	33	0	8	1	28	82%
	All Cities	244	181	0	62	1	161[b]	88%
Homeowners	Baltimore	94	39	1	54	0	34	85%
	Charleston	102	25	0	74	3	22	79%
	Savannah	58	28	0	30	0	26	93%
	All Cities	254	92	1	158	3	82[c]	85%
All Participants	Baltimore	226	140	1	85	0	126	89%
	Charleston	172	72	0	97	3	63	84%
	Savannah	100	61	0	38	1	54	87%
	All Cities	498	273	1	220	4	243	87%

(a) Response Rate = [Total Number Completed/ (Eligible + Eligible Refused + Refused Screener)]
(b) One worker in Charleston, SC, and another in Savannah, GA, could not give blood.
(c) One homeowner in Savannah, GA, could not give blood.

As expected in a study that is primarily based upon a "volunteer" sample, the overall response rate (87%) was very high. The response rate was calculated as the number of completes over the sum of eligibles, eligible refused, and refused screener. Workers had a sightly higher response rate (88%) than did homeowners (85%).

Overall, the intensive recruitment activities were effective; the target sample sizes were attained and complete information was collected from 243 respondents (117 respondents in Charleston, SC; and Savannah, GA; and 126 respondents in Baltimore, MD). However, it was necessary to maintain intensive recruitment throughout the entire study period. Initial enrollment was slow and information from the largest portion of participants (45%) was not collected until the last data collection session in each city.

3.1.2 Field Experiences

Data collection sessions were held in three cities: Charleston, South Carolina; Savannah, Georgia; and Baltimore, Maryland. Overall, the predominant mood of the study participants was one of cooperation. Participants seemed interested in the study and in their own blood-lead results. The following three sections discuss, in greater detail, the field experiences in each city.

3.1.2.1 Field Experiences in Charleston, South Carolina. Three data collection sessions were held at Roper Hospital North from 4:00 p.m. to 8:00 p.m. on April 21, May 12, and May 28, 1997. The site, located in a suburban area north of Charleston, SC, required participants to arrive by car. Hospital officials supplied a single conference room where study participants checked in, completed the self-administered questionnaire (SAQ), and gave a sample of blood.

A two-person data collection team oversaw each data collection session. The study manager checked in arriving participants, collected paperwork, and paid those who both successfully completed the SAQ and gave a sample of blood. A study supervisor provided SAQs to participants, screened walk-ins (not pre-screened for eligibility by phone), field-edited questionnaires, and prepared data for mailing and transport. Two phlebotomists drew blood and labeled the blood samples. Because of the large number of participants expected during the last two visits, an additional person was added to the data collection team to greet respondents, give directions, and offer refreshments.

At each session, a pre-screened participant was directed into the conference room, where he/she was then seated around a large conference table with about 10 seats. After the study manager confirmed the appointment, the participant was seated in order to read and sign the study consent form. After signing the consent the participant completed the SAQ, and then moved to the end of the table behind a screen, where a phlebotomist drew a blood sample. Afterward, participant and a study supervisor discussed any missing or unclear answers given in the SAQ. They then returned to the study manager, who paid them and double-checked for mailing address and telephone number changes.

Data collection proceeded in an orderly manner for all three data collections sessions. Most respondents were orderly and kept their appointments, arriving alone or in small groups of two to three. Renovation and remodeling workers tended to arrive earlier, at the end of their workday, while homeowners usually came later in the evening. Since arrivals were spread over the session, participants were able to begin paperwork and SAQs within minutes, and the phlebotomists had no trouble taking samples in a reasonable amount of time. The average respondent completed the SAQ in about 30 minutes, and the blood draw and payment process took an additional 15 minutes.

At the end of each session, phlebotomists packed, refrigerated, and prepared blood samples for shipping, according to the study protocol described in "Quality Assurance Project Plan (QAPjP) for the R&R Worker Characterization and Blood-Lead Study," (July 8, 1994). However, CDC performance samples were unavailable for the April 21, 1997, data collection

session. The CDC performance samples were included in blood shipments for the remaining data collection sessions.

Some small problems arose during the second and third sessions due to the large number of respondents. Since the supervisor responsible for field-editing SAQs also performed several other tasks (administering SAQs to poor readers and screening and enrolling walk-in respondents), some SAQs were not completely field edited. In those cases, missing data were retrieved later by phone. In addition, one respondent was unable to produce a blood sample during their session.

There was very little activity in the hospital in the evenings and, other than the security guard and phlebotomists, no other hospital staff were available on-site to access in case of any sort of difficulty. The hospital liaison, through whom the data collection sessions were arranged, was located at Roper's main facility several miles away. Since so few people were inside the facility, all entrances but one were locked after 5:00 p.m. This caused some confusion when a few respondents, arriving late in the evening and finding the front entrances locked, left without participating in the study. Most, however, were later contacted and recruited for future sessions.

3.1.2.2 Field Experiences in Savannah, Georgia. Two data collection sessions were held at Chatham County Health Department from 5:00 p.m. to 8:00 p.m. on May 14 and May 29, 1997. The health department is located a few miles south of downtown Savannah, GA, and most respondents arrived by car. A large classroom-style room was provided for check-in and completing SAQs. Participants were led to a separate room for collection of the blood sample.

Collection sessions in Savannah, GA, were scheduled one or two days following those in Charleston, SC, maximizing recruitment activities between the two cities and minimizing travel costs. As a result, the same data collection team and collection procedures were used in both Savannah, GA, and Charleston, SC. Two phlebotomists were hired through the health department, and like the second and third Charleston, SC, sessions, an additional person was added to the data collection team to escort study participants.

Because of the large, classroom style room, data collection sessions proceeded in an orderly fashion, even though most participants arrived during the first 2 hours of each session in groups of three to five. Although some were forced to wait in lines to check in, receive consent forms and SAQs, give blood samples, and receive payment, almost 30 seats were available for those filling out forms. Several family members who came along with screened respondents were also accommodated. Also, only one respondent was screened on-site; the rest were screened over the telephone.

Two participants refused to supply blood samples. Since both had already completed SAQs, they were each paid $25.

Unlike the situation encountered in Charleston, SC, health department employees were most cooperative and greatly facilitated the data collection in Savannah, GA. In particular, a specific health department staffer was assigned as liaison each evening in case troubles arose. In addition, maintenance staff were available to rearrange the room and supply needed furniture and

materials. As in Charleston, SC, phlebotomists prepared and shipped blood samples, according to the WCBS QAPjP protocol.

3.1.2.3 Field Experiences in Baltimore, Maryland. Data collection sessions were held at Johns Hopkins University's Bayview Campus on June 26, May 15, and May 16, 1997. The data collection sessions began at 4:00 p.m. and lasted until 9:30 p.m. The campus, located east of downtown near a large urban residential district, was accessed by respondents both by car and by foot. Only a small conference room was available for check-in and completing SAQs; blood samples were taken in another room down two long hallways. Because of limited space in the conference room, and increasing numbers of expected participants, the lobby was used as a waiting area during the last two data collection sessions.

Data collection procedures in Baltimore, MD, were essentially the same as those used in the other cities. However, three changes were made to accommodate a larger number of participants: (1) an additional editor and interviewer were added to the data collection team; (2) participants were asked to wait in a reception area separate from where data collection was being performed; and (3) a security guard was hired to ensure the safety of study staff.

There were some problems with data collection in Baltimore, MD. The most notable was screening walk-in respondents for eligibility. During the first two data collection sessions in Baltimore, MD, a small number of walk-in participants arrived and wanted to participate in the study. These participants were screened on site, and, if eligible, allowed to participate in the study on a first-come, first-serve policy. Those whose responses to the screening interview indicated that they were ineligible for the study were not permitted to participate. Ineligible participants left the data collection sessions without any problems. In addition, all eligible participants were able to provide a sample of blood.

In the third Baltimore, MD, session, however, there were a large number of workers (up to 40) who did not pre-screen for the study but who wanted to participate. A trained interviewer administered the screener to these potential participants while they were waiting in the reception area. However, it became apparent that some of the participants who were screened on-site were, in fact, not eligible for the study and were providing inaccurate information on the screener in order to receive the $50 incentive. Blood and questionnaire information from these respondents were not used in this study. Although every effort was made to include eligible walk-in participants, due to their large numbers, limited supplies, and the inaccuracy in screener responses, the inclusion of on-site screening for participation in Baltimore, MD, was curtailed.

Several problems related to refrigerating and shipping the collected blood samples needed to be overcome. In contrast with practices at Charleston, SC, and Savannah, GA, the hospital recommended that the samples not be stored at their facility overnight. Throughout the sample collection period, temperatures in Baltimore, MD, exceeded 100 degrees at the time and the study protocol needed to be slightly amended to ensure that the blood-samples did not overheat. As at previous sites, phlebotomists packed samples each evening. Packages were then taken to a separate facility and stored in a secured refrigerator until picked up by the delivery service (usually the next business day). Care was taken to ensure that the boxes remained refrigerated at all times.

3.2 QUALITY CONTROL FOR BLOOD-LEAD

The laboratory analysis was conducted by the same laboratory that conducted the analyses for the WCBS: ESA Laboratories. With a few exceptions, the laboratory and field quality control (QC) measures used in the WCBS study were employed in this study. These measures are discussed in detail in the July 8, 1994, QAPjP for the WCBS. However, the laboratory analysis protocol for this study differed from that used in the WCBS in the number and frequency of analytic quality control samples.

The following provides a summary of the laboratory analysis protocol used for this study.

Following each field collection session, blood samples were sent to the laboratory for analysis where the concentration of lead in each sample (duplicate analysis for each sample) was determined using Graphite Furnace Atomic Absorption Spectroscopy (GFAAS) with Zeeman background correction. The instrumental detection limit for this method was 1 μg/dL with a linear operating range from 1- to 60-μg/dL. The linearity of the method was based on a four-point calibration curve using standards at nominal concentrations of 5, 13, 30, and 50 μg/dL. A correlation coefficient of greater than 0.995 was maintained throughout the analyses.

As in the WCBS, to ensure the quality and consistency of the laboratory analysis results, both internal laboratory and field QC measurements were taken. The internal (laboratory) quality control consisted of blanks (matrix modifiers), continuing calibration reference materials, and calibration check standards. Field measurements consisted of analytic blind samples (CDC performance samples) and field duplicates (a second blood sample from a respondent). A duplicate blood sample was collected from approximately 15 percent of the respondents[7]. In addition, at least two chemical analyses were performed on each blood sample. Table 2 summarizes the analytical results for the Quality Control and CDC performance samples that were collected.

The results from the internal quality control and performance samples indicate that the data quality objectives were met and that the blood-lead data were accurate and reliable. All QC samples met the precision criteria for this study and only two QC samples fell outside the accuracy criteria for the study and both occurred with the lower Blood-Lead Level Laboratory Reference System 1.9 μg/dL samples (BLLRS 1.9).

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[7] The duplicate blood samples were collected immediately following the collection of the primary sample.

Table 2. Summary of Laboratory Quality Control and CDC Performance Samples

Sample Identification	Accuracy Criteria	Precision Criteria	Type of Quality Control Sample	Reference Lead Conc. µg/dL	Mean Recovery (%)
Blank	< 1.0 µg/dL	N/A	Matrix Modifier	0.0	--
BLLR 1.9	±25%	1.14-2.66	Continuing Calibration Reference Material Samples	1.9	111.52
BLLR 3.3	±25%	2.64-3.96	Continuing Calibration Reference Material Samples	3.3	103.77
BioRad2	±25%	26.8-35.3	Continuing Calibration Reference Material Samples	30.4	97.63
BioRad3	±25%	47.0-61.4	Continuing Calibration Reference Material Samples	55.3	97.74
NIST SRM (Level 1)	±10%	3.31-6.06	Calibration Check Standard	5.01	96.47
CDC RS 1494	±20%	N/A	Blind Performance	4.5	99.76
CDC RS 696	±20%	N/A	Blind Performance	10.6	95.92
CDC RS 894	±20%	N/A	Blind Performance	20.8	101.63

Duplicate blood samples were collected from 41 respondents. Each of the duplicate samples were analyzed in the same manner as the regular blood samples and reference samples (at least two measurements of blood-lead level per sample collection tube). Blood samples were collected from 243 respondents. Table 3 presents the estimated log standard deviation attributable to the variability between workers, between duplicate blood draws, and between duplicate chemical analysis on the same blood draw, as estimated by a variance components model.

As in the WCBS, the estimated variability between participants appeared to be an order of magnitude (10 times) greater than the estimated variability attributed to either chemical analysis or sampling variability. In addition, the magnitudes of the estimated variance components relative to those for laboratory analysis or sampling variability were similar for workers and homeowners. However, the estimate of the variability in the blood-lead levels between homeowners was higher than the corresponding estimate for workers. This might be due to the fact that some homeowners tend to perform R&R activities on a more sporadic basis than others and at differing levels of intensity. For example, some homeowners perform a large amount of R&R but only for a short period of time, while others perform only a few hours of R&R, but over a longer duration.

Table 3. Variance Component Estimates for Blood-Lead Concentrations

Source of Variation	σ_{Worker} (Field Samples) log(μg/dL)	σ_{Worker} (Duplicates) log(μg/dL)	$\sigma_{Quality\ Control}$ (Reference Samples) log(μg/dL)
All Participants			
Between Participants	0.7374	0.7560	0.7748
Between Duplicate Blood Draws	N/A	0.0400	
Between Duplicate Chemical Analyses	0.0448	0.0594	0.0463
Workers			
Between Participants	0.6680	0.6108	N/A
Between Duplicate Blood Draws	N/A	0.0368	
Between Duplicate Chemical Analyses	0.0378	0.0688	N/A
Homeowners			
Between Participants	0.8544	1.0050	N/A
Between Duplicate Blood Draws	N/A	0.0487	
Between Duplicate Chemical Analyses	0.0567	0.0320	N/A

3.3 TELEPHONE SCREENING RESULTS

As discussed in Section 2.2.1, the first objective of the screener questionnaires was to determine the eligibility of a potential respondent. Eligibility was determined using a hierarchial series of questions (see Appendix A). That is, potential respondents answered questions until they reached a question indicating ineligibility. For professional R&R workers, six questions were used to determine eligibility. For homeowners, eight questions were used to determine eligibility.

Table 4 presents a breakdown of the ineligible workers for each question used to determine eligibility. As shown in the table, the predominant reason for ineligibility among workers was related to the amount of R&R that was conducted in the last 30 days. Nearly 84 percent of all ineligible workers were ineligible because they either did not perform at least 10 days of R&R work in the past 30 days (45.2%) or they did not perform at least 10 days performing R&R in homes built before 1940 (38.7%). Moreover, this pattern was consistent across the three cities.

Table 5 presents a breakdown of ineligible homeowners based on answers to questions used to determine eligibility. As with the ineligible workers, most of the ineligible homeowners were not eligible to participate in the study because they had not performed a significant amount of R&R in their home. Approximately 32 percent of the ineligible homeowners were ineligible because no R&R work was performed in their home during the last 12 months. Additionally, 42.4 percent of the ineligible homeowners did not meet the study criterion corresponding to the number of hours spent performing R&R in the last 30 days (to be eligible, homeowners needed to spend more than 20 hours in the last 30 days performing R&R).

Table 4. Reasons for Worker Ineligibility

Reason for Ineligibility	Screener Question Number	Baltimore, MD	Charleston, SC	Savannah, GA	Total
Did not perform R&R for a living[a]	1	1 (3.2%)	1 (4.4%)	2 (25.0%)	4 (6.5%)
Did not do hands-on R&R work	1a	1 (3.2%)	0 (0.0%)	0 (0.0%)	1 (1.6%)
Spent less than 10 days (in the last 30) performing general R&R	2	13 (41.9%)	13 (56.5%)	2 (25.0%)	28 (45.2%)
Spent less than 10 days (in the last 30) performing general R&R in homes built before 1940	2a	14 (45.2%)	7 (30.4%)	3 (37.5%)	24 (38.7%)
Spent less than 9 weeks in the last 12 months performing R&R in homes built before 1940	3	2 (6.5%)	2 (8.7%)	1 (12.5%)	5 (8.1%)
All	N/A	31 (100%)	23 (100%)	8 (100%)	62 (100%)

(a) The homeowner screening questionnaire was also administered to these potential participants.

Table 5. Reasons for Homeowner Ineligibility

Reason for Ineligibility	Screener Question Number	Baltimore, MD	Charleston, SC	Savannah, GA	Total
Performed R&R for a living	1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
No R&R performed in home in the last 12 months	2	9 (16.7%)	32 (43.2%)	9 (30.0%)	50 (31.7%)
Did not live in home while R&R was being performed	2a	9 (16.7%)	7 (9.5%)	5 (16.7%)	21 (13.3%)
Home was built post-1940	2b	0 (0.0%)	0 (0.0%)	2 (6.7%)	2 (1.3%)
Did not perform a large portion of the R&R work themselves	2c	2 (3.7.%)	5 (6.8%)	4 (13.3%)	11 (7.0%)
Spent less than 20 hours in the past 30 days performing general R&R	2d,2e	29 (53.7%)	29 (39.2%)	9 (30.0%)	67 (42.4%)
Performed some R&R in less than 9 weeks over the past 12 months	3	5 (9.3%)	1 (1.4%)	1 (3.3%)	7 (4.4%)
All	N/A	54 (100%)	74 (100%)	30 (100%)	158 (100%)

The second objective of the screening interview was to collect information that could be used to examine if there was a non-response bias. A non-response bias can occur if respondents completing the study (study participants) have characteristics that differ from those that did not participate (non-participants). Non-participants consist of those respondents that were screened as eligible but: (1) refused the main questionnaire, (2) completed the questionnaire but did not provide a blood sample, or (3) did not show up for their data collection session. There were 243 participants (161 workers and 82 homeowners) and 31 non-participants (20 workers and 11 homeowners). Information on demographics, R&R work history, and the R&R target activities was collected during the screener interview.

Table 6 summarizes the demographic information for participants and non-participants. Although there appear to be some differences between homeowners and professional workers, participating workers have, on average, a similar age, race, and gender distribution as do non-participating workers. Similarly, participating homeowners have approximately the same age, race, and gender distribution as non-participating homeowners.

Table 6. Summary of Demographic Information for Participants and Non-Participants

Variable Description		Workers		Homeowners		All	
		Participants	Non-Participants	Participants	Non-Participants	Participants	Non-Participants
Sample Size		161	20	82	11	243	31
Age	25th Percentile	32.5	29.5	31.0	33.0	32.0	30.0
	Mean	37.2	37.2	40.0	43.0	38.2	39.2
	75th Percentile	42.0	44.5	46.0	52.0	44.0	45.0
Race	White	65.2%	75.0%	79.3%	81.8%	70.0%	77.4%
	Black	33.5%	25.0%	19.5%	18.2%	28.8%	22.6%
	Other	1.2%	0.0%	1.2%	0.0%	1.2%	0.0%
Sex	Male	86.3%	85.0%	56.1%	63.6%	76.1%	77.4%
	Female	13.7%	15.0%	43.9%	36.4%	23.9%	22.6%
City	Baltimore, MD	57.1%	45.0%	41.5%	54.6%	51.9%	48.4%
	Charleston,SC	25.5%	30.0%	26.8%	27.3%	25.9%	29.0%
	Savannah, GA	17.4%	25.0%	31.7%	18.2%	22.2%	22.6%

Table 7 summarizes the responses for participants and non-participants in terms of their general R&R work history. As shown in the table, with the exception of the number of weeks performing R&R in the past 12 months, participating and non-participating workers have very similar distributions of R&R work history. Thus, based on the results presented in Table 7, it does not appear that non-participants were more likely to be exposed (because they perform more

R&R work) than participants. Similarly, it does not appear that non-participating homeowners were more likely to be exposed than participating homeowners.

Table 7. Summary of General R&R Work History of Participants and Non-Participants

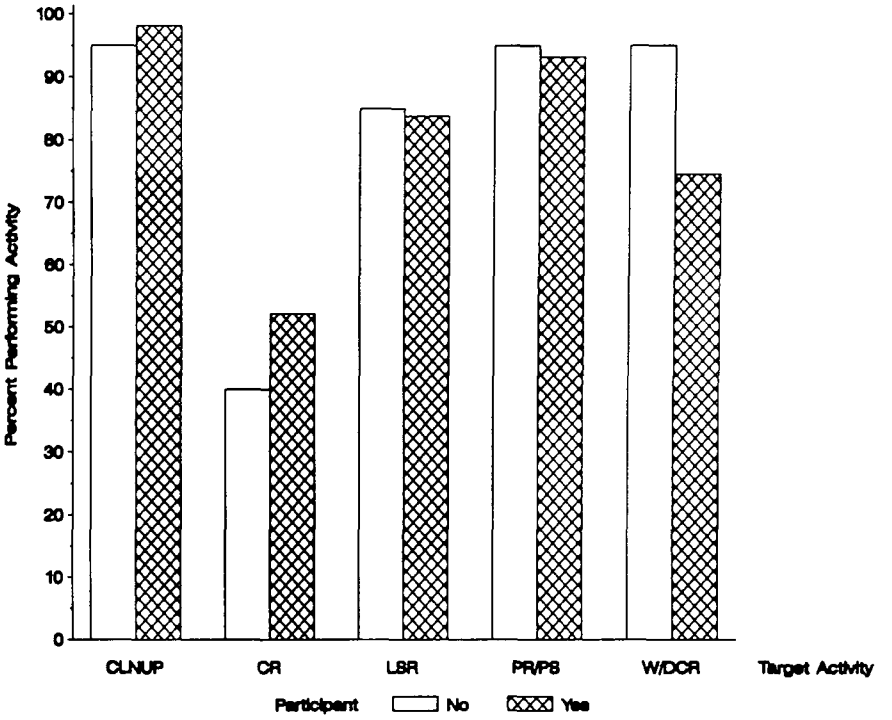
Variable Description		Workers		Homeowners	
		Participants	Non-Participants	Participants	Non-Participants
Days spent performing R&R in the last 30 days	25th Percentile	20.0	20.0	N/A	N/A
	Mean	23.9	21.45		
	75th Percentile	28.0	24.5		
Days, in the last 30 days, spent performing R&R in homes built before 1940[a]	25th Percentile	18.0	15.0	8.0	6.0
	Mean	21.4	20.4	14.2	11.5
	75th Percentile	25.0	24.5	20.0	12.0
Hours spent performing R&R on a typical day where performed R&R.	25th Percentile	N/A	N/A	4.0	5.0
	Mean			5.6	6.5
	75th Percentile			7.0	8.0
Weeks performed R&R in last 12 months	1-8 Weeks	5.0%	0.0%	8.5%	0.0%
	9-26 Weeks	26.1%	10.0%	43.9%	18.2%
	> 26 Weeks	68.9%	90.0%	47.6%	81.8%
Years spent performing R&R	25th Percentile	6.0	6.0	N/A	N/A
	Mean	12.8	13.7		
	75th Percentile	18.0	19.0		
Days spent performing R&R in residential buildings in last 30 days	25th Percentile	20.0	15.0	N/A	N/A
	Mean	20.9	18.9		
	75th Percentile	25.0	24.5		
Days spent performing R&R in non-residential buildings in last 30 days	25th Percentile	0	0	N/A	N/A
	Mean	4.1	2.4		
	75th Percentile	5	0		

(a) For homeowners, this questions pertains to R&R in their own home.

In addition to collecting information on demographics and general R&R work history, the screener interview obtained information on the target activities[8] that were performed in the past 30 days. Approximately the same percentage of participating and non-participating workers performed hands-on cleanup, large structure removal, and paint removal/surface preparation. More participants than non-participants removed carpets while a higher percentage of

[8] The target activities include: large structure removal [LSR], carpet removal [CR], paint removal/surface preparation [PR/PS], window/door casement removal [W/DCR], and cleanup [CLNUP].

non-participating workers remove windows or door casements. Figure 3 presents the percent of participating and non-participating workers that performed each target activity in the last 30 days.

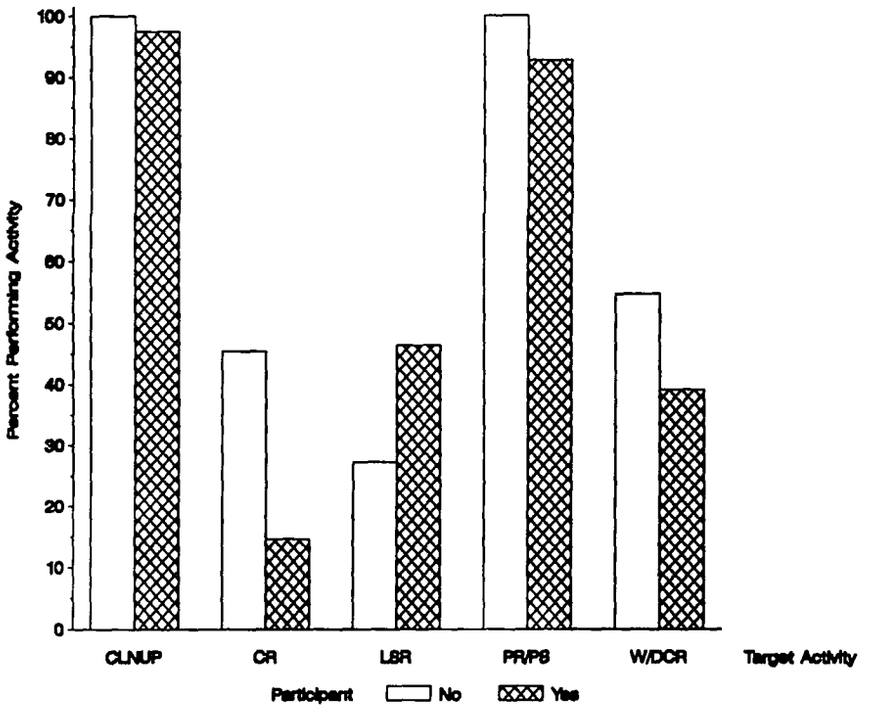


* CLNUP = Cleanup; CR = Carpet Removal; LSR = Large Structure Removal; PR/PS = Paint Removal/Prepare Surfaces; W/DCR = Window/Door Casement Replacement

Figure 3. Percent of Participating and Non-Participating Workers Performing Target Activities*

Figure 4 presents the percent of participating and non-participating homeowners that performed each target activity in the last 30 days. Nearly the same percentage of participating and non-participating homeowners performed cleanup and paint removal/surface preparation (two of the most common types of R&R performed by homeowners). A higher percentage of non-participating homeowners removed carpets and window/door casements but not large structures.

In summary, all three types of information collected during the screening interview were similar between study participants and those that did not participate. That is, workers and homeowners recruited and participating in this study did not appear to have different characteristics than did non-participants.



* CLNUP = Cleanup; CR = Carpet Removal; LSR = Large Structure Removal; PR/PS = Paint Removal/Prepare Surfaces; W/DCR = Window/Door Casement Replacement

Figure 4. Percent of Participating and Non-Participating Homeowners Performing Target Activities*

3.4 PARTICIPANT CHARACTERIZATION

The main questionnaires for this study collected information that can be used to characterize study participants. Section 3.4.1 summarizes participant demographics while Sections 3.4.2 and Section 3.4.3 summarize the R&R work history and R&R work practices of study participants.

3.4.1 Demographics

Demographic information on the participants in this study is presented in Table 8. Noteworthy points include:

- There were more workers from Baltimore, MD (92), than from Charleston, SC (41), and Savannah, GA (28), combined. However, there were more homeowners from the southern cities (48) than from Baltimore, MD (34). Further, there were twice as many worker participants as there are homeowner participants.

- The sample of workers included approximately the same number of Carpenters (47), Laborers (44), and Painters (44), and fewer "Other" workers (26).

Table 8. Summary of Demographic Data

Variable Description		Worker Group				All Workers	All Homeowners	All Participants
		Carpenter	Laborer	Painter	Other			
Sample Size	Total	47	44	44	26	161	82	243
	Baltimore, MD	28	30	20	14	92	34	126
	Charleston, SC	11	10	12	8	41	22	63
	Savannah, GA	8	4	12	4	28	26	54
Age	25th Percentile	33.0	33.0	27.0	33.0	32.5	31.0	32.0
	Mean	38.4	36.1	36.4	38.0	37.2	40.0	38.2
	75th Percentile	43.0	41.0	42.0	45.0	42.0	46.0	44.0
Gender	Male	89.4%	90.9%	70.4%	100.0%	86.3%	56.1%	76.1%
	Female	10.6%	9.1%	29.6%	0.00%	13.7%	43.9%	23.9%
Race	White	78.7%	56.8%	59.1%	65.4%	65.2%	79.3%	70.0%
	Black	17.0%	43.2%	40.9%	34.6%	33.5%	19.5%	28.8%
	Other	4.3%	0.0%	0.0%	0.0%	1.2%	1.2%	1.2%
Education	Not A High School Graduate	12.8%	25.0%	34.1%	23.1%	23.6%	4.9%	17.3%
	High School Graduate	38.3%	50.0%	25.0%	11.5%	33.5%	4.9%	23.9%
	More Than High School	48.9%	25.0%	40.9%	65.4%	42.9%	90.3%	58.8%
Number of Children Under Six in Home	None	82.6%	65.1%	81.4%	80.8%	77.2%	87.8%	80.8%
	One	10.9%	18.6%	11.6%	11.5%	13.3%	4.9%	10.4%
	Two or More	6.5%	16.3%	7.0%	7.7%	9.5%	7.3%	8.8%
Union Member	Yes	2.1%	4.7%	0.0%	7.7%	3.1%	NA	NA
	No	97.9%	95.3%	100.0%	92.3%	96.9%		
Age of Home	Pre -1940	53.2%	56.8%	45.4%	69.2%	54.7%	97.6%	69.1%
	1940-1978	31.9%	29.6%	27.3%	19.2%	27.9%	1.2%	18.9%
	Post-1978	14.9%	13.6%	27.3%	11.5%	17.4%	1.2%	11.9%
Renovation in Own Home During Last 12 Months	Yes	68.1%	61.4%	52.3%	80.8%	64.0%	100.0%	74.9%
	No	31.9%	38.6%	47.7%	19.2%	36.0%	0.0%	25.1%

- The overall age of workers (37.2 years) was very similar to the overall age of participating homeowners (40 years). The average age within each worker group was also similar.

- More males (76.1%) than females (23.9%) participated in the study. The ratio of male to female participants (6.3 to 1) was greater for workers than for homeowners (1.3 to 1). Among the worker groups, the ratio of males to females was smaller for painters (2.4 to 1) than for any other worker group.

- An overwhelming majority (90.3%) of homeowners had more than a high school education. However, only about 43 percent of workers had more than a high school education. A higher percentage of workers in the "Other" worker group than in any other worker group had more than a high school education.

- The majority (80.8%) of participants did not have children under the age of six years residing in their home. However, Laborers had a greater percentage of children under the age of six living in their home (34.9%) than did any other worker group or homeowners.

- Only a small fraction (3.1%) of workers belonged to a union.

- Over half (54.7%) of the participating workers lived in homes built before 1940.

3.4.2 R&R Work History

3.4.2.1 R&R Work History for Professional R&R Workers. Information on the R&R work history of professional R&R workers was collected using a series of six questions for each target activity (see Appendix A). Table 9 summarizes the responses among all workers to questions related to R&R work history specific to each target activity. Table B-2 in Appendix B presents a similar summary for each worker group.

· The sampled workers spent an average of 24 days performing R&R in the last 30 days. On average, 21 days were spent performing R&R in historic homes or homes built before 1940. Carpenters, Laborers, Painters, and Other workers spent about the same number of days performing work in homes built before 1940.

Of the target activities, "hands-on" cleanup was the activity performed the most (average of 19 days in all homes and average of 15 days in pre-1940 homes). Following cleanup, workers as a whole spent days performing (from most to least) paint removal/prepare surfaces, large structure removal, window/door casement removal, and carpet removal. This pattern was consistent for Carpenters, Laborers, and Other workers. As expected, Painters spent more days performing paint removal than any other target activity except for cleanup.

Table 9. Summary of Worker Responses for Questions Pertaining to R&R Target Activities

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
Days performing the activity in the last 30 days	25th Percentile	20	5	10	0	0	10
	Mean	23.93	12.81	15.91	7.40	3.62	18.70
	75th Percentile	28	20	24	11	4	25
Days performing the activity in Pre-1940 housing in the last 30 days	25th Percentile	18	2	5	0	0	10
	Mean	21.37	10.80	13.65	6.24	2.87	15.28
	75th Percentile	25	20	20	10	3	23
Days using a respirator while performing activity	25th Percentile	(a)	0	0	0	0	0
	Mean	(a)	5.05	6.66	3.17	1.54	6.17
	75th Percentile	(a)	10	10	2	0	10
Number of weeks spent performing activity in last year	< 1 Week	0.0%	13.7%	6.8%	25.5%	58.4%	3.2%
	1-8 Weeks	5.0%	30.4%	26.7%	42.2%	27.3%	30.4%
	> 8 Weeks	95.0%	55.9%	66.5%	32.3%	14.3%	66.5%
Number of years spent performing activity over career	25th Percentile	6	3	3	2	1	4
	Mean	12.81	8.79	9.11	7.77	5.25	10.13
	75th Percentile	18	14	14	12	8	15
Number of weeks spent performing activity in average year	< 1 Week	(a)	16.9%	14.4%	32.9%	53.7%	14.7%
	1-8 Weeks	(a)	36.4%	26.8%	33.6%	27.6%	23.7%
	> 8 Weeks	(a)	46.8%	58.8%	33.6%	18.7%	61.5%

(a) This question was not asked for general R&R activity.

The number of weeks and the number of years spent conducting each target activity appears to be strongly associated with the number of days spent performing the activity in the last 30 days. For example, paint removal/preparing surfaces was the second highest activity in terms of days performed, weeks performed, and years performed.

The number of weeks spent performing a particular activity in the past 12 months was roughly the same as the number of weeks spent performing the activity in a "typical" year. However, care should be taken when interpreting such results because of the difficulties inherent with memory recall; workers may be biased toward responding as if the current year was a "typical" year (i.e., work activities in the current year are more easily recalled than are work activities in previous years).

3.4.2.2 R&R Work History for Homeowners. Information on the R&R work history of homeowners was collected using a series of eight questions for each target activity (see Appendix A). Table 10 summarizes the responses to each of these questions by R&R target activity.

Over their entire lives, homeowners have performed a wide mix of activities; more than one-half of the homeowners indicated that they had performed each target activity at least once. In addition, most of this work was conducted within the past five years. However, in the past 30 days, nearly all of the homeowners performed cleanup and paint removal but less than one-half performed large structure removal, window/door casement removal, or carpet removal.

Homeowners worked an average of 14 days in the last 30 days. Further, they spent an average of about 80 hours performing R&R in their home during the last 30 days. In terms of the number of days spent performing an activity, homeowners spent the most number of days performing cleanup followed by paint removal, large structure removal, window/door casement replacement, and carpet removal. However, in terms of overall hours spent in the last 30 days, homeowners spent more time performing paint removal/preparing surfaces than any other target activity. Following paint removal/surface preparation, homeowners spent the majority of their hours on: (from most to least) cleanup, large structure removal, window/door casement replacement, and carpet removal.

Over the last 12 months, homeowners performed some R&R for an average of 6 hours per day, 3.5 days per week, and in 28 of the 52 weeks. In terms of weeks in which some R&R was performed, homeowners performed cleanup the most followed by paint removal, large structure removal, window/door casement replacement, and carpet removal. A similar pattern was observed when examining the number of days worked over the last 12 months.

In addition to performing the target activities themselves, homeowners also indicated that professional R&R workers have performed the target activities in their home. Forty-five percent of homeowners had professional R&R workers perform large structure removal, paint removal, and cleanup in their home. A smaller percent of homeowners had professional contractors replace windows (40%) or remove carpets (15%). Most of the work performed by professional R&R workers in homes owned by participant homeowners was performed within the last 12 months.

3.4.3 R&R Work Practices

Summary statistics on work practices are presented for each worker group, all workers, and all homeowners in Table 11. Information on work practices included: tobacco use, respirator use, hobbies with potential lead exposure, training and educational materials, hours of cleanup, and type of paint removal. The following main points of interest summarize the statistics presented in Table 11 for each of the items related to work practices:

Table 10. Summary of Homeowner Responses for Questions Pertaining to R&R Target Activities

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
Ever performed activity	Yes	(c)	85.4%	97.6%	68.3%	56.1%	100.0%
	No	(c)	14.6%	2.4%	31.7%	43.9%	0.0%
Performed activity in last 30 days	Yes	(c)	46.3%	92.7%	39.0%	14.6%	97.6%
	No	(c)	53.7%	7.3%	61.0%	85.4%	2.4%
Days spent performing activity in own home during the last 30 days	25th Percentile	8	0	3	0	0	4
	Mean	14.17	2.61	6.84	1.02	0.39	9.41
	75th Percentile	20	3	10	1	0	15
Average number of hours per day spent performing activity during the last 30 days	25th Percentile	4	0	3	0	0	1
	Mean	5.60	2.35	4.89	1.78	0.54	2.50
	75th Percentile	7	4	6	3	0	3
Average number of hours spent performing activity during the last 30 days[a]	25th Percentile	42	0	12	0	0	8
	Mean	78.38	13.65	36.50	5.70	2.09	25.51
	75th Percentile	100	12	50	4	0	26
Number of weeks spent performing activity in own home during the last year	25th Percentile	15	1	3	0	0	3
	Mean	27.64	4.70	11.38	2.37	0.88	13.78
	75th Percentile	40	5	20	2	1	22
Number of days spent performing activity in typical week during the last year	25th Percentile	2	1	2	0	0	2
	Mean	3.47	2.06	2.93	1.39	0.68	2.83
	75th Percentile	5	3	4	2	1	4
Number of days spent performing activity during the last year[b]	25th Percentile	40	1	8	0	0	6
	Mean	101.52	15.68	36.33	5.76	2.81	48.56
	75th Percentile	150	12	60	4	1	60
Number of hours spent performing activity on a typical day during the last year	25th Percentile	4	1	4	0	0	1
	Mean	5.91	4.13	5.04	2.61	1.46	2.91
	75th Percentile	8	6	6	4	2	4
Last time performed activity	Never	(c)	14.6%	2.4%	31.7%	43.9%	0.0%
	Within 30 Days	(c)	46.3%	92.7%	39.0%	15.9%	97.6%
	Between 30 Days and 1 Year	(c)	32.9%	4.9%	22.0%	25.6%	2.4%
	Between 1 and 5 Years	(c)	4.9%	0.0%	6.1%	12.2%	0.0%
	More Than 5 Years	(c)	1.2%	0.0%	1.2%	2.4%	0.0%
Contractor ever performed activity	Yes	(c)	44.4%	45.1%	39.5%	14.8%	45.7%
	No	(c)	55.6%	53.7%	60.5%	85.2%	54.3%
Last time contractor performed activity	Never	(c)	55.6%	53.7%	60.5%	85.2%	54.3%
	Within 30 Days	(c)	7.4%	11.0%	6.2%	2.5%	14.8%
	Between 30 Days and 1 Year	(c)	22.2%	20.7%	19.8%	2.5%	21.0%
	Between 1 and 5 Years	(c)	12.3%	8.5%	9.9%	3.7%	7.4%
	More Than 5 Years	(c)	2.5%	4.9%	3.7%	6.2%	2.5%

(a) Calculated as the product of the number of days and the number of hours per day.
(b) Calculated as the product of the number of weeks and the number of days per week.
(c) This question was not asked for general R&R activity.

Table 11. Summary of Responses for Questions Pertaining to Work Practices

Variable Description	Variable Category	Carpenter	Laborer	Painter	Other	All Workers	All Homeowners
Sample Size		47	44	44	26	161	82
Use Tobacco Products	Yes	57.4%	65.9%	72.7%	57.7%	64.0%	30.5%
	No	42.6%	34.1%	27.3%	42.3%	36.0%	69.5%
Respirator or Dust Mask	None	39.1%	32.6%	37.2%	41.7%	37.2%	56.8%
	Dust Mask	39.1%	58.1%	39.5%	41.7%	44.9%	29.6%
	Half Mask	15.2%	11.6%	7.0%	12.5%	11.5%	13.6%
	Full Face Mask	10.9%	2.3%	20.9%	4.2%	10.3%	2.5%
	Type C Supplied Air Mask	0.0%	0.0%	2.3%	0.0%	0.6%	0.0%
	PAPR	2.2%	2.3%	0.0%	0.0%	1.3%	1.2%
	SCBA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hobbies with Pb Exposure	No	29.8%	25.0%	20.5%	42.3%	28.0%	67.1%
	Yes	70.2%	75.0%	79.5%	57.7%	72.0%	32.9%
Received Pb Training[a]	Yes	29.8%	9.3%	31.8%	26.9%	24.4%	N/A
	No	70.2%	90.7%	68.2%	73.1%	75.6%	
Received Educational Material	Yes	38.3%	25.0%	34.1%	34.6%	32.9%	37.8%
	No	61.7%	75.0%	65.9%	65.4%	67.1%	62.2%
Hours of Cleanup	None	0.0%	0.0%	4.5%	3.8%	1.9%	2.5%
	< ½ Hrs/Day	8.5%	2.3%	9.1%	11.5%	7.5%	0.0%
	½-1 Hrs/Day	31.9%	13.6%	20.5%	7.7%	19.9%	28.8%
	1-4 Hrs/Day	46.8%	50.0%	52.3%	53.8%	50.3%	55.0%
	>4 Hrs/Day	12.8%	34.1%	13.6%	23.1%	20.5%	13.8%
Paint Removal[b]	Dry Power-Sanding	53.2%	65.9%	63.6%	57.7%	60.2%	57.3%
	Dry Hand-Sanding	76.6%	68.2%	88.6%	73.1%	77.0%	76.8%
	Dry Scraping	78.7%	68.2%	79.5%	73.1%	75.2%	82.9%
	Burning, Torching, Heat Gun	31.9%	29.5%	29.5%	38.5%	31.7%	30.5%
	Wet Scraping	21.3%	38.6%	29.5%	30.8%	29.8%	9.8%
	Wet-Sanding	19.1%	34.1%	22.7%	19.2%	24.2%	6.1%
	Chemical Stripping	38.3%	47.7%	43.2%	30.8%	41.0%	36.6%
	Used Dust Collector When Sanding	25.5%	43.2%	47.7%	30.8%	37.3%	17.1%

(a) This question was not asked to homeowners.
(b) Percentages given represent the percentage of workers or homeowners that indicated they performed the activity.

- Overall, two-thirds of workers used tobacco products. Among the worker groups, more painters (72.7%) used tobacco products than any other worker group. However, only 30.5 percent of the homeowners used tobacco products.

- The OSHA Lead in Construction Standard requires workers to wear an approved respirator if exposed to an airborne concentration of lead of greater than 30 micrograms per cubic meter of air (30 $\mu g/m^3$) calculated as an 8-hour time-weighted average (TWA) as a result of performing R&R activities. However, only 23.7 percent of workers reported using a respirator in the last 30 days. Similarly, only 16 percent of homeowners used a respirator in the last 30 days. Homeowners and workers in every work group used a dust mask more frequently than any type of respirator (44.9 percent of workers and 29.6 percent of homeowners reported using dust masks).

- Several questions were asked of both workers and homeowners that pertain to their participation in hobbies which have historically been associated with increased lead exposure. These hobbies include: casting lead bullets or fishing sinkers, crimping fishing sinkers onto the line with teeth, dismantling batteries, and working with stained glass. Most workers (72%) did have at least one hobby where they could be exposed to lead. Conversely, only (33%) homeowners had at least one hobby where they could be exposed to lead.

- The OSHA Lead in Construction Standard requires training of employees prior to initial assignment to areas where there is a possibility of exposure over the permissible exposure limit (PEL) of 50 $\mu g/m^3$ averaged over an 8-hour workday. However, more than two-thirds of the workers in each work group reported that they had not received training for reducing lead exposure in the workplace. Over all four worker groups, Laborers had the smallest percentage (9.3%) receiving training. Similar patterns were observed with respect to workers receiving educational materials (67 percent did not receive materials). Only 38 percent of homeowners reported receiving any educational materials on reducing lead exposures.

- All but a very small percentage of workers (2%) and homeowners (2.5%) performed hands-on cleanup. About one-half of workers and homeowners spent 1-4 hours a day performing cleanup. As expected, among the four worker groups, Laborers performed the highest proportion of cleanup; approximately 84 percent performed this activity for more than 1 hour a day.

- Most of the participants (either workers or homeowners) performed dry sanding or scraping for paint removal and the percentage of homeowners performing these activities was approximately the same as the corresponding percentages of workers. Also, the percentage of workers using dry scraping or dry sanding for paint removal was similar for all four worker groups. Further, a similar percentage of workers and homeowners used burning, torching, or a heat gun to remove paint (~30%). However, workers and homeowners differed in the use of other methods for paint removal. In particular, three times more workers than homeowners used wet scraping, four times

more workers that homeowners used wet sanding, and two times as many workers as homeowners used dust collectors when sanding.

3.5 OVERVIEW OF BLOOD-LEAD CONCENTRATIONS

This section presents the results of an initial examination of the blood-lead measurements collected in this study. This analysis served two purposes. First, it provided detailed descriptive statistics using the blood-lead concentrations of the study participants. These descriptive statistics, presented in Section 3.5.1, were used as a guide when developing the statistical models discussed in the next section.

The second purpose of this analysis was to place the blood-lead concentrations of the study participants into perspective. The blood-lead concentrations of the study participants were compared to workers participating in Phase II of the R&R study (WCBS). Also of interest was a comparison of the blood-lead concentrations of study participants to those of the general, adult U.S. population. Detailed comparisons to participants in the WCBS are presented in Section 3.5.2; comparisons to the general U.S. population (as described by NHANES III, Phase 2) are presented in Section 3.5.3. In both sections, the results indicate that workers and homeowners performing R&R activities in historic or older homes are more exposed to lead than either the general U.S. population or general R&R workers (i.e., workers not necessarily working in historic or older homes).

3.5.1 Descriptive Statistics for the Blood-Lead Concentrations of Study Participants

Blood samples were obtained from 161 workers and 82 homeowners. The lead concentration of each sample was measured in at least two separate laboratory analyses. The results of multiple chemical analyses and duplicate blood samples were averaged for each participant to provide a single blood-lead concentration for each participant.

As in the WCBS and in other recent studies, the distributions of blood-lead concentrations for participants in this study were skewed. Figures 5 and 6 present histograms of the blood-lead concentrations for workers and homeowners, respectively. Because of the skewness of these distributions, a natural log transformation was employed. Normal and log-normal probability plots are displayed in Figures D-1 through D-4 in Appendix D.

Table 12 presents the geometric mean, standard error, and a 95 percent confidence interval of the mean blood-lead concentrations for each city and study group. Table 13 presents selected percentiles and the number of participants with blood-lead concentrations above 10, 15, and 20 μg/dL. Overall, the geometric mean blood-lead concentrations for workers and homeowners were well below 10 μg/dL (5.73 μg/dL for workers and 4.45 μg/dL for homeowners). However, 20.2 percent (49 of 243) of the study participants had a blood-lead concentration greater than 10 μg/dL and 2.9 percent (7 participants) had blood-lead concentrations greater than 25 μg/dL. In addition, three participants (all workers) had blood-lead concentrations above 40 μg/dL.

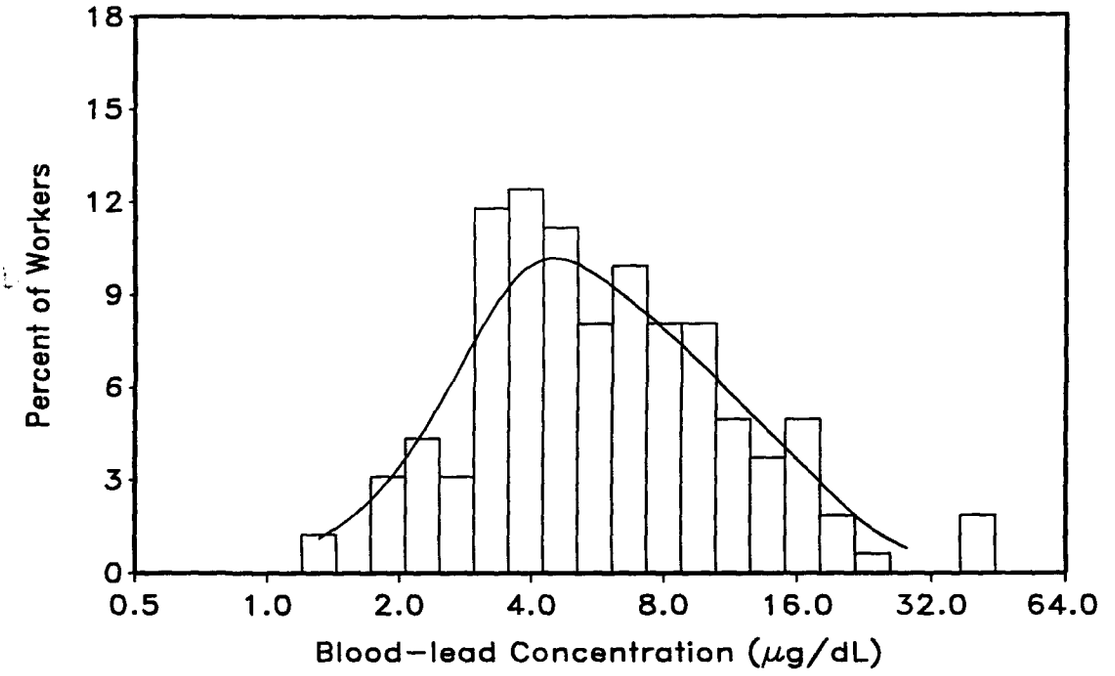


Figure 5. Histogram of Worker Blood-Lead Concentration (Semi-Logarithmic Scale)

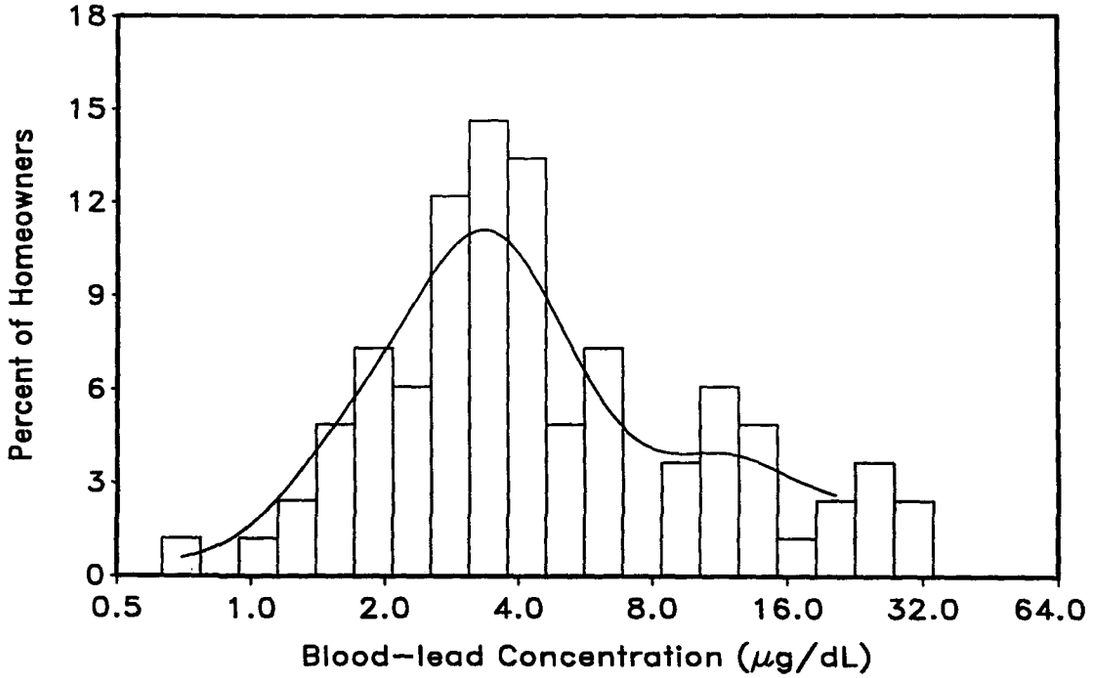


Figure 6. Histogram of Homeowner Blood-Lead Concentration (Semi-Logarithmic Scale)

Table 12. 95 Percent Confidence Intervals for Geometric Mean of Blood-Lead Concentrations by City and Study Group

Study Group	City	N	Geometric Mean (μg/dL)	log Std. Error log (μg/dL)	95% Confidence Interval (μg/dL)
Workers	Baltimore,MD	92	5.54	0.061	(4.91, 6.25)
	Charleston,SC	41	6.30	0.118	(5.00, 7.94)
	Savannah,GA	28	5.57	0.156	(4.10, 7.56)
	All Cities	161	5.73	0.053	(5.16, 6.36)
Homeowners	Baltimore,MD	34	3.84	0.148	(2.87, 5.14)
	Charleston,SC	22	5.28	0.170	(3.79, 7.38)
	Savannah,GA	26	4.66	0.174	(3.31, 6.56)
	All Cities	82	4.45	0.094	(3.70, 5.36)
All Participants	Baltimore,MD	126	5.02	0.062	(4.45, 5.66)
	Charleston,SC	63	5.93	0.097	(4.90, 7.16)
	Savannah,GA	54	5.11	0.116	(4.07, 6.42)
	All Cities	243	5.26	0.048	(4.79, 5.78)

Table 13. Selected Percentiles and Occurrence of Elevated Blood-Lead Levels by City and Study Group

Study Group	City*	N	25th Percentile	Median	75th Percentile	Number > 10 μg/dL (Percent)	Number > 15 μg/dL (Percent)	Number > 25 μg/dL (Percent)
Workers	Baltimore	92	3.77	5.32	7.94	13 (14.1%)	5 (5.4%)	1 (1.1%)
	Charleston	41	3.75	5.20	12.20	12 (29.3%)	7 (17.1%)	1 (2.4%)
	Savannah	28	3.07	5.75	9.70	7 (25.0%)	3 (10.7%)	1 (3.6%)
	All Cities	161	3.65	5.25	8.80	32 (19.9%)	15 (9.3%)	3 (1.9%)
Homeowners	Baltimore	34	2.30	3.40	4.90	6 (17.7%)	3 (8.8%)	1 (2.9%)
	Charleston	22	2.95	4.25	9.30	5 (22.7%)	3 (13.6%)	1 (4.6%)
	Savannah	26	2.17	3.77	9.20	6 (23.1%)	2 (7.7%)	2 (7.7%)
	All Cities	82	2.75	3.68	6.85	17 (20.7%)	8 (9.8%)	4 (4.9%)
All Participants	Baltimore	126	3.30	4.60	7.52	19 (15.1%)	8 (6.4%)	2 (1.6%)
	Charleston	63	3.25	5.05	11.2	17 (27.0%)	10 (15.9%)	2 (3.2%)
	Savannah	54	2.45	4.32	9.30	13 (24.1%)	5 (9.3%)	3 (5.6%)
	All Cities	243	3.20	4.60	8.80	49 (20.2%)	23 (9.5%)	7 (2.9%)

* Baltimore, Maryland; Charleston, South Carolina; Savannah, Georgia

Of the seven participants with blood-lead levels greater than 25 μg/dL, three were workers and four were homeowners. Among the three workers: all were approximately the same age (34, 38, and 42 years); two of the three were white; two completed high school, and the third graduated from college or technical school. One of the workers smoked and crimped fishing sinkers onto the line with their teeth. Among the four homeowners: all were white; highly educated (graduated college or technical school); but ranged in age from 35 years to 63 years old. None of the four homeowners smoked, only one had a hobby with potential exposure (working with stained glass). Table 14 presents some of the R&R work characteristics of the three workers and four homeowners with blood-lead concentrations above 25 μg/dL. As shown in the table, all of these study participants performed a substantial amount of paint removal.

The geometric mean blood-lead concentrations for workers were not significantly different across the three cities (p-value = 0.584). Similarly, the geometric mean blood-lead concentrations for homeowners were not significantly different across the cities (p-value = 0.378). However, the geometric mean blood-lead concentrations for workers were significantly (p-value = 0.012) greater than those for homeowners (on average 1.3 μg/dL greater; 95 percent confidence interval [1.06, 1.48]), Figures D-5 and D-6 in Appendix D display side-by-side box plots of blood-lead concentrations for each city and study group. Despite differences in the geometric mean, a similar percentage of workers and homeowners had blood-lead concentrations above 10 μg/dL, 15 μg/dL, and 25 μg/dL.

Each worker was assigned to one of four worker groups based upon their job title and job activities (see Section 2.4.1). Table 15 presents descriptive statistics for each worker group and Figures D-7 through D-11 in Appendix D display side-by-side box plots of blood-lead concentrations for each worker group. The blood-lead concentrations among the worker groups were on the borderline of being significantly different (p-value = 0.067).

3.5.2 Comparison to the WCBS

The design and results of the WCBS are described in detail in the published EPA Report, "Lead Exposure Associated with Renovation and Remodeling Activities: Worker Characterization and Blood-Lead Study," May 1997, EPA 747-R-96-006. Briefly, the WCBS was a targeted survey of union carpenters and employees of independent contractors in two cities: Philadelphia, Pennsylvania, and St. Louis, Missouri. Blood and questionnaire information were collected from 585 participants (581 had complete blood and questionnaire information).

3.5.2.1 Demographic Characteristics. The current study and the WCBS collected information that was used to characterize study participants. Demographic characteristics were similar for participants in this study and those participating in the WCBS. For example, workers in the WCBS were on average 38 years old, predominantly white (83.8%), and high school graduates (93.5%). In comparison, the average age of workers in this study was 37, 70 percent were white, and 82.7 percent were high school graduates. However, there was a higher percentage of female workers (13.7%) in this study than in the WCBS (2.1%). Responses to

Table 14. Characteristics of Study Participants with Blood-Lead Levels Above 25 μg/dL

Blood-Lead Level	Job Title	Main Activities	Days Spent Performing Target Activity in Historic Homes or Homes Built Prior to 1940					Types of Respirator Used	Received Educational Materials	Received Training
			Large Structure Removal	Paint or Preparing Surface	Window or Door Casements Removal	Carpet Removal	Clean-up			
Workers										
44.4	Owner Paint Company	Painting, sanding, stripping	0	30	0	0	30	Half Mask	No	No
43.2	Painter	Painting, prep	15	15	15	0	30	Dust Mask	Yes	No
42.2	Renovation Contractor	Painting, remodeling	10	15	5	0	20	Dust Mask	Yes	Yes
Homeowners										
26.7	N/A	Burnt & scraped old paint, installed closet, refinished floors	0	15	5	0	15	None	No	N/A
33.8	N/A	Paint removal (including burning and sanding), plaster repair, painting	0	4	0	0	5	Dust Mask	No	N/A
32.5	N/A	Removed plaster, scraped and sanded woodwork, removed tin ceiling	3	12	2	0	20	None	Yes	N/A
25.5	N/A	Scrape and sand paint, refinish wood, repair window glazing	0	20	0	0	20	Dust Mask	No	N/A

Table 15. Descriptive Statistics of Blood-Lead Concentrations by Worker Group

Worker Group	N	25th Percentile	Median	75th Percentile	Geometric Mean (μg/dL)	Log Std. Error log (μg/dL)	95% Confidence Interval (μg/dL)
Carpenter	47	3.75	6.85	10.60	6.47	0.098	(5.34, 7.84)
Laborer	44	3.30	4.15	7.12	4.64	0.094	(3.86, 5.59)
Painter	44	3.81	6.12	9.32	6.40	0.117	(5.09, 8.05)
Other	26	3.75	5.17	7.60	5.42	0.102	(4.44, 6.62)

questions on other characteristics, such as the age of home and whether there was renovation in their own home, were similar between the two studies.

3.5.2.2 Work History. In the WCBS, as in this study, a series of three questions were used to collect information on short-, mid-, and long-term work history for each target activity. Figure 7 summarizes the work history for workers in the current study compared to those in the WCBS. Overall, workers in the WCBS performed less R&R in older housing than did workers in the current study.

Figure 7 presents comparisons between the short-term work activities of workers in the WCBS and those in the current study. Workers in the current study performed, on average during the last 30 days, 10 more days of general R&R in older housing than workers in the WCBS. The greatest differences between workers in the WCBS and workers in the current study were for the average number of days spent performing paint removal/surface preparation and cleanup. The lower half of Figure 7 presents the average number of days that workers in the two studies spent performing the target activities in older homes (pre-1950 for the WCBS, and pre-1940 for the current study). The pattern of the average number of days worked in older homes was similar to the average number of days spent performing R&R in any home.

Figure 8 displays the percentage of workers in the two studies that spent more than 8 weeks in the last 12 months performing a target activity. Again, a larger percentage of workers in the current study spent more than 8 weeks performing the target activities than did workers in the WCBS.

Workers in both studies performed the target activities for approximately the same number of years.

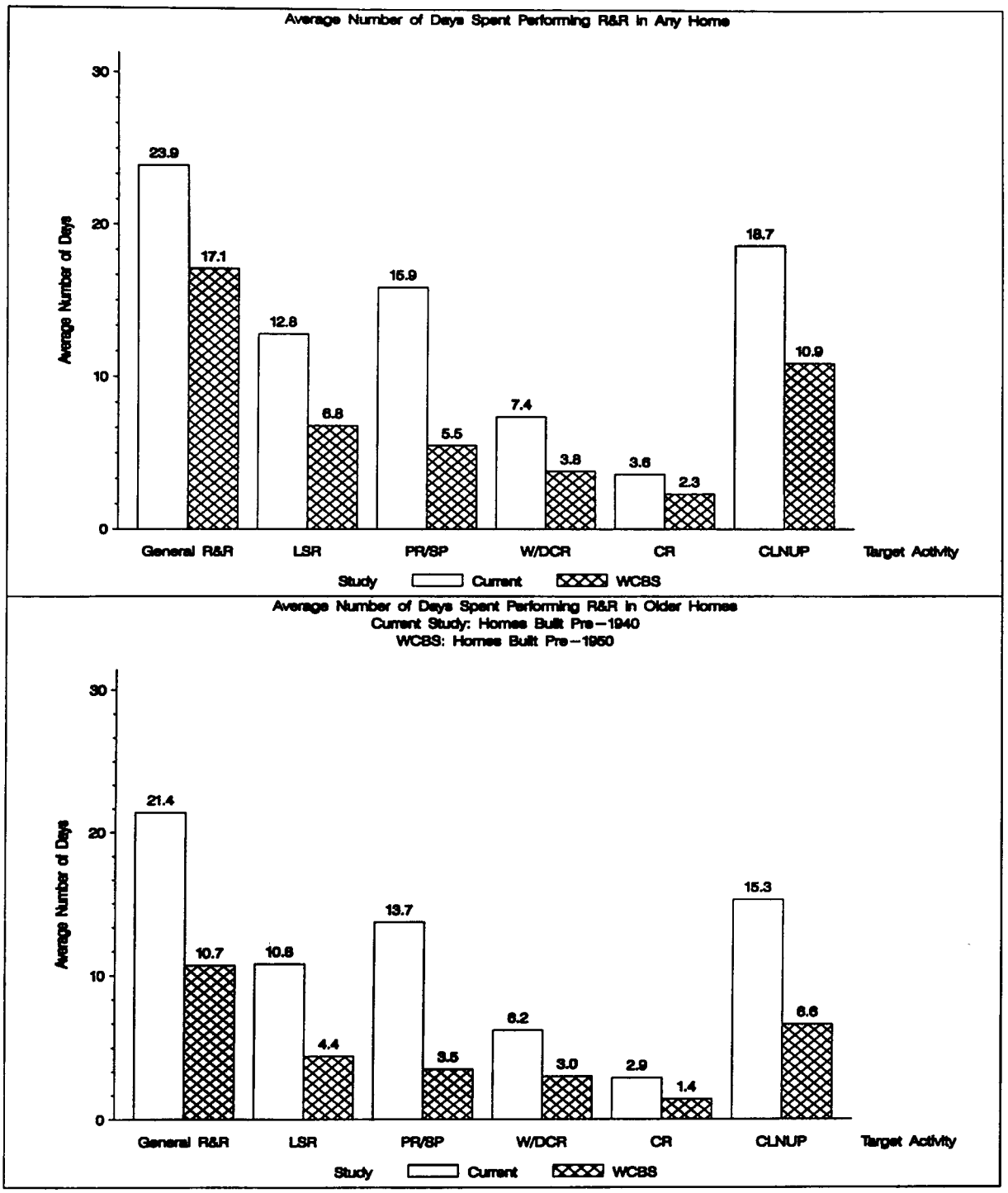


Figure 7. Comparison of Short-Term Work History for Workers in the Current Study (Phase IV) to Those in the WCBS (Phase II)

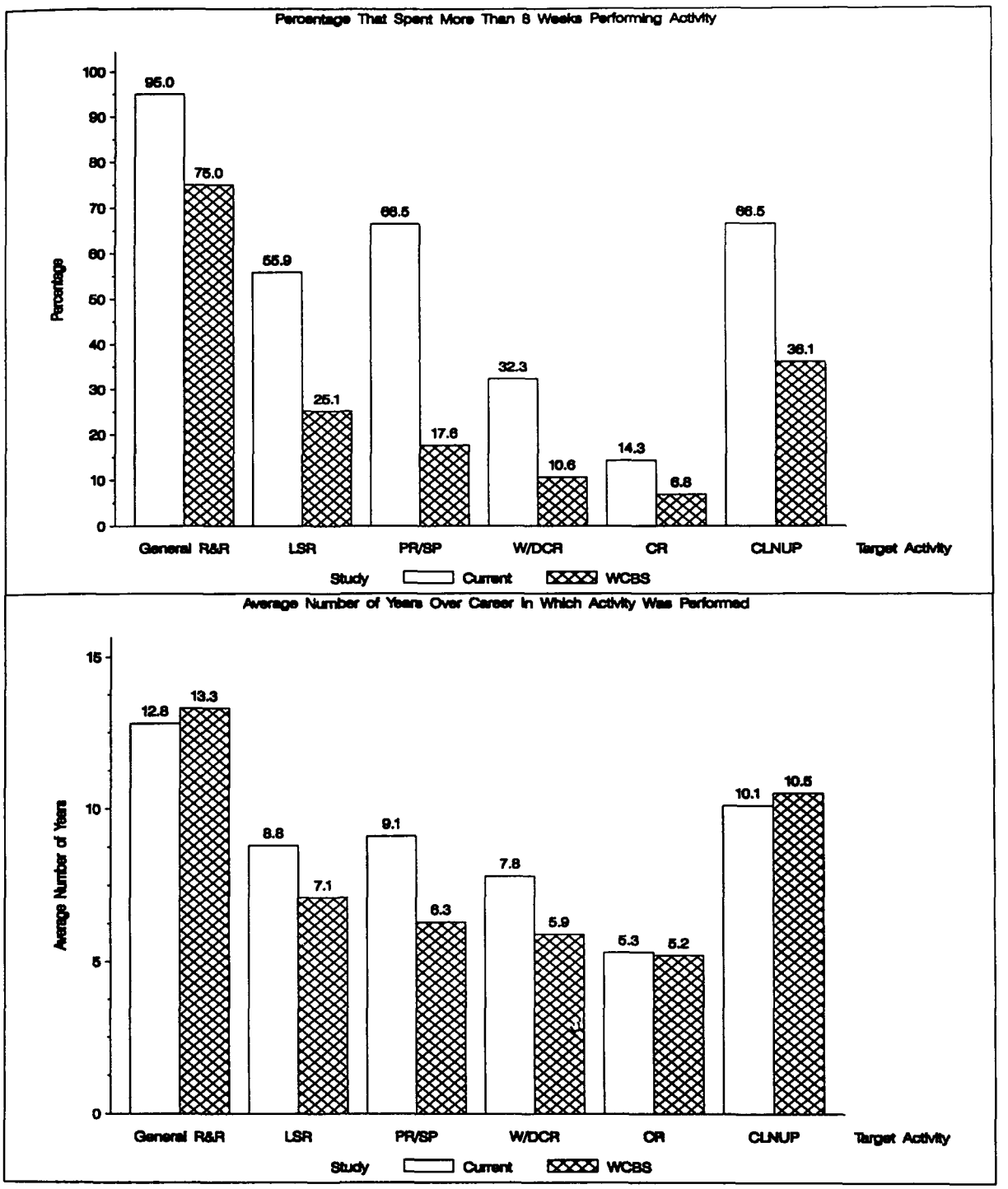


Figure 8. **Comparison of Mid- and Long-Term Work History for Workers in the Current Study (Phase IV) to Those in the WCBS (Phase II)**

3.5.2.3 Blood-Lead Concentrations

Table 16 presents the geometric means and 95 percent confidence intervals for all 581 workers that participated in the WCBS and the 243 participants in the current study. The geometric mean for homeowners in the current study was not significantly different from the geometric mean for workers in the WCBS. While significantly different, the geometric mean blood-lead concentration for workers in the current study was only 1.3 μg/dL (95 percent confidence interval of 1.1 μg/dL to 1.4 μg/dL) higher than the geometric mean blood-lead concentration for workers in the WCBS.

Carpenters were the only worker group where there was a significant difference between the geometric mean blood-lead concentrations for workers in the current study and those in the WCBS. The geometric mean blood-lead for carpenters in the current study was 1.3 μg/dL (95 percent confidence interval from 1.0 μg/dL to 1.6 μg/dL) higher than the geometric mean blood-lead concentration of non-union carpenters in the WCBS.

Table 16. Geometric Means and 95 Percent Confidence Intervals for Blood-Lead Concentrations of Participants from the WCBS and the Current Study

	Current Study			WCBS		
Description	N	Geometric Mean (μg/dL)	95% Confidence Interval	N	Geometric Mean (μg/dL)	95% Confidence Interval
Carpenter[a]	47	6.5	(5.3, 7.8)	104	5.0	(4.5, 5.7)
Laborer	44	4.6	(3.9, 5.6)	54	4.9	(4.1, 5.7)
Painter	44	6.4	(5.1, 8.1)	34	7.2	(5.8, 8.8)
Other	26	5.4	(4.4, 6.6)	14	5.3	(3.9, 7.3)
Union Carpenter[b]	N/A	N/A	N/A	159	4.4	(4.0, 4.8)
Drywall Worker[b]	N/A	N/A	N/A	64	5.8	(5.0, 6.8)
Floor Layer[b]	N/A	N/A	N/A	81	2.6	(2.3, 3.0)
Supervisor[b]	N/A	N/A	N/A	57	3.8	(3.2, 4.4)
Window installer[b]	N/A	N/A	N/A	14	5.4	(3.9, 7.4)
All Workers	161	5.7	(5.2, 6.4)	581[b]	4.5	(4.2, 4.7)
All Homeowners	82	4.5	(3.7, 5.4)	N/A	N/A	N/A

(a) This represents the geometric mean for non-union carpenters participating in the WCBS.

(b) Additional worker groups (union carpenter, drywall worker, floor layer, supervisor, and window installer) were used in the WCBS.

Although differences in the geometric mean blood-lead concentrations were not significantly different or slightly higher, a larger percentage of participants in the current study had elevated blood-lead levels than did workers in the WCBS. Table 17 presents the percent of participants with blood-lead levels above 10 μg/dL, 15 μg/dL, and 25 μg/dL in this study and those in the WCBS. The distributions corresponding to the percent of workers and homeowners

with elevated blood-lead levels were significantly different from those observed in the WCBS (likelihood ratio p-values < 0.02). Moreover, as shown in Table 17, with the exception of workers having blood-lead levels above 25 μg/dL, the percentage of homeowners and workers in the current study with blood-lead levels greater than or equal to 10 μg/dL, 15 μg/dL, and 25 μg/dL was twice as large as the corresponding percentages for workers in the WCBS.

Table 17. Occurrence of Elevated Blood-Lead Levels for Participants in the Current Study (Phase IV) and Workers in the WCBS (Phase II)

Blood-Lead Levels	Study		
	Current Study (Phase IV)		WCBS (Phase II)
	Homeowners	Workers	
Number and Percentage with Blood-Lead Levels ≥10 μg/dL	17 (20.7%)	32 (19.9%)	52 (9.0%)
Number and Percentage with Blood-Lead Levels ≥15 μg/dL	8 (9.8%)	15 (9.3%)	22 (3.8%)
Number and Percentage with Blood-Lead Levels ≥25 μg/dL	4 (4.9%)	3 (1.9%)	7 (1.2%)
Total Sample Size	82	161	581

3.5.3 Comparison to NHANES III, PHASE 2

The design and results of the National Health and Nutrition Examination Surveys (NHANES) are described in detail in two reports from the Centers for Disease Control and Prevention (CDC):

> Centers for Disease Control (1992), "Sample Design: Third National Health and Nutrition Examination Survey. Series 2: Data Evaluation and Methods Research," National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, DHHS Publication No. (PHS) 92-1887.
>
> Centers for Disease Control (1994), "Plan and Operation of the Third National Health and Nutrition Examination Survey, 1988-94," National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, DHHS Publication No. (PHS) 94-1308, 1994.

Briefly, NHANES is conducted by the CDC's National Center for Health Statistics (NCHS), and traces the health and nutritional status of the non-institutionalized, civilian, U.S. population. Information is collected from both adults and youths using questionnaires and a standardized physical examination (including a venipuncture blood sample). A complex survey design is employed so that the resulting sample is nationally representative. The information presented in this report was based upon the public use data set collected from adults (18 years of age or older) as part of NHANES III, Phase 2.

3.5.3.1 Blood-Lead Concentrations. Table 18 presents geometric means and 95 percent confidence intervals for blood-lead concentrations of study participants and those of the adult U.S. population (as described by NHANES III, Phase 2). As shown in the table, the geometric mean blood-lead level for homeowners was significantly higher than the geometric mean blood-lead level for the adult U.S. population (1.86 times higher with a 95 percent confidence interval of 1.54 to 2.26). Similarly, the geometric mean blood-lead level for workers was 2.4 times higher (95 percent confidence interval of 2.14 to 2.70) than the geometric mean blood-lead level for the adult U.S. population. Similar differences exist irrespective of race and gender.

Table 18. Geometric Means and 95 Percent Confidence Intervals for Blood-Lead Concentrations of Participants in the Current Study and Adults in NHANES III, Phase 2

Demographic Characteristic	Level	Study		
		Current Study (R&R Phase IV)		NHANES III, Phase 2
		Homeowners	Workers	
Race	White	4.89 (3.91, 6.12)	5.76 (5.04, 6.59)	2.34 (2.22, 2.47)
	Non-White	3.11 (2.53, 3.82)	5.66 (4.79, 6.70)	2.62 (2.44, 2.81)
Sex	Males	5.86 (4.52, 7.58)	6.09 (5.47, 6.77)	3.07 (2.90, 3.26)
	Females	3.14 (2.53, 3.89)	3.90 (2.83, 5.39)	1.89 (1.79, 2.00)
All		4.45 (3.70, 5.36)	5.73 (5.16, 6.36)	2.39 (2.27, 2.51)

Table 19 presents a comparison of the percentage of participants in this study at or above 10 µg/dL, 15 µg/dL, and 25 µg/dL, to the percentage of adults in the general U.S. population with blood-lead concentrations at or above these thresholds. As shown in the table, a much higher percentage of people participating in the study had elevated blood-lead levels compared to the U.S. population (likelihood ratio p-value < 0.001).

Table 19. Occurrence of Elevated Blood-Lead Levels for Participants in the Current Study (Phase IV) and in the Adult U.S. Population

Blood-Lead Levels	Study		
	Current Study (Phase IV)		NHANES III, Phase 2
	Homeowners	Workers	
Number and Percentage with Blood-Lead Levels ≥10 μg/dL	17 (20.7%)	32 (19.9%)	293 (3.5%)
Number and Percentage with Blood-Lead Levels ≥15 μg/dL	8 (9.8%)	15 (9.3%)	74 (0.88%)
Number and Percentage with Blood-Lead Levels ≥25 μg/dL	4 (4.9%)	3 (1.9%)	15 (0.18%)
Total Sample Size	82	161	8,457

Odds ratios examining the odds of blood-lead levels greater than 25 μg/dL among study participants to that of adults in the general U.S. population are presented in Table 20. For both workers and homeowners, the odds ratios were significantly greater than one. This implies that participants in this study were more likely to have blood-lead levels above 25 μg/dL than the general U.S. population. Specifically, workers were 10.68 times and homeowners were 28.86 times more likely to have blood-lead concentrations above 25 μg/dL than the general U.S. population (95 percent confidence intervals were [3.06, 37.28] and [9.37, 88.92], respectively). Workers were 6.90 times more likely (95 percent confidence interval of 4.88 to 9.80) and homeowners were 7.30 times more likely (95 percent confidence interval; 4.57 to 11.63) to have blood-lead levels ≥10 μg/dL than adults in the general U.S. population.

Table 20. Odds Ratios Comparing Odds of Blood-Lead Concentrations Greater Than 25 μg/dL Among Study Participants to the General U.S. Population

Study Group	No. with Blood-Lead Levels <25 μg/dL	No. with Blood-Lead Levels ≥25 μg/dL	Total Sample Size	Odds Ratio* and (95% CI)
Workers	158	3	161	10.68 (3.06, 37.28)
Homeowners	78	4	82	28.86 (9.37, 88.92)
NHANES III, Phase 2	8,442	15	8,457	--

* These odds ratios compare the odds of blood-lead concentrations above 25 μg/dL for the study group referenced in the row to the general U.S. population.

3.6 STATISTICAL MODELING RESULTS

3.6.1 Statistical Model Building

Statistical models were used to investigate the relationships between log-transformed blood-lead concentrations and potential lead exposure associated with specific R&R activities. Questionnaire responses were used to construct variables that represent potential lead exposure resulting from the R&R activities. In addition to general R&R, lead exposure variables were constructed for several R&R "target activities" including: large structure removal, paint removal/preparing surfaces, window/door casement replacement, carpet removal, and cleanup. For workers, three periods of exposure, short-, mid- and long-term, were captured by the questionnaire for each target activity. For homeowners, information on only two periods of exposure, short- and mid-term, were captured.

For workers, the number of days (in the last 30 days) an activity was performed in historic homes or homes built before 1940 was selected as the measure of short-term exposure. Mid-term exposure for each target activity was characterized by the ordinal response number for the number of weeks a worker performed the activity over the past 12 months. Long-term exposure in each activity was measured by the number of years a worker performed the activity over their career. Thus, a total of 18 variables, one for each combination of target activity and exposure period, were used to characterize a worker's potential lead exposure resulting from R&R.

For homeowners, both the number of days an activity (in the last 30 days) was performed in their own home and the total number of hours (in the last 30 days) that the activity was performed were used to characterize short-term exposure. Mid-term exposure was characterized by the number of weeks in the past 12 months in which the target activity was performed and by the total number of days that the target activity was performed during the past 12 months. Thus, a total of 24 variables, two for each combination of target activity and exposure period, were used to characterize a homeowner's potential lead exposure resulting from R&R.

3.6.1.1 Selection of Ancillary Covariates. Although the objectives of this study were to investigate the relationship between blood-lead concentrations and the R&R target activities, both the worker and homeowner questionnaires collected information on work practices and demographics that might also be related to blood-lead levels. These variables were defined as "ancillary variables" (i.e., variables that were not of immediate interest, but that needed to be accounted for in the statistical models, such as gender and race). That is, the relationships between the target activities and blood-lead concentrations need to be "adjusted" to account for the effects of these variables.

In both the worker and homeowner questionnaires, information on two categories of ancillary variables were collected:

- Variables related to the conduct of R&R
  - — Respirator use
  - — General work practices

- — R&R activity in own home (workers only)
- — Previous lead training (workers only) and education
- — R&R work conducted by contractors in home (homeowners only)

- Variables not related to the conduct of R&R
  - — Other occupations with potential lead exposure
  - — Age of home (workers only)
  - — Hobbies with potential lead exposure
  - — Race and ethnicity
  - — Age
  - — Tobacco use
  - — Education level
  - — City

The large number of candidate ancillary variables required an initial screening to select covariates for use in the statistical models.

Each potential ancillary covariate was classified as being either discrete or continuous. Scatter plots and regression lines were used to characterize the relationships between continuous potential covariates and blood-lead concentrations (see Figure D-7 in Appendix D). Box plots were used to characterize the relationship between categorical covariates and blood-lead concentrations (see Figures D-8 through D-12 in Appendix D).

Whenever appropriate, the levels of some discrete variables were collapsed to improve power for statistical tests. In addition, an effort was made to reduce the number of potential covariates, when possible, by creating a single quantal variable from the responses of several questions. For example, a single variable was constructed to reflect the number of hobbies a participant had with high potential for lead exposure.

The statistical significance of each candidate ancillary covariate's effect on blood-lead concentration is displayed in Table C-1 of Appendix C for workers and Table C-2 of Appendix C for homeowners. Worker ancillary covariates that had significant relationships with blood-lead were then simultaneously placed into a single model for worker blood-lead. Homeowner covariates with significant relationships with blood-lead were then simultaneously placed into a single model for homeowner blood-lead. The following variables were selected, based on these analyses, for inclusion in covariate-adjusted models for workers and homeowners:

Workers	Homeowners
1. Sex	1. Age
2. Room Additions or Renovation in Own Home	2. Sex
3. Smoke, Use Snuff, or Chewing Tobacco	3. Race

Table 21 provides the geometric mean blood-lead concentration and log (standard error) for each level of the selected ancillary covariates.

Table 21. Geometric Mean Blood-Lead Concentration and Log (Standard Error) for Each Level of the Ancillary Covariates

Study Group	Variable	Level	Sample Size	Blood-Lead (μg/dL)	
				Geometric Mean	Log Std. Error
Workers	Sex	Male	139	6.1	0.055
		Female	22	3.9	0.165
	Room additions or renovation in own home	Yes	103	5.2	0.058
		No	58	6.7	0.130
	Smoke, use snuff, or chewing tobacco	Yes	58	4.9	0.096
		No	103	6.2	0.062
Homeowners	Age of participant	<31	16	4.0	0.206
		31-40	32	3.8	0.152
		>40	34	5.4	0.146
	Sex	Male	46	5.9	0.132
		Female	36	3.1	0.110
	Race	White	65	3.1	0.105
		Non-White	17	4.9	0.113

3.6.2 Blood-Lead Concentration Comparisons Using Covariate-Adjusted Model Results

The geometric mean blood-lead concentration of homeowners, workers, and each worker group were estimated after adjusting for ancillary covariates. The covariate-adjusted geometric means for each study group and worker group are presented in Table 22. These means were calculated from a linear combination of the levels of each covariate with weights equal to the percent of participants at each level. Separate models were used to estimate the adjusted geometric means for each worker group and for workers and homeowners. The covariate-adjusted geometric means were similar to the unadjusted means. Figure 9 displays the 95 percent confidence intervals for the covariate-adjusted geometric means.

Table 22. Geometric Mean and 95 Percent Confidence Intervals for Each Study Group and by Worker Group Based Upon Covariate-Adjusted Models

Description		Geometric Mean	95% Confidence Interval
Worker Group	Carpenters	6.1	(5.1, 7.4)
	Laborers	4.2	(3.5, 5.1)
	Painters	6.3	(5.1, 7.7)
	Other	5.0	(3.9, 6.4)
All Workers		5.7	(5.2, 6.3)
Homeowners		4.4	(3.7, 5.2)

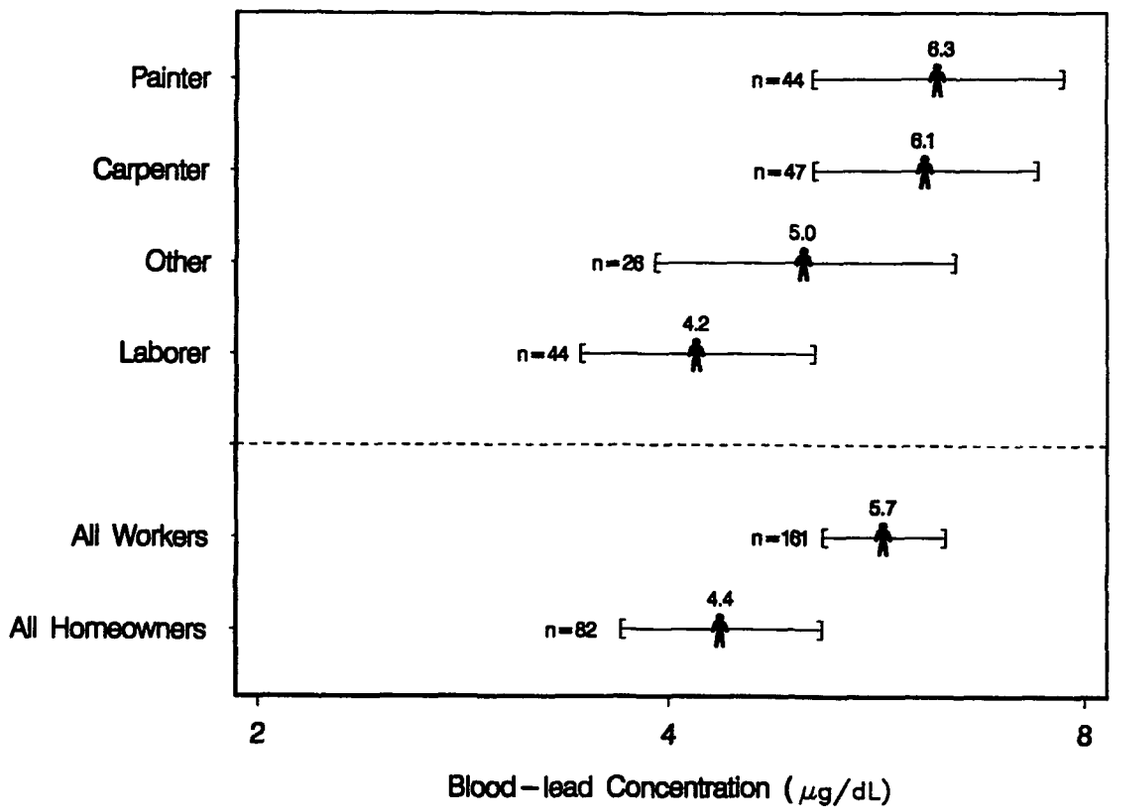


Figure 9. 95 Percent Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for Each Worker Group and Study Group Based Upon Covariate-Adjusted Models

3.6.3 Relationship Between R&R Target Activities and Participant Blood-Lead Concentrations

As discussed in Section 2.4.4, statistical models were used to examine the relationship between the R&R target activities and the blood-lead concentrations of study participants. Section 3.6.3.1 presents the results for workers, Section 3.6.3.2 presents the results for homeowners.

3.6.3.1 Relationship Between R&R Target Activities and Worker Blood-Lead Concentrations. The effect of each of the 18 target activity variables, unadjusted for covariates or the conduct of other target activities, was estimated by fitting separate linear regression models (one model for each target activity, exposure period, and study group). Estimated slopes, standard errors, and p-values for each exposure measure are displayed in Table C-3 in Appendix C.

With the exception of carpet and large structure removal, there was a statistically significant positive relationship between worker blood-lead concentration and short-term conduct in pre-1940 houses for each target activity. The relationships between worker blood-lead concentration and mid-term and long-term exposure associated with target activities were also positive, with the exception of carpet removal. The apparent negative association between blood-lead concentration and carpet removal should be interpreted with caution. It is important to note that workers spending time performing carpet removal must spend less time performing activities that may generate a greater exposure. Thus, a negative association may not imply that carpet removal does not generate a lead exposure, rather that carpet removal does not generate as much of an exposure as other target activities.

The relationship between cleanup and R&R activities presented in Table C-3 could depend upon the specific type of cleanup performed (certain types of cleanup activities, such as dry sweeping, may distribute lead-dust more than others). The questionnaire for this study did not collect information on the specific type of cleanup performed. However, in the WCBS only 14.3 percent of all workers performed cleaning activities using a HEPA vacuum or wet mop with TSP (even among these workers a large percentage also reported cleaning with a broom or vacuum). Based upon anecdotal comments from respondents in this study, it is very likely that this same result was true among participants in this study. In which case, the underestimation of the relationship between cleanup and blood-lead concentrations would be minimized.

Many of the slope estimates presented in Table C-3 were positive and statistically significant (p-value < 0.05). For each target activity, Table 23 presents the predicted changes in blood-lead concentration for 10 days of work activity per month in pre-1940 buildings unadjusted for other covariates[9]. The second column displays predicted blood-lead concentration for each target activity, for workers who performed the activity for zero and 10 days in pre-1940

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[9] As shown in Table 9, the interquartile range for the number of days workers spent performing R&R work in pre-1940 buildings was 7 days, and on average, workers spent 21 days performing R&R in pre-1940 homes. However, 10 days were used for this table to allow for comparisons to the results of the WCBS.

houses during the previous month. The predicted increases in blood-lead concentration ranged from 0.1 μg/dL for large structure removal to 0.9 μg/dL for window/door casement replacement. The maximum predicted blood-lead concentration associated with 10 days of work in pre-1940 buildings, 6.1 μg/dL, was estimated for work related to window/door casement replacement. The last row of Table 23 contains the results for conducting general R&R. Because all of the workers spent more than 10 days performing general R&R in pre-1940 homes (this was one of the eligibility criterion) the "Base Level" for general R&R represents 10 days of work in pre-1940 homes. As shown in Table 23, there was a significant predicted increase in blood-lead concentration associated with performing 10 days versus 20 days of general R&R in pre-1940 homes (1.7 μg/dL).

The covariate-adjusted effects for each combination of target activity and exposure period were also estimated using separate linear regression models. Estimated slopes, standard errors, and p-values are shown in Table C-4 in Appendix C. With a few exceptions, the estimated slopes for target activities were positive after adjusting for the effects of selected ancillary covariates. The magnitudes of the covariate-adjusted slope estimates were typically less than the unadjusted slope estimates.

The predicted changes in worker blood-lead concentrations, based on the covariate-adjusted models, associated with 10 days of work in pre-1940 buildings are presented in the third column of Table 23. The smaller slope estimates for the covariate-adjusted models compared to the unadjusted models resulted in smaller predicted increases in worker blood-lead concentrations. With the exception of general R&R, the estimated increase in blood-lead concentration from the base level was very small (less than 1 μg/dL) for both the unadjusted and covariate-adjusted models. The estimated increase for conducting 20 days of R&R instead of 10 days was 1.5 μg/dL with the covariate-adjusted model.

Table 23. Predicted Changes in Worker Blood-Lead Concentrations Associated with 10 Days of Work in Pre-1940 Homes

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.

Covariate-adjusted models that included all three exposure periods (short-, mid-, and long-term) were also fit for each target activity. This series of models was used to assess which exposure period, if any, was the best predictor of blood-lead concentrations. Estimated slopes, standard errors, and p-values are displayed in Table C-5. Overall, the p-values associated with the parameter estimates in Table C-5 are not consistent across the six target activities. Short-term exposure (days pre-1940) appeared to be the best predictor for cleanup and general R&R while mid-term exposure (weeks in last 12 months) appeared to be the best predictor for carpet removal. None of the parameter estimates for long-term exposure (years in career) were significantly associated with blood-lead levels after short and mid-term exposure measures were included in the model. There were no significant relationships found at all for large structure removal, paint removal/preparing surfaces, and window/door casement replacement. However, the inconsistent results of these models are likely due to the high degree of correlation among the three exposure period measures for each target activity.

3.6.3.2 Relationship Between R&R Target Activities and Homeowner Blood-Lead Concentrations. As with workers, the effect of each of the 24 target activity variables, unadjusted for covariates or the conduct of other target activities, was estimated by fitting separate linear regression models. Estimated slopes, standard errors, and p-values for each exposure measure are displayed in Table C-6 in Appendix C.

Very few target activities, for any exposure measure, were significantly related to blood-lead concentrations. Both short-term exposures (days in last 30 days and total hours in last 30 days) for paint removal/surface preparation were significantly related to blood-lead levels. General R&R as measured by hours in the last 30 days (short-term) and days in the last 12 months (mid-term) was significantly related to blood-lead levels. General R&R was the only target activity where mid-term exposure was significantly related to blood-lead concentrations.

Estimated slopes, standard errors, and p-values are shown in Table C-7 in Appendix C for covariate-adjusted models (a separate model for each combination of target activity and exposure period measure). The estimated slopes for target activities were mostly positive after adjusting for the effects of selected ancillary covariates. As with the unadjusted models, paint removal/ surface preparation and general R&R were the only two target activities with significant relationship to blood-lead concentrations. Once adjustments for the ancillary covariates were made, all exposure measures, both short- and mid-term, for paint removal/surface preparation were significantly related to blood-lead levels (marginally significant for days in the last 30 days, p-value = 0.054). A similar pattern was observed for general R&R (marginally significant for days in the last 30 days, p-value = 0.077).

Table 24 presents the predicted changes in homeowner blood-lead concentrations for selected days of work activity in pre-1940 buildings. The third column displays predicted changes in blood-lead concentration for each target activity, for homeowners who performed the activity for zero days and the average number of days for each target activity in their home during the previous month. For example, the second row presents the predicted changes (from 3.3 to 4.5 μg/dL) in homeowner blood-lead concentrations associated with performing an

additional three days of large structure removal. The fourth column displays the corresponding predicted changes based upon the covariate-adjusted models.

Table 24. Predicted Changes in Homeowner Blood-Lead Concentrations Associated With Changes in the Number of Days Spent Performing a Target Activity in Their Pre-1940 Home

Target Activity	Additional Number of Days**	Based on Model Unadjusted for Covariates	Based on Covariate-Adjusted Model
		Base Level[a] → Level When Homeowner Conducts Additional Days per Month of Activity	Base Level[a] → Level When Homeowner Conducts Additional Days per Month of Activity
General R&R	15	3.3 → 4.5	3.3 → 4.4
Large Structure Removal	3	4.5 → 4.5	4.2 → 4.4
Paint Removal/ Prepare Surface	7	3.3 → 4.5*	3.5 → 4.4
Window/ Door Casement Removal	1	4.4 → 4.5	4.3 → 4.4
Carpet Removal	0.5	4.6 → 4.4	4.4 → 4.4
Cleanup	10	4.0 → 4.1	3.7 → 4.4

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

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

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

As expected by the many insignificant estimated slope parameters, the predicted changes to homeowner blood-lead levels were small. The largest predicted changes based upon the additional number of days spent performing the target activity were for paint removal/surface preparation (1.2 μg/dL for the unadjusted model and 0.9 μg/dL for the adjusted model) and general R&R (1.2 μg/dL for the unadjusted model and 1.1 μg/dL for the adjusted model). Similarly, the largest predicted changes when measuring short-term exposure by the total number of hours (see Table 25) were also for general R&R and paint removal/surface preparation.

As for workers, covariate-adjusted models that included both exposure periods were also fit for each target activity. In all, 12 models were fit: the first six models, one for each target activity, included short- and mid-term exposure variables related to duration (i.e., days in the last 30 days and weeks in the last 12 months), the second six models, again one for each target activity, included short and mid-term exposure variables related to intensity (i.e., total hours in the last 30 days and days in the last 12 months). The estimated slopes, standard errors, and p-values for these models are displayed in Table C-8 in Appendix C. As in the earlier models that included only one exposure period per target activity, general R&R and paint removal/surface preparation were the only target activities with exposure terms significantly related to blood-lead. Considering the models based upon duration, it appears that mid-term exposure (number of weeks in the past 12 months) was a better predictor of blood-lead than short-term exposure (number of days in the last 30 days) for these two target activities.

However, when considering the models based upon intensity, the parameter estimates were not as consistent. Short-term exposure (total hours in the past 30 days) appeared to be a better predictor for paint removal/surface preparation while mid-term exposure (days in the last 12 months) appeared to be a better predictor for general R&R.

Table 25. Predicted Changes in Homeowner Blood-Lead Concentrations Associated With Changes in the Number of Hours Spent Performing a Target Activity in Their Pre-1940 Home

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

(e) 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.

3.6.4 Overall Statistical Models for Participant Blood-Lead Concentrations

The statistical models described in Section 3.6.3 helped to characterize the strength of the relationship between each target activity and worker or homeowner blood-lead concentrations. The following two sections present the results from developing statistical models that were used to characterize how each of the target activities interacted in their association with blood-lead concentrations while accounting for the effect of potential confounding ancillary covariates. Section 3.6.4.1 presents the results for workers and Section 3.6.4.2 presents the results for homeowners.

3.6.4.1 Overall Statistical Model for Worker Blood-Lead Concentrations. An initial series of models were fit to the data to assess which of the specific target activities, if any, had the largest impact on worker blood-lead concentrations during each exposure period. That is, for each of the three exposure periods, the effects of all of the target activities (with the exception of general R&R work) were estimated simultaneously using covariate-adjusted models. General R&R work was not included in these models because it was not independent from the other

target activities (e.g., the amount of general R&R must be at least as great as the amount of any other target activity). Estimated slopes, standard errors, and p-values as presented in Table C-9.

When all of the target activities were considered simultaneously, only one or two of them, within each exposure period, had a significant impact on worker blood-lead concentrations. This was likely a result of the strong inter-correlations among the target activity variables within an exposure period.

In the WCBS, it was observed that target activities varied across the worker groups and that there were differences in the geometric mean blood-lead concentrations among the nine worker groups[10]. In this follow-up study, however, the opposite was observed. That is, with a few exceptions, workers in the four worker groups spent a similar amount of time performing the target activities and differences in the geometric mean blood-lead concentrations among the four worker groups were not significant (see Section 3.5). A series of models were fit to assess the impact of worker group on the relationships between the target activities and worker blood-lead concentrations. The estimated slopes, standard errors, and p-values for these models are displayed in Table C-10.

After including worker group in the three exposure models, cleanup was the only target activity significantly related to worker blood-lead concentrations in the short-term exposure model. In the mid-term exposure model, paint removal/surface preparation and carpet removal were significantly related to worker blood-lead concentrations. In the long-term exposure model, carpet removal and cleanup were significantly related to worker blood-lead concentrations. With the exception of the long-term exposure model where cleanup became significant, worker group generally had only a small impact on the estimated slopes, standard errors, and p-values. This result is illustrated in Table 26, which provides general F-tests for model effects after adjusting for the effects of selected covariates and other effects included in the model.

The first row of Table 26 shows the R^2 value (12.7%), F-test (7.58) and corresponding p-value (<0.001) for a model that included only the selected ancillary covariates. The next three rows correspond to models that for each exposure period, included the ancillary covariates and exposure measures for the five target activities. The combined effect of all five target activities was statistically significant for each exposure period, and accounted for between 8.6 and 13.9 percent of the variability in worker blood-lead concentrations after adjusting for the covariates. The fifth row displays the results for a model that included the effects of the selected ancillary covariates and worker group. The effect of worker group was statistically significant and explained 7.1 percent of the variability in blood-lead after adjusting for the covariates. The sixth through eighth rows describe, for each exposure period, the combined effect of all five target activities after adjusting for the effects of ancillary covariates and worker group. The F-test for the combined exposure measures shows that the combined effects of target activities are significantly related to worker blood-lead concentrations after adjusting for covariates and worker group. The final three rows describe, for each exposure period, the effect of worker

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[10] The nine worker groups used in the WCBS were: (1) Union Carpenter, (2) Non-Union Carpenter, (3) Laborer, (4) Painter, (5) Drywall Worker, (6) Window Installer, (7) Supervisor, (8) Floor Layer, and (9) Other.

group after adjusting for the effects of ancillary covariates and the combined effect of all five target activities. For the short- and mid-term exposure models, the relatively small impact of worker group is indicated by the marginally significant relationship between worker group and worker blood-lead concentrations. In the long-term exposure model worker group appeared to be more related to worker blood-lead concentrations and, this is reflected in the significance (p-value <0.05) of the worker group term.

Table 26. General F-Tests for Model Terms on Worker Blood-Lead Concentrations, After Adjusting for the Effects of Covariates and Other Terms Included in the Model

Base Model	Variables Under Investigation	R^2	R^2_p	F	P-Value
	Covariates	0.127	----	7.58	<0.001
Covariates	Target Activities (Days Pre-1940)	0.250	0.139	4.80	<0.001
	Target Activities (Weeks)	0.243	0.134	4.69	<0.001
	Target Activities (Years)	0.183	0.086	2.75	0.021
Covariates	Worker Group	0.189	0.071	3.92	0.010
Covariates + Worker Group	Target Activities (Days Pre-1940)	0.284	0.120	3.97	0.002
	Target Activities (Weeks)	0.277	0.110	3.66	0.004
	Target Activities (Years)	0.241	0.091	2.88	0.017
Covariates + TA (Days Pre-1940)	Worker Group	0.284	0.045	2.30	0.080
Covariates + TA (Weeks)	Worker Group	0.277	0.045	2.34	0.075
Covariates + TA (Weeks)	Worker Group	0.241	0.071	3.63	0.015

R^2 = The coefficient of determination for the base model and variables under investigation.

R^2_p = The partial coefficient of determination for the variables under investigation, after adjusting for the effects of variables indicated in the base model.

F-test pertains only to the variables under investigation, after adjusting for variables included in the base model.

Since it appeared that both the target activities and, to some extent worker group, were related to worker blood-lead concentrations, the final predictive model was developed using both of these components. The first step in developing the final predictive model for workers was to refine the models presented in Table C-10 for each exposure period. In particular, since there was strong inter-correlation among the target activities, a series of stepwise models were fit to: (1) determine which of the target activities were the most related to blood-lead concentrations, and (2) reduce the number of terms in the models presented in Table C-10 by removing target activities that were not significantly related to blood-lead.

The three models (one for each exposure period) presented in Table C-10 were used as the initial models for developing the final predictive models. In the first iteration, the single variable that was the least related to blood-lead was removed from the model (for short-term this

was paint removal/surface preparation, and large structure removal for the mid-term and long-term exposure models). In subsequent iterations, a single insignificant variable was removed from the model. This process was repeated until all terms were significant. Each removed variable was then re-entered into the final model for each exposure period to verify that they were not significant. Table C-11 presents the slopes, standard error, and p-values for each target activity in the final model for each exposure period.

The results for the iterative process were similar to those indicated by Table C-10 where all target activities were fit simultaneously for each exposure period. That is, cleanup was the only significant term retained in the short-term exposure model, paint removal/surface preparation and carpet removal were the significant terms retained in the mid-term model, and carpet removal was significant and included in the model for long-term exposure. Where the results differ is in the significance of window/door casement replacement instead of cleanup in the long term-exposure model.

The final predictive model for workers was developed using similar iterative steps. The initial model included all terms from the three final models for each exposure period, the ancillary covariates, and worker group. Only one term, years in career spent removing carpets, was not significant and removed from the model. Thus, the final model included the following activities from each exposure period:

- Short-term: Number of days, in the last 30 days, spent performing *cleanup.*
- Mid-term: Number of weeks spent performing *paint removal/surface preparation* and the number of weeks spent performing *carpet removal.*
- Long-term: Number of years spent replacing *window/door casements.*

The model was further refined by examining the assumption of a common slope for all worker groups for each of the target activities. That is, a model was fit with unequal slopes for each worker group and activity and an F-test was performed to determine the activities, if any, for which the assumption of common slopes did not appear to be valid. The assumption of equal slopes appeared to be valid only for the number of weeks spent performing carpet removal in the last 12 months. Different slopes for each worker group were used for the remaining three target activities. Table C-12 presents the estimated parameters, standard errors, and p-values for the final model.

To illustrate how worker blood-lead concentration is a function of the amount of time spent performing cleanup, paint removal/surface preparations, carpet removal, or window/door casement replacement, Table 27 displays the estimated blood-lead concentration (and 95 percent confidence interval) associated with low, medium, and high exposure indices based on the final model. The low, medium, and high exposure indices were based upon the 25th, 50th, and 75th percentiles of questionnaire responses from workers on these target activities and exposure periods. For Carpenters, Laborers, and Painters, the model predicts an increase in blood-lead concentrations of 1.7 μg/dL for Laborers, 3.3 μg/dL for Carpenters, and 5.7 μg/dL for Painters. However, the model predicts a decrease for the Other worker group of 1.5 μg/dL. This may be

due to the fact that the Other worker group includes supervisors, managers, foremen, etc. and time spent performing some of the activities may not be realistic of actual hands-on time.

Tukey's multiple comparison procedure for unbalanced data was employed to conduct pairwise comparisons between the geometric mean worker blood-lead concentrations predicted for each worker group at the Medium Exposure Index (see Table 27). The overall Type I error rate for these simultaneous tests was ≤0.10. Carpenters had a significantly higher geometric mean blood-level than Laborers. All other comparisons were not significant.

Table 27. Predicted Worker Blood-Lead Concentrations Associated with Low, Medium, and High Exposure Indices for Each Worker Group

Worker Group	Low Exposure Index[a]: 0 Weeks CR, 10 Days of Cleanup, 5-8 Weeks PR/SP, 2 Years Over Career W/DCR		Medium Exposure Index[b]: <1 Week CR, 15 Days of Cleanup, 9-12 Weeks PR/SP, 6 Years Over Career W/DCR		High Exposure Index[c]: 1-4 Weeks CR, 23 Days of Cleanup, >26 Weeks PR/SP, 12 Years Over Career W/DCR	
	Geometric Mean	95% C.I.	*Geometric* Mean	95% C.I.	*Geometric* Mean	95% C.I.
Carpenter	5.5	(4.1, 7.3)	6.3	(5.2, 7.6)	8.8	(6.8, 11.3)
Laborer	4.2	(3.3, 5.4)	4.8	(4.0, 5.7)	5.9	(4.5, 7.9)
Painter	4.7	(3.4, 6.6)	6.0	(4.9, 7.4)	10.4	(7.6, 14.1)
Other	6.8	(5.0, 9.1)	5.8	(4.6, 7.4)	5.3	(3.5, 8.0)

The low, medium, and high exposure indices were based upon the 25th, 50th, and 75th percentiles of questionnaire responses from workers on these target activities and exposure periods.

(a) Low Exposure Index = 0 Weeks of Carpet Removal (CR) in the last 12 months, 10 days of Cleanup in the last 30 days, 5-8 Weeks of Paint Removal/Surface Preparation (PR/SP), and 2 Years Spent Performing Window/Door Casement Replacement (W/DCR) Over Entire Career

(b) Medium Exposure Index = <1 Week of Carpet Removal (CR) in the last 12 months, 15 days of Cleanup in the last 30 days, 9-12 Weeks of Paint Removal/Surface Preparation (PR/SP), and 6 Years Spent Performing Window/Door Casement Replacement (W/DCR) Over Entire Career

(c) High Exposure Index = 1-4 Weeks of Carpet Removal (CR) in the last 12 months, 23 days of Cleanup in the last 30 days, >26 Weeks of Paint Removal/Surface Preparation (PR/SP), and 12 Years Spent Performing Window/Door Casement Replacement (W/DCR) Over Entire Career

An alternative predictive model based on the days, weeks, and years that a worker spent performing general R&R activities was also investigated. The estimated parameters, standard errors, and p-values for this alternative final model are presented in Table C-13. Unlike the final predictive model, this model does not include interaction terms with worker group (they were not significant at the 0.05 level). Further, the estimated parameters indicate that worker blood-lead

concentrations are positively related to general R&R activity. However, this relationship was significant only for short-term exposure and the alternative model did not predict worker blood-lead concentrations as well as the final predictive model.

3.6.4.2 Overall Statistical Model for Homeowner Blood-Lead Concentrations. A similar methodology to that employed in Section 3.6.4.1 for workers was used to develop an overall predictive model for homeowner blood-lead concentrations. Therefore, an initial series of models were fitted to the data to assess which of the specific target activities, if any, had the greatest impact on homeowner blood-lead concentrations during each exposure period. That is, for each of the two exposure periods (short- and mid-term), the effects of all of the target activities (with the exception of general R&R work) were estimated simultaneously using covariate-adjusted models. As with the models for workers, general R&R work was not included in these models. However, two separate models were fit for each exposure period, one corresponding to duration and one examining intensity. Estimated slopes, standard errors, and p-values for the four models are presented in Table C-14.

When all of the target activities were considered simultaneously, only paint removal/ surface preparation had a significant impact on homeowner blood-lead concentrations. Mid-term (weeks in last 12 months) paint removal/surface preparation and short-term (total hours in last 30 days) paint removal/surface preparation were significantly related to homeowner blood-lead concentration. Again, this could have been due to the strong inter-correlations among the target activity variables within an exposure period so additional steps were taken to develop the final predictive models for each exposure period.

The four models presented in Table C-14 were used as the initial models for developing the final predictive models for each exposure period (two models for each exposure period). In the first iteration, the single variable that was the least related to blood-lead was removed from the model and in subsequent iterations, a single insignificant variable was removed, in each iteration, from the model. This process was repeated until all terms were significant. Each removed variable was then re-entered into the final model for each exposure period to verify insignificance. In all four models, paint removal/surface preparation was the only target activity that was significantly related to homeowner blood-lead concentrations. Table C-15 presents the slopes, standard error, and p-values for paint removal/surface preparation for the final models in each exposure period.

After the final models for each exposure period were developed, additional models were developed to determine which measure, intensity or duration, better predicted homeowner blood-lead concentrations. Models corresponding to duration and intensity of paint removal/ surface preparation were developed by combining the short- and mid-term measures for duration and intensity of paint removal/surface preparation into a model. That is, the number of days and the number of weeks spent performing paint removal/surface preparation were included in one model, and the number of hours in the last 30 days and the number of days in the last 12 months were included in another model.

The final predictive model for homeowners included the significant measures in the models from the preceding step. Thus, the final model contains both a measure of intensity (total

hours in the last 30 days) and a measure of duration (weeks in the last 12 months). Table C-16 presents the slopes, standard error, and p-values for the final predictive model for homeowners. Figure 10 illustrates the predicted increase in homeowner blood-lead concentrations as a function of the number of hours spent in the last 30 days performing paint removal/surface preparation and the number of weeks in the last 12 months in which some paint removal/surface preparation was performed.

An alternative predictive model for homeowner blood-lead concentrations was developed using general R&R. Since there were two measures of general R&R for each exposure period, the same steps used to develop the final predictive model were employed. The final alternative model, like the predictive model using paint removal/surface preparation, included a short-term measure of intensity and a mid-term measure of duration. The slopes, standard error, and p-values for general R&R duration and intensity are presented in Table C-17. This model predicted homeowner blood-lead concentrations nearly as well as the final predictive model.

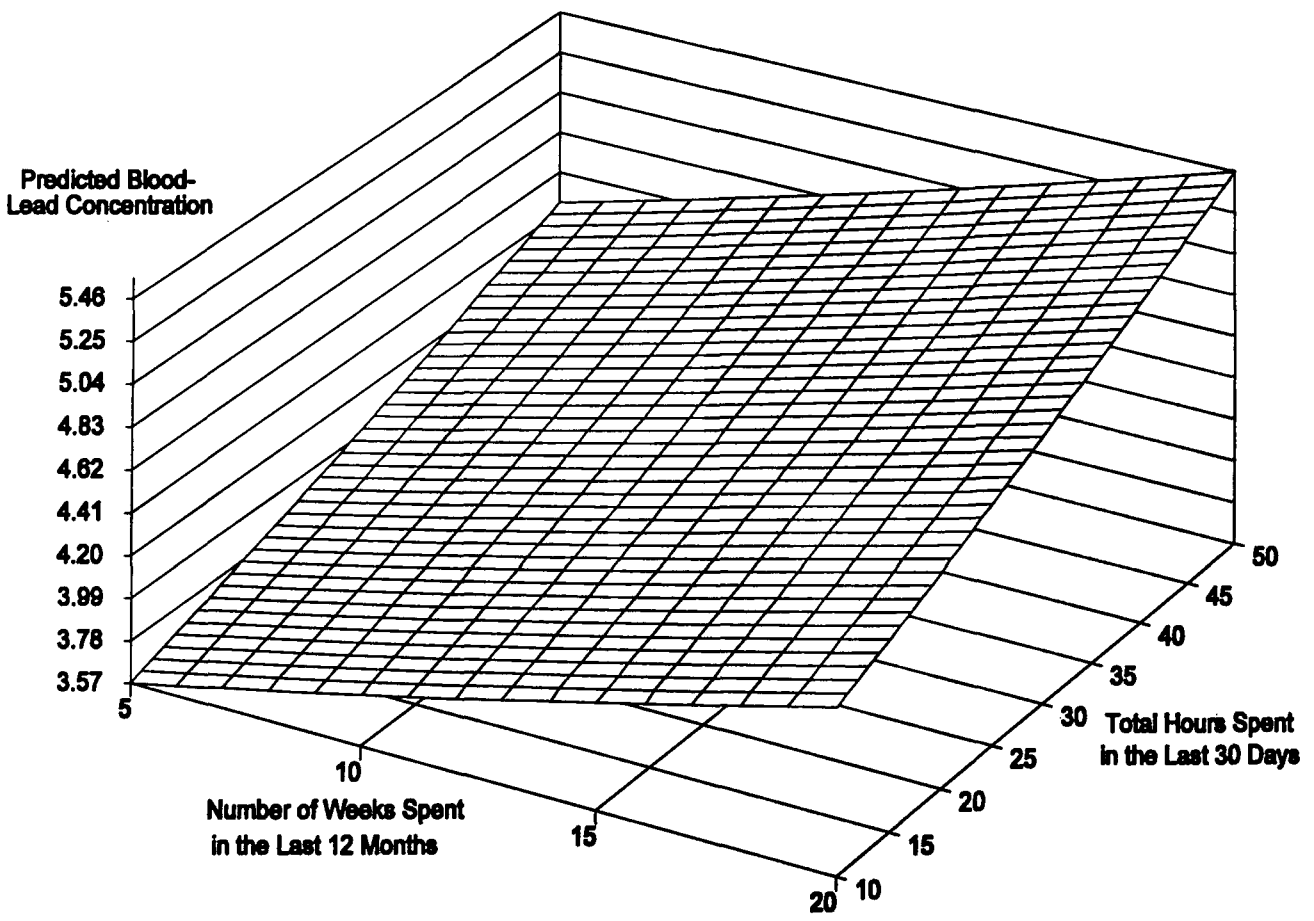

Figure 10. Predicted Increase in Homeowner Blood-Lead Concentrations as a Function of Hours and Weeks Spent Performing Paint Removal/Surface Preparation

To illustrate the relationship between homeowner blood-lead concentrations and the amount of general R&R work performed, Table 28 displays the estimated blood-lead concentration (and 95 percent confidence interval) associated with low, medium, and high indices based upon the alternative predictive model. The low, medium, and high exposure indices were based upon the 25th, 50th, and 75th percentiles of the total hours and weeks spent performing general R&R. The predicted homeowner blood-lead concentrations using paint removal/surface preparation are also presented for comparison.

Table 28. Predicted Homeowner Blood-Lead Concentrations Associated with Low, Medium, and High Exposure Indices Using General R&R

Model	Low Exposure Index 42 Hours in the Last 30 Days 15 Weeks in the Last 12 Months		Medium Exposure Index 78 Hours in the Last 30 Days 28 Weeks in the Last 12 Months		High Exposure Index 100 Hours in the Last 30 Days 40 Weeks in the Last 12 Months	
	Geometric Mean	95% C.I.	Geometric Mean	95% C.I.	Geometric Mean	95% C.I.
Using General R&R	3.4	(2.7, 4.2)	4.6	(3.8, 5.4)	5.8	(4.6, 7.2)
Using Paint Removal/Surface Preparation[a]	3.5	(2.8, 4.4)	4.6	(3.9, 5.3)	5.5	(4.4, 6.7)

(a) The low, medium, and high exposure indices for paint removal were based upon the 25th, 50th, and 75th percentiles of the total hours and weeks spent performing paint removal/surface preparation (12, 37, and 50 hours; 3, 12, and 20 weeks).

4.0 SUMMARY AND CONCLUSIONS

This study surveyed two groups of persons (professional workers and homeowners) who performed renovation and remodeling in historic homes or homes built before 1940. Information from both groups of persons was collected in three cities (Charleston, South Carolina; Savannah, Georgia; and Baltimore, Maryland). A total of 243 respondents completed questionnaires and gave blood samples (161 workers, and 82 homeowners). The questionnaire and blood-lead information was used to:

1. Characterize the types of work activities and work practices in which workers and homeowners performing R&R in historic (or pre-1940) homes engaged

2. Determine if the blood-lead concentrations of homeowners differ from those of workers

3. Determine if the blood-lead concentrations of workers in specific worker groups differ after adjusting for potential confounding factors

4. Determine the relationship between blood-lead concentrations and work practices or activities performed by workers or homeowners in old or historic homes, after controlling for potential confounding factors

5. Determine if the blood-lead concentrations of participants in this study were different from those of participants in the WCBS or adults in the general U.S. population.

The overall results for the study are summarized below.

Questionnaires were collected from 246 participants (163 workers and 83 homeowners). The sample was composed of individuals that were predominantly white (70%), male (77%), and on average 39 years old. The percentage of study participants that were female was larger for homeowners (44%) than for workers (14%). Although separate questionnaires were used for workers and homeowners, both questionnaires captured information on how often each participant performed general renovation and remodeling as well as specific target activities. The workers 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

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

- 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.

- Despite the OSHA Lead in Construction Standard, only 23.7 percent of workers reported using a respirator in the last 30 days. Similarly, only 16 percent of

homeowners used a respirator in the last 30 days. Homeowners and workers in every work group used a dust mask more frequently than any type of respirator (44.9 percent of workers and 29.6 percent of homeowners reported using dust masks).

- The majority of workers (64%) used tobacco products, but only 30 percent of homeowners used tobacco products.

- Over two-thirds of the workers had hobbies that had some potential for lead exposure (e.g., working with stained glass windows, casting lead bullets or sinkers, etc.). Conversely, only one-third of homeowners had similar hobbies.

- Despite the OSHA Lead in Construction Standard, 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 (homeowners were not asked about training).

- Over 75 percent of workers and homeowners reported using dry sanding/scraping to remove paint. About one-third of homeowners and workers reported using chemical stripping or burning/torching/heat gun to remove paint. Three times more workers than homeowners used wet scraping, four times more workers than homeowners used wet sanding, and two times as many workers as homeowners used dust collectors when sanding.

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. Additional blood-lead results indicate that

- The distributions of blood-lead concentrations for workers and homeowners were approximately log-normal. The geometric mean blood-lead concentrations were 5.7 μg/dL for workers and 4.5 μg/dL for homeowners with geometric standard deviations of 1.95 μg/dL and 2.3 μg/dL, respectively.

- Geometric mean blood-lead concentrations for workers was significantly greater than those for homeowners (on average 1.3 μg/dL greater with a 95 percent confidence interval of 1.1 μg/dL to 1.5 μg/dL).

- Covariate-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. The covariate-adjusted geometric mean blood-lead concentrations were not significantly different among the worker groups.

- The predicted blood-lead concentrations for each worker group, using a medium exposure index and parameter estimates from the final predictive model, were significantly different. In particular, the predicted blood-lead concentration for Carpenters (6.3 μg/dL) was significantly higher than the predicted blood-lead concentration for Laborers (4.8 μg/dL).

- Three ancillary variables were related to worker blood-lead concentrations: gender, tobacco use, and whether room additions or renovations have been made in the worker's own home. For gender and tobacco use, the effect of estimated parameters were as expected: male workers and tobacco users had higher blood-lead concentrations. However, workers who had room additions or renovations made in their own homes had lower blood-lead concentrations.

- Three ancillary variables were related to homeowner blood-lead concentrations: gender, race, and age of homeowner. For age and gender, the estimated effect of each factor was as anticipated: older males had higher blood-lead concentrations. However, white homeowners had higher blood-lead concentrations than black homeowners.

For each study group (workers and homeowners) a series of statistical models were fit to the data to investigate the relationship between blood-lead concentrations and various types of work or target activities. Initially, separate models were fitted to the data for each target activity and study group. In all, the models indicated that there was a significant relationship between the conduct of certain R&R activities and blood-lead concentrations. Specific results based on the separate, covariate-adjusted, models fit to each target activity and study group are presented below for each study group.

For workers:

- 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. However, the estimated increases in predicted blood-lead concentration associated with performing 10 additional days of paint removal/surface preparation or cleanup in homes built pre-1940 were small: 0.7 μg/dL and 0.8 μg/dL, respectively.

- Mid-term exposure, as measured by the number of weeks worked in the past 12 months, was significantly related to increases in worker blood-lead concentrations for general R&R work and paint removal/surface preparation, and decreases in worker blood-lead concentrations for carpet removal.

- The number of years workers spent performing general R&R was significantly related to increases in worker blood-lead concentrations.

For homeowners:

- The number of days a homeowner spent performing paint removal/surface preparation was marginally related to increases in homeowner blood-lead concentrations. As with workers, the estimated increase was small: 0.9 μg/dL.

- The total number of hours a homeowner spent performing general R&R and paint removal/surface preparation was significantly related to increases in homeowner blood-lead concentrations. The estimated increase in homeowner blood-lead concentrations associated with 80 additional hours of general R&R in a 30-day period was 1.4 μg/dL. The estimated increase associated with 36 additional hours of paint removal/surface preparation in a 30-day period was 0.9 μg/dL.

- The number of weeks in the last 12 months in which some general R&R or paint removal/surface preparation was performed was significantly related to increases in homeowner blood-lead concentrations.

- Significant increases in homeowner blood-lead concentrations were related to the total number of days in the last 12 months in which some general R&R or paint removal/surface preparation was performed.

Final models were developed for each study group that included ancillary covariates and selected target activities. For workers, the final model included at least one target activity for three exposure periods (short-term, mid-term, and long-term). For homeowners, two alternative models were developed: one based upon general R&R and the other based upon paint removal/ surface preparation. Results based upon the final models for each study group are presented below.

For workers:

- Although some of the variability in worker blood-lead concentration was explained by worker group, most of the variability was explained by the combined effect of the number of days spent performing cleanup, the number of weeks spent performing paint removal/surface preparation, the number of weeks spent performing carpet removal, and the number of years in their R&R career where some time was spent replacing window or door casements.

- For Carpenters, Laborers, and Painters, the number of days spent performing cleanup and the number of years where time was spent replacing window/door casements were significantly related to increases in blood-lead concentrations. These same activities for the Other worker group were related to decreased blood-lead concentrations.

- For Carpenters, Painters, and the Other worker group, the number of weeks spent performing paint removal/surface preparation was significantly related to increased

blood-lead concentrations. For Laborers, this activity was related to decreased blood-lead concentrations.

- For all worker groups, the number of weeks spent performing carpet removal was significantly related to decreases in blood-lead concentrations.

- An empirically based index of low, medium, and high potential for lead exposure was estimated based upon the 25th, 50th, and 75th percentiles of questionnaire responses from workers on the target activities and exposure periods included in the final model. For Carpenters, Laborers, and Painters, the model predicts an increase in blood-lead concentrations from the low to the high index; 1.7 μg/dL for Laborers, 3.3 μg/dL for Carpenters, and 5.7 μg/dL for Painters. However, the model predicts a decrease for the Other worker group of 1.5 μg/dL. This may be due to the fact that the Other worker group is largely composed of supervisors, managers, foremen, etc. and time spent performing some of the activities may not be realistic of actual hands-on time. Further, it may be that the longer this group of persons work in their current capacity instead of performing the hands-on work, there would be less exposure to lead.

For homeowners:

- Two models were developed for homeowners. The first was developed using the five target activities, the second using general R&R. The models fit the homeowner blood-lead concentrations equally well and explained a similar amount of variability.

- Of the five target activities, paint removal/surface preparation was the single target activity that explained the most variability in blood-lead levels. Furthermore, no other target activity had a significant effect over-and-above the effect of paint removal/surface preparation.

- Significant increases in homeowner blood-lead concentrations were related to increases in short-term intensity (total hours in the last 30 days) and mid-term duration (weeks in the last 12 months) of conducting paint removal/surface preparation.

- Significant increases in homeowner blood-lead concentrations were related to increases in short-term intensity (total hours in the last 30 days) mid-term duration (weeks in the last 12 months) of conducting general R&R.

- Low, medium, and high exposure indices were developed from the 25th, 50th, and 75th percentiles of general R&R and paint removal/surface preparation. For the model using general R&R, the low exposure index was defined to be 42 hours performing general R&R in the last 30 days and 15 weeks in the last 12 months. The high exposure index was defined as 100 hours and 40 weeks. For the model using paint removal/surface preparation, the low index was defined to be 12 hours

and 3 weeks, the high index was 50 hours and 20 weeks. Regardless of the model, increases were predicted in homeowner blood-lead concentrations between the two indices compared: 2.4 μg/dL for the model with paint removal/surface preparation and 2.0 μg/dL for the model using general R&R.

The WCBS was a targeted survey of union carpenters and employees of independent contractors in two cities: Philadelphia, Pennsylvania, and St. Louis, Missouri. Blood and questionnaire information were collected from 585 participants (581 had complete blood and questionnaire information). Participants in this study, by design, tended to work in older homes more than participants in the WCBS did. Thus, it would seem reasonable to assume that participants in the current study are at higher risk for lead exposure than workers that participated in the WCBS (i.e., because older homes are more likely to contain lead-based paint). Indeed, the geometric mean blood-lead level for workers in this study was significantly greater than that of workers in the WCBS. However, the geometric mean blood-lead level was only 1.3 μg/dL (95 percent confidence interval from 1.1 μg/dL to 1.4 μg/dL) higher than the geometric mean blood-lead concentration of workers in the WCBS. The geometric mean blood-lead level for homeowners in the current study was not significantly different from that of workers in the WCBS; however, a significantly larger proportion of individuals in this study had elevated blood-lead concentrations (20 percent above 10 μg/dL compared to 9.0 percent in the WCBS).

In relation to adults in the general U.S. population, the geometric mean blood-lead level for the study participants was significantly higher than that of adults in the general U.S. population regardless of race or gender. Furthermore, a significantly larger proportion of individuals in this study have blood-lead concentrations greater than 10 μg/dL (~20 percent above 10 μg/dL compared to 3.5 percent in the general U.S. population). Finally, odds ratios comparing the odds of elevated blood-lead levels among study participants to those of adults in the general U.S. population were significantly greater than one. In particular, workers were 10.68 times more likely to have blood-lead concentrations above 25 μg/dL than the general U.S. population. Homeowners were even more likely (28.86 times) to have blood-lead concentrations above 25 μg/dL than the general U.S. population.

In summary, the results of this study do not contradict those of the WCBS. Overall, the results demonstrate that there is a significant relationship between the conduct of certain R&R activities and blood-lead concentrations. Further, for some workers or homeowners, conducting these activities results in elevated blood-lead concentrations.

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APPENDIX A

QUESTIONNAIRES

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ID #: ☐-☐-☐☐☐☐

RECORD #: 0 1

WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY

TELEPHONE INTERVIEW SCREENER FOR R&R WORKERS

Hello, my name is _____. Thank you for calling the Study Line. The Battelle Memorial Institute is conducting a study of people engaged in renovation and remodeling activities in historic homes. The study is being done for the U.S. Environmental Protection Agency. I'd like to ask a few questions about renovation and remodeling work you have done. This should take about five minutes, and everything you say will be kept confidential. **[IF R ASKS ABOUT CONFIDENTIALITY, REFER TO ATTACHED SHEET DESCRIBING CONFIDENTIALITY PROCEDURES.]**

1. Do you work in home or building construction or renovation and remodeling for a living? That is, do you earn money to support yourself doing this?

   YES .... (CONTINUE) 1
   NO ..... (HH Q2) 2

1a. Do you do hands-on work? For example do you do painting, surface preparation such as sanding and scraping, carpentry, demolition, cleanup or installation?

   YES .... (CONTINUE) 1
   NO ..... (STOP) 2

IF R ANSWERS "NO" TO Q1 OR Q1a, STOP.

2. In the last 30 days, how many days did you spend doing any kind of renovation and remodeling work? Please include any home improvement or building construction work.

   NUMBER OF DAYS ..... ☐☐

   a. [IF Q2 > 0] Of these days worked, how many were in historic homes, or homes built before 1940?

   # DAYS WORKED ..... ☐☐

3. Altogether in the last 12 months, how many weeks did you spend doing renovation and remodeling work in historic homes, or homes built before 1940?

   NONE 01
   LESS THAN 1 WEEK 02
   1 - 4 WEEKS 03
   5 - 8 WEEKS 04
   9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) 05
   13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) 06
   MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ... 07

IF R ANSWERS 10 DAYS OR MORE TO Q2a AND 9 WEEKS OR MORE TO Q3, CONTINUE.

4. How many years altogether have you earned your living by working in the renovation and remodeling industry?

NUMBER OF YEARS ..... ⌊__⌋

5. In the last 30 days, how many days have you worked in residential buildings such as homes or apartments?

DAYS IN HOMES ..... ⌊__⌋

6. In the last 30 days, how many days have you worked in non-residential buildings such as offices, schools or government buildings?

DAYS IN NON-RES. ..... ⌊__⌋

7A. In the last 30 days, have you spent time removing carpets?

YES 1
NO 2

7B. In the last 30 days, have you spent time removing windows or door casements?

YES 1
NO 2

7C. In the last 30 days, have you spent time maintaining, repairing or cleaning heating, ventilation or air conditioning systems?

YES 1
NO 2

7D. In the last 30 days, have you spent time removing large structures such as making openings for large windows or doorways, tearing down ceilings, putting up walls or removing kitchen cabinets?

YES 1
NO 2

7E. In the last 30 days, have you spent time removing paint or preparing surfaces?

YES 1
NO 2

7F. In the last 30 days, have you spent time doing hands-on cleanup, where you cleaned up the dirt, dust and *debris caused by renovation and remodeling* activities?

YES 1
NO 2

8. In your own home, have any room additions or any major remodeling changes been made in the last 12 months?

YES .... (CONTINUE) 1
NO ..... (SKIP TO Q9) 2

8a. Did you live in the house while any of the work was being performed?

YES 1
NO 2

9. Approximately what year was your house built?

BUILT SINCE 1990 1

BUILT BETWEEN 1978 AND 1990 2

BUILT BETWEEN 1940 AND 1978 3

BUILT BEFORE 1940 4

10. What is your current job title and what are your main activities at work?

JOB TITLE: _____ ☐☐

MAIN ACTIVITIES: _____ ☐☐

11. Now I'd like to ask you just a few more questions about yourself. How old are you?

AGE ..... ☐☐

12. What is your race and ethnic group?
PROBE FOR HISPANIC ORIGIN

SPECIFY: _____

WHITE, NOT HISPANIC 01
WHITE, HISPANIC 02
BLACK, NOT HISPANIC 03
BLACK, HISPANIC 04
AMERICAN INDIAN 05
ASIAN/PACIFIC ISLANDER 06
OTHER ... (SPECIFY) 07

13. RECORD GENDER WITHOUT ASKING, IF POSSIBLE.
IF NOT, ASK "Are you male or female?"

MALE 1
FEMALE 2

That completes this portion of the interview. The answers you just gave indicate that you are eligible for the study. I would like to schedule an appointment for you to complete a short questionnaire about your renovation and remodeling work and to have a small blood sample taken. (IF ASKED, IT IS ABOUT A TABLESPOON.) The blood sample will be analyzed for lead levels only. We will pay you $50 for your cooperation.

We will be holding the data collection in your city on two dates from 4:00 pm to 8:00 pm at XXXX. (REFER TO SCHEDULE) On which date could you attend? Approximately what time could you arrive?

RECORD APPOINTMENT INFORMATION ON NEXT PAGE.

May I have your name, address and phone number?

RECORD IDENTIFYING INFORMATION ON NEXT PAGE.

Thank you once again for taking the time to speak with me. If you have any questions or concerns, the study manager, John Egel, would be happy to speak with you. You can reach him at 1-800-444-5234, ext. 104.

ID #: ☐ - ☐ - ☐☐☐☐

RECORD APPOINTMENT INFORMATION HERE.

DATE: _____ TIME: _____ LOC: _____

CONFIRM APPOINTMENT TIME AND DATE.

RECORD IDENTIFYING INFORMATION HERE.

NAME: _____

ADDRESS: _____

_____

PHONE (____) _____

RECORD FINAL SCREENING DISPOSITION

Eligible, scheduled	01
Eligible, refused main study	02
Not eligible	03
Refused screener	04
Other/specify	05

SPECIFY: _____

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ID#: ⌊_⌋-⌊_⌋-⌊_|_|_|_⌋

RECORD #: ⌊0|1⌋

DATE: ⌊_|_⌋-⌊_|_⌋-⌊_|_⌋
MM DD YY

WORKER EXPOSURE STUDY

This questionnaire collects basic information about you, your work, and some of your hobbies and activities. All information you give will be kept confidential. No names will be used and no one outside the study will be able to tell which person gave which answers. If you have any questions about this study, the Study Manager will be happy to talk with you.

Please answer the questions as completely as you can. In some cases, you will be asked to write in an answer. Other times, you will be asked to check a box next to the answer that best applies to you.

If you have any questions about what a question means or how to answer a question or section, the study staff will be happy to help you.

Thank you for your help in this important research project.

SECTION A: DEMOGRAPHICS

A1. How old are you?

AGE . . . . . ☐☐

A2. What is your race and ethnic group? **(Check only one.)**

WHITE, NOT HISPANIC . . . . . ☐ 01
WHITE, HISPANIC . . . . . ☐ 02
BLACK, NOT HISPANIC . . . . . ☐ 03
BLACK, HISPANIC . . . . . ☐ 04
AMERICAN INDIAN . . . . . ☐ 05
ASIAN/PACIFIC ISLANDER . . . ☐ 06
OTHER . . . (SPECIFY) . . . . . ☐ 07

SPECIFY: _____

A3. Are you male or female?

MALE . . . . . ☐ 1
FEMALE . . . . . ☐ 2

A4. How much schooling have you had? **Check the highest level completed.**

GRADES 1 THROUGH 8 . . . . . ☐ 1
SOME HIGH SCHOOL . . . . . ☐ 2
HIGH SCHOOL/GED . . . . . ☐ 3
APPRENTICESHIP TRAINING . . ☐ 4
SOME COLLEGE/TECH SCHOOL ☐ 5
COLLEGE/TECH SCHOOL GRAD ☐ 6

A5. How many children under age 6 currently live with you in your home?

CHILDREN UNDER 6 . . . . ☐☐

A6. Do you belong to a union?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

If yes, SPECIFY _____

SECTION B: RESIDENTIAL INFORMATION — In this section, we want to find out about your home. By home, we mean the house, apartment building, or any other building where you live, whether or not you own it.

B1. How old is your home? If you've lived in more than one home during the last 12 months, how old is the home you lived in the longest?

- BUILT SINCE 1990 ..... ☐ 1
- BUILT BETWEEN 1978 AND 1990 . ☐ 2
- BUILT BETWEEN 1940 AND 1978 ..... ☐ 3
- BUILT BEFORE 1940 ..... ☐ 4

B2. Have any room additions or any major remodeling changes been made to your home in the last 12 months?

- YES ..... ☐ 1
- NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION B2, SKIP TO SECTION C - WORK HISTORY.

A. Was the inside of the house remodeled in the last 12 months?

- YES ..... ☐ 1
- NO ..... ☐ 2

B. Was the exterior of the house remodeled in the last 12 months?

- YES ..... ☐ 1
- NO ..... ☐ 2

C. Was paint stripped or sanded during the remodeling?

- YES ..... ☐ 1
- NO ..... ☐ 2

D. Did the remodeling include major work on the kitchen or the bathroom?

- YES ..... ☐ 1
- NO ..... ☐ 2

E. Did you do any of the work yourself?

- YES ..... ☐ 1
- NO ..... ☐ 2

If you did any of the work yourself, please describe what you did on the *SPECIFY* line below.

SPECIFY _____ ☐☐

_____ ☐☐

_____ ☐☐

OFFICE USE

F. Did you live in the house while the work was being done?

- YES ..... ☐ 1
- NO ..... ☐ 2

The following sections ask about your work. By work, we mean any work you've done on the job or on the side. That is, we are interested in work you've done for an employer and work you do in your spare time for yourself or for family and friends.

SECTION C: WORK HISTORY

C1. What is your current job title and what are your main activities at work?

JOB TITLE: _____ ☐☐

MAIN ACTIVITIES: _____ ☐☐

OFFICE USE

C2. During the last 30 days, how many days did you spend doing any kind of renovation and remodeling work? _____ days

C3. During the last 30 days, how many days did you spend renovating or remodeling historic homes, or homes built before 1940? _____ days

C4. During the last 30 days, how many days did you work in residential buildings (homes, apartments)? _____ days

C5. During the last 30 days, how many days did you work in non-residential buildings (offices, schools, government buildings)? _____ days

C6. Altogether in the last 12 months, how many weeks did you spend doing renovation and remodeling?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 4 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

C7. For how many years altogether have you done renovation and remodeling work? _____ years

C8. Altogether in the last 12 months, how many weeks did you spend doing renovation and remodeling in historic homes, or homes built before 1940?

- NONE ☐ 01
- LESS THAN 1 WEEK ☐ 02
- 1 - 4 WEEKS ☐ 03
- 5 - 8 WEEKS ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐ 07

C9. During the last 30 days, how many days did you spend doing any kind of renovation and remodeling work in your own home?

_____ days

C10. Altogether in the last 12 months, how many weeks did you spend doing renovation and remodeling in your own home?

- NONE ☐ 01
- LESS THAN 1 WEEK ☐ 02
- 1 - 4 WEEKS ☐ 03
- 5 - 8 WEEKS ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐ 07

SECTION D: LARGE STRUCTURE REMOVAL — These questions are about removing any kind of large structures. Include things like:

- **making openings for large windows or doorways**
- **tearing down ceilings**
- **removing walls**
- **removing kitchen cabinets**

D1. In the last 30 days, how many days did you remove large structures? _____ days

IF YOU ANSWERED NO TO QUESTION D1, SKIP TO QUESTION D4.

D2. In the last 30 days, on how many days did you use a respirator while you removed large structures? _____ days

D3. In the last 30 days, how many days did you remove large structures from historic homes or homes built before 1940? _____ days

D4. Altogether in the past 12 months, how many weeks did you spend removing large structures?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

D5. Think about all the years you've done renovation or remodeling. In how many of these years did you remove large structures at least some of the time? _____ years

IF YOU ANSWERED '0 YEARS' TO QUESTION D5, SKIP TO SECTION E.

D6. Think about all the years you've removed large structures. In an average year, how many <u>weeks</u> did you spend removing large structures?

- LESS THAN 1 WEEK ..... ☐ 1
- 1 - 4 WEEKS ..... ☐ 2
- 5 - 8 WEEKS ..... ☐ 3
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 4
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 5
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 6

D7. When was the last time you removed large structures?

- WITHIN THE LAST 30 DAYS .. ☐ 1
- MORE THAN 30 DAYS AGO .. ☐ 2
- MORE THAN A YEAR AGO ... ☐ 3
- MORE THAN 5 YEARS AGO .. ☐ 4

SECTION E: PAINT REMOVAL AND SURFACE PREPARATION — By surface preparation, we mean activities such as sanding, scraping, torching, or floor refinishing. (Include work done inside and outside.)

E1. During the last 30 days, how many days did you remove paint or prepare surfaces? _____ days

IF YOU ANSWERED NO TO QUESTION E1, SKIP TO QUESTION E6.

E2. During the last 30 days, how many days did you remove paint or prepare surfaces in historic homes, or homes built before 1940? _____ days

E3. During the last 30 days, how many days did you use a respirator when you removed paint or prepared surfaces? _____ days

E4. During the last 30 days how many days did you remove paint or prepare surfaces inside? _____ days

E5. When you removed paint in the last 30 days, how many days did you use the following?

A. dry power sanding? ..... _____ days

B. dry hand sanding? ..... _____ days

C. dry scraping? ..... _____ days

D. burning, torching, or a heat gun? ..... _____ days

E. wet scraping? ..... _____ days

F. wet sanding? ..... _____ days

G. chemical stripping? ..... _____ days

H. a dust collector when you sanded? ..... _____ days

E6. Altogether in the past 12 months, how many weeks did you spend doing paint removal or surface preparation?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

E7. Think about all the years you've done renovation and remodeling. In how many of these years did you do paint removal and surface preparation at least some of the time? (Please include in your answer any time you spent doing this while in the military.)

_____ years

IF YOU ANSWERED '0 YEARS' TO QUESTION E7, SKIP TO SECTION F.

E8. Think about all the years you've done paint removal and surface preparation. In an average year, how many weeks did you spend doing paint removal and surface preparation?

- LESS THAN 1 WEEK ..... ☐ 1
- 1 - 4 WEEKS ..... ☐ 2
- 5 - 8 WEEKS ..... ☐ 3
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 4
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 5
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 6

E9. When was the last time you did any paint removal or surface preparation?

- WITHIN THE LAST 30 DAYS .. ☐ 1
- MORE THAN 30 DAYS AGO .. ☐ 2
- MORE THAN A YEAR AGO ... ☐ 3
- MORE THAN 5 YEARS AGO .. ☐ 4

SECTION F: WINDOW OR DOOR CASEMENT REPLACEMENT

F1. In the last 30 days, how many days did you remove windows or door casements? _____ days

IF YOU ANSWERED NO TO QUESTION F1, SKIP TO QUESTION F4.

F2. In the last 30 days, how many days did you use a respirator while you removed windows or door casements? _____ days

F3. In the last 30 days, how many days did you remove windows or door casements from historic homes, or homes built before 1940? _____ days

F4. Altogether in the past 12 months, how many weeks did you spend removing windows or door casements?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

F5. Think about all the years you've done renovation or remodeling. In how many of these years did you remove windows or door casements at least some of the time? _____ years

IF YOU ANSWERED '0 YEARS' TO QUESTION F5, SKIP TO SECTION G.

F6. Think about all the years you've removed windows or door casements. In an average year, how many weeks did you spend removing window or door casements?

- LESS THAN 1 WEEK ..... ☐ 1
- 1 - 4 WEEKS ..... ☐ 2
- 5 - 8 WEEKS ..... ☐ 3
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 4
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 5
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 6

F7. When was the last time you removed windows or door casements?

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

SECTION G: CARPET REMOVAL

G1. In the last 30 days, how many days did you remove carpet? _____ days

IF YOU ANSWERED NO TO QUESTION G1, SKIP TO QUESTION G4.

G2. In the last 30 days, how many days did you use a respirator while you removed carpet? _____ days

G3. In the last 30 days, how many days did you remove carpet from historic homes, or homes that were built before 1940? _____ days

G4. Altogether in the last 12 months, how many weeks did you spend removing carpet?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

G5. Think about all the years you've done renovation or remodeling. In how many of these years did you remove carpet at least some of the time? _____ years

IF YOU ANSWERED '0 YEARS' TO QUESTION G5, SKIP TO SECTION H.

G6. Think about all the years you've removed carpet. In an average year, how many weeks did you spend removing carpet?

- LESS THAN 1 WEEK ..... ☐ 1
- 1 - 4 WEEKS ..... ☐ 2
- 5 - 8 WEEKS ..... ☐ 3
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 4
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 5
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 6

G7. When was the last time you removed carpet?

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

SECTION H: CLEANUP — By cleanup work, we mean the hands-on cleanup where you cleaned up the dirt, dust and debris caused by the renovation and remodeling activities. We want to know about the time you spent doing this kind of work. Don't include times when you were around others doing cleanup, but you weren't doing the work.

H1. During the last 30 days, how many days have you spent doing hands-on cleanup?

_____ days

IF YOU ANSWERED NO TO QUESTION H1, SKIP TO QUESTION H6.

H2. In the last 30 days, about how many hours in a typical day did you spend doing hands-on cleanup?

- LESS THAN ½ HOUR/DAY ... ☐ 1
- ½ TO LESS THAN 1 HOUR/DAY ☐ 2
- 1 TO 2 HOURS/DAY ..... ☐ 3
- 3 TO 4 HOURS/DAY ..... ☐ 4
- MORE THAN 4 HOURS/DAY .. ☐ 5

H3. In the last 30 days, how many days did you spend doing hands-on cleanup in historic homes or homes built before 1940?

_____ days

H4. In the last 30 days, how many days did you use a respirator while doing hands-on cleanup work?

_____ days

H5. Altogether in the past 12 months, how many weeks did you spend doing hands-on cleanup?

- NONE ..... ☐ 01
- LESS THAN 1 WEEK ..... ☐ 02
- 1 - 4 WEEKS ..... ☐ 03
- 5 - 8 WEEKS ..... ☐ 04
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 05
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 06
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 07

H6. Think about all of the years you have done renovation and remodeling. In how many years altogether have you spent doing hands-on cleanup work at least some of the time?

_____ years

IF YOU ANSWERED '0 YEARS' TO QUESTION H6, SKIP TO SECTION I.

H7. Think about all the years you've done hands-on cleanup. In an average year, how many <u>weeks</u> did you spend doing hands-on cleanup?

- LESS THAN 1 WEEK ..... ☐ 1
- 1 - 4 WEEKS ..... ☐ 2
- 5 - 8 WEEKS ..... ☐ 3
- 9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) .... ☐ 4
- 13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) .... ☐ 5
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) .. ☐ 6

H8. When was the last time you did any hands-on cleanup work?

- WITHIN THE LAST 30 DAYS .. ☐ 1
- MORE THAN 30 DAYS AGO .. ☐ 2
- MORE THAN A YEAR AGO ... ☐ 3
- MORE THAN 5 YEARS AGO .. ☐ 4

SECTION I: TOBACCO USE

I1. Do you currently use snuff or chewing tobacco?
YES ..... ☐ 1
NO ..... ☐ 2

I2. Do you currently smoke?
YES ..... ☐ 1
NO ..... ☐ 2

If you do not smoke, go to J1. If you do smoke, please answer questions A through C below.

A. Do you smoke while you work?
YES ..... ☐ 1
NO ..... ☐ 2

B. Do you smoke while on break?
YES ..... ☐ 1
NO ..... ☐ 2

C. Do you carry your cigarettes, cigars, pipe or pipe tobacco in your shirt or pants pocket at work?
YES ..... ☐ 1
NO ..... ☐ 2

SECTION J: NON-WORK ACTIVITIES

J1. Do you cast lead into bullets or fishing sinkers?
YES ..... ☐ 1
NO ..... ☐ 2

J2. Do you go fishing more than 10 times a year?
YES ..... ☐ 1
NO ..... ☐ 2

If you answered no, skip to question J3. If you do go fishing more than 10 times a year, answer question A below.

A. Do you crimp fishing sinkers onto the line with your teeth?
YES ..... ☐ 1
NO ..... ☐ 2

J3. Do you dismantle car or truck batteries?
YES ..... ☐ 1
NO ..... ☐ 2

J4. Do you work with stained glass?
YES ..... ☐ 1
NO ..... ☐ 2

SECTION K: MEDICAL HISTORY

K1. Have you ever been diagnosed by a health care professional as having an elevated lead level in your blood?

YES ..... ☐ 1
NO ..... ☐ 2

K2. In the last 12 months, have you been diagnosed by a health care professional as having anemia?

YES ..... ☐ 1
NO ..... ☐ 2

K3. Has anyone living in your household ever had their blood tested for lead? **Check all that apply.**

YES, MYSELF ..... ☐ 1
YES, OTHER ADULT ..... ☐ 3
YES, CHILD ..... ☐ 4
NO ..... ☐ 2

K4. Has anyone living in your household ever been identified by a health care professional as having an elevated blood lead level? **Check all that apply.**

YES, MYSELF ..... ☐ 1
YES, OTHER ADULT ..... ☐ 3
YES, CHILD ..... ☐ 4
NO ..... ☐ 2

SECTION L: OTHER ISSUES

L1. When you used a respirator in the last 30 days, what type did you use? **Check all that apply.**

DIDN'T USE RESPIRATOR .... ☐ 01
DUST MASK ..... ☐ 02
HALF MASK ..... ☐ 03
FULL FACE MASK ..... ☐ 04
TYPE C SUPPLIED AIR MASK . ☐ 05
PAPR ..... ☐ 06
SCBA ..... ☐ 07

L2. Has your home ever been tested for lead paint?

YES ..... ☐ 1
NO ..... ☐ 2

L3. Do you think that lead poses a potential problem for you at work?

YES ..... ☐ 1
NO ..... ☐ 2

L4. Have you ever received any pamphlets or other information about how to reduce potential lead exposures when conducting renovation and remodeling work?

YES ..... ☐ 1
NO ..... ☐ 2

L5. Have you ever received any training about how to reduce potential lead exposures when conducting renovation and remodeling work?

YES ..... ☐ 1
NO ..... ☐ 2

L6. Are there other ways you think you may be exposed to lead that we haven't asked about?

_____

_____

L7. Is there anything else you'd like to tell us, or do you have any additional comments you would like to make?

_____

_____

Thank you very much for taking the time to help us understand how people may or may not be exposed to lead. If you have any questions about the study, or would like the results of this study, you can call John Egel at 1-800-444-5234, ext. 104.

ID #: ⌊_⌋-⌊_⌋-⌊_⌋⌊_⌋⌊_⌋⌊_⌋

RECORD #: ⌊0⌋⌊1⌋

WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY

TELEPHONE INTERVIEW SCREENER FOR HOMEOWNERS

Hello, my name is _____. Thank you for calling the Study Line. The Battelle Memorial Institute is conducting a study of people engaged in renovation and remodeling activities in historic homes. The study is being done for the U.S. Environmental Protection Agency. I'd like to ask a few questions about renovation and remodeling work you have done on your home. This should take about five minutes, and everything you say will be kept confidential. **[IF R ASKS ABOUT CONFIDENTIALITY, REFER TO ATTACHED SHEET DESCRIBING CONFIDENTIALITY PROCEDURES.]**

1. Do you work in home or building construction or renovation and remodeling for a living? That is, do you earn money to support yourself doing this?

   YES ... (R&R SCREENER) 1
   NO ..... (CONTINUE) 2

2. Have any room additions or any remodeling changes been made to your home in the last 12 months?

   YES .... (CONTINUE) 1
   NO ..... (STOP) 2

2a. Did you live in the house while any of the work was being performed?

   YES .... (CONTINUE) 1
   NO ..... (STOP) 2

2b. Approximately what year was your house built?

   BUILT SINCE 1990 (STOP).. 1

   BUILT BETWEEN
   1978 - 1990...(STOP) 2

   BUILT BETWEEN
   1940 AND 1978..(STOP) 3

   BUILT BEFORE 1940 4

2c. Did you do a large portion (more than 25%) of the hands-on work yourself? For example did you do surface preparation (PROBE: for example sanding and scraping), painting, carpentry, demolition, cleanup or installation?

   YES .... (CONTINUE) 1
   NO ..... (STOP) 2

2d. In the last 30 days, how many days did you spend doing major renovation and remodeling work in your home?

NUMBER OF DAYS ..... ⌊_⌋⌊_⌋

2e. In the last 30 days, about how many hours did you spend doing renovation and remodeling on a typical day?

HOURS PER DAY ..... ⌊_⌋⌊_⌋

IF ANSWER TO Q2d MULTIPLIED BY THE RESPONSE TO Q2e > 20 HOURS, CONTINUE.

3. During the last 12 months, in how many weeks did you do some kind of major renovation and remodeling activities in your home?

1 - 4 WEEKS 1
5 - 8 WEEKS 2
9 - 12 WEEKS (ABOUT 2 - 3 MONTHS) 3
13 - 26 WEEKS (ABOUT 4 - 6 MONTHS) 4
MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) 5

IF ANSWER TO Q3 > 9 WEEKS, CONTINUE.

4. Do you routinely perform major renovation and remodeling activities in homes other than your own? (For example, in friends' and relatives' homes.)

YES .... (ANSWER 4a) 1
NO ..... (SKIP TO 5a) 2

4a. In the last 30 days, how many days did you spend doing any kind of renovation and remodeling work in homes other than your own?

NUMBER OF DAYS ..... ⌊_⌋⌊_⌋

5a. In the last 30 days, have you spent time removing carpets?

YES 1
NO 2

5b. In the last 30 days, have you spent time removing windows or door casements?

YES 1
NO 2

5c. In the last 30 days, have you spent time maintaining, repairing or cleaning your heating, ventilation or air conditioning system?

YES 1
NO 2

5d. In the last 30 days, have you spent time removing large structures such as making openings for large windows or doorways, tearing down ceilings, putting up walls or removing kitchen cabinets?

YES 1
NO 2

5e. In the last 30 days, have you spent time removing paint or preparing surfaces?

YES 1
NO 2

5f. In the last 30 days, have you spent time doing the hands-on cleanup, where you cleaned up the dirt, dust and debris caused by the renovation and remodeling activities?

YES 1
NO 2

6. Now I'd like to ask you just a few questions about yourself. What is your current job title and what are your main activities at work?

JOB TITLE: _____ ☐☐

MAIN ACTIVITIES: _____ ☐☐

7. How old are you?

AGE ..... ☐☐

8. What is your race and ethnic group?
PROBE FOR HISPANIC ORIGIN

SPECIFY: _____

WHITE, NOT HISPANIC 01
WHITE, HISPANIC 02
BLACK, NOT HISPANIC 03
BLACK, HISPANIC 04
AMERICAN INDIAN 05
ASIAN/PACIFIC ISLANDER 06
OTHER ... (SPECIFY) 07

9. RECORD GENDER WITHOUT ASKING, IF POSSIBLE.
IF NOT, ASK "Are you male or female?"

MALE 1
FEMALE 2

That completes this portion of the interview. The answers you just gave indicate that you are eligible for the study. I would like to schedule an appointment for you to complete a short questionnaire about your renovation and remodeling work and to have a small blood sample taken. (IF ASKED, IT IS ABOUT A TABLESPOON.) The blood sample will be analyzed for lead levels only. We will pay you $50 for your cooperation.

We will be holding the data collection in your city on two dates from 4:00 pm to 8:00 pm at XXXX. (REFER TO SCHEDULE) On which date could you attend? Approximately what time could you arrive?

RECORD APPOINTMENT INFORMATION ON NEXT PAGE.

May I have your name, address and phone number?

RECORD IDENTIFYING INFORMATION ON NEXT PAGE.

Thank you once again for taking the time to speak with me. If you have any questions or concerns, the study manager, John Egel, would be happy to speak with you. You can reach him at 1-800-444-5234, ext. 104.

ID #: ☐-☐-☐☐☐☐

RECORD APPOINTMENT INFORMATION HERE.

DATE: _____ TIME: _____ LOC: _____

CONFIRM APPOINTMENT TIME AND DATE.

RECORD IDENTIFYING INFORMATION HERE.

NAME: _____

ADDRESS: _____

_____

PHONE (____) _____

RECORD FINAL SCREENING DISPOSITION

Eligible, scheduled	01
Eligible, refused main study	02
Not eligible	03
Refused screener	04
Other/specify	05

SPECIFY: _____

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ID#: ⌊_⌋-⌊_⌋-⌊_⌋⌊_⌋⌊_⌋⌊_⌋

RECORD #: ⌊0⌋⌊1⌋

DATE: ⌊_⌋⌊_⌋-⌊_⌋⌊_⌋-⌊_⌋⌊_⌋
MM DD YY

HOMEOWNER EXPOSURE STUDY

This questionnaire collects basic information about you, your renovation and remodeling activities, and some of your hobbies and other activities. All information you give will be kept confidential. No names will be used and no one outside the study will be able to tell which person gave which answers. If you have any questions about this study, the Study Manager will be happy to talk with you.

Please answer the questions as completely as you can. In some cases, you will be asked to write in an answer. Other times, you will be asked to check a box next to the answer that best applies to you.

If you have any questions about what a question means or how to answer a question or section, the study staff will be happy to help you.

Thank you for your help in this important research project.

SECTION A: DEMOGRAPHICS

A1. How old are you?

AGE . . . . . ☐☐

A2. What is your race and ethnic group? **(Check only one)**

WHITE, NOT HISPANIC . . . . . ☐ 01
WHITE, HISPANIC . . . . . ☐ 02
BLACK, NOT HISPANIC . . . . . ☐ 03
BLACK, HISPANIC . . . . . ☐ 04
AMERICAN INDIAN . . . . . ☐ 05
ASIAN/PACIFIC ISLANDER . . . ☐ 06
OTHER . . . (SPECIFY) . . . . . ☐ 07

SPECIFY: _____

A3. Are you male or female?

MALE . . . . . ☐ 1
FEMALE . . . . . ☐ 2

A4. How much schooling have you had? **Check the highest level completed.**

GRADES 1 THROUGH 8 . . . . . ☐ 1
SOME HIGH SCHOOL . . . . . ☐ 2
HIGH SCHOOL/GED . . . . . ☐ 3
APPRENTICESHIP TRAINING . . ☐ 4
SOME COLLEGE/TECH SCHOOL ☐ 5
COLLEGE/TECH SCHOOL GRAD ☐ 6

A5. How many children under age 6 currently live with you in your home?

CHILDREN UNDER 6 . . . . ☐☐

SECTION B: RESIDENTIAL INFORMATION — In this section, we want to find out about your home. By home, we mean the house, apartment building, or any other building where you live, whether or not you own it.

B1. How old is your home? If you've lived in more than one home <u>during the last 12 months</u>, how old is the home you lived in the longest?

BUILT SINCE 1990 . . . . . ☐ 1
BUILT BETWEEN 1978 AND 1990 . . . . . ☐ 2
BUILT BETWEEN 1940 AND 1978 . . . . . ☐ 3
BUILT BEFORE 1940 . . . . . ☐ 4

B2. Have any room additions or any major remodeling changes been made to your home <u>in the last 12 months</u>?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

A. Was the inside of the house remodeled <u>in the last 12 months</u>?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

B. Was the exterior of the house remodeled in the last 12 months?

YES ..... ☐ 1
NO ..... ☐ 2

C. Was paint stripped or sanded during the remodeling?

YES ..... ☐ 1
NO ..... ☐ 2

D. Did the remodeling include major work on the kitchen or the bathroom?

YES ..... ☐ 1
NO ..... ☐ 2

E. Did you do a large portion (more than 25%) of the hands-on work yourself?

YES ..... ☐ 1
NO ..... ☐ 2

If you did any of the work yourself, please describe what you did on the *SPECIFY* lines below.

SPECIFY: _____ ☐☐

_____ ☐☐

_____ ☐☐

OFFICE USE

F. Did you live in the house while any of the work was being done?

YES ..... ☐ 1
NO ..... ☐ 2

SECTION C: RENOVATION AND REMODELING WORK HISTORY

C1. During the last 30 days, how many days did you spend doing any kind of renovation and remodeling work in your home? _____ days

C2. During the last 12 months, in how many weeks did you do some renovation and remodeling in your home? _____ weeks

C3. In the past 12 months have you done renovation and remodeling work in homes other than in your own residence? (For example friends and relatives)

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION C3, THEN SKIP TO QUESTION C4.

A. During the last 30 days, how many days did you work in homes OTHER THAN YOUR OWN that were built before 1940? _____ days

B. During the last 30 days, how many days did you work in homes OTHER THAN YOUR OWN that were built in or after 1940? _____ days

C. During the last 12 months, in how many weeks did you do some renovation and remodeling in homes OTHER THAN YOUR OWN that were built before 1940? _____ weeks

D. During the last 12 months, in how many weeks did you do renovation and remodeling in homes OTHER THAN YOUR OWN that were built in or after 1940? _____ weeks

C4. During the last 30 days, about how many hours did you spend working on a typical renovation and remodeling work day? (In your own home, or any other home.) _____ hours per day

C5. During the last 12 months, how many days did you do renovation and remodeling work in a typical week? _____ days per week

C6. During the last 12 months, how many hours did you do renovation and remodeling work in a typical renovation and remodeling work day? _____ hours per day

SECTION D: LARGE STRUCTURE REMOVAL — **These questions are about removing any kind of large structures. Include things like:**

- **making openings for large windows or doorways**
- **tearing down ceilings**
- **removing walls**
- **removing kitchen cabinets**

D1. Have you ever removed large structures (as defined in the instructions above)?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION D1, THEN SKIP TO QUESTION D10.

D2. During the last 30 days, did you remove large structures from a home?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION D2, THEN SKIP TO QUESTION D6.

D3. In the last 30 days, how many days did you remove large structures from:

a) Your home? _____ days

b) OTHER homes (not yours) built before 1940? _____ days

c) OTHER homes (not yours) built in or after 1940? _____ days

D4. On a typical day within the last 30, when you removed large structures, about how many hours did you perform the work? _____ hours

D5. In the last 30 days, on how many of those days did you use a respirator while removing large structures? _____ days

D6. During the past 12 months, in how many weeks did you spend any time removing large structures? _____ weeks

IF YOU ANSWERED '0 WEEKS' TO QUESTION D6, THEN SKIP TO QUESTION D9.

D7. In a typical week in the past 12 months when you removed large structures, on about how many days did you perform the work? _____ days per week

D8. On a typical day in the past 12 months when you removed large structures, about how many hours did you perform the work?

_____ hours per day

D9. When was the last time you removed large structures? (Include only when you did the work yourself.)

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

D10. Has someone else, such as a contractor, ever removed large structures from your home?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

IF YOU ANSWERED NO TO QUESTION D10, SKIP TO SECTION E.

D11. When was the last time someone else, such as a contractor, removed large structures from your home?

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

SECTION E: PAINT REMOVAL AND SURFACE PREPARATION — By surface preparation, we mean activities such as sanding, scraping, torching, or floor refinishing. (Include work done inside and outside.)

E1. Have you ever removed paint or prepared surfaces for painting?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION E1, THEN SKIP TO QUESTION E12.

E2. During the last 30 days, did you remove paint or prepare surfaces for painting?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION E2, THEN SKIP TO QUESTION E8.

E3. In the last 30 days, how many days did you remove paint or prepare surfaces for painting in:

a) Your home? _____ days

b) OTHER homes (not yours) built before 1940? _____ days

c) OTHER homes (not yours) built in or after 1940? _____ days

E4. On a typical day within the last 30, when you removed paint or prepared surfaces for painting, about how many hours did you perform the work? _____ hours

E5. During the last 30 days, on how many days did you use a respirator while removing paint or preparing surfaces for painting? _____ days

E6. During the last 30 days when you removed paint or prepared surfaces, how many days did you do this inside? _____ days

E7. When you removed paint in the last 30 days, how many days did you use the following?

A. dry power sanding? . . . . . _____ days

B. dry hand sanding? . . . . . _____ days

C. dry scraping? . . . . . _____ days

D. burning, torching, or a heat gun? . . . . . _____ days

E. wet scraping? . . . . . _____ days

F. wet sanding? . . . . . _____ days

G. chemical stripping? . . . . . _____ days

H. a dust collector when you sanded? . . . . . _____ days

E8. During the past 12 months, in how many weeks did you spend any time doing paint removal or surface preparation? _____ weeks

IF YOU ANSWERED '0 WEEKS' TO QUESTION E8, THEN SKIP TO QUESTION E11.

E9. In a typical week in the past 12 months when you removed paint or prepared surfaces for painting, on about how many days did you perform the work? _____ days per week

E10. In a typical day in the past 12 months when you removed paint or prepared surfaces for painting, about how many hours did you perform the work? _____ hours per day

E11. When was the last time you did any paint removal or surface preparation? (Include only when you did the work yourself.)

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

E12. Has someone else, such as a contractor, ever removed paint or prepared surfaces for painting in your home?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

IF YOU ANSWERED NO TO E12, SKIP TO SECTION F.

E13. When was the last time someone else, such as a contractor, removed paint or prepared surfaces for painting in your home?

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

SECTION F: WINDOW OR DOOR CASEMENT REPLACEMENT

F1. Have you ever removed any windows or door casements?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION F1, THEN SKIP TO QUESTION F10.

F2. During the last 30 days, did you remove windows or door casements?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION F2, THEN SKIP TO QUESTION F6.

F3. In the last 30 days, how many days did you remove *windows or door casements from:*

a) Your home? _____ days

b) OTHER homes (not yours) built before 1940? _____ days

c) OTHER homes (not yours) built in or after 1940? _____ days

F4. On a typical day within the last 30, when you removed windows or door casements, about how many hours did you perform the work? _____ hours

F5. In the last 30 days, on how many of those days did you use a respirator while removing windows or door casements? _____ days

F6. During the past 12 months, in how many weeks did you spend any time removing windows or door casements? _____ weeks

IF YOU ANSWERED '0 WEEKS' TO QUESTION F6, THEN SKIP TO QUESTION F9.

F7. In a typical week in the past 12 months when you removed windows or door casements, on about how many days did you perform the work? _____ days per week

F8. On a typical day in <u>the past 12 months</u> when you removed windows or door casements, about how many <u>hours</u> did you perform the work?

_____ hours per day

F9. When was the last time you removed windows or door casements? (Include only when you did the work yourself.)

WITHIN THE LAST 30 DAYS . . ☐1
MORE THAN 30 DAYS AGO . . ☐2
MORE THAN A YEAR AGO . . . ☐3
MORE THAN 5 YEARS AGO . . ☐4

F10. Has someone else, such as a contractor, ever removed windows or door casements from your home?

YES . . . . . ☐1
NO . . . . . ☐2

IF YOU ANSWERED NO TO QUESTION F10, SKIP TO SECTION G.

F10. When was the last time someone else, such as a contractor, removed windows or door casements from your home?

WITHIN THE LAST 30 DAYS . . ☐1
MORE THAN 30 DAYS AGO . . ☐2
MORE THAN A YEAR AGO . . . ☐3
MORE THAN 5 YEARS AGO . . ☐4

SECTION G: CARPET REMOVAL

G1. Have you ever removed carpet?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION G1, THEN SKIP TO QUESTION G10.

G2. During the last 30 days, did you remove carpets?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION G2, THEN SKIP TO QUESTION G6.

G3. In the last 30 days, how many days did you remove carpet from:

a) Your home? _____ days

b) OTHER homes (not yours) built before 1940? _____ days

c) OTHER homes (not yours) built in or after 1940? _____ days

G4. On a typical day within the last 30, when you removed carpet, about how many hours did you perform the work? _____ hours

G5. In the last 30 days, on how many of those days did you use a respirator while removing carpet? _____ days

G6. During the past 12 months, how many weeks did you spend removing carpet? _____ weeks

IF YOU ANSWERED '0 WEEKS' TO QUESTION G6, THEN SKIP TO QUESTION G9.

G7. In a typical week in the past 12 months when you removed carpet, on about how many days did you perform the work? _____ days per week

G8. In a typical day in the past 12 months when you removed carpet, about how many hours did you perform the work?

_____ hours per day

G9. When was the last time you removed carpets? (Include only when you did the work yourself.)

WITHIN THE LAST 30 DAYS . . ☐1
MORE THAN 30 DAYS AGO . . ☐2
MORE THAN A YEAR AGO . . . ☐3
MORE THAN 5 YEARS AGO . . ☐4

G10. Has someone else, such as a contractor, ever removed carpets from your home?

YES . . . . . ☐1
NO . . . . . ☐2

IF YOU ANSWERED NO TO QUESTION G10, SKIP TO SECTION H.

G11. When was the last time someone else, such as a contractor, removed carpets from your home?

WITHIN THE LAST 30 DAYS . . ☐1
MORE THAN 30 DAYS AGO . . ☐2
MORE THAN A YEAR AGO . . . ☐3
MORE THAN 5 YEARS AGO . . ☐4

SECTION H: CLEANUP — By cleanup work, we mean the *hands-on* cleanup where you cleaned up the dirt, dust and debris caused by the renovation and remodeling activities. We want to know about the time you spent doing this kind of work. Don't include times when you were around others doing cleanup, but you weren't doing the work.

H1. Have you ever done any hands-on cleanup (as defined in the above instructions)?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION H1, THEN SKIP TO QUESTION H10.

H2. In the last 30 days, have you ever done any hands-on cleanup?

YES ..... ☐ 1
NO ..... ☐ 2

IF YOU ANSWERED NO TO QUESTION H2, THEN SKIP TO QUESTION H6.

H3. In the last 30 days, how many days did you do hands-on cleanup in:

a) Your home? _____ days

b) OTHER homes (not yours) built before 1940? _____ days

c) OTHER homes (not yours) built in or after 1940? _____ days

H4. On a typical day within the last 30, when you did hands-on cleanup, about how many hours did you perform the work? _____ hours

H5. In the last 30 days, how many days did you use a respirator while doing hands-on cleanup? _____ days

H6. Altogether in the past 12 months, how many weeks did you spend doing hands-on cleanup? _____ weeks

IF YOU ANSWERED '0 WEEKS' TO QUESTION H6, THEN SKIP TO QUESTION H9.

H7. In a typical week in the past 12 months when you did hands-on cleanup, on about how many days did you perform the work? _____ days per week

H8. In a typical day in the past 12 months when you did hands-on cleanup, how many hours did you spend doing the work?

_____ hours per day

H9. When was the last time you did hands-on cleanup? (Include only when you did the work yourself.)

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

H10. Has someone else, such as a contractor, ever done cleanup of renovation and remodeling work in your home?

YES . . . . . ☐ 1
NO . . . . . ☐ 2

IF YOU ANSWERED NO TO QUESTION H10, SKIP TO SECTION I.

H11. When was the last time someone else, such as a contractor, did cleanup of renovation and remodeling work in your home?

WITHIN THE LAST 30 DAYS . . ☐ 1
MORE THAN 30 DAYS AGO . . ☐ 2
MORE THAN A YEAR AGO . . . ☐ 3
MORE THAN 5 YEARS AGO . . ☐ 4

SECTION I: TOBACCO USE

I1. Do you currently use snuff or chewing tobacco?

YES ..... ☐1
NO ..... ☐2

I2. Do you currently smoke?

YES ..... ☐1
NO ..... ☐2

If you do not smoke, go to J1. If you do smoke, please answer questions A through C below.

A. Do you smoke while you do renovation and remodeling work?

YES ..... ☐1
NO ..... ☐2

B. Do you smoke while taking a break from renovation and remodeling work?

YES ..... ☐1
NO ..... ☐2

C. Do you carry your cigarettes, cigars, pipe or pipe tobacco in your shirt or pants pocket while you do renovation and remodeling work?

YES ..... ☐1
NO ..... ☐2

SECTION J: HOBBIES

J1. Do you cast lead into bullets or fishing sinkers?

YES ..... ☐1
NO ..... ☐2

J2. Do you go fishing more than 10 times a year?

YES ..... ☐1
NO ..... ☐2

If you answered no, skip to question J3. If you do go fishing more than 10 times a year, answer question A below.

A. Do you crimp fishing sinkers onto the line with your teeth?

YES ..... ☐1
NO ..... ☐2

J3. Do you dismantle car or truck batteries?

YES ..... ☐1
NO ..... ☐2

J4. Do you work with stained glass?

YES ..... ☐1
NO ..... ☐2

SECTION K: MEDICAL HISTORY

K1. Have you ever been diagnosed by a health care professional as having an elevated lead level in your blood?

YES ..... ☐ 1
NO ..... ☐ 2

K2. In the last 12 months, have you been diagnosed by a health care professional as having anemia?

YES ..... ☐ 1
NO ..... ☐ 2

K3. Has anyone living in your household ever had their blood tested for lead? **Check all that apply.**

YES, MYSELF ..... ☐ 1
YES, OTHER ADULT ..... ☐ 3
YES, CHILD ..... ☐ 4
NO ..... ☐ 2

K4. Has anyone living in your household ever been identified by a health care professional as having an elevated blood lead level? **Check all that apply.**

YES, MYSELF ..... ☐ 1
YES, OTHER ADULT ..... ☐ 3
YES, CHILD ..... ☐ 4
NO ..... ☐ 2

SECTION L: OTHER ISSUES

L1. When you used a respirator in the last 30 days, what type did you use? **Check all that apply.**

DIDN'T USE RESPIRATOR .... ☐ 01
DUST MASK ..... ☐ 02
HALF MASK ..... ☐ 03
FULL FACE MASK ..... ☐ 04
TYPE C SUPPLIED AIR MASK . ☐ 05
PAPR ..... ☐ 06
SCBA ..... ☐ 07

L2. Has your home ever been tested for lead paint?

YES ..... ☐ 1
NO ..... ☐ 2

L3. Do you think that lead poses a potential problem for you when you are doing renovation and remodeling work?

YES ..... ☐ 1
NO ..... ☐ 2

L4. Have you ever received any pamphlets or other information about how to reduce potential lead exposures when conducting renovation and remodeling work?

YES ..... ☐ 1
NO ..... ☐ 2

L5. Are there other ways you think you may be exposed to lead that we haven't asked about?

_____

_____

L6. Is there anything else you'd like to tell us, or do you have any additional comments you would like to make?

_____

_____

Thank you very much for taking the time to help us understand how people may or may not be exposed to lead. If you have any questions about the study, or if you would like the results of this study, you can call John Egel at 1-800-444-5234, ext. 104.

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APPENDIX B

ADDITIONAL QUESTIONNAIRE TABLES

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Table B-1. Main Activities and Job Titles for Each Worker Group

Job Title	Main Activities
Main Activities for Carpenters	
	Renovate Old House
	Total Restoration
	Restoration
	Do Work and Watch Other Workers
Technician	Remodel & Repairs
Carpenter and Plasterer	Repair Old Windows and Doors; ornamental Plaster
	Carpenter
	Carpentry
	Building; remodeling
Carpenter	Demolition
	Restoring Old Houses
	Home Renovation & Remodeling
	All Phases of Remodeling
	Renovation
	Framing, Trim, Repair, Etc...
	Renovations; painting
	Jill of All Things
	Remodeling (Framing Drywall Trim Plumb. Electric); Demolition
	Carpentry; prep; painter
	Rehabbing Rental Properties
Carpenter	Replace Molding; scrape; paint
Home Improvement Worker	Renovate Homes; plumbing
	Residential Remodeling
	Renovation; cleaning; painting
	Carpentry Repairs, Additions
	Hanging Windows & Doing Floors & Doors
	Maintenance & Repairs
	Demolition; new Additions; HVAC Installation
Carpenter	Painting; drywall; framing
Carpenter	Painting; scraping
Carpenter/welder	Improvement
Carpenter	Home Improvement
Carpenter	Missing
Carpenter	Renovations and Restorations

Table B-1. Main Activities and Job Titles for Each Worker Group (Continued)

Job Title	Main Activities
Carpenter	Removing Lead Paint
Builder	Remodeling
	Home Improvement Contractor
	General Home Improvements
	Remodeling; replace Window, Doors; tear out Walls, Floors
	Remodel/take down Walls & Windows; replace Walls; replace Windows
	Paint; masonry; demo
	Remodeling Homes
	Everything
	Remodeling; tearing Paneling; removing Paint
Carpenter	Missing
Carpenter & Mason Tender	Missing
Carpenter	Home Improvement
Main Activities for Laborers	
	Tearing down Foundation
Demolition	Tearing Down; building up
	Whatever Boss Says-clean up
	Clean up
	Labor-clean up
	Clean up
	Laborer
	Drive-clean up
	Cleaning
Helper	Cleanup; nail Studs
Carpenter Helper	Form Builder
Laborer	Window & Doors, Floors
Building Laborer	Painting; sheet Rock; laying Pipes
Carpenter Helper	Help Scrape Paint; put up Walls; put down Carpet
	Laborer-construction
	Pulling Wood-ceilings Etc.
Laborer	Scrape Paint; clean up
	Cleans Up; tears down
	Cleaning; demolishing Houses
	Demolition; hauling
	Demo; drywall & Insulation; paint

Table B-1. Main Activities and Job Titles for Each Worker Group (Continued)

Job Title	Main Activities
Labor/helper	Taking down Windows; helping Paint
Laborer	Painting
Temporary Labor	Demolition; clean up
	Clean up
Renovation Helper	All Phases of Rehab-remodel
Laborer	All Activities
Laborer	Remove; rebuild Walls
	Demolition
	Demolition; clean up
General Laborer Helper	Paint; clean; sheetrock
Temporary Laborer	Construction
	Gutting out Houses
Laborer	Scrape Walls, Duct Work; removing Frames; clean up
Maintenance Associate-laborer	Gral Repairs-remodeling
	Demolition
	Demolition
	Clean up
Labor & Helper	Prep; paint; carpet
	Demolition
	Demolition
Laborer	Painting
	Assistant Laborer
	Demolition
Main Activities for Painters	
	Painting; sand Blasting
	Painting
	Painting
	Prep Work for Painting; painting
	Painting; sanding & Stripping
	Painting; supervising
	Prep Work for Painting; cleanup
	Prep Work; spray Paint and Painting
	Paint; prep; demolition
	Painting; sanding; blowing Ceiling
	Painting; preparation to Paint

Table B-1. Main Activities and Job Titles for Each Worker Group (Continued)

Job Title	Main Activities
	Light Painting; cleanup; strip Paint off Windows
	Paint Houses
Painter	Sanding off Paint
	Grinding Pressure Washing; painting
	Grinding, Pressure Washing; painting
Painter Remodeling	Tearing Out; cleaning Up; painting
	Preping; painting
	Prep; painting; glazing & Window Replacement
	Paint; prep
	Painter Prep
	Grinding, Sanding, Scraping & Pressure Washing; painting
	Remodeling; painting; plaster
	Painting; remodeling (Most Everything That Goes along W/it)
	Painting; remodeling
	Plaster; painting; remodeling
	Painting; remodeling
House Painter	Scraping, Sanding; caulking, Glazing
Painter	Preparing Surfaces for Paint; vinyl Siding
	Painting; sanding
	Paint; clean up after Remodeled
Painting	Demolition; painting
Painting	Clean up Sometime Office; painting
	Clean Up; paint Removal; paint
	Painting; demolition; sanding
	Painter; drywall Finisher
	Demolition; painting
	Clean Up; paint; sand
	Painting
	Painting
	Plaster; paint Removal/prep
	Painting; sand Blasting; roofing
	Paint; remove Old Paint
	Scrape Paint, Remove Chipping

Table B-1. Main Activities and Job Titles for Each Worker Group (Continued)

Job Title	Main Activities
Main Activities for Other Workers	
President of R&r Company	Run Field Operations-mostly Finishing Work
Registered Architect	Construction Admin/ep Production/design
Ornamental Plasterer	Restoring Ornamental Plasterwork
Demolition Foreman	Tearing down
Plumber	Cut out Old Pipes & Put in New
Millworker	Repairing Shutters; removing Old Paint
Small Business Owner	Heating/air Conditioning
Warehouse Manager for Chas. Repairs	Material Procurement; jobsite Safety; clean up
Construction Inspector (Commercial)	Assure Const. To Specs/plans Sign off Insp. If Pas
Plumber, Remodeling	Plumbing
Lead Man	Tell People What to Do
Job Forman	Sheetrocking; painting; refurbushing of Wood Floors, Mantles, & Stairways
Lead Abatement Worker	Removal; washdown Hepa-vac; painting
Laborer	Sheetrock
Dry Wall Labor	to Get up Dry Wall
Plumber	Install Copper Water Pipe & Waste Pipes
Owner	Run Concrete; home Improvement Bus.
Lead Paint Technician	Removal of Lead from Window Sills, Doors, Etc.
Home Improvement	HVAC; plumbing; drywall
Contractor	Drywalls; building Decks
Iron Worker	Welding
President-property Mgmt. Co.	Renovates
Construction Worker	Construction
Brick Layer-owner	Cleaning Brick
Handy Man Pipe Fitter	Cutting Old Pipe Out; remodeling Old Houses
Bricklayer	Cleaning Brick, Masonry; lead Paint Removal

Table B-2. Summary of Responses for Questions Pertaining to R&R Target Activities for Each Worker Group

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
		CARPENTER					
Days performing the activity in the last 30 days	25th Percentile	20	5	10	2	0	15
	Mean	24.64	14.55	15.06	9.40	3.17	20.36
	75th Percentile	30	22	22	15	3	28
Days performing the activity in Pre-1940 housing in the last 30 days	25th Percentile	20	5	5	1	0	6
	Mean	22.60	12.89	13.30	7.34	2.30	16.62
	75th Percentile	28	22	21	12	2	25
Days using a respirator while performing activity	25th Percentile	[a]	0	0	0	0	0
	Mean	[a]	5.02	6.11	3.00	1.13	5.60
	75th Percentile	[a]	10	13	1	0	10
Number of weeks spent performing activity in last year	< 1 Week	0.0%	4.3%	8.5%	19.1%	57.4%	4.3%
	1-8 Weeks	2.1%	29.8%	34.0%	40.4%	31.9%	31.9%
	> 8 Weeks	97.9%	66.0%	57.4%	40.4%	10.6%	63.8%
Number of years spent performing activity over career	25th Percentile	8	5	5	3	1	7
	Mean	14.45	10.98	9.68	10.21	6.87	13.45
	75th Percentile	21	15	15	16	10	20
Number of weeks spent performing activity in average year	< 1 Week	[a]	10.6%	17.8%	20.0%	60.0%	19.1%
	1-8 Weeks	[a]	38.3%	31.1%	42.2%	22.5%	23.4%
	> 8 Weeks	[a]	51.1%	51.1%	37.8%	17.5%	57.4%

Table B-2. Summary of Responses for Questions Pertaining to R&R Target Activities for Each Worker Group (Continued)

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
LABORER							
Days performing the activity in the last 30 days	25th Percentile	20	7	6	2	0	11
	Mean	22.86	14.07	14.02	8.23	4.73	18.68
	75th Percentile	27	21	20	12	6	25
Days performing the activity in Pre-1940 housing in the last 30 days	25th Percentile	18	4	5	0	0	9
	Mean	20.14	11.26	12.36	7.07	4.11	15.27
	75th Percentile	23	20	20	10	5	20
Days using a respirator while performing activity	25th Percentile	[a]	0	0	0	0	0
	Mean	[a]	6.07	7.59	3.91	2.45	6.95
	75th Percentile	[a]	10	13	5	1	15
Number of weeks spent performing activity in last year	<1 Week	0.0%	9.1%	9.1%	22.7%	47.7%	2.3%
	1-8 Weeks	9.1%	29.5%	29.5%	43.2%	29.5%	20.5%
	>8 Weeks	90.9%	61.4%	61.4%	34.1%	22.7%	77.3%
Number of years spent performing activity over career	25th Percentile	5	3	2	2	1	2
	Mean	10.84	7.56	7.74	6.79	4.67	7.12
	75th Percentile	15	12	12	10	7	10
Number of weeks spent performing activity in average year	<1 Week	[a]	23.3%	19.5%	38.5%	42.9%	9.8%
	1-8 Weeks	[a]	25.6%	26.8%	20.5%	28.6%	22.0%
	>8 Weeks	[a]	51.2%	53.7%	41.0%	28.6%	68.3%

Table B-2. Summary of Responses for Questions Pertaining to R&R Target Activities for Each Worker Group (Continued)

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
PAINTER							
Days performing the activity in the last 30 days	25th Percentile	23	0	15	0	0	10
	Mean	24.75	9.48	20.07	5.82	3.98	17.80
	75th Percentile	29	15	25	10	6	25
Days performing the activity in Pre-1940 housing in the last 30 days	25th Percentile	17	0	10	0	0	10
	Mean	21.80	7.93	16.43	5.07	2.91	15.16
	75th Percentile	27	13	24	10	4	21
Days using a respirator while performing activity	25th Percentile	[a]	0	0	0	0	0
	Mean	[a]	3.95	6.16	3.70	1.64	5.00
	75th Percentile	[a]	7	10	6	0	10
Number of weeks spent performing activity in last year	<1 Week	0.0%	29.5%	0.0%	34.1%	63.6%	2.4%
	1-8 Weeks	4.5%	29.5%	13.6%	45.5%	25.0%	33.3%
	>8 Weeks	95.5%	40.9%	86.4%	20.5%	11.4%	64.3%
Number of years spent performing activity over career	25th Percentile	4	2	4	1	0	3
	Mean	11.95	6.66	10.39	5.74	4.53	9.84
	75th Percentile	17	10	15	9	8	15
Number of weeks spent performing activity in average year	<1 Week	[a]	21.1%	4.5%	47.2%	62.1%	14.3%
	1-8 Weeks	[a]	44.7%	15.9%	33.3%	24.1%	16.7%
	>8 Weeks	[a]	34.2%	79.5%	19.4%	13.8%	69.0%

Table B-2. Summary of Responses for Questions Pertaining to R&R Target Activities for Each Worker Group (Continued)

Variable Description	Statistic	Target Activities					
		General R&R	Large Structure	Paint Removal	Window Replacement	Carpet Removal	Cleanup
OTHER							
Days performing the activity in the last 30 days	25th Percentile	20	5	4	0	0	10
	Mean	23.08	13.19	13.58	5.08	1.96	17.27
	75th Percentile	28	20	25	10	2	25
Days performing the activity in Pre-1940 housing in the last 30 days	25th Percentile	15	3	4	0	0	4
	Mean	20.50	11.12	11.77	4.81	1.73	13.08
	75th Percentile	25	20	21	10	2	24
Days using a respirator while performing activity	25th Percentile	[a]	0	0	0	0	0
	Mean	[a]	5.23	6.96	1.35	0.58	7.88
	75th Percentile	[a]	10	10	0	0	18
Number of weeks spent performing activity in last year	<1 Week	0.0%	11.5%	11.5%	26.9%	69.2%	4.0%
	1-8 Weeks	3.8%	34.6%	30.8%	38.5%	19.2%	40.0%
	>8 Weeks	96.2%	53.8%	57.7%	34.6%	11.5%	56.0%
Number of years spent performing activity over career	25th Percentile	7	4	3	2	0	4
	Mean	14.62	10.54	8.19	8.31	4.46	9.58
	75th Percentile	20	15	10	10	5	13
Number of weeks spent performing activity in average year	<1 Week	[a]	11.5%	17.4%	26.1%	47.4%	15.4%
	1-8 Weeks	[a]	38.5%	39.1%	39.1%	42.1%	38.5%
	>8 Weeks	[a]	50.0%	43.5%	34.8%	10.5%	46.2%

(a) This question was not asked for general R&R activity

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APPENDIX C

STATISTICAL MODEL TABLES

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Table C-1. Summary of Relationships Between Covariates and Blood-Lead Concentrations for Workers

Covariate Description	Combined		Baltimore		Charleston		Savannah	
	F	P-Value	F	P-Value	F	P-Value	F	P-Value
Worker's Age	1.51	0.222	3.12	0.081	1.75	0.193	1.02	0.322
Race (All Levels)	1.47	0.203	0.86	0.510	6.36	0.004	2.37	0.136
Race (White/Other)	0.02	0.876	0.70	0.404	9.37	0.004	2.37	0.136
Gender	8.58	0.004	8.09	0.006	4.97	0.032	0.05	0.833
Education (All Levels)	0.46	0.806	0.10	0.992	1.33	0.278	1.45	0.253
Education (High School or Less/More than High School)	0.01	0.908	0.16	0.691	1.75	0.194	2.08	0.162
Union Status (Yes/No)	0.19	0.665	0.14	0.710	---	---	---	---
Age of Home (Pre 1940, 1940-1978, Post-1978)	1.22	0.299	1.41	0.250	1.11	0.338	0.14	0.870
Room Additions or Renovation in Own Home (Yes/No)	5.13	0.025	1.02	0.315	4.63	0.038	0.20	0.662
Cast Lead into Bullets or Fishing Sinkers (Yes/No)	0.02	0.897	1.35	0.249	1.55	0.220	0.37	0.547
Dismantle Truck Batteries (Yes/No)	1.32	0.253	4.22	0.043	0.32	0.577	1.83	0.188
Work With Stained Glass (Yes/No)	1.28	0.260	1.17	0.282	0.25	0.621	<.0001	0.991
Smoke, Use Snuff, or Chewing Tobacco (Yes/No)	4.65	0.033	2.85	0.095	4.36	0.043	0.14	0.716
Fishing (No/Yes, Crimp Sinkers with Teeth/Yes, Do Not Crimp Sinkers)	0.52	0.594	0.13	0.878	2.63	0.085	0.02	0.983

Table C-1. Summary of Relationships Between Covariates and Blood-Lead Concentrations for Workers (Continued)

Covariate Description	Combined		Baltimore		Charleston		Savannah	
	F	P-Value	F	P-Value	F	P-Value	F	P-Value
Any Exposure Through Non-Work Activities (Yes/No)	1.22	0.271	1.38	0.243	1.93	0.173	0.30	0.591
Number of Non-Work Activities	0.673	0.416	5.47	0.028	1.67	0.223	3.09	0.153
Respirator Use (None/Respirator)	0.02	0.875	0.32	0.573	0.80	0.377	0.42	0.522
Respirator Use (None/Dust Mask/Other Respirator)	0.50	0.606	0.16	0.852	2.93	0.066	0.29	0.752
Large Structure Removal: Number of Days Used Respirator In Last 30 Days	0.77	0.383	0.36	0.550	0.51	0.481	3.53	0.072
Paint Removal and Surface Preparation: Number of Days Used Respirator In Last 30 Days	1.00	0.320	0.158	0.693	0.20	0.654	1.11	0.302
Window or Door Casement Replacement: Number of Days Used Respirator In Last 30 Days	0.55	0.460	0.03	0.858	0.34	0.565	11.81	0.002
Carpet Removal: Number of Days Used Respirator In Last 30 Days	2.89	0.091	2.39	0.126	0.89	0.352	0.44	0.514
Cleanup: Number of Days Used Respirator In Last 30 Days	0.635	0.427	0.005	0.945	0.003	0.954	3.70	0.065
Received Information on Reducing Lead Exposures (Yes/No)	0.14	0.708	0.03	0.860	0.11	0.743	0.48	0.494
Received Training on Reducing Lead Exposures (Yes/No)	0.72	0.397	0.36	0.551	0.61	0.439	0.03	0.864

Table C-2. Summary of Relationships Between Covariates and Blood-Lead Concentrations for Homeowners

Covariate Description	Combined		Baltimore		Charleston		Savannah	
	F	P-Value	F	P-Value	F	P-Value	F	P-Value
Worker's Age	7.75	0.007	9.34	0.004	0.55	0.467	1.53	0.224
Race (All Levels)	1.61	0.194	0.23	0.636	0.99	0.331	1.34	0.286
Race (White/Other)	3.90	0.052	0.23	0.636	0.99	0.331	3.27	0.083
Gender	12.26	0.001	6.71	0.014	1.01	0.328	3.14	0.089
Education (All Levels)	1.01	0.395	0.06	0.980	0.90	0.354	1.42	0.263
Education (High School or Less/More than High School)	0.95	0.333	0.01	0.914	--[f]	--	1.56	0.224
Age of Home (Pre 1940, 1940-1978, Post-1978)	0.58	0.563	0.82	0.451	--	--	--	--
Room Additions or Renovation in Own Home (Yes/No)	4.59[a]	0.035	1.69	0.202	--	--	2.98	0.097
Done Renovation or Remodeling in Other Homes (Yes/No)	0.45	0.503	1.1	0.295	0.13	0.721	1.88	0.183
Cast Lead into Bullets or Fishing Sinkers (Yes/No)	0.02[b]	0.898	--	--	--	--	0.04	0.842
Dismantle Truck Batteries (Yes/No)	2.95*	0.090	4.20	0.049	--	--	--	--
Work With Stained Glass (Yes/No)	1.09[d]	0.299	0.01	0.919	0.55	0.468	5.95	0.023

Table C-2. Summary of Relationships Between Covariates and Blood-Lead Concentrations for Homeowners (Continued)

Covariate Description	Combined		Baltimore		Charleston		Savannah	
	F	P-Value	F	P-Value	F	P-Value	F	P-Value
Smoke, Use Snuff, or Chewing Tobacco (Yes/No)	1.42	0.238	0.38	0.541	1.89	0.185	2.54	0.124
Fishing (No / Yes, Crimp Sinkers with Teeth / Yes, Do Not Crimp Sinkers)	0.42[g]	0.657	--	--	0.26	0.770	0.72	0.498
Any Exposure Through Non-Work Activities (Yes/No)	0.04	0.845	2.00	0.167	0.46	0.505	0.25	0.621
Contractor Did Large Structure Removal in Home	1.94	0.168	0.13	0.722	1.78	0.197	2.55	0.123
Contractor Did Paint Removal / Surface Preparation	0.31	0.732	0.17	0.842	<0.01	0.953	1.84	0.188
Contractor Removed Window or Door Casements	2.84	0.096	0.18	0.610	3.02	0.097	3.41	0.077
Contractor Removed Carpet	1.33	0.252	2.78	0.105	1.47	0.240	2.46	0.130
Contractor Performed Cleanup	1.57	0.213	0.04	0.837	0.01	0.940	4.13	0.053
Respirator Use (None/Respirator)	3.05	0.085	1.04	0.315	0.85	0.369	2.96	0.098
Respirator Use (None/Dust Mask/Other Respirator)	1.60	0.209	0.51	0.606	0.69	0.515	1.43	0.260

Table C-2. Summary of Relationships Between Covariates and Blood-Lead Concentrations for Homeowners (Continued)

Covariate Description	Combined		Baltimore		Charleston		Savannah	
	F	P-Value	F	P-Value	F	P-Value	F	P-Value
Large Structure Removal: Number of Days Used Respirator In Last 30 Days	0.53	0.469	0.18	0.671	0.90	0.354	0.10	0.758
Paint Removal and Surface Preparation: Number of Days Used Respirator In Last 30 Days	2.93	0.091	4.69	0.038	1.11	0.305	1.13	0.299
Window or Door Casement Replacement: Number of Days Used Respirator In Last 30 Days	0.743	0.391	0.581	0.452	0.34	0.566	0.04	0.842
Carpet Removal: Number of Days Used Respirator In Last 30 Days	0.03	0.867	--	--	0.25	0.623	--	--
Cleanup: Number of Days Used Respirator In Last 30 Days	1.41	0.239	3.87	0.058	0.33	0.572	0.04	0.845
Received Information on Reducing Lead Exposures (Yes/No)	0.20	0.656	0.35	0.556	0.19	0.669	<0.01	0.953

(a) Only three homeowners indicated that there were no room additions made to their home in the last year.
(b) Only two homeowners indicated that they cast lead into bullets or fishing sinkers.
(c) Only two homeowners dismantled truck or car batteries.
(d) Only three homeowners indicated that they work with stained glass.
(e) Only two homeowners indicated that they lived in home built after 1940.
(f) All homeowners in Charleston had more than a high school education.
(g) Only six homeowners indicated that the went fishing more than 10 times a year (and only two indicated that they crimp sinkers onto the line with their teeth).

Table C-3. Summary of Univariate Relationships Between Conduct of Target Activity and Worker Blood-Lead Concentrations for Each Target Activity*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0354	0.0088	0.000	0.1390	0.0585	0.019	0.0192	0.0065	0.003
Large Structure Removal	0.0019	0.0059	0.751	0.0005	0.0285	0.985	0.0144	0.0074	0.055
Paint Removal/ Surface Preparation	0.0126	0.0060	0.039	0.0906	0.0304	0.003	0.0163	0.0079	0.039
Window/Door Casement Replacement	0.0158	0.0079	0.047	0.0416	0.0281	0.141	0.0145	0.0077	0.063
Carpet Removal	-0.0094	0.0104	0.367	-0.0749	0.0343	0.031	-0.0055	0.0085	0.516
Cleanup	0.0160	0.0057	0.006	0.0570	0.0330	0.086	0.0164	0.0072	0.024

* There are a total of 18 models being fit (one for each target activity and exposure period combination).

Table C-4. Summary of Univariate Relationships Between Conduct of Target Activity and Worker Blood-Lead Concentrations for Each Target Activity (Adjusted for Ancillary Covariates)*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0323	0.0085	0.000	0.1693	0.0549	0.002	0.0156	0.0066	0.019
Large Structure Removal	0.0011	0.0056	0.852	-0.0011	0.0274	0.969	0.0097	0.0075	0.198
Paint Removal/ Surface Preparation	0.0141	0.0058	0.016	0.0839	0.0289	0.004	0.0137	0.0076	0.073
Window/Door Casement Replacement	0.0135	0.0077	0.080	0.0225	0.0279	0.421	0.0111	0.0076	0.149
Carpet Removal	-0.0066	0.0101	0.513	-0.0809	0.0326	0.014	-0.0089	0.0082	0.277
Cleanup	0.0177	0.0054	0.001	0.0515	0.0316	0.106	0.0124	0.0071	0.080

* There are a total of 18 models being fit (one for each target activity and exposure period combination).

Table C-5. Summary for Each Target Activity of the Covariated Adjusted Relationship Between Worker Blood-Lead Concentration and the Combined Effect of All Three Exposure Period Measures*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0266	0.0086	0.002	0.1109	0.0566	0.052	0.0082	0.0066	0.215
Large Structure Removal	0.0019	0.0081	0.812	-0.0217	0.0402	0.590	0.0129	0.0081	0.115
Paint Removal/ Surface Preparation	0.0055	0.0072	0.446	0.0608	0.0365	0.098	0.0093	0.0076	0.223
Window/Door Casement Replacement	0.0134	0.0103	0.196	-0.0188	0.0365	0.607	0.0076	0.0085	0.376
Carpet Removal	0.0168	0.0133	0.208	-0.1170	0.0466	0.013	-0.0007	0.0096	0.945
Cleanup	0.0194	0.0065	0.003	-0.0102	0.0361	0.778	0.0107	0.0072	0.135

* There are a total of six models fit and the table reads across the rows.

Table C-6. Summary of Univariate Relationships Between Conduct of Target Activity and Homeowner Blood-Lead Concentrations for Each Target Activity*

Target Activity	Short Term (Days in Last 30)			Mid-Term (Weeks in Last Year)			Short Term (Hours in Last 30 Days)			Mid Term (Days in Last 12 Months)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0209	0.0123	0.094	0.0125	0.0067	0.068	0.0049	0.0019	0.010	0.0030	0.0012	0.017
Large Structure Removal	-0.003	0.0218	0.899	0.0016	0.0144	0.912	-0.0016	0.0036	0.653	0.0016	0.0034	0.642
Paint Removal/Surface Preparation	0.0436	0.0184	0.020	0.0148	0.0095	0.122	0.0077	0.0028	0.007	0.0028	0.0024	0.242
Window/Door Casement Replacement	0.0025	0.0444	0.956	-0.0089	0.0192	0.642	-0.0007	0.0057	0.899	-0.0028	0.0052	0.594
Carpet Removal	-0.065	0.0545	0.240	-0.0296	0.0266	0.269	-0.0069	0.0071	0.336	-0.0050	0.0055	0.367
Cleanup	0.0113	0.0124	0.364	0.0001	0.0070	0.989	-0.0015	0.0029	0.594	0.0009	0.0015	0.551

* There are a total of 24 models being fit (one for each target activity and exposure period combination).

Table C-7. Summary of Univariate Relationships Between Conduct of Target Activity and Homeowner Blood-Lead Concentrations for Each Target Activity (Adjusted for Ancillary Covariates)*

Target Activity	Short Term (Days in Last 30)			Mid-Term (Weeks in Last Year)			Short Term (Hours in Last 30 Days)			Mid Term (Days in Last 12 Months)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0199	0.0111	0.077	0.0157	0.0059	0.010	0.0046	0.0017	0.007	0.0034	0.0011	0.002
Large Structure Removal	0.0161	0.0213	0.450	0.0059	0.0145	0.686	0.0012	0.0035	0.726	0.0025	0.0033	0.461
Paint Removal/Surface Preparation	0.0328	0.0167	0.054	0.0199	0.0083	0.020	0.0069	0.0024	0.006	0.0045	0.0021	0.039
Window/Door Casement Replacement	0.0181	0.0416	0.665	-0.0008	0.0192	0.969	0.0020	0.0053	0.704	-0.0011	0.0049	0.827
Carpet Removal	-0.038	0.0512	0.457	-0.0229	0.0249	0.361	-0.0051	0.0066	0.446	-0.0043	0.0051	0.401
Cleanup	0.0162	0.0110	0.145	0.0049	0.0063	0.433	0.0017	0.0027	0.521	0.0020	0.0013	0.121

* There are a total of 24 models being fit (one for each target activity and exposure period combination).

Table C-8. Summary for Each Target Activity of the Covariated Adjusted Relationship Between Homeowner Blood-Lead Concentration and the Combined Effect of All Three Exposure Period Measures*

Target Activity	Short Term (Days in Last 30)			Mid-Term (Weeks in Last Year)			Short Term (Hours in Last 30 Days)			Mid Term (Days in Last 12 Months)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	0.0130	0.0113	0.251	0.0138	0.0062	0.029	0.0027	0.0019	0.146	0.0025	0.0012	0.048
Large Structure Removal	0.0105	0.0278	0.708	0.0016	0.0184	0.930	-0.0014	0.0044	0.750	0.0033	0.0042	0.435
Paint Removal/Surface Preparation	0.0207	0.0180	0.255	0.0158	0.0090	0.084	0.0058	0.0026	0.028	0.0027	0.0022	0.232
Window/Door Casement Replacement	0.0278	0.0498	0.578	-0.0075	0.0227	0.743	0.0092	0.0090	0.313	-0.0078	0.0082	0.347
Carpet Removal	0.0347	0.1342	0.797	-0.0385	0.0653	0.558	0.0080	0.0441	0.856	-0.0102	0.0333	0.759
Cleanup	0.0154	0.0119	0.198	0.0021	0.0066	0.757	-0.0002	0.0030	0.952	0.0022	0.0015	0.139

* There are a total of 12 models being fit (two for each target activity). The models for each target activity are separated by a double line.

Table C-9. Summary for Exposure Period of the Covariate Adjusted Relationship Between Worker-Blood Lead Concentration and the Combined Effect of All Five Target Activities Exposure Variables*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	-0.0125	0.0064	0.052	-0.0204	0.0308	0.509	-0.0032	0.0159	0.839
Large Structure Removal	0.0102	0.0064	0.111	0.0952	0.0310	0.003	0.0109	0.0106	0.304
Paint Removal/ Surface Preparation	0.0152	0.0086	0.080	0.0472	0.0355	0.186	0.0220	0.0155	0.156
Window/Door Casement Replacement	-0.0237	0.0106	0.027	-0.1315	0.0362	0.000	-0.0253	0.0100	0.013
Carpet Removal	0.0212	0.0064	0.001	0.0049	0.0054	0.363	0.0597	0.0321	0.065

* There are a total of three models being fit. Each model represents a single period of exposure and the table reads down the three columns.

Table C-10. Summary for Exposure Period of the Relationship Between Worker Blood-Lead Concentration and the Combined Effect of All Five Target Activities Exposure Variables, After Adjusting for the Effects of Covariates and Worker Group*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	-0.0115	0.0064	0.074	-0.0221	0.0313	0.481	-0.0003	0.0163	0.984
Large Structure Removal	0.0074	0.0064	0.253	0.0859	0.0327	0.010	0.0054	0.0110	0.629
Paint Removal/ Surface Preparation	0.0151	0.0086	0.082	0.0391	0.0356	0.273	0.0212	0.0152	0.164
Window/Door Casement Replacement	-0.0191	0.0106	0.074	-0.1173	0.0366	0.002	-0.0272	0.0099	0.007
Carpet Removal	0.0204	0.0064	0.002	0.0063	0.0054	0.241	0.0672	0.0319	0.037

* There are a total of three models being fit. Each model represents a single period of exposure and the table reads down the three columns.

Table C-11. Summary for Exposure Period of the Relationship Between Worker Blood-Lead Concentration and the Effect of Significant Target Activities Exposure Variables, After Adjusting for the Effects of Covariates and Worker Group*

Target Activity	Short Term (Days of Pre-1940 Activity)			Mid-Term (Weeks in Last 12 Months)			Long Term (Years over Career)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
General R&R	--	--	--	--	--	--	--	--	--
Large Structure Removal	--	--	--	0.099	0.030	0.001	--	--	--
Paint Removal/ Surface Preparation	--	--	--	--	--	--	0.023	0.009	0.012
Window/Door Casement Replacement	--	--	--	-0.101	0.033	0.003	-0.026	0.010	0.007
Carpet Removal	0.017	0.005	0.002	--	--	--	--	--	--

* The results from three models are being presented, each model represents a single period of exposure and the Table reads down the three columns.

Table C-12. Final Predictive Model for Worker Blood-Lead Concentrations

Variable	Description	Effect on Log (blood-lead)	Standard Error	P-Value
Intercept		1.632	0.358	<0.001
Gender	Male	0.480	0.141	<0.001
	Female[a]	--	--	--
Room Additions in Own Home	Yes	-0.345	0.010	<0.001
	No[a]	--	--	--
Use Tobacco Products	No	-0.181	0.094	0.056
	Yes[a]	--	--	--
Worker Group	Carpenter	-0.516	0.428	0.230
	Laborer	-0.195	0.411	0.636
	Painter	-1.101	0.537	0.041
	Other[a]	--	--	--
Carpet Removal	Weeks Spent in Last 12 Months	-0.141	0.033	<0.001
Worker Group * Days Spent Performing Cleanup	Carpenter * Cleanup days	0.019	0.010	0.050
	Laborer * Cleanup days	0.022	0.011	0.052
	Painter * Cleanup days	0.037	0.010	<0.001
	Other * Cleanup days	-0.017	0.012	0.142
Worker Group * Weeks Spent Performing Paint Removal/Surface Preparation (PR/SP)	Carpenter * PR/SP Weeks	0.089	0.054	0.098
	Laborer *PR/SP Weeks	-0.079	0.060	0.188
	Painter *PR/SP Weeks	0.160	0.068	0.020
	Other *PR/SP Weeks	0.121	0.064	0.062
Worker Group * Years Spent Performing Window/Door Casement Replacement (W/DCR)	Carpenter * W/DCR Years	0.023	0.012	0.050
	Laborer * W/DCR Years	0.058	0.018	0.002
	Painter * W/DCR Years	0.010	0.014	0.468
	Other * W/DCR Years	-0.010	0.014	0.498

(a) Reference level

Table C-13. Alternative Predictive Model for Worker Blood-Lead Concentrations Based Upon General R&R

Variable	Description	Effect on Log (blood-lead)	Standard Error	P-Value
Intercept		0.251	0.418	0.548
Gender	Male	0.574	0.153	<0.001
	Female[a]	--	--	--
Room Additions in Own Home	Yes	-0.305	0.102	0.003
	No[a]	--	--	--
Use Tobacco Products	No	-0.168	0.102	0.102
	Yes[a]	--	--	--
Worker Group	Carpenter	0.105	0.149	0.483
	Laborer	-0.140	0.151	0.354
	Painter	0.181	0.157	0.251
	Other[a]	--	--	--
Short-Term Exposure	Days in the Last 30 Days	0.025	0.009	0.005
Mid-Term Exposure	Weeks in the Last 12 Months	0.093	0.057	0.106
Long-Term Exposure	Years Over Career	0.007	0.007	0.321

(a) Reference level

Table C-14. Summary for Exposure Period of the Covariate Adjusted Relationship Between Homeowner Blood-Lead Concentration and the Combined Effect of All Five Target Activities Exposure Variables*

Target Activity	Short Term (Days in Last 30)			Mid-Term (Weeks in Last Year)			Short Term (Hours in Last 30 Days)			Mid Term (Days in Last 12 Months)		
	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value	Beta	Std. Error	P-value
Large Structure Removal	0.0053	0.0272	0.845	0.0025	0.0168	0.881	0.0005	0.0049	0.915	0.0020	0.0047	0.668
Paint Removal/Surface Preparation	0.0265	0.0195	0.179	0.0255	0.0106	0.018	0.0083	0.0028	0.004	0.0042	0.0027	0.127
Window/Door Casement Replacement	0.0332	0.0717	0.645	-0.0023	0.0259	0.930	0.0045	0.0082	0.587	0.0058	0.0158	0.714
Carpet Removal	-0.085	0.0724	0.243	-0.0390	0.0317	0.223	-0.0178	0.0095	0.066	-0.0166	0.0149	0.269
Cleanup	0.0080	0.0124	0.520	-0.0044	0.0072	0.543	0.0004	0.0028	0.898	0.0011	0.0016	0.477

* There are a total of four models being fit (two for each exposure period). The table reads down the four columns.

Table C-15. Summary for Exposure Period of the Covariate Adjusted Relationship Between Homeowner Blood-Lead Concentration and the Effect of Significant Target Activities Exposure Variables*

Activity	Exposure Period	Measurement	Statistic		
			Beta	Std. Error	P-value
Paint Removal/ Surface Preparation	Short-Term Exposure	Days in last 30	0.033	0.017	0.054
		Total Hours in Last 40 days	0.007	0.002	0.006
	Mid-Term Exposure	Weeks in Last 12 Months	0.020	0.008	0.020
		Total Days in Last 12 Months	0.005	0.002	0.039

* Four models are being represented in the table which reads across the four rows.

Table C-16. Final Predictive Model for Homeowner Blood-Lead Concentrations

Variable	Description	Effect on Log (blood-lead)	Standard Error	P-Value
Intercept		0.011	0.327	0.972
Gender	Male	0.585	0.165	<0.001
	Female[a]	--	--	--
Ethnicity	Non-White	-0.313	0.212	0.144
	White[a]	--	--	--
Age of Homeowner		0.022	0.007	0.002
Paint Removal/ Surface Preparation	Total hours spent in the last 30 days	0.006	0.003	0.033
Paint Removal/ Surface Preparation	Number of weeks in the last 12 months	0.014	0.009	0.122

(a) Reference level

Table C-17. Alternative Predictive Model for Homeowner Blood-Lead Concentrations Using General R&R

Variable	Description	Effect on Log (blood-lead)	Standard Error	P-Value
Intercept		-0.375	0.393	0.343
Gender	Male	0.545	0.168	0.002
	Female[a]	--	--	--
Ethnicity	Non-White	-0.324	0.217	0.140
	White[a]	--	--	--
Age of Homeowner		0.025	0.007	0.001
General R&R	Total hours spent in the last 30 days	0.013	0.006	0.038
General R&R	Number of weeks in the last 12 months	0.004	0.002	0.035

(a) Reference level

APPENDIX D

ADDITIONAL FIGURES

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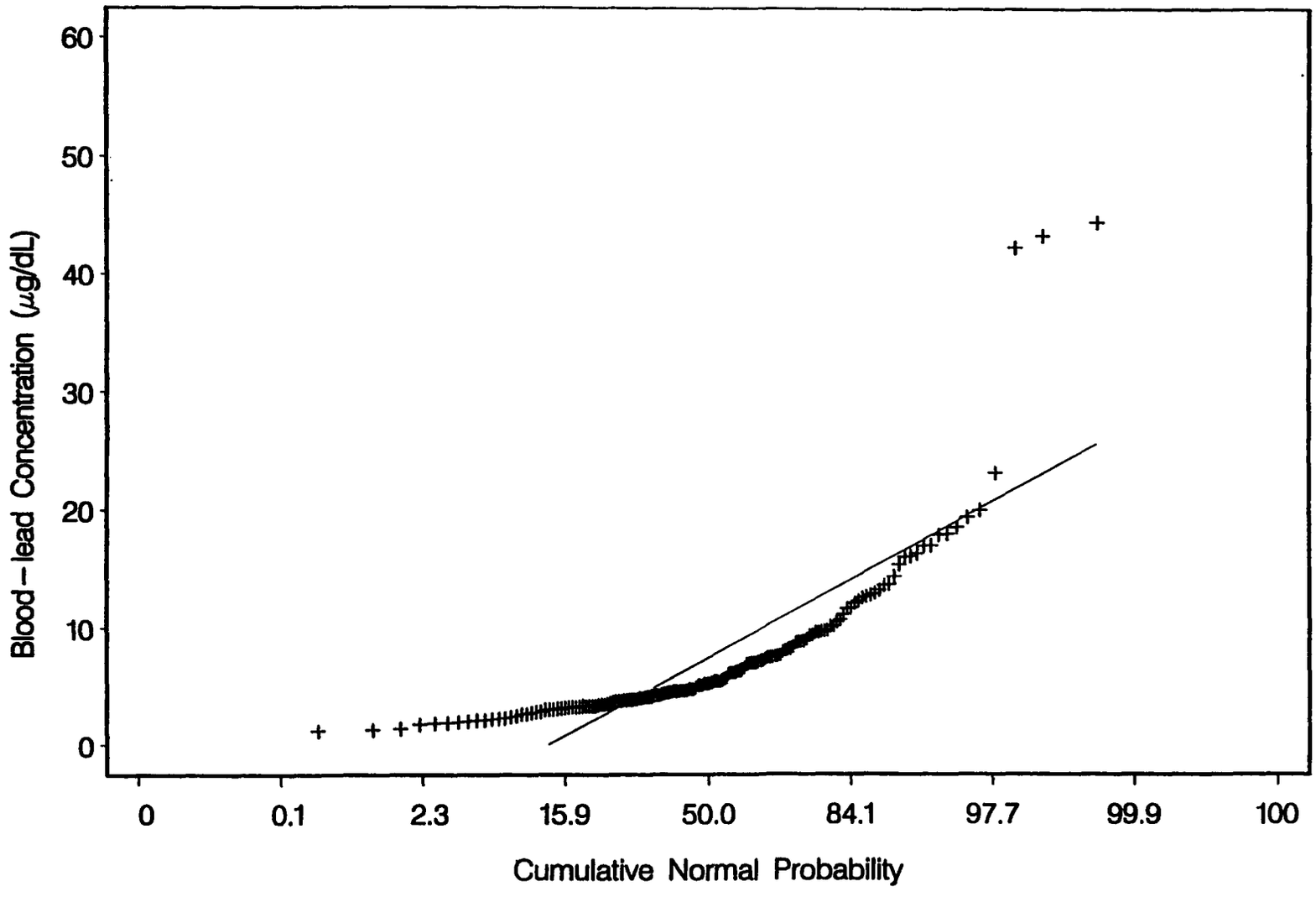

Figure D-1. Normal Probability Plot of Worker Blood-Lead Concentrations (straight line indicates normality).

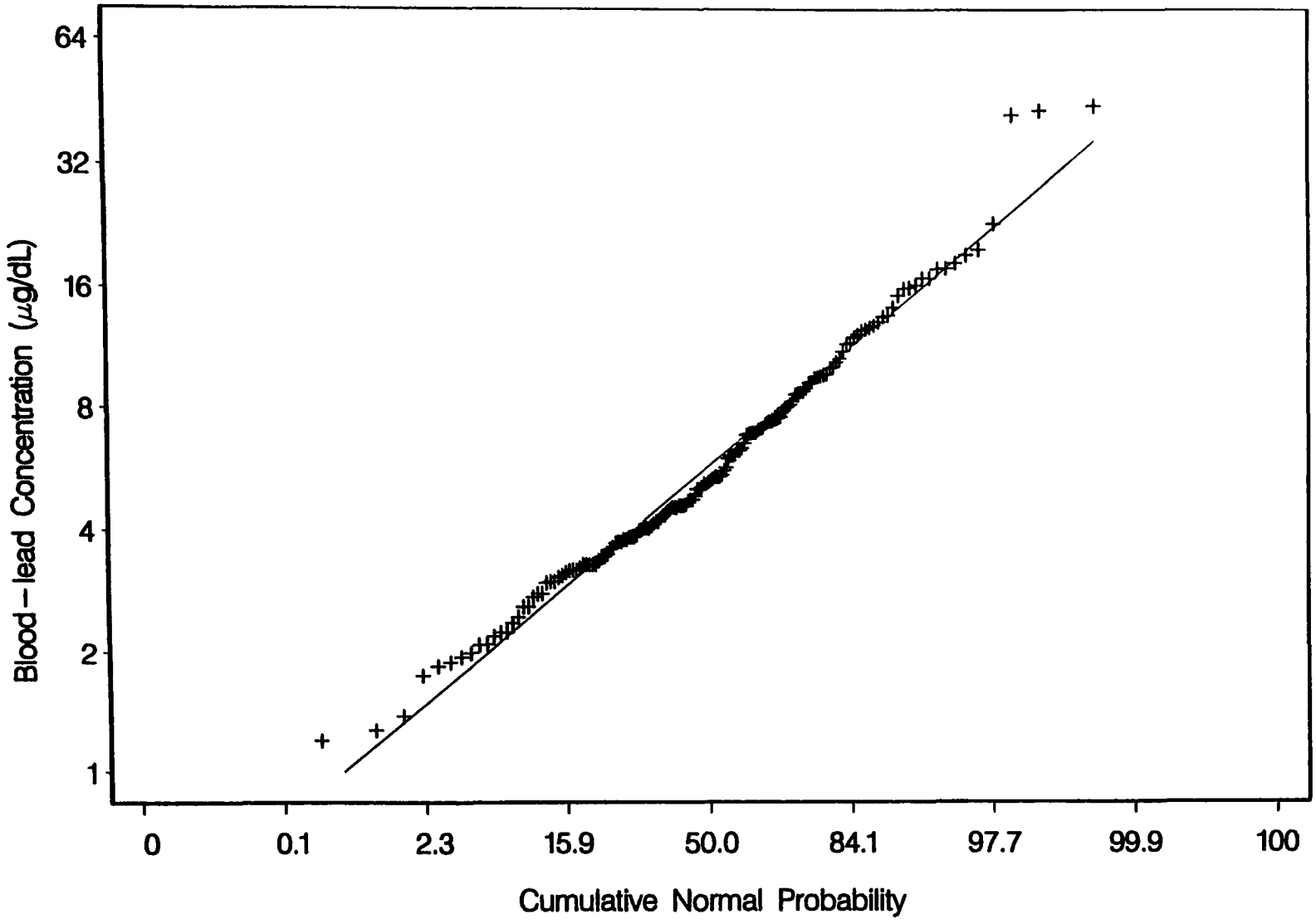

Figure D-2. Semi-log Probability Plot of Worker Blood-Lead Concentrations (straight line indicates normality).

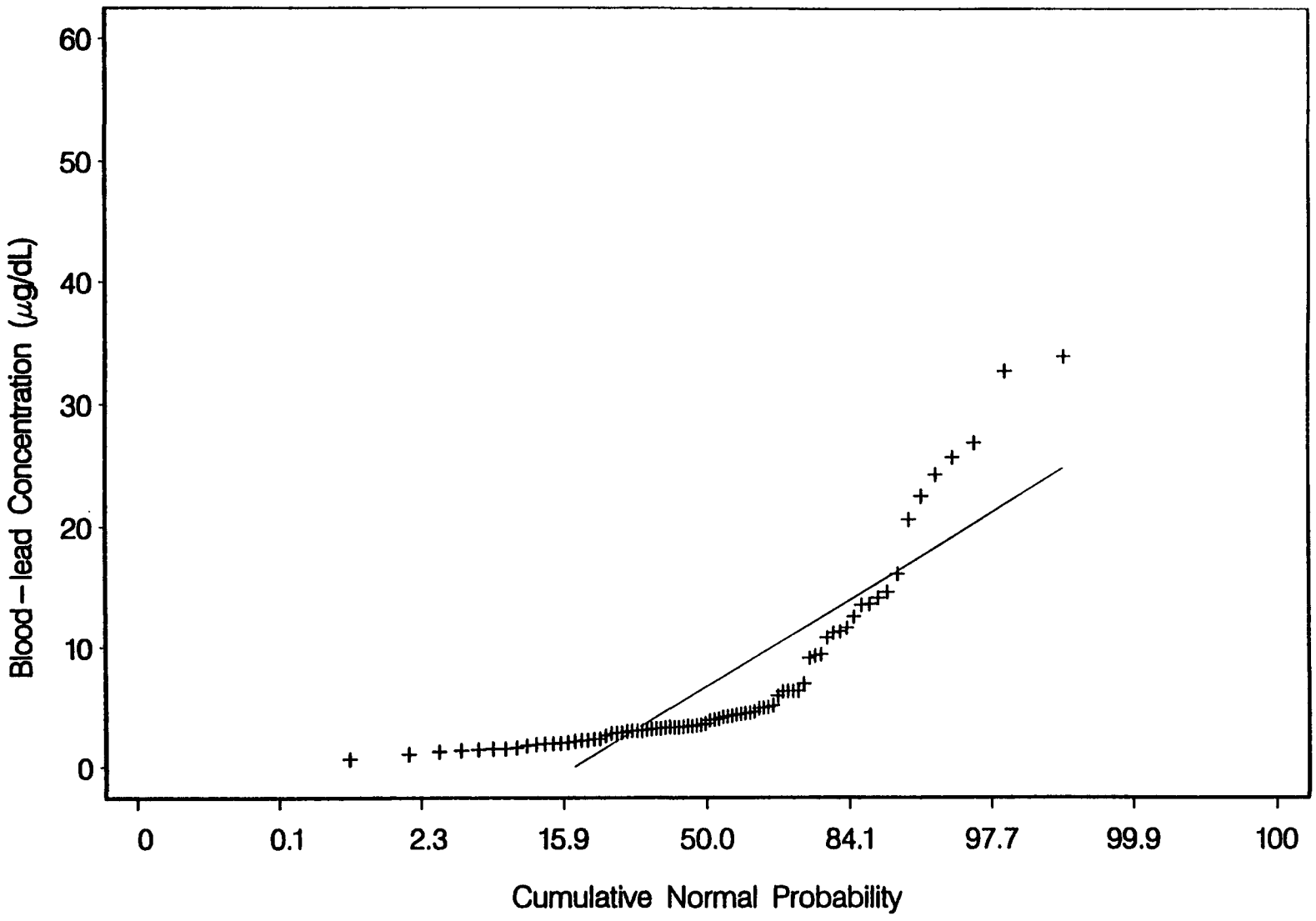

Figure D-3. Normal Probability Plot of Homeowner Blood-Lead Concentrations (straight line indicates normality).

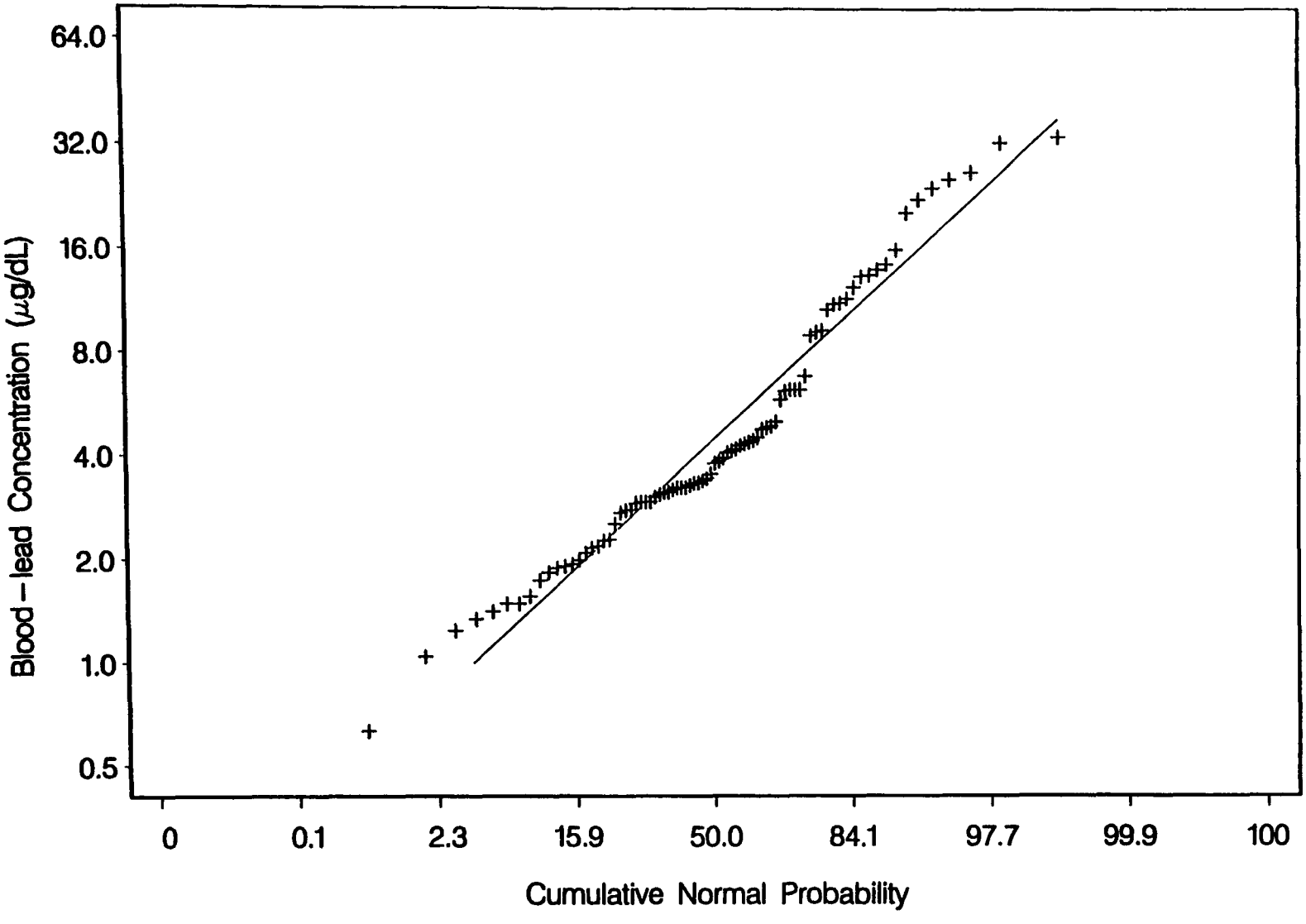

Figure D-4. Semi-log Probability Plot of Homeowner Blood-Lead Concentrations (straight line indicates normality).

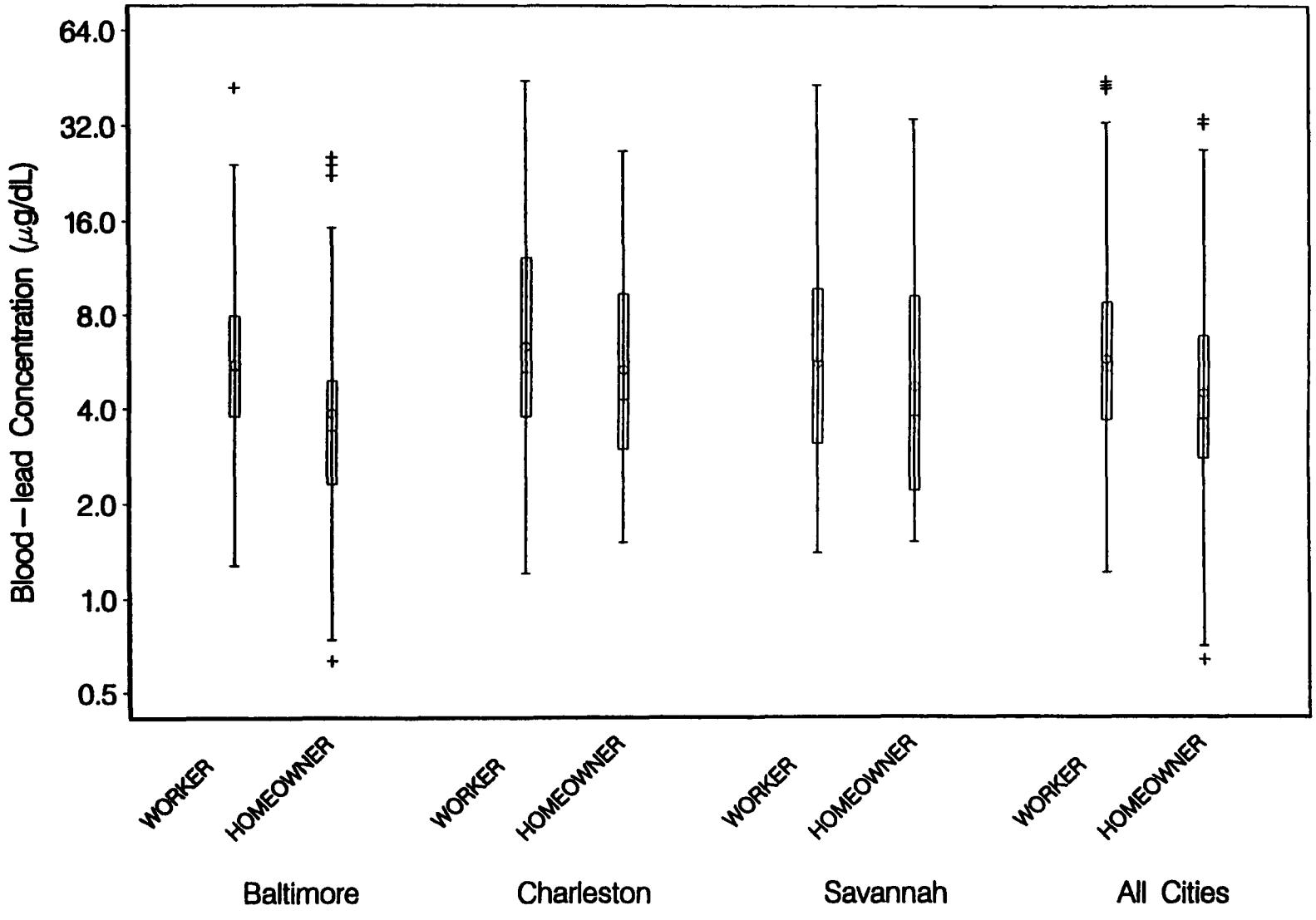

Figure D-5. Boxplot of Blood-Lead Concentrations for Each Study Group and City.

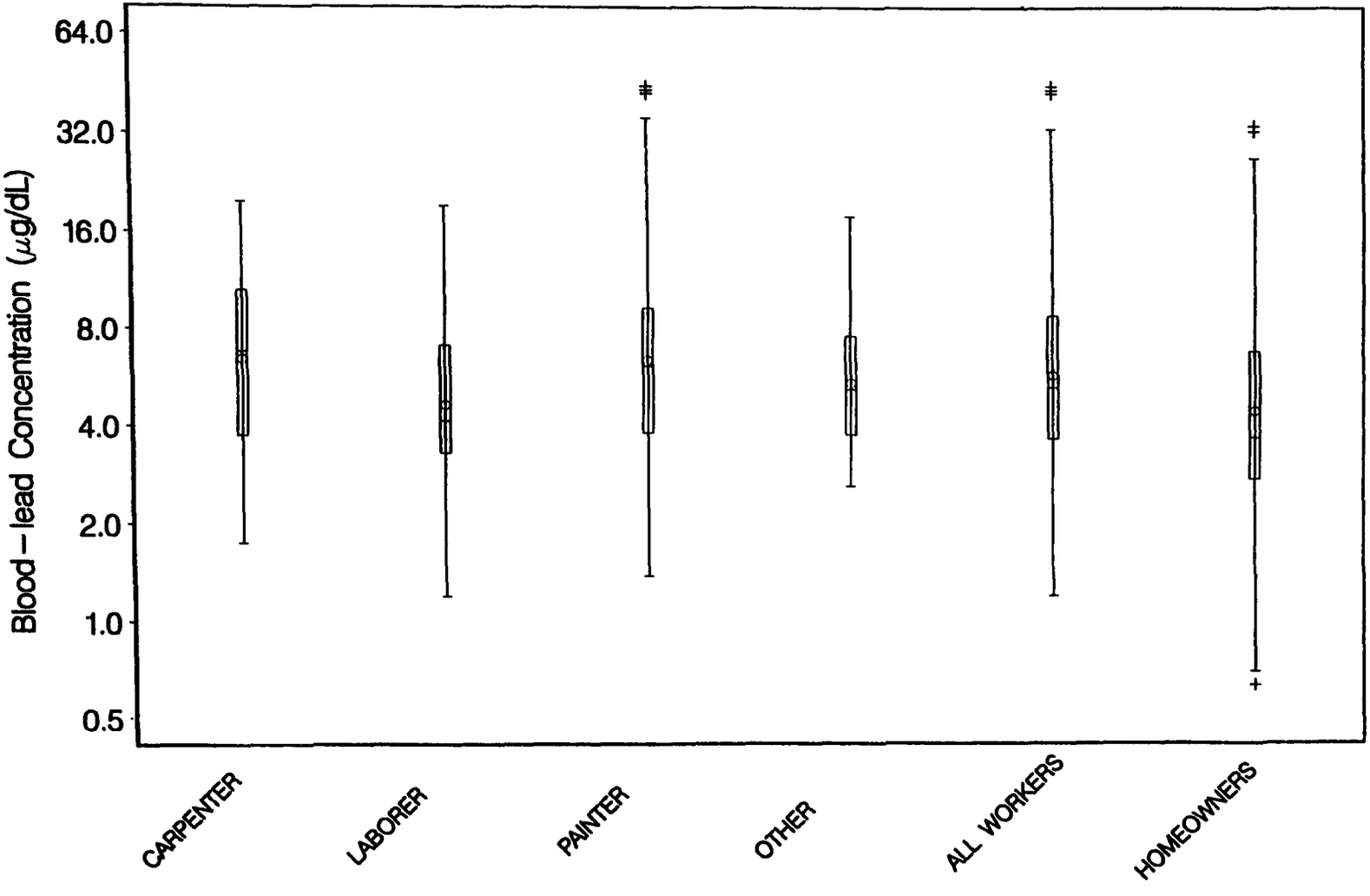

Figure D-6. Boxplot of Blood-Lead Concentrations by Worker Group.

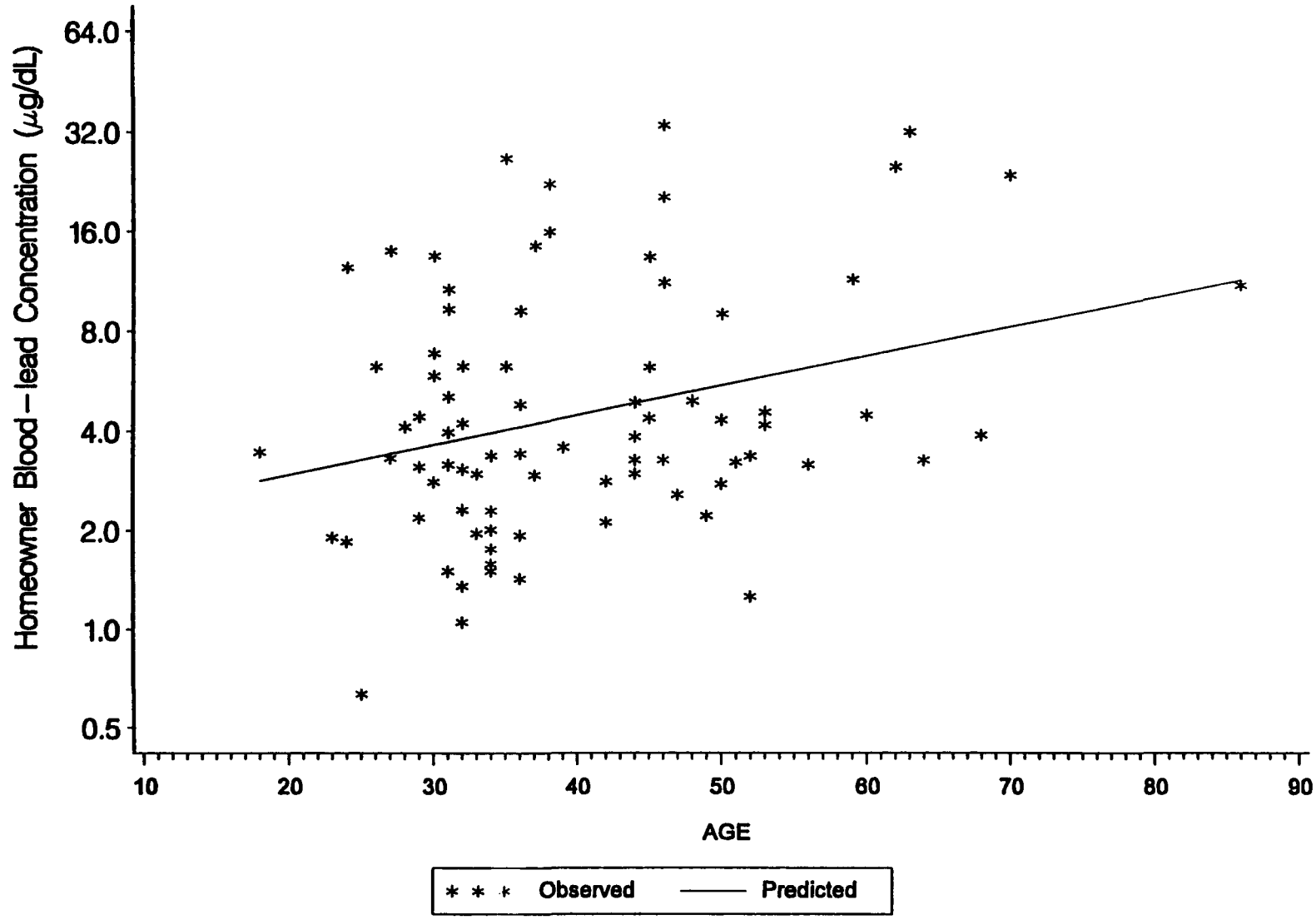

Figure D-7. Scatterplot and Predicted Homeowner Blood-Lead Concentration by Age.

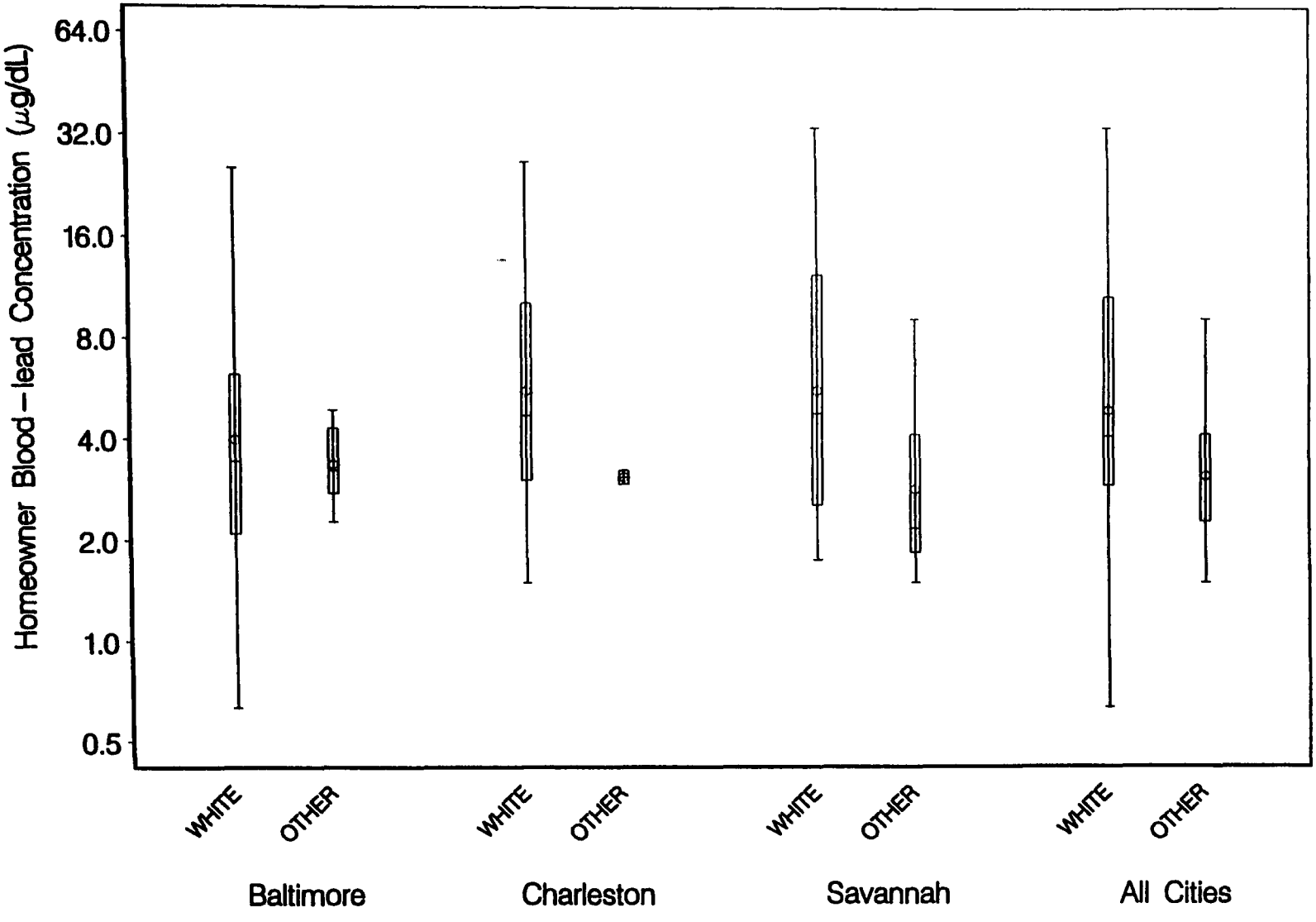

Figure D-8. Boxplot of Homeowner Blood-Lead Concentration by City and Race.

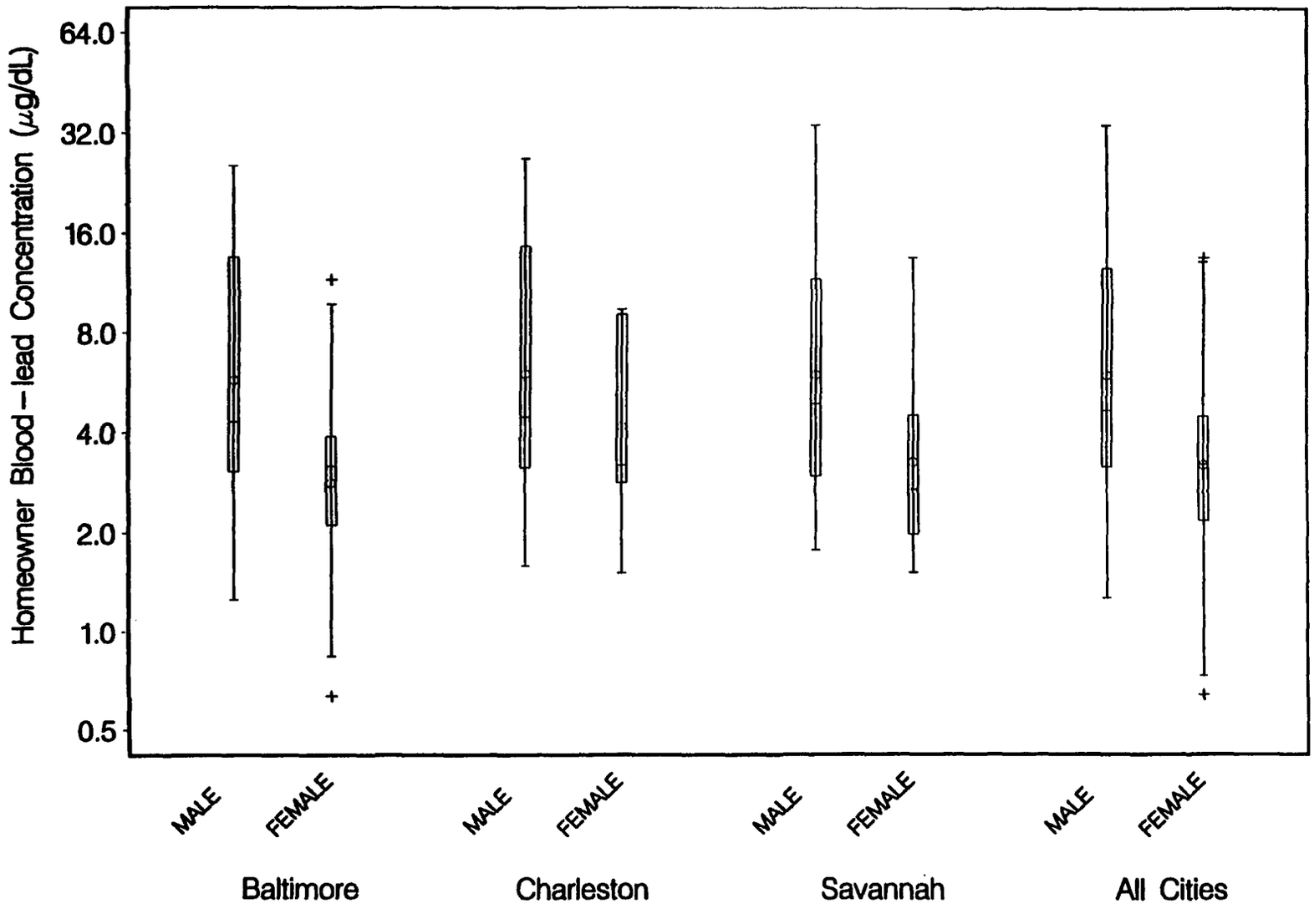

Figure D-9. Boxplot of Homeowner Blood-Lead Concentration by City and Gender.

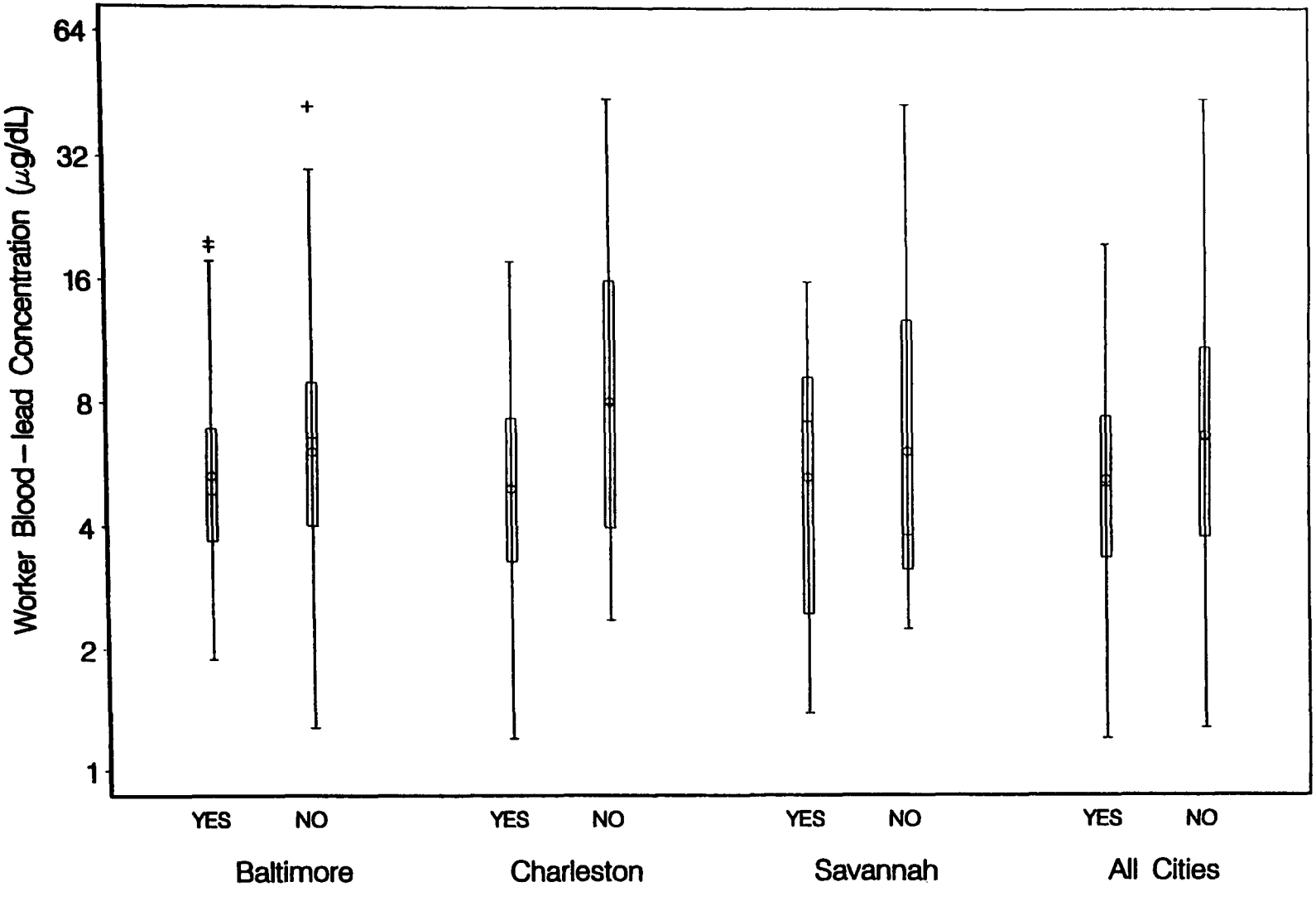

Figure D-10. Boxplot of Worker Blood-Lead Concentration by City and Incidence of Home Renovation/Remodeling in Last 12 Months.

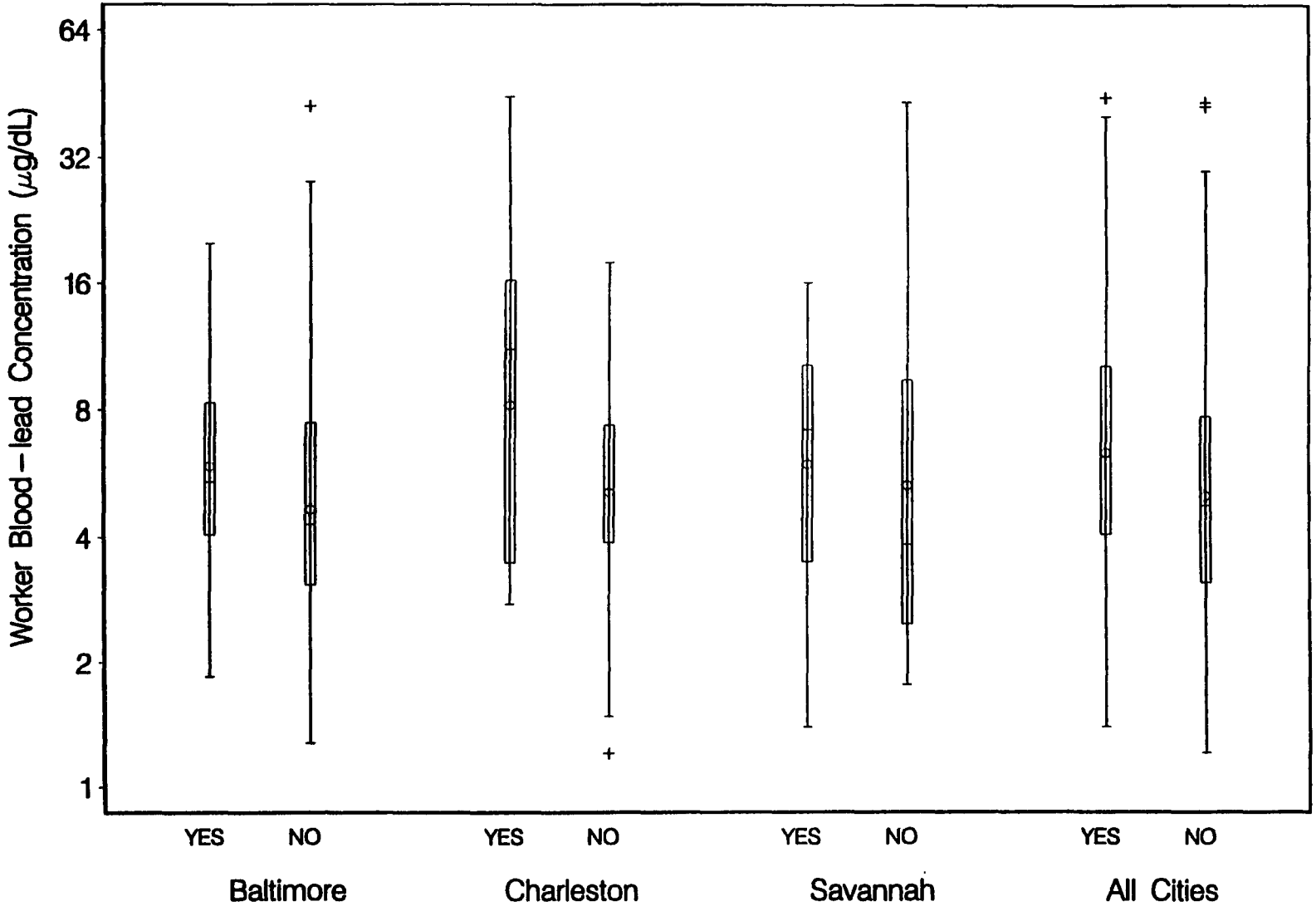

Figure D-11. Boxplot of Worker Blood-Lead Concentration by City and Tobacco Use.

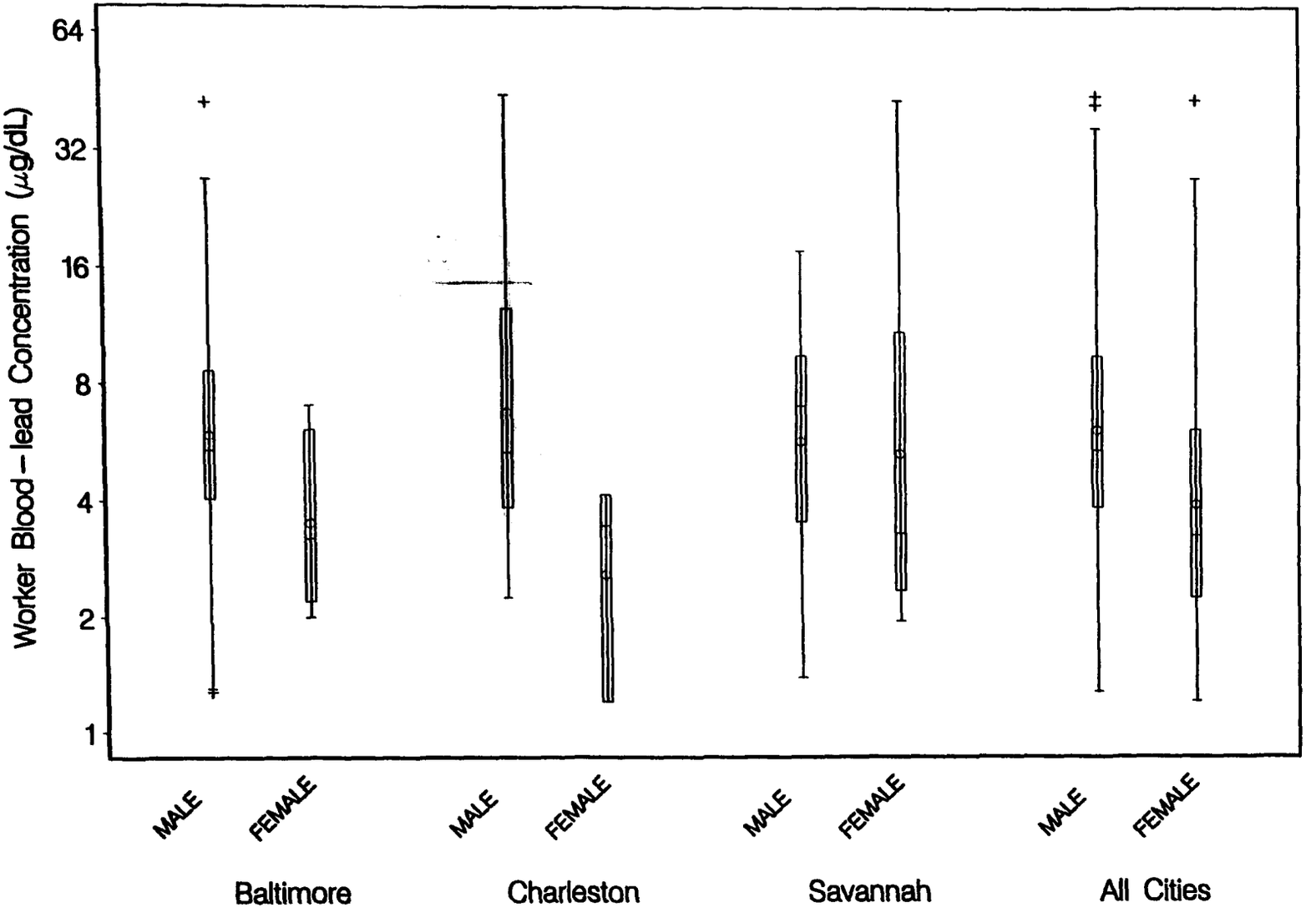

Figure D-12. Boxplot of Worker Blood-Lead Concentration by City and Gender.

APPENDIX E

RECRUITMENT MATERIALS, HUMAN SUBJECTS APPROVAL, AND INFORMED CONSENT

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BATTELLE

NEWS RELEASE

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For Immediate Release

BATTELLE TO EXAMINE BLOOD-LEAD LEVELS IN RENOVATORS AND REMODELERS OF HISTORIC HOMES

Battelle is conducting a study of the potential lead exposure hazards associated with renovating and remodeling old or historic homes.

The study, funded by the U.S. Environmental Protection Agency, will be performed in Charleston, S.C., Savannah, Ga., Baltimore, and Washington, D.C. These cities were selected because of the large numbers of old homes and renovations projects.

Ben Pierce, a Battelle researcher and head of the study, said the object of the study is to determine whether any particular work activities or practices are associated with elevated blood-lead levels.

Pierce is seeking homeowners and workers to participate in the study. Participants are asked to fill out a questionnaire and allow a small blood sample to be taken. Those who participate will receive a stipend of $50.

Lead poisoning can cause neurological and cognitive development problems in children. In adults, lead exposure has been linked to high blood pressure, kidney problems, headaches, fatigue, and stomach problems. Extreme exposure can result in seizures.

Renovators ingest lead through airborne particles in the workplace but can reduce the likelihood of lead exposure by taking precautions such as wearing a respirator, wetting down surfaces before working, avoiding dry power sanding, sealing off work areas, and washing hands before eating.

Interested candidates should contact Battelle Study Manager Joan Huber at 800.444.5234.

Founded in 1929, Battelle is an international technology organization based in Columbus, Ohio. With laboratories and offices around the world, Battelle serves industry and government by developing, commercializing and managing technology. Battelle's primary business areas are environmental, medical, national defense, transportation, and commercial and industrial technology.

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Centers for Public Health
Research and Evaluation
401 N. Lindbergh Boulevard, Suite 330
St. Louis, Missouri 63141-7839
Telephone (314) 993-5234
Fax (314) 993-5163

Renovation and Remodeling Lead Exposure Study

Who's conducting the study and why?

The Battelle Memorial Institute is studying the potential lead exposure hazard associated with renovation, remodeling, restoration and preservation in old or historic homes. The study is being conducted on behalf of the U.S. Environmental Protection Agency (EPA). The objectives of this study are (1) to determine the relationship (if any) between renovation and remodeling activities in historic homes and lead exposure to those doing the work, and (2) to gather information on the types of work activities and work practices engaged in by people who do renovation and remodeling of old or historic homes. The study will take place in Charleston, Savannah and Baltimore.

Who can participate?

Participants in the study will be people who perform the hands-on work of renovation, remodeling, restoration and preservation in old or historic homes. We are looking for workers who make their living at renovation and remodeling, as well as homeowners who are themselves renovating or remodeling their houses.

What will a study participant do?

When a prospective study participant calls the 800 number below, we will ask a few questions to determine if he or she is eligible for the study. If so, we will then ask him/her to come to Johns Hopkins University on June 26 or July 15 at 5501 Hopkins Bayview Circle for a 45-minute data collection session. He/she will complete a questionnaire about his/her renovation and remodeling work history. After completion of the questionnaire, a staff member of the hospital blood lab will collect a small blood sample (approximately 1 tablespoon). The blood sample will later be analyzed for lead content only. We will pay the participant $50 as compensation for completion of the questionnaire and the blood sample.

Is the data collection confidential?

Extensive safeguards will be used to protect the confidentiality of information obtained from this study. A participant identification number will be assigned to each questionnaire and blood sample and will be the only identifier associated with that information.

Who do I call for more information?

You can call Battelle in St. Louis, MO. The toll-free number is 1-800-444-5234.

What is the Battelle Memorial Institute?

Battelle is a research institute founded in 1929 and headquartered in Columbus, Ohio. It has offices around the world engaged in a broad range of science-based services in the areas of commercial and industrial technology, health, environment, national security, and transportation.

ATTENTION: RENOVATORS AND REMODELERS!

DO YOU WORK IN THE HOME RENOVATION AND RESTORATION INDUSTRY?

OR

DO YOU LIVE IN AN OLD OR HISTORIC HOME THAT YOU ARE CURRENTLY RENOVATING OR RESTORING?

YOU MAY BE ELIGIBLE FOR AN IMPORTANT STUDY ON LEAD EXPOSURE!

Workers or homeowners that are renovating/restoring old or historic homes are needed for a landmark research project being conducted by Battelle for the U.S. Environmental Protection Agency. This study will explore the potential for lead exposure among homeowners or workers that have performed remodeling, renovation, and restoration work in old or historic homes.

Eligible respondents will be paid $50 for their participation.

For more information on how you can participate in this study, please call toll free at 1-800-444-5234

DO YOU OWN AN OLD OR HISTORIC HOME? YOU MAY BE ELIGIBLE FOR AN IMPORTANT STUDY ON LEAD EXPOSURE.

Owners of old or historic homes are needed for an important research project being conducted by the Battelle Memorial Institute for the U.S. Environmental Protection Agency. This study will explore the potential for lead exposure among adult homeowners who have performed remodeling, renovation and restoration work on their homes.

Eligible homeowners will receive $50 for their participation.

You could be eligible if your home meets the study criteria, and you have performed renovation and remodeling work on it.

For more information on how you can participate in this study, please call toll free at 1-800-444-5234 Monday through Friday 9:00 am - 6:00 pm.

HOME RENOVATION AND RESTORATION WORKERS!

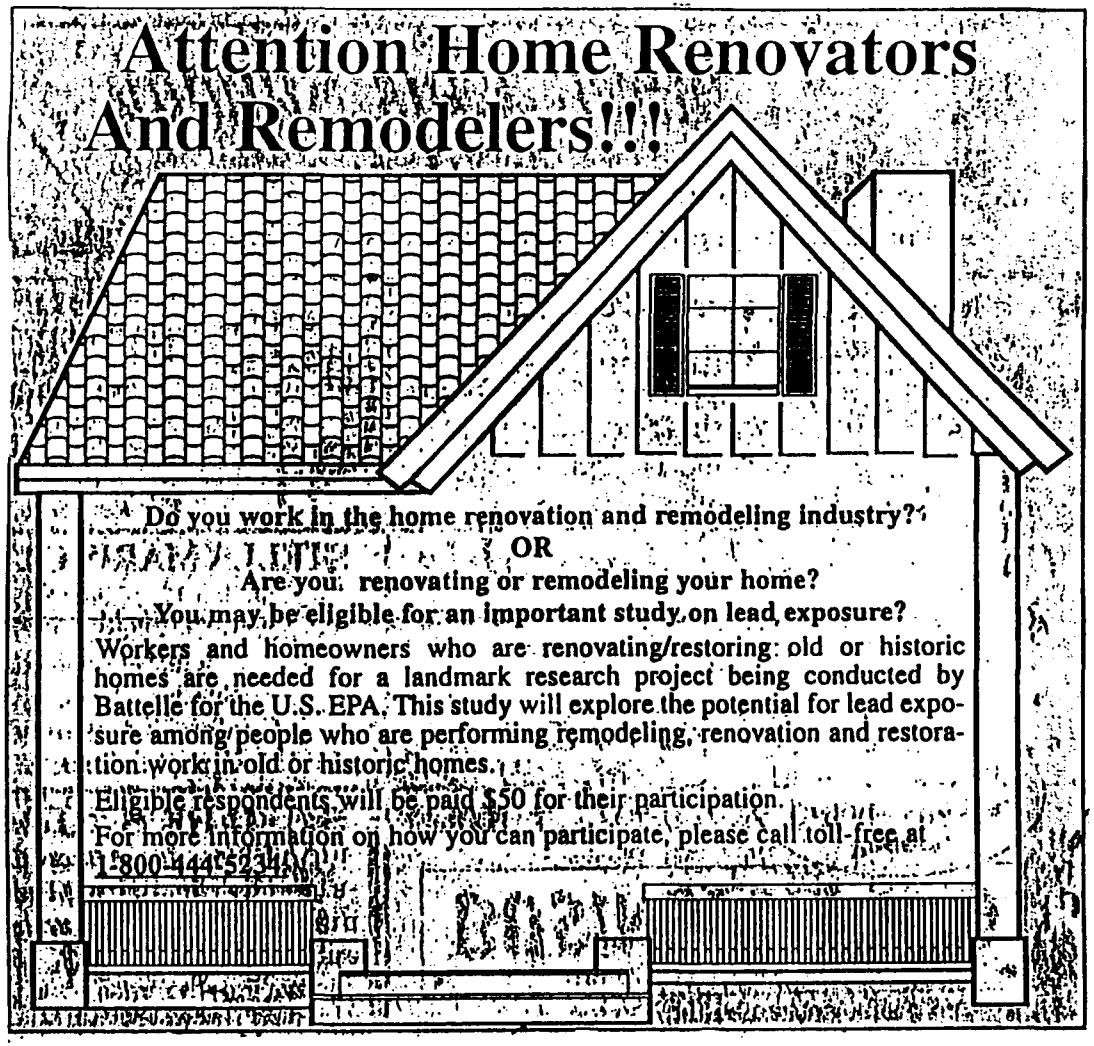
Workers in the home renovation and restoration industries are needed for a landmark research project being conducted by the Battelle Memorial Institute for the U.S. Environmental Protection Agency. This study will explore the potential for lead exposure among carpenters and laborers who work in old or historic homes.

Eligible workers will be paid $50 for their participation.

You could be eligible if you work in the preservation, restoration, renovation and remodeling of old or historic homes.

For more information on how you can participate in this study, please call toll free at 1-800-444-5234 Monday through Friday 9:00 am - 6:00 pm.

Attention Home Renovators And Remodelers!!!



Do you work in the home renovation and remodeling industry?

OR

Are you renovating or remodeling your home?

You may be eligible for an important study on lead exposure?

Workers and homeowners who are renovating/restoring old or historic homes are needed for a landmark research project being conducted by Battelle for the U.S. EPA. This study will explore the potential for lead exposure among people who are performing remodeling, renovation and restoration work in old or historic homes.

Eligible respondents will be paid $50 for their participation.

For more information on how you can participate, please call toll-free at 1-800-444-5234.

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Survey Research Associates, Inc.
100 Capitola Drive, Suite 301
Durham, North Carolina 27713
Tel 919-544-3717
Fax 919-544-0830

February 6, 1997

Patricia Henderson
401 N. Lindbergh Blvd, Suite 330
St. Louis, Missouri 63141-7816

Dear Ms. Henderson;

I have reviewed the revisions as requested by the Battelle/SRA Institutional Review Board (IRB) for the study protocol entitled "Worker Characterization & Blood-Lead Study of Renovation & Remodeling Workers in Historic Homes" (FG002889YS) and find the revisions acceptable. You also have made a minor modification in the study population to include homeowners who are doing their own renovations. This modification is acceptable. You are therefore granted approval to proceed with this study.

As with all SRA studies, this study will be subject to an annual IRB review at the end of next year. We will send you the necessary form for annual review at the appropriate time. In the meantime, should any changes occur in your protocol or questionnaire, please inform the IRB. Similarly, the IRB needs to be notified in the event of any injury or unexpected outcome arising from this study.

I wish you the best in your study.

Sincerely,

Margaret Pennybacker

Margaret R. Pennybacker, Ph.D.
IRB Chair

cc: Charlotte Coley

Survey Research Associates, Inc. (SRA)
100 Capitola Drive, Suite 301
Durham, NC 27713

INSTITUTIONAL REVIEW BOARD NOTICE OF APPROVAL

PROJECT DIRECTOR: Patricia M. Henderson

TITLE: Worker Characterization & Blood-Lead Study of Renovation & Remodeling Workers in Historic Homes

CLIENT: EPA & Battelle/ESTD PROTOCOL DATE: 12/4/96

SRA PROJECT CODE: SG002889YS or PROPOSAL NUMBER: _ *(if preaward)*

NATURE OF REVIEW: *(check one)*

- [X] FULL → MEETING DATE: 12/18/96
- [ ] EXPEDITED *(specify reason)*: _____
- [ ] EXEMPT *(specify reason)*: _____

TYPE OF APPROVAL: *(check one)*

- [ ] PRELIMINARY. SCHEDULE NEXT REVIEW PRIOR TO INVOLVEMENT OF HUMAN SUBJECTS.
- [ ] PRETEST/PILOT TEST. SCHEDULE NEXT REVIEW PRIOR TO FULL IMPLEMENTATION.
- [X] FULL IMPLEMENTATION.
- [ ] RENEWAL
- [ ] AMENDMENT DATED / /

Please note the following requirements:

PROBLEMS OR ADVERSE REACTIONS: If any problems in treatment of human subjects or unexpected adverse reactions occur as a result of this study, you must notify the IRB Chairperson immediately.

CHANGES IN PROTOCOL: If there are significant changes in procedures or study protocol, you must notify the IRB Chairperson before they are implemented.

RENEWAL: You are required to apply for renewal of approval at least annually for as long as the study is active. Your next review date should be on or before 12/18/97.

Barbara A. Moser 12/18/96

IRB Chairperson Date

Barbara A. Moser
Print or Type Name

X Copy of approved Informed Consent attached.

cc: Project Director
IRB Administrator

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Survey Research Associates, Inc.
100 Capitale Drive, Suite 301
Durham, North Carolina 27713
Tel 919-544-3717
Fax 919-544-0830

December 20, 1996

Patricia Henderson
401 N. Lindbergh Blvd, Suite 330
St. Louis, Missouri 63141-7816

Dear Ms. Henderson;

The Battelle/SRA Institutional Review Board (IRB) has reviewed the protocol for the study entitled "Worker Characterization & Blood-Lead Study of Renovation & Remodeling Workers In Historic Homes" (SG002889YS) and requests some revisions prior to granting you approval to proceed with this study.

Please revise the following:

1. Add an IRB contact to the informed consent.

2. Delete the statement "in keeping with legal requirements" form the informed consent, as it is unclear what this means.

3. Please check what states require reporting of blood-lead levels and what is done with this information; and include this information in the informed consent. If the process differs from state to state, please develop appropriate informed consents for each.

4. On your protocol application, stipend given to subjects can not be considered a benefit of the study. Please revise that page and delete that reference.

5. State the amount of blood to be drawn in lay terms, i.e., teaspoons vs. ml.

The Board also had several comments/suggestions:

1. Define OSHA.

2. On page 3 of the protocol application, please also check the box for biological specimens.

3. The directions for the self-administered questionnaire reference an advance letter, but one was not included. Please revise the directions to delete this reference.

Work can not begin on joint SRA/CPHRE projects until both the SRA IRB and the Battelle Human Subjects Committee (HSC) have reviewed the protocol and approved it. I will forward the necessary materials to the Battelle HSC for review after the above revisions have been made and will notify you as soon as I receive the decision of the Battelle HSC.

As with all SRA studies, this study will be subject to an annual IRB review at the end of next year. We will send you the necessary form for annual review at the appropriate time. In the meantime, should any changes occur in your protocol or questionnaire, please inform the IRB. Similarly, the IRB needs to be notified in the event of any injury or unexpected outcome arising from this study.

I wish you the best in your study.

Sincerely,

Barbara A. Moser
IRB Chair

cc: M.R. Pennybacker
C.H. Coley

STUDY ID: _____

ENVIRONMENTAL PROTECTION AGENCY WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY OF RENOVATION AND REMODELING WORKERS IN HISTORIC HOMES

INFORMED CONSENT DOCUMENT

The U.S. Environmental Protection Agency (EPA) has contracted with Battelle/Survey Research Associates (Battelle/SRA) to study the lead exposure hazard associated with renovation and remodeling in historic HOMES. The objectives of this study are to (1) characterize the relationship (if any) between renovation and remodeling activities in historic HOMES and worker blood-lead levels, and (2) gather information on the types of work activities and work practices engaged in by renovation and remodeling workers.

As a participant in this study, you will be asked to complete a questionnaire that includes information relevant to lead exposures on (a) work history (both current and long term); (b) personal characteristics and habits related to lead exposure; (c) non-work activities; and (d) knowledge on lead. After completion of the questionnaire, a trained and licensed phlebotomist will collect a 1.5 ml blood sample which will later be analyzed for blood-lead content only. We estimate that it will take approximately 40 minutes for completion of the questionnaire and collection of the blood sample. What we learn about the relationship of blood-lead levels to renovation and remodeling activities in historic HOMES will help EPA determine what, if any, guidance is needed for renovation and remodeling workers.

If you would like a summary of study results and the result of your blood-level measurement, please check here. ☐

There is currently no established minimum acceptable level of lead in the bloodstream. OSHA has established 50 µg/dl as the blood-lead level at which workers must be removed from jobs having significant lead exposures. Some states require that a blood-lead measure in adults greater than or equal to 25 µg/dl be reported to the state registry. If your blood-lead measure is greater than or equal to 25 µg/dl, we will attempt to notify you of this regardless of whether you requested your results. We will also pay you $25.00 as compensation for completion of the questionnaire and $25.00 for collection of the blood sample.

Risks: The risk incurred by participation in this study is the risk associated with having a venous blood sample drawn. The sample will be drawn by a licensed and trained phlebotomist using standard procedures and precautions including the use of a new sterile syringe and needle for every blood draw. However, there is a slight risk of local infection and you may experience discomfort, bruising, and/or bleeding at the site of the needle insertion, or feel dizzy, faint or upset to your stomach.

Confidentiality: All reasonable efforts will be made to protect the confidentiality of information obtained from this study in keeping with legal requirements. A participant identification number will be assigned to your questionnaire and blood sample and will be the only identifier associated with that information. The file listing participant's names and their participant identification number will not be released outside of Battelle/SRA.

If you have any questions or comments regarding this study, or if you experience and difficulties as a result of participation in this study, please contact: Mr. Bennett Pierce, Battelle, 2115 East Jefferson Street, Suite 400, Rockville Maryland 20852. His phone number is (301) 770-2280. You may also call the Battelle/SRA Study Manager, John Egel, at (314) 993-5234.

YOU HAVE THE RIGHT TO WITHDRAW FROM PARTICIPATION IN THIS STUDY AT ANY TIME WITHOUT PENALTY TO YOUR COMPENSATION

Battelle/SRA will retain a copy of this Informed Consent Document. A copy of this form will also be provided to you upon completion of the study.

I consent to participate in this study by completing the associated questionnaire and allowing a venous blood sample to be collected.

I, _____, UNDERSTAND THE NATURE OF THIS STUDY AND AGREE TO PARTICIPATE.

_____ _____

SIGNATURE DATE

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA-747-R-99-001	2.	3. Recipient's Accession No.
4. Title and Subtitle "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"			5. Report Date March 1999 6.
7. Author(s) Bennett Pierce, Patricia Henderson, Joan Huber, and Patrick Kiser			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Battelle Memorial Institute 505 King Avenue Columbus, Ohio 43201-2693			10. Project/Task/Work Unit No. G003470-05 11. Contract(C) or Grant(G) No. (C) 68-D5-0008
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics (7401) 401 M Street, S.W. Washington, D.C. 20460			13 Type of Report & Period Covered Final Report 14.
15. Supplementary Notes			

16. Abstract (Limit 200 words)

(Section 402(c)) of Title IV of the Toxic Substances Control Act, enacted in 1992, required EPA to conduct a study of lead exposure associated with renovation and remodeling activities (R&R Study). This report documents Phase IV of that study.

Phase IV was designed as a follow-on study to Phase II. Questionnaire and blood-lead measurements were collected from 161 R&R workers and 82 homeowners at high-risk for lead-exposure because they perform R&R in older homes that typically contain lead-based paint. Target R&R activities examined in Phase IV included removal of large structures (demolition), window replacement, carpet removal, paint removal/surface preparation, and post-activity cleanup.

Overall, the blood-lead data indicate that Phase IV study participants were more highly exposed to lead than R&R workers who do not specialize in R&R of older homes. The geometric mean blood-lead concentrations were 5.73 μg/dL for workers and 4.45 μg/dL for homeowners.

Statistical models indicate that there was a significant relationship between the conduct of certain R&R activities and blood-lead concentrations. Among homeowners, paint removal/surface preparation was positively associated with blood-lead concentrations For workers, the models indicated that worker blood-lead concentrations were associated with: cleanup, paint removal/surface preparation, carpet removal, and replacing window or door casements.

17. Document Analysis

a. Descriptors: Blood-lead concentration, renovation and remodeling, workers, homeowners, survey

b. Identifiers/Open-Ended Terms: Section 402, Renovation and Remodeling Study

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release Unlimited	Unclassified	181
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(See ANSI-239.18)

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