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LEAD EXPOSURE ASSOCIATED WITH RENOVATION AND REMODELING ACTIVITIES:

WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY

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Contributing Organizations

This study was funded and managed by the U.S. Environmental Protection Agency. The study was conducted collaboratively by two organizations under contract to the Environmental Protection Agency, Battelle, and Midwest Research Institute. Each organization's responsibilities are listed below.

Battelle

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

Midwest Research Institute (MRI)

MRI was responsible for chemical analysis and quality assurance for blood-lead chemical analysis.

U.S. Environmental Protection Agency

The Environmental Protection Agency was responsible for oversight in developing the study plan, managing and coordinating the study, and reviewing and editing this report. EPA Project Managers included Dan Reinhart and Darlene Watford. Cindy Stroup was the Branch Chief of the Technical Programs Branch under whose direction the study was conducted.

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United Brotherhood of Carpenters

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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 (R&R) activities (the R&R study). Information obtained from the R&R study is to be used to help determine which groups of R&R workers require training, certification, or educational materials because of the potential lead exposure resulting from the R&R activities they perform. This report presents the results of one of the principal data collection efforts in the R&R study: the Worker Characterization and Blood-lead Study (WCBS). The primary goal of the WCBS was to collect data and information that would permit an assessment of the relationship between R&R activities and lead exposure to the R&R workers conducting the activities. The study surveyed two groups of workers (union carpenters and employees of independent contractors) in two cities (Philadelphia, Pennsylvania, and St. Louis, Missouri). The collected data included

1. Worker blood samples that were chemically analyzed for lead concentration

2. Questionnaire data on demographics, the extent to which specific R&R work activities were conducted, work practices, previous training on or knowledge about lead, and non-work activities and personal characteristics that are potentially related to lead exposure.

Questionnaires were collected from a total of 585 workers. The questionnaire results indicated that:

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

2. 90% of the workers did not use a respirator.

3. 88% of the workers did not use cleanup methods recommended for use in a lead-contaminated environment, and 99% used dry sweeping.

4. 97% of the workers used dry methods for paint removal.

5. 67% of the workers had not received any materials on lead hazards, and 87% has received no lead exposure training.

Blood samples were collected from 581 of the 585 workers. Worker blood-lead concentrations were generally low: 9.1% were above 10 µg/dL, 1.2% were above 25 µg/dL, and only one worker had a blood-lead concentration greater than 40 µg/dL. The geometric mean blood-lead concentration for all workers was 4.5 µg/dL.

A statistical model was developed and fit to the data that included effects for variables potentially related to lead exposure, such as education level, smoking status, and age of worker's home; worker group; and the amount of R&R activity conducted during the past 30 days, last year, and over the worker's career. Although blood-lead concentrations predicted by the model for each worker group studied were low, there were significant differences among the worker groups. Drywall workers and painters had the highest predicted blood-lead concentrations, and floor layers had the lowest.

1.0 INTRODUCTION TO THE OVERALL RENOVATION AND REMODELING STUDY

Lead poisoning has long been recognized as one of this country's most important environmental health problems. With the phase-out of lead in gasoline, lead-based paint is now the primary source of lead exposure, particularly for children and construction workers. Federal programs undertaken to understand and mitigate the lead exposure associated with lead-based paint have focused on 1) deteriorated lead-based paint, and 2) methods of abatement. Therefore, exposure data for both renovation and remodeling (R&R) workers and building occupants tend to be related to either the presence of deteriorated paint or the occurrence of abatement.

However, disturbance of *intact* lead-based paint surfaces by R&R activities (conducted with no abatement intent) may also result in lead exposure for both R&R workers and building occupants. In fact, extensive R&R is often performed in older homes or public buildings with a high probability of containing lead-based paint. Workers in many of these homes may not be aware of a potential lead problem.

To address potential lead exposure associated with R&R, the United States Congress directed the U.S. Environmental Protection Agency (EPA) Administrator to conduct a study of lead exposure associated with R&R activities. The 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). The results of this study, hereafter referred to as the R&R study, are documented in three reports:

- "Lead Exposure Associated With Renovation and Remodeling Activities: Summary Report," containing overall study results
- "Lead Exposure Associated With Renovation and Remodeling Activities: Environmental Field Sampling Study (EFSS)," a technical report on the results of one component of the R&R study
- "Lead Exposure Associated With Renovation and Remodeling Activities: Worker Characterization and Blood-Lead Study (WCBS)," a technical report on the results of the WCBS, a second component of the R&R study.

Chapter 1 of this report includes a discussion of the overall design of the R&R study and the complementary roles of its two principal data collection efforts: the WCBS and the EFSS. Subsequent chapters deal only with the design, implementation, and results of the WCBS.

1.1 OBJECTIVES OF THE R&R STUDY

The primary purpose of the R&R study was to help determine which groups of people require training, certification, or educational materials because of their potential lead exposure. In particular the study was designed to satisfy two technical objectives:

1. Determine the extent to which persons engaged in various types of R&R activities in target housing, public buildings constructed before 1978, and commercial buildings are exposed to lead.

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

1.2 SCOPE OF THE R&R STUDY

The broad scope of the study mandated by Title X, along with time and budget constraints, led to a design strategy that required multiple targeted field studies. Decisions had to be made on priorities, focus, and representativeness. Details on the decisions related to delineating the scope of this study, including key definitions and specification of populations, environments and target activities, are given in Chapters 1 and 2 of the EFSS Technical Report.

A list of R&R activities associated with lead exposure was assembled by the EPA. As a result of over 200 interviews with other government agencies, lead poisoning prevention experts, industry representatives, labor unions, and other concerned groups. From input obtained in a summary meeting with several of these contacted individuals, the EPA defined eleven categories of R&R activity with potential for lead exposure that could be addressed by this study. These activities, subsequently called ***target activities***, were

1. Paint removal
2. Surface preparation
3. Removal of large structures
4. Window replacement
5. Enclosure of exterior painted surfaces (i.e., siding)
6. Carpet or other floor covering removal
7. Wallpaper removal
8. HVAC repair or replacement including duct work
9. Repairs or additions resulting in isolated small surface disruptions
10. Exterior soil disruption
11. Large renovation projects involving multiple target activities.

The data collection effort in the EFSS focused on the following six target activities: removal of large structures (interior demolition), window replacement, carpet removal, HVAC repair or replacement, surface preparation, and repairs resulting in limited surface disruption. Target activities examined in the WCBS included window replacement, carpet removal, removal of large structures (demolition), HVAC repair or replacement, and paint removal. Post-activity cleanup was also observed.

1.3 OVERALL APPROACH TO THE R&R STUDY

The R&R study consisted of three phases:

1. An information gathering and literature review phase to uncover the existing body of information concerning lead exposure related to R&R activity. The major conclusion of this phase was that, with the exception of paint removal, little data was available.

2. The EFSS, which involved assessing the relative disturbance of and potential exposure to lead associated with selected R&R activities by measuring lead in air and dust.

3. The WCBS, which used questionnaire information and blood-lead measurements to determine if specific worker groups or specific R&R activities are associated with increases in blood-lead levels.

A follow-on study to assess the relationship between incidence of R&R activity and elevated blood-lead concentration in children is currently in the design stages.

Discussion of the decision process related to environmental measurements versus blood-lead measurements is given in the EFSS Technical Report. The EFSS and WCBS were part of an overall design strategy to address the broad scope of the R&R study. This strategy included:

1. Use of the EFSS to relate environmental exposure estimates to specific R&R activities. These activity-specific exposure estimates could then be used, along with worker profile information, as building blocks for constructing exposure assessments for a wide variety of R&R worker groups.

2. Use of the WCBS results to

    a. Assess the health effect (internal dose) associated with exposure to R&R activities for a subset of activities and worker groups
    b. Validate the EFSS environmental exposure (potential dose) measurements
    c. Provide worker profile information for a subset of R&R worker groups.

The overall design of the R&R study is presented in Figure 1. Information from the WCBS was combined with the EFSS results in a summary report to help determine which groups of people require training, certification or educational materials because of the potential lead hazard associated with renovation and remodeling activities they perform. This report presents the technical results of the WCBS.

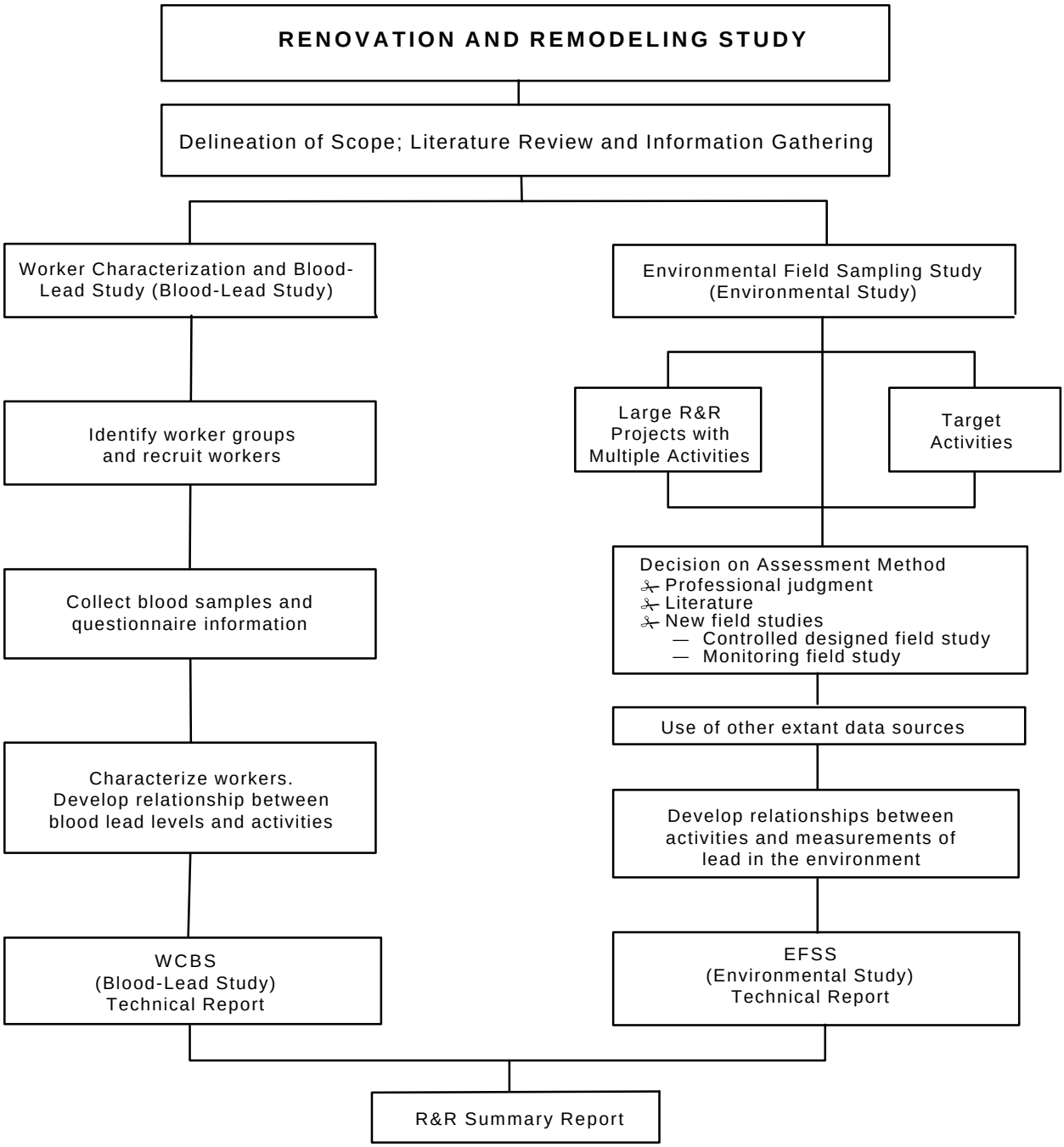

Figure 1. Overall Design Structure of the Renovation and Remodeling Study

1.4 OVERVIEW OF THE WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY

The WCBS involved a targeted survey of two groups of renovation and remodeling workers (union carpenters and employees of independent contractors) in two cities (Philadelphia, Pennsylvania, and St. Louis, Missouri). The data collected included:

1. Worker blood samples that were chemically analyzed for lead

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

The questionnaire data included information relevant to lead exposures on (a) demographics (b) work history (both current and long-term) (c) personal characteristics and habits (d) non-work activities (e) medical history and (f) previous training or knowledge on lead.

Statistical models were used to determine if there were significant associations between blood-lead levels and various target activities. The questionnaire data were used to characterize the extent to which workers perform specific activities and use specific work practices. The questionnaire data also were used to control for potential confounding factors when interpreting blood-lead levels, such as smoking and the age of a worker's residence.

1.5 PEER REVIEW

This report on the Worker Characterization and Blood-Lead Study (WCBS) 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. All peer reviewers recommended publishing the report with minor revisions.

Concern was expressed over the inability to collect both blood-lead and environmental lead measurements from the same group of workers and/or occupants. Human subjects review, for both ethical and legal reasons, would not allow measuring blood-lead concentrations for occupants (young children) before and after conduct of an activity that was suspected of causing a hazard. For workers, the difficulty in this study was *recruiting* typical R&R workers operating in an unregulated environment. For this group of workers, employers were very reluctant to participate even as the study was conducted. Contractors were concerned over lawsuits by workers in the event that the study revealed a worker's blood-lead increased as a result of a specific job they were assigned to. We had very few contractors participating in either phase of the study. Employees participated in the WCBS largely because of either their own interest or the interest and encouragement of their national and local union. Gaining access to work sites for environmental and biological sampling would have required participation of the contractors, homeowners, and workers. If such sampling was conducted under forced cooperation, then the results may have been biased. If the study had focused on lead abatement workers this may not have been a problem, but with a focus on typical R&R workers who were not, at the time of this study, using worker protection practices, there were many problems recruiting contractors to

participate. In short, the difficulty in recruiting contractors was in getting at the population of interest: unregulated R&R workers not specializing in lead abatement.

One reviewer requested more information to show that the QC data are consistent with the statistical analysis applications and results. As a result of this comment, more documentation was added to the report and inconsistencies in the presentation of QC results were resolved and clarified.

Another reviewer questioned the basis for using 1950 as the dividing line between older (meaning greater likelihood of lead exposure) and newer buildings. Prevalence statistics from the HUD National Survey ("Report on the National Survey of Lead-Based Paint in Housing," U.S. EPA, EPA 747-R-95-003, April, 1995) were used as the basis for selecting 1950 as the dividing line between older (greater likelihood of lead exposure) and newer buildings. Although lead paint was used well into the 1970s, the HUD National Survey indicates that homes built prior to 1950 contain significantly higher levels of lead in paint, dust, and soil, than homes built after 1950. In general, the likelihood of lead-based paint, and other indicators of lead contamination such as dust-lead levels, increase with the age of housing. For example, the HUD National Survey estimates that 48% of occupied homes built prior to 1940 have dust-lead loadings above 100 $\mu g/ft^2$, while only 3% of homes built between 1960-1979 have dust-lead loadings above 100 $\mu g/ft^2$.

EPA has established a public record for the peer review under administrative record AR152, “Lead Exposure Associated with Renovation and Remodeling Activities Peer Review.” 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

The WCBS was conducted in two phases. In Phase I, workers were recruited from each worker group in each city. A brief screening questionnaire was administered to the selected workers over the telephone. The purpose of the telephone screening was to determine the eligibility, as defined in Section 2.3.1, of the selected workers to recruit workers for Phase II, and to collect preliminary information on targeted work activities. Phase II involved collecting worker blood samples and questionnaire data from the workers recruited in Phase I.

This section presents the overall design of the study, including the study objectives, method for chemical analysis of lead in blood, sampling plan, basis for sample size, and data handling and analysis procedures. A detailed description of the field, laboratory, and data analysis methods was provided in the document, "Quality Assurance Project Plan (QAPjP) for the R&R Worker Characterization and Blood Lead Study" (July 8, 1994).

2.1 STUDY OBJECTIVES

The primary goal of the WCBS was to collect the data and information that would permit an assessment of the relationship between renovation and remodeling activities and the actual exposure to lead of the R&R workers conducting the activities. The objectives of the study were to

1. Determine the relationship between blood-lead concentrations and work practices or activities performed by R&R workers, after controlling for potential confounding factors

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

3. Gather information on the types of work activities and work practices in which R&R workers engage.

2.2 SURVEY DESIGN

Components of the WCBS survey design included defining the target population, constructing a sampling frame, specifying sampling methods, and recruiting the targeted number of workers in the survey.

2.2.1 Target Population

The target population for this study consisted of two groups of renovation and remodeling workers:

- Union carpenters

- Employees of independent, non-union contractors.

Carpenters were chosen because of the wide variety of R&R activities they perform. Carpenters represent the generalists of the R&R industry, considered by some to comprise the backbone of the industry. Employees of independent, non-union contractors were chosen because a large portion of the remodeling and renovation business is conducted by these workers. Moreover, work practices and activities conducted by this diverse group of workers is expected to vary widely. Initially, laborers were targeted as a third group because they can be considered among the most highly exposed groups of R&R workers. Demolition of a wall or ceiling (rip and strip), generally performed by laborers, is often performed by pick and sledge hammer. Although initially cooperative and interested in the study, the union representing laborers elected not to participate in the study. As a result, it was not possible to construct a sampling frame of laborers. However, some individuals participating in the study considered themselves laborers.

The WCBS targeted workers in two cities: St. Louis and Philadelphia. These two cities were selected because of the support and cooperation of local union leadership, and because a large number of children with elevated blood-lead levels have been found in both cities. Lead-based paint exposure is considered a major factor in elevated blood-lead levels in children; therefore, the presence of large numbers of children with elevated blood-lead levels is one indicator of potential lead exposure in these two cities.

2.2.2 Sampling Frame

Sampling frames were defined separately for each group of workers. Union members were identified using lists provided by union leadership. The population of potential respondents in the independent, non-union group was much more diverse and not as well defined as the union group. A list of independent workers was compiled by researching the local construction/ remodeling market in each city. An intense recruitment effort was conducted for potential independent workers, which included obtaining information from the National Association of Home Builders, advertisements in telephone books, newspaper advertisements, public service announcements, and referrals by other workers. While the frame constructed for union members was considered complete, including all eligible members, it was not possible to identify all eligible non-union R&R workers.

Union Carpenters

The sampling frame for the union carpenters was based on a list of current union members provided by the United Brotherhood of Carpenters and Joiners of America (UBC) leadership in each city. In St. Louis the union provided four lists of workers defined by worker type:

1. Apprentice carpenters
2. Floor layers
3. Journeyman carpenters
4. Carpenters who worked specifically for the city of St. Louis.

In Philadelphia the list included approximately 1,300 union members; but, unlike St. Louis, the list was not subdivided by type of work.

Non-Union Workers

Three strategies were used to identify independent workers in St. Louis:

1. The local Home Builders Association (HBA) provided a list of 250 contractors who are current members of the association.

2. One hundred forty-four (144) potential respondents were identified using information found in local telephone books.

3. Advertisements in local newspapers, public service announcements on television, and referrals from study participants yielded 194 potential respondents.

In Philadelphia, 202 potential respondents for the non-union group were identified using advertisements in local newspapers.

2.2.3 Sampling Methods

Sampling methods differed for union and non-union workers. Workers from union membership lists were randomly sampled for participation in the study. For the non-union groups, an attempt was made to contact everyone identified in the sampling frame to maximize our ability to find qualified, willing independent workers for the study.

Union Workers

In St. Louis, an attempt was made to contact 100% of the apprentice carpenters, journeyman carpenters, and carpenters who were union members and worked specifically for the city of St. Louis. However, only a random sample of approximately 60% of the floor layers was contacted because it was believed that their potential lead exposure would be lower than in the other three groups. In Philadelphia, a random sample of approximately 55% of the union members working for the city was contacted.

Non-union Workers

An attempt was made to contact all non-union workers identified in the frame building process. This included:

1. All contractors identified by the HBA and all employees identified by contacting HBA contractors

2. Everyone identified through telephone book listings

3. Everyone whose name was received as a referral from other workers

4. Everyone who responded to the newspaper advertisements and public service announcements.

2.2.4 Recruitment

To meet the study objectives, R&R workers meeting specified criteria were needed to participate in the study. Recruitment activities consisted of (1) gaining the support of national leadership of the UBC and the National Association of Home Builders (NAHB), (2) obtaining the support of local leadership, (3) compiling sample frames, and (4) contracting and recruiting qualified workers from each sampling frame.

Support of the UBC national leadership was a prerequisite for obtaining cooperation at the local level. The Director of the Health Effects Division of the UBC Health and Safety Fund facilitated and coordinated contacts with national and local leadership in the UBC. The Director arranged meetings between Battelle and the St. Louis District Council of the UBC, and between Battelle and the Metropolitan District Council of the UBC in Philadelphia. These meetings were instrumental in obtaining UBC membership lists in St. Louis and Philadelphia.

The Executive Director of the NAHB introduced Battelle to NAHB staff in St. Louis, who provided Battelle with a membership list.

Workers in the sample frame were initially contacted by telephone. Recruitment during telephone screening involved 1) determining if the worker was eligible, 2) convincing eligible workers to participate, and 3) scheduling appointments for data collection. Recruitment did not end with the telephone screening. It also involved getting a person to complete the questionnaire and provide a blood sample during data collection and rescheduling appointments for individuals that failed to show up at the scheduled appointment time. A $50 cash incentive was offered to the workers who participated in the data collection procedure.

When it became clear that the telephone screening was not recruiting sufficient numbers of non-union, independent R&R workers, other strategies were implemented. An advertisement was placed in newspapers in both cities, a videotape was sent to the Public Broadcasting Service (PBS) station in each city for broadcast, and a word-of-mouth referral approach was employed with workers who did participate. The referral approach involved cash payments to each worker that provided the names of at least three R&R workers that were eligible for the study. The turnaround in the success of recruitment efforts with this group can be attributed primarily to the newspaper advertisements. The referral approach was the next most helpful. Only the PBS station in St. Louis broadcast the videotape; the broadcast was not a significant contributor in bringing independent workers into the study.

2.3 SAMPLE COLLECTION

2.3.1 Questionnaire Data

Two questionnaires were used in this study: a telephone screening questionnaire and the main study questionnaire. Both questionnaires are provided in Appendix A. The telephone screening questionnaire was administered by an interviewer, and the main study questionnaire was self-administered. A complete pretest of both questionnaires was conducted to ensure that the data would be reliable and useful.

For both questionnaires, questions with pre-coded responses were chosen to avoid ambiguous answers to open-ended questions. This practice ensured consistency in the respondents' answers and minimized the potential for information bias. It also facilitated data editing, cleaning, coding, analysis, and interpretation. A few questions were not amenable to closed-ended responses and were left open. For example, "What is your current job title and what are your main responsibilities?"; responses were categorized retroactively.

Telephone Screening Questionnaire

The screening questionnaire included 11 questions related to current work activities and demographic characteristics. These data were used to

- Determine whether a respondent was eligible for the study.

  A worker was included if 1) the worker's primary source of income was derived from R&R activities and 2) the worker actually did "hands-on" R&R work.

- Characterize the population.

  Because a larger number of workers was contacted by phone than participated in the main study, information from the phone screen was particularly useful for helping to characterize the population of workers according to basic demographic characteristics and current work activities such as carpet removal, paint removal, and cleanup.

- Ensure variability in lead exposure.

  The telephone screening questionnaire was used to ensure that workers with a range of potential lead exposure were identified. In the union sample in St. Louis, for every two respondents who indicated they had worked on buildings built before 1950, one worker was recruited who had been working in buildings built after 1950. This maximized the chances of recruiting highly exposed workers. This practice was initiated after determining that a large proportion of union workers initially recruited were not working in older homes.

- Assess potential selection bias.

Finally, the information from the phone screen allowed for comparison between basic demographic characteristics and targeted work activities for workers who agreed to participate in the main study and those who refused to participate.

Main Study Questionnaire

Table 1 summarizes the main study questionnaire and shows the links between the questions and the study objectives. Although the questionnaire was self-administered, an interviewer was always available to help the respondent with particular questions or to administer the entire questionnaire, if necessary. The completed questionnaire was also reviewed for consistency and completeness before the respondent left the data collection center.

2.3.2 Blood Samples

To minimize the potential for contamination and to insure comparability to data collected in other studies, blood samples were collected by venipuncture, rather than by finger prick. Blood draws were performed by trained and licensed phlebotomists. One to three phlebotomists attended each data collection session, depending on the recruited number of workers.

The phlebotomy was performed immediately following administration of the questionnaire. The protocol for collecting, storing, and shipping the blood samples appeared in the QAPjP for the WCBS.

Table 1. Summary of Questionnaire and Rationale for Each Section

Section(s)	Objective	Rationale
A. Demographics	1, 2, 3	Includes questions on demographic factors — such as age, race, education, and gender — which may be related to the worker exposure. This information is also useful to characterize the population of workers in terms of basic demographic factors.
B to H. Work History: Performance of specific Work Activities and Practices	1, 2, 3	Includes queries about each specific work activities, and specific work practices associated with each activity. Targeted activities assessed are carpet removal, window or door replacement, heating, ventilation and air conditioning work, removal of large structures, paint removal/surface preparation, and cleanup.
I. Work History: General Work Practice Questions	1, 2	Includes questions about potential confounding factors such as smoking and eating at the worksite.
J. Work History: Other Occupational Exposures	1, 2	Includes questions about potentially confounding non-R&R occupational lead exposures.
K. Personal Characteristics	1, 2	Includes questions about the worker's home and dietary habits which may be related to worker's non-occupational lead exposure.
L. Non-work Activities	1, 2	Includes questions about hobbies and sporting activities which may be related to a worker's non-occupational lead exposure.
M. Medical History	1, 2	Includes questions on worker's medical history, which may reflect his/her potential for lead exposure (diagnosed with an elevated lead level).
N. Previous Training	1, 2, 3	Includes questions about training and information that the worker has received about potential lead exposures in the workplace.

2.4 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. A copy of the confidentiality pledge, which all interviewers and field workers are required to sign, is provided in Appendix G. 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 documents not received from the field.

2. Data editing and coding

   All data underwent 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.

2.5 STATISTICAL METHODS

The statistical analysis included several preliminary steps, including constructing exposure variables, calculating descriptive statistics, and exploring data analysis. Statistical models were then fitted to the data to meet the study objectives listed in Section 2.1. 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: exposure during the previous month, exposure during the past year, and historical exposure. All statistical analyses were performed using the SAS® computing system (version 6.10).

2.5.1 Construction of Exposure and Worker Group 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.

Measures of potential lead exposure resulting from conducting R&R work were constructed for three exposure periods: last 30 days, last year, and the entire career. These exposure measures were constructed for each target activity (carpet removal, window replacement, paint removal and surface preparation, work on HVAC systems, large structure removal, and cleanup) and for conducting R&R work in general.

For each specific target activity, the potential lead exposure variables 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 1950?

Mid-term (last year): 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) 4-8 Weeks
(4) 9-26 Weeks
(5) > 26 Weeks

Long-term (entire career): Think about all the years you've done renovation and remodeling. How many of these years did you work on the target activity at least some of the time?

Variables constructed from the responses to these questions were used to assess the effects of target activities on blood-lead concentration.

Since there were two questions related to short-term exposure, an effort was made to determine which one was most strongly related to blood-lead concentration. The distinction between a target activity in pre-1950 and post-1950 buildings is important because it is believed that lead exposures resulting from R&R may be greater in older homes. For each target activity, relationships were examined between worker blood-lead concentration and the number of days the target activity was conducted, the number of days conducted in pre-1950 houses, and the number of days conducted in post-1950 housing (calculated by computing the difference between the number of days worked and the number of days worked in pre-1950 buildings). Based on plots and univariate regressions, the number of days an activity was performed in homes built before 1950 was selected as the measure of short-term exposure.

In addition to union status (union carpenter and non-union carpenter), each worker was assigned to a specific worker group based on his response to the following question: What is your current job title and what are your main activities at work? A listing of the main activities was 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.

Demographic variables such as age, gender, race/ethnicity, and level of education were constructed from the questionnaire responses. The questionnaire 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 responded positively to one or more of those questions then he was 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.

2.5.2 Descriptive Statistics

Summary tables of demographic variables were prepared for each worker group and are included in Appendices C and D. For specific worker groups, Table D-3 displays the amount of time each target activity was performed and how often specific work practices were utilized. Two-way frequency tables of the number of days the activity was performed versus the number of days the activity was performed in pre-1950 homes were prepared for each target activity. Tables in Appendix C summarize the distribution of blood-lead concentrations for each R&R worker group and for each sampling frame. Tables (Section 3.5) were also prepared to assess the variability in measured blood-lead concentrations between duplicate blood samples and among duplicate chemical analyses.

2.5.3 Exploratory Data Analysis for Ancillary Variables

Exploratory data analyses were performed to assess the relationships between blood-lead concentration and various ancillary variables describing worker demographics, worker 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 over all workers and for each sampling frame.

2.5.4 Statistical Models

2.5.4.1 Blood-Lead Concentrations

The QAPjP 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 9, 23.3, and 41.1 µg/dL, respectively. An ANOVA model appropriate for random effects was fitted 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. In addition, as specified in the QAPjP, approximately 10% of the workers was 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.

Analyses were conducted to determine if statistically significant differences exist between the blood-lead concentrations of specific R&R worker groups and between the blood-lead concentrations of different sampling frames. Side-by-side box plots of blood-lead concentrations

for each worker group and for each sampling frame were prepared (Appendix F). ANOVA models appropriate for random effects were then fitted to the blood-lead concentrations. The following effects were included in these models: 1) fixed effects for either worker group or sampling frame, and 2) random effects for worker and chemical analysis. Statistical contrasts were conducted between the sampling frames. Because of the larger number of worker groups, pairwise comparisons between worker groups were performed using Tukey's studentized range test.

2.5.4.2 Relationships Between Target Activities and Blood-Lead Concentrations

A series of statistical models were fitted to the data to determine if there were any significant associations between blood-lead concentration and various types of work or target activities. The relationship between worker blood-lead concentrations and potential lead exposure associated with R&R target activities was investigated for exposure during the previous month, exposure during the past year, and historical exposure. Multiple regression models were employed to examine these relationships. To simplify the regression models, results of multiple chemical analyses and duplicate blood samples were averaged for each worker to provide a single blood-lead concentration for each worker.

Figure 2 portrays the paradigm utilized for fitting the models. First, as shown at the top of the figure, results of the preliminary analyses were employed to

1. Define the measures of exposure
2. Select the most appropriate distribution for blood-lead concentrations
3. Select covariates for the statistical models.

Second, presented on the left branch of Figure 2, separate models were fitted to the data for each target activity. Initially, linear regression models were fitted 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 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 fitted to the data for each target activity.

The above analyses helped characterize the strength of the relationship between each target activity and worker blood-lead concentrations. The final goal, however, was to develop a model which explained 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 branch of Figure 2, regression models that examined all of the target activities simultaneously, were fitted to the data. The initial models included effects for all six target activities for each exposure period: short-term, mid-term, and long-term. For instance, a model was fitted to the data that included the previously selected ancillary variables and the number of days the activity was conducted in pre-1950 homes for each of the target activities. Next, these models were repeated with worker group added to the model. Finally, an attempt was made to construct a model that would assess the effects of short-term, mid-term, and

long-term exposures simultaneously for all of the explanatory variables. Correlations among the target activities and among the three exposure periods within each target activity were high. Therefore, as shown in Figure 2, only a subset of the variables for the various exposure period and target activity combinations were included in the final model.

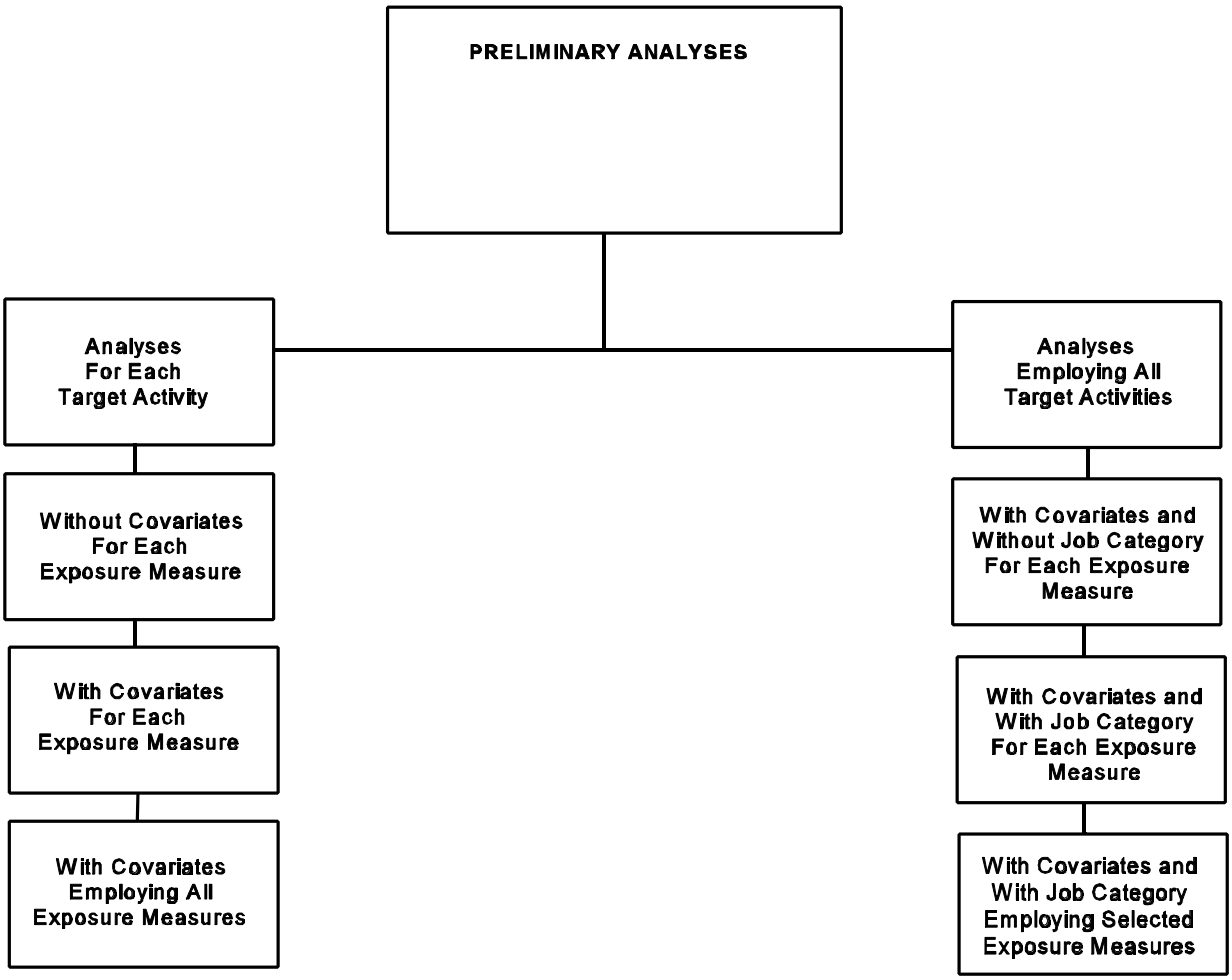

Figure 2. Paradigm for Fitting Statistical Models to Blood-Lead Concentrations

3.0 RESULTS

3.1 RECRUITMENT RESULTS AND FIELD EXPERIENCES

3.1.1 Recruitment of Respondents

Individual workers were recruited during the telephone screening process. Up to five telephone calls were made to each worker. If a contacted worker was judged to meet study eligibility criteria and scheduled for an appointment for data collection, then the worker was classified as **Recruited.** Otherwise, the worker was assigned one of the following classifications:

Not Located: Potential respondents who could not be contacted (e.g., due to invalid telephone number, or not at home).

Refused Screener: Potential respondents reached who refused to participate in the telephone screening/recruiting interview.

Not Eligible: Respondents who participated in the telephone screening/recruiting interview, but did not meet the criteria for the main study data collection. A respondent failed to meet study eligibility criteria if 1) he did not conduct "hands-on" R&R work for a living, or 2) he belonged to a group (e.g. floor layers) whose quota for the study was already met.

Eligible Refused: Telephone screening/recruiting interview respondents who met the participation criteria for the main study, but declined to participate.

Other: Telephone interview respondents who had dispositions other than those listed above. Examples include potential respondents taken from the union membership list who were no longer union members, potential respondents who were deceased, and potential respondents whose spouses did not cooperate in providing access to the respondent.

Table 2 provides a breakdown of recruitment results for the telephone screening for all potential respondents. (A potential respondent is anyone the telephone screening process attempted to reach. Total respondents are presented in the third column of Table 2.) A subset of the recruited workers participated in the questionnaire and blood data collection. Workers who completed both the questionnaire and the blood draw were classified as **Complete**. To measure the rate of screening recruitment, participation, and overall response, the following rates were calculated:

$$\textbf{Screening Recruitment Rate} \quad \frac{\text{Recruited}}{\text{Recruited} \quad \text{Eligible} \quad \text{Refused}}$$

$$\textbf{Participation Rate} \quad \frac{\text{Total Complete}}{\text{Recruited}}$$

$$\textbf{Response Rate} \quad \frac{\text{Total Complete}}{\text{Recruited} \quad \text{Eligible Refused} \quad \text{Refused Screener}}$$

The screening recruitment rate measures the recruitment rate of the telephone screening interview in Phase I. Given that a worker was successfully recruited in Phase I, the participation rate measures the response rate of questionnaire and blood sample collection in Phase II. The overall response rate of both study phases is measured by the response rate.

Summary of Overall Recruitment Results and Participation

Once workers were reached at home, the interviewers had little problem convincing them to do the telephone screening interview. Of the 1,686 workers contacted, only 150 (9%) refused the telephone interview. The interviewers had even less of a problem recruiting eligible respondents to set an appointment date for the main data collection (self-administered questionnaire and phlebotomy). Overall recruitment results and actual participation are summarized in Table 3 for each sampling frame. "Total Contacted" in Table 3 represents the number of potential respondents who were actually reached and represents the sum of Refused Screener, Not Eligible, Eligible Refused, Recruited, and Other categories. Total self-administered questionnaire (SAQ) represents the number of respondents who completed the questionnaire. Blood samples were not collected from four of the 585 workers who completed the questionnaire due to unsuccessful blood draws.

Recruitment Results for Each Sampling Frame

Recruitment of union workers in St. Louis began in mid-August, 1994. The screening recruitment rate for St. Louis union workers was 94%. The participation rate was 60%, and the response rate was 43%. This group had the lowest screening recruitment rate, participation rate, and response rate.

Recruitment of union workers in Philadelphia began in mid-September, 1994. Unlike the St. Louis sample, the Philadelphia workers were not divided into subgroups (i.e., apprentice, journeyman, etc.). As shown in Table 3, recruitment of union members in Philadelphia went better than in St. Louis. The screening recruitment rate for Philadelphia union workers was 96%. The participation rate was 63%, and the response rate was 54%.

Table 2. Summary of Recruitment for Telephone Screening Interview

City	Group	Total Called	Recruited	Not Located	Refused Screener	Not Eligible	Eligible Refused	Other
ST. LOUIS UNION	Apprentice	97	26	28	11	29	3	0
	Floor Layer	393	130	157	41	44	7	14
	Journeyman	500	85	134	24	247	7	3
	Carpenter	96	10	38	5	40	0	3
	Totals	1086	251	357	81	360	17	20
ST. LOUIS NON-UNION	Independents[1]	103	20	41	16	22	2	2
	Local Home Builders Association	32	13	5	4	8	2	0
	Referrals / Ads	189	174	3	3	8	0	1
	Totals	324	207	49	23	38	4	3
PHILADELPHIA UNION	Union	674	312	140	38	166	12	6
PHILADELPHIA NON-UNION	Non-Union	189	108	41	8	27	1	3

[1] Workers obtained through the telephone work.

Table 3. Summary of Overall Recruitment and Participation for WCBS

Group	Total Called	Total Contacted	Total Recruited	Total SAQ[1]	Total Complete[2]	Screening Recruitment Rate	Participation Rate	Response Rate
St. Louis Union	1086	729	251	151	150	94%	60%	43%
St. Louis Non-Union	324	275	207	161	160	98%	77%	68%
Philadelphia Union	674	534	312	197	197	96%	63%	54%
Philadelphia Non-Union	189	148	108	76*	74*	99%	69%	63%
Totals	2273	1686	878	585	581	96%	66%	55%

[1] Number of respondents completing the self-administered questionnaire.
[2] Number of respondents completing both the questionnaire and the phlebotomy.
* From a total of 78 workers, 76 questionnaires were obtained, and 76 blood samples were collected. Both questionnaire and blood data were collected from 74 workers.

Recruitment of non-union carpenters in St. Louis began in September, 1994. After two weeks only six workers had been recruited and therefore, the additional recruitment methods presented below were employed:

1. R&R contractor names were abstracted from the telephone book and newspaper advertisements. The intent was to reach small-time contractors who do remodeling work themselves.

2. Classified advertisements were placed in five St. Louis newspapers: *The Post, Dispatch, The Suburban Journal,* the *Riverfront Times,* and *Today's Advantage.*

3. A 30-second Public Service Announcement (PSA) promoting the WCBS was videotaped and broadcast on public television. The St. Louis PBS affiliate, KETC Channel 9, was contacted and asked if they would be willing to advertise the WCBS on "This Old House," "Home Time," and other R&R instruction shows. The PSA was shown multiple times following these programs.

4. A news release on the study was sent to Philadelphia and St. Louis newspapers on the study. The press release was conducted on November 17, 1994.

5. Solicitation of references from workers already recruited was attempted. This consisted of paying a recruited respondent $25 for the names of at least three people who do remodeling work.

These various methods resulted in three general subgroups of non-union workers:

1. Independents — Workers drawn from the telephone book

2. HBA workers — R&R workers recruited through their employer, an HBA member

3. Referrals/ads — Workers referred by other respondents and those who called in response to a newspaper/ television advertisement

Despite the early setbacks, recruitment of non-union workers in St. Louis ended successfully. This success was especially due to the use of the advertisements and word-of-mouth referrals from other workers. These two methods resulted in 84% (174) of the total St. Louis non-union workers recruited. The screening recruitment rate for St. Louis non-union workers was 98%. The participation rate was 77%, and the response rate was 68%.

Recruitment of non-union workers in Philadelphia did not begin until mid-October, 1994. Newspaper advertisements were selected as the primary recruitment source based on the recruitment experience in St. Louis. Advertisements were placed in the following Philadelphia newspapers: The *Philadelphia Inquirer, The Daily News, The Leader, The Breeze, The Review, The Recorder,* and the *Germantown Paper.* The screening recruitment rate for Philadelphia non-union workers was 99%. The participation rate was 69%, and the response rate was 63%.

3.1.2 Field Experiences

3.1.2.1 Field Experiences in St. Louis

All of the telephone interviewing and recruiting was performed in the St. Louis office of Survey Research Associates (SRA). As a result of the high screening recruitment rate, no substantial refusal conversion effort was necessary. However, no-shows were called to reschedule data collection appointments.

Initially, Battelle anticipated scheduling half of the data collection sessions at central locations (e.g., SRA's St. Louis office, union halls) and half in respondents' homes. In the St. Louis area, however, only 12 in-home visits were required; six in Missouri and six in Illinois. Respondents were very willing to travel to a central location for the data collection. The weeknight dates worked best since the respondents could come in after work. The weekend sessions had slightly poorer turnout and were stopped about half way through the field period.

In St. Louis, two locations were used for the centralized data collection sessions: the United Brotherhood of Carpenters Hall and SRA's office.

Respondents tended to arrive in groups of five to ten. A receptionist would check a respondent in upon arrival and provide instructions on how to proceed. The original plan was to have an interview specialist help respondents complete the questionnaire. It soon became clear, however, that the respondents did not have much trouble with the questionnaire. The Study Manager therefore handled most of the questions and the interview specialist assisted with editing and data retrieval. (There were two respondents who required assistance reading the questionnaire. One was a Russian immigrant who understood spoken English well, but had a hard time reading the questions and response choices. The other was a respondent who asked that the questionnaire be read to him after he had tried to go through it himself.)

The phlebotomy went smoothly with few problems being encountered. Although there was some early concern with the need for multiple sticks for a successful draw, only two St. Louis respondents were unable to complete the blood draw. The nurses were very good at explaining the phlebotomy procedures and relaxing the respondents. Any respondent feeling unsteady after the blood draw was not allowed to leave until he was feeling better.

As mentioned previously, only a small number of respondents required in-home visits. For those respondents in Missouri, the primary reason for the in-home session was an inability to come to a central location during the scheduled times; usually this was due to a conflicting work schedule. For the in-home sessions in Illinois, the primary reason given by respondents was the distance to the central locations (at least a half-hour drive through rush hour traffic). An interview specialist and a phlebotomist traveled to the respondent's home and collected the data and blood draw in a similar fashion to procedures used at the central location.

3.1.2.2 Field Experiences in Philadelphia

Philadelphia union recruitment was even smoother than in St. Louis. One factor was that recruitment in Philadelphia occurred after recruitment in St. Louis and, as a result, the interviewers were more experienced with the process.

In Philadelphia, three locations were used for the centralized data collection sessions: the UBC Carpenters Hall, the UBC training facility, and the Center City Hotel. The hotel facility was secured to hold the data collection sessions for the non-union workers. Data collection sessions were scheduled on Saturday during the day and on weeknights.

The procedures and data collection flow in Philadelphia were essentially the same as in St. Louis. As in St. Louis, two respondents were unable to successfully provide a blood sample.

There were some problems with the Philadelphia data collection. The first concerned the editing function. The purpose of the editing was to catch missing information and retrieve the data before the respondent left. Some of the forms sent in for processing from Philadelphia did not have proper editing. This caused the data preparation staff in St. Louis to telephone the respondents to retrieve the missing data. In some cases it was not possible to reach the respondent, and therefore the response(s) were coded as missing data. This problem was noticed early in the data collection, allowing the Study Manager time to travel to Philadelphia and re-train the entire staff.

The second problem was related to the payment of the $50 cash incentive. Cash payments do yield more cooperation among prospective respondents compared to sending a check at a later date. However, staff in Philadelphia were concerned with safety in handling the large amounts of cash required for the study, sometimes as much as $2,500. The staff was especially concerned with safety at the Center City Hotel site. To ameliorate that concern, the hotel provided a security guard to provide a security presence in the room.

No in-home sessions were done in Philadelphia for two reasons. First, the telephone interviewing staff were unfamiliar with the large geographic area around Philadelphia. Second, with the high turnout in both cities, it was not worthwhile to work out the logistical problems associated with in-home visits for a small number of respondents. No one refused to participate because of the travel to a central location. In fact, some of the respondents indicated that they had traveled from 45 minutes to 1-hour away.

3.1.2.3 Working with Difficult Respondents

A common problem in St. Louis and Philadelphia was dealing with difficult respondents. The primary difficulty was respondents arriving for the data collection after drinking alcohol. This was mostly a problem with the non-union workers in Philadelphia. While intoxicated respondents were certainly not the rule, the questionnaire and blood data of two workers in Philadelphia were not utilized because of the respondents' drunkenness.

Without question, the predominant mood of the respondents was one of cooperation. They seemed happy to participate and were genuinely concerned with the goals of the study as well as their own blood-lead results.

3.2 QUALITY CONTROL FOR BLOOD-LEAD DATA

3.2.1 Laboratory Quality Control Data Summary

The assessment of the overall quality of the blood-lead data was performed by the Senior Quality Assurance Officer at Midwest Research Institute using statistical quality control (SQC) procedures. Data quality indicators, as defined in the QAPjP, were used to assess the data obtained from quality control and performance evaluation specimens. This section summarizes the laboratory quality control data evaluation; details are presented in Appendix B.

Data quality objectives were met with analytical data meeting all objectives of accuracy, precision, and completeness of specimen collection. Analytical results are considered representative of lead levels in the R&R population and comparable with results from other studies.

Measurement quality objectives (MQO) were assessed using internal quality control and CDC performance samples. The internal quality control samples consisted of QC blanks (matrix modifier) and a series of standard reference materials that were used as calibration standards (NIST 995a SRMs at Levels 1, 2, 3, and 4), calibration check standards (NIST SRM Level 2), calibration verification standards (NY State SRM), and continuing calibration samples (BioRad-1, BioRad-2, and BioRad-3). Performance criteria and results are summarized in Table 4. In addition to the SRMs used for internal quality control, all of the samples were analyzed in duplicate (same extract) and selected samples were analyzed in replicate (different sample extract) to assess method precision. Precision criterion established for these samples was ±20%.

Results from internal quality control and external performance evaluation specimens indicated that the blood-lead data were accurate and reliable. The instrument detection limit (IDL), method detection level (MDL) and method quantitation level (MQL) were 1.3, 1.9, and 3.2 µg/dL, respectively. Only 20 out of 581 worker blood lead concentrations were below the IDL. Precision criteria were met for the majority of cases; those that did not meet established precision criteria were reanalyzed. Details of all quality control data analysis, including Shewhart plots and statistical evaluations of the data, are shown in Appendix B.

In summary, blood-lead data met the quality criteria with the exception of the positive bias noted for the time period of December 15þ30, 1994, for specimens in the range of 10þ20 µg/dL, as assessed by the calibration verification quality control sample. As a result, reported lead levels in these samples had the potential for being less than 1 µg/dL above the actual lead level in the sample. This bias has little clinical significance.

Table 4. Quality Control and CDC Performance Samples

Sample Identification	MQO Accuracy	MQO Precision	Type of Quality Control Sample	Reference Lead Conc. µg/dL	Mean Recovery (%)	Control Limits
Blank	< 1.0 µg/dL	N/A	Matrix modifier	0.0	-0.08	1.59
BioRad 1	±25%	±10%	Continuing calibration Reference material samples	5.0 - 8.3	99.74	58 - 142
BioRad 2	±25%	±10%	Continuing calibration Reference material samples	24.4 - 24.5	95.24	72 - 118
BioRad 3	±25%	±10%	Continuing calibration Reference material samples	55.4	95.98	81 - 111
New York State SRM	±10%	N/A	Calibration verification	16.0	98.25	68 - 130
NIST SRM 995a	±10%	N/A	Calibration Check Standard	13.53	101.0	79 - 122
CDC RS 590	±20%	N/A	Blind performance	9.0	93.35	77 - 110
CDC RS 991	±20%	N/A	Blind performance	23.3	98.72	89 - 109
CDC RS 1394	±20%	N/A	Blind performance	41.1	102.6	91 - 114

3.2.2 Field QC Data

The quality of blood-lead results from the WCBS were characterized using several different field samples. First, CDC Quality Control reference (CDC QC) samples were repeatedly measured over the course of the study. Second, field duplicate samples (a second blood sample) were analyzed for roughly 10% of the workers. Finally, at least two chemical analyses were performed on each blood sample.

The quality of the blood-lead results will be discussed in terms of bias and precision. The CDC QC samples were used to characterize any potential bias in the blood-lead data. Duplicate analyses of the same sample were used to characterize the precision in the chemical method of analysis. Blood-lead concentrations from the field duplicate samples were used to characterize the variability in both sampling and chemical analysis.

3.2.2.1 CDC QC Reference Samples

Three CDC QC samples were analyzed 30 times each over the course of the study (yielding a total of 90 reference samples). These reference standards consisted of bovine blood which was spiked with known concentrations of lead (in units of 9.0, 23.3, and 41.1 µg/dL). The CDC QC samples were analyzed along with the regular worker blood samples to characterize any potential bias in the blood-lead results. Each of the 90 CDC reference samples were shipped

blindly to the laboratory in collection tubes similar to those that contained worker blood. The lead concentration in each tube was then analyzed using duplicate injections (chemical measurements) similar to the worker samples.

Table C-1 in Appendix C presents descriptive statistics for the CDC QC samples. These results are based on the geometric mean blood-lead concentration of the duplicate chemical analyses made on each sample. The log standard deviation represents the variability between different sample tubes of the same reference standard.

Table 5 presents 95% confidence intervals for the lead concentration in each CDC reference standard. Only one of the three confidence intervals contained the nominal blood-lead concentration. This, however, is not cause for immediate concern, due to the fact that the estimated confidence intervals were very narrow and just barely excluded the nominal concentrations. Additionally, differences between the observed geometric means and the nominal concentrations were relatively small. All but one of the blood-lead concentrations, as discussed in Appendix B, met the measurement quality objective for the CDC QC reference samples.

Table 5. 95% Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for CDC QC Reference Samples

CDC Reference Number	Nominal Concentration (µg/dL)	Measured Responses			
		N	Geometric Mean (µg/dL)	log Std. Error log (µg/dL)	95% Confidence Interval for Geometric Mean (µg/dL)
590	9.0	30	8.4	0.010	(8.2, 8.6)
991	23.3	30	23.0	0.006	(22.8, 23.3)
1394	41.1	30	42.3	0.007	(41.8, 42.9)

3.2.2.2 Worker Blood-Lead Samples

Duplicate blood samples were collected from 73 workers. Each of the duplicate samples was chemically analyzed in the same manner as the regular worker samples and reference samples (with at least two measurements of blood-lead level per sample collection tube). Table C-2 provides descriptive statistics on the log standard deviation of duplicate blood-lead concentrations. The variability between duplicate samples was very small, and the variability estimates were similar among the sampling frames. In fact, the variability in log blood-lead concentrations between duplicate blood samples is comparable to that observed between duplicate laboratory analyses made on the same sample.

Blood samples were obtained from 581 workers during the WCBS. Table C-3 provides descriptive statistics on the distribution of the log standard deviation between duplicate chemical measures of blood-lead among 580 workers (one worker had a missing value). These results do not include the 73 duplicate blood-lead samples that were discussed above. The variability

between duplicate chemical analyses within a sample was also very small and the variability estimates were similar among the sampling frames.

Table 6 displays estimated variance components for the variability between workers, between duplicate blood draws for a worker, and between duplicate chemical analyses on same blood draw. These variance components are based on analyses of the worker blood samples, the duplicate blood draw data, and the CDC QC reference samples. Based on the worker blood samples, the estimated variability between workers [β=0.6158] was roughly an order of magnitude greater than that attributed to chemical analysis [β=0.0677]. The estimated variance components for duplicate blood samples also demonstrated that the variability between workers [β=0.6800] was an order of magnitude greater than those for sampling variability [β=0.0677] and chemical analysis [β=0.0602]. The estimated variance components for the CDC QC samples showed that the variability within a sample [β=0.0315] (attributed to chemical analysis) and between samples [β=0.0369] were similar.

Table 6. Variance Component Estimates for Blood-Lead Concentrations

Source of Variation	β_{Worker} (Field Samples) log(µg/dL)	β_{Worker} (Duplicates) log(µg/dL)	$\beta_{Quality\ Control}$ (Reference Samples) log(µg/dL)
Between Workers	0.6158	0.6800	0.0369
Between Duplicate Blood Draws	N/A	0.0677	
Between Duplicate Chemical Analyses	0.0677	0.0602	0.0315

Overall, the variability attributed to chemical analysis of worker blood-lead appears to be twice that attributed to chemical analysis of CDC QC samples. This difference may be due to differences between human and bovine blood samples. The variability in blood-lead concentrations due to sampling and analyses was relatively small, exceeded expectations for this study, indicated that measured blood-lead concentrations are of sufficient quality, and provided evidence of an instrument detection limit of less than 1 µg/dL.

3.3 TELEPHONE SCREENING RESULTS

The telephone screening phase had three main objectives. The first objective was to recruit a sufficient number of workers for the main study and to ensure variability in lead exposures among those workers. This first objective was successfully met, as discussed in Section 3.1. The second objective was to provide preliminary information on work activities practiced by R&R workers. Table 7 summarizes the responses to key questions on the questionnaire. Conclusions about the R&R workers in the study that were reached from a qualitative assessment of Table 7 include:

Table 7. Summary of Telephone Screening Questionnaire Responses Relating to Type and Amount of Specific Target Activities

Question Number: Description	Group	0	1-5	6-10	>10
3: Days[(a)] worked in last month (includes workers responding `0')	Participant[(b)]	4.6%	5.5%	9.3%	80.6%
	Nonparticipant[(c)]	8.9%	6.7%	7.3%	77.1%
4: Number of years of renovation and remodeling work	Participant	1.4%	17.3%	22.1%	59.2%
	Nonparticipant	1.2%	13.5%	27.2%	57.8%
5: Days worked in pre-1950 buildings	Participant	29.9%	15.8%	13.2%	41.1%
	Nonparticipant	44.2%	14.1%	10.7%	31.0%
6: Days worked in residential buildings	Participant	32.6%	11.5%	10.3%	45.6%
	Nonparticipant	49.8%	8.9%	7.3%	33.9%
7: Days worked in nonresidential buildings	Participant	47.3%	8.1%	6.7%	38.0%
	Nonparticipant	40.9%	5.8%	7.1%	46.2%
8A: Days spent removing carpets	Participant	64.3%	27.1%	4.3%	4.3%
	Nonparticipant	72.7%	21.5%	2.8%	3.1%
8B: Days spent removing windows	Participant	47.9%	35.7%	8.4%	8.1%
	Nonparticipant	62.3%	27.6%	5.2%	4.9%
8C: Days spent working on HVAC systems	Participant	76.8%	17.8%	2.4%	2.9%
	Nonparticipant	83.4%	13.2%	1.8%	1.5%
8D: Days spent removing large structures	Participant	30.2%	29.8%	17.7%	22.3%
	Nonparticipant	39.0%	27.0%	14.7%	19.3%
8E: Days spent removing paint	Participant	46.3%	26.1%	11.3%	16.3%
	Nonparticipant	60.0%	20.9%	6.2%	12.9%
8F: Days spent performing cleanup	Participant	19.9%	22.8%	11.0%	46.3%
	Nonparticipant	33.7%	20.2%	8.6%	37.4%

(a) Number of days activity was performed during the last 30 days.
(b) Participants represented those workers actually participating in the WCBS.
(c) Nonparticipants encompass those individuals who were eligible but either refused participation or did not show.

1. R&R workers conducted a wide range of activities, as reflected by the percent of workers who conducted the different R&R activities at least one day in the past month.

2. R&R workers spent considerable time doing large structure removal and paint removal or surface preparation, activities with potential for creating high lead exposures. Therefore, the generalists of the R&R industry — carpenters and small independent contractors — and not just specialists such as painters, conduct a significant amount of these activities.

3. The R&R workers were divided evenly between those that work in residential and those that work in non-residential buildings.

The third objective was to provide information on potential nonresponse bias. A nonresponse bias arises whenever nonrespondents differ from respondents. The effect of nonresponse was investigated by determining if participation was related to exposure.

Effects of nonresponse were characterized by comparing the participant group (eligible workers who participated in the main study) to the nonparticipant group (eligible workers who

did not participate in the main study). The nonparticipant group encompassed individuals who were either eligible but did not show up for the WCBS (90%) or were eligible but refused participation (10%). As described in Section 3.1.1, the total overall screening recruitment rate was 96%; the participation rate was 66% and the response rate was 55%. There were 585 participants and 327 non-participants (293 were eligible but did not show and 34 eligible refused).

Demographic comparisons between participants and nonparticipants are summarized in Table 8 (age levels were comparable between the two groups). Demographic characteristics were comparable between participants and nonparticipants. As shown in Table 3, almost 60% of union workers, and approximately 74% of independents participated in the study. In addition, as displayed in Table 7, 81% of participants conducted more than 10 days of general R&R work in the last 30 days compared to 77% of nonparticipants, and 41% of participants conducted more than 10 days of work in pre-1950 housing compared to 31% of nonparticipants. These percentages suggest that the study participants were more likely to perform large amounts of R&R work in pre-1950 housing, and therefore more likely to be exposed.

Table 8. Demographic Comparison Between Participants and Nonparticipants

Category		Participant (%)	Nonparticipant (%)
Gender	Male	97	98
	Female	3	2
City	Philadelphia	47	49
	St. Louis	53	51
St. Louis	Union[a]	48	70
	Independent	52	30
Philadelphia	Union	72	79
	Independent	28	21
Race	White	84	89
	Black	15	10
	Other	1	1

[a] The large discrepancy between participants and nonparticipants in this category results from the higher proportion of individuals in St. Louis who were independents. About 75% of Philadelphia workers were union versus 56% for St. Louis. Participation rates within each city are consistent.

General R&R work comparisons are summarized in Figure 3. Nonparticipants performed less R&R work, and worked fewer days in residential (more in nonresidential) and pre-1950 buildings. Means (and standard deviations) were comparable between participants and nonparticipants for years of general activity (14.1 (9.00) and 14.0 (8.83) for participants and nonparticipants, respectively).

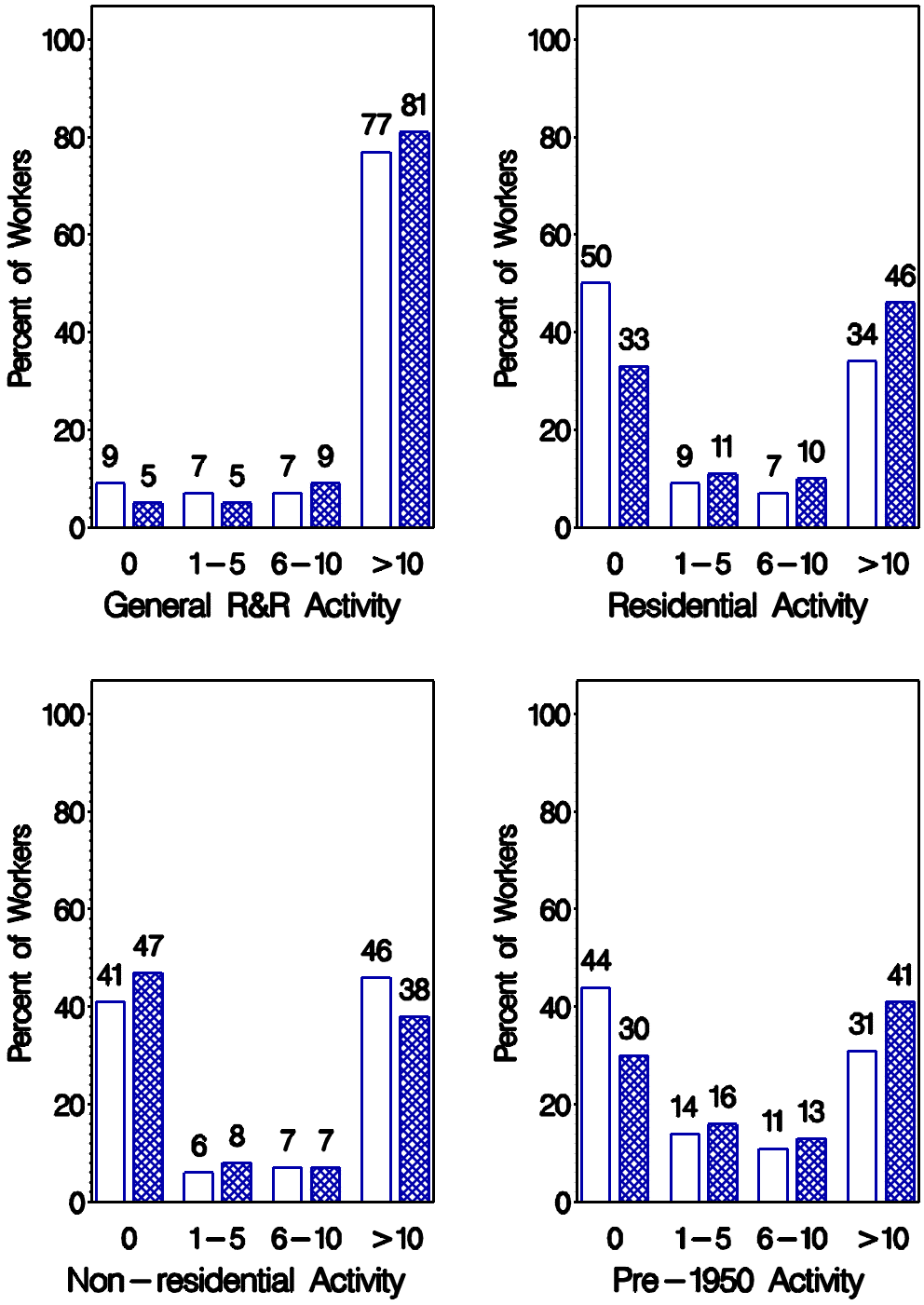

Figure 3. Days in Last Month Spent Conducting General R&R, Residential, Non-residential and Pre-1950 Work for Participants (shaded) versus Non-Participants

Comparisons between the conduct of specific target activities for participants and nonparticipants are presented in Figures F-1 and F-2 in Appendix F. The mixture of target activities performed by participants and nonparticipants is very similar, although nonparticipants spent fewer days conducting each target activity compared to participants. Generally, the percentage of workers performing an activity a large proportion of their time (>10 days) was higher for participants. In fact, the workers (approximately 70%) conducting a large amount of any specific target activity were participants.

In summary, the workers recruited and participating in the WCBS were more likely to be exposed than nonparticipants, as determined by conduct of larger amounts of R&R work (both general and specific). A higher percentage of participants than nonparticipants were independents (non-union) and Black. The study was very successful in recruiting individuals who conducted a wide variety of R&R activities, permitting the estimation of lead exposure associated with target activities.

3.4 WORKER CHARACTERIZATION RESULTS

3.4.1 Demographics

Demographic information on WCBS participants is presented in Tables 3 and 9. Noteworthy points include:

1. There is an almost even division between workers in St. Louis (53%) and workers in Philadelphia (47%).

2. St. Louis workers were nearly evenly divided between union (48%) and non-union (52%) workers while the Philadelphia workers were nearly 75% union.

3. Nearly half (45%) of the workers participating were carpenters, of which 60% were union members.

4. The mean age of the workers was 38 years with 50% of the workers being between the ages of 31 and 43 years. Supervisors had the highest mean age at 41 years.

5. For black workers, the greatest number were laborers (36%), painters (19%), and non-union carpenters (14%). In fact, black workers made up approximately half of the total number of laborers and painters.

6. Approximately 41% of workers lived in homes constructed prior to 1950.

7. Of those workers who had done home renovation in the last 12 months, 93% performed the renovation themselves.

Table 9. Summary of Demographic Data

Variable Description		Worker Group									
		Union Carpenter	Non-Union Carpenter	Drywall Worker	Floor Layer	Laborer	Painter	Supervisor	Window	Other	Total
Sample Size		159	105	64	82	56	34	57	14	14	585
Age	25th Percentile	32 [a]	32	29	30	30	31	35	29	31	31
	Mean	38.11	38.01	37.16	38.12	35.27	39.03	41.14	34.86	40.36	38.04
	75th Percentile	43	43	45	47	40.50	46	46	45	49	43
Gender	Male	98.7% [b]	99.0%	100.0%	98.8%	91.1%	94.1%	98.2%	100.0%	100.0%	97.9%
	Female	1.3%	1.0%	0%	1.2%	8.9%	5.9%	1.8%	0%	0%	2.1%
Race	White	93.7%	85.7%	93.8%	96.3%	42.9%	50.0%	93.0%	71.4%	57.1%	83.8%
	Black	5.0%	11.4%	4.7%	3.7%	55.4%	47.1%	3.5%	28.6%	42.9%	14.5%
	Other	1.3%	2.9%	1.6%	0%	1.8%	2.9%	3.5%	0%	0%	1.7%
Education	Didn't finish High School	3.8%	7.6%	3.1%	6.1%	14.3%	26.5%	0%	0%	0%	6.5%
	High School Graduate	96.2%	92.4%	96.9%	93.9%	85.7%	73.5%	100.0%	100.0%	100.0%	93.5%
Age of Home	Pre-1950	41.5%	48.6%	39.1%	24.4%	58.9%	41.2%	31.6%	21.4%	50.0%	40.5%
	(1950-1978)	40.3%	40.0%	35.9%	46.3%	28.6%	47.1%	38.6%	50.0%	42.9%	40.0%
	Post-1978	18.2%	11.4%	25.0%	29.3%	12.5%	11.8%	29.8%	28.6%	7.1%	19.5%
Home Renovation in the last 12 months	None	64.2%	61.9%	54.7%	74.4%	62.5%	64.7%	54.4%	71.4%	64.3%	63.2%
	Contracted	2.5%	2.9%	0%	2.4%	5.4%	2.9%	1.8%	14.3%	0%	2.7%
	Self-Performed	33.3%	35.2%	45.3%	23.2%	32.1%	32.4%	43.9%	14.3%	35.7%	34.0%

[a] 25 percent of the 159 union carpenters were at or under the age of 32.
[b] 98.7 percent of all union carpenters were males.

Generalizations based on worker groups in which only a small number were sampled should be made with caution.

3.4.2 Target Activities

Tables 10 and D-2 summarize the extent to which each target activity was performed for each worker group. The sampled workers spent an average of 17 days during the past month on general R&R, of which 11 were spent in pre-1950 homes. The most frequent activity performed was cleanup, which occurred an average of 11 days during the month. Over all workers, large structure removal was conducted on an average of 7 days during the month, paint removal on 6 days, window or door replacement on 4 days, carpet removal on 2 days, and HVAC work on 1 day. As with all workers combined, for all of the worker groups except supervisor, the activity conducted most frequently was cleanup.

As shown in Figure F-3, laborers, drywall workers, non-union carpenters, painters, and window installers spent more time performing the target activities in pre-1950 dwellings compared to floor layers, union carpenters, and supervisors. As expected, paint removal was conducted most often by painters, window replacement was performed most often by window installers, and carpet removal was conducted most often by floor layers. Laborers, drywall workers, non-union carpenters, and window installers conducted, on the average, more than 5 days of large structure removal in pre-1950 dwellings. Laborers and non-union carpenters performed a wide mix of target activities, and floor layers and supervisors spent fewer days conducting the selected target activities compared to the other worker groups.

Tables 10 and D-2 also present summary statistics on the number of days a respirator was used while performing the activity, number of weeks spent performing activity in last year, and number of years spent performing activity over career. Dust masks and/or respirators were used less than half of the time the activities were performed. Generally, respirator usage was proportionally greatest for paint removal and large structure removal.

The number of weeks and number of years spent conducting each target activity reflects the number of days spent performing the activity in the last month. For example, large structure removal comprises the second largest activity in terms of days performed, weeks performed, and years performed. It is important to note that workers currently conducting target activities have done so historically as well.

3.4.3 Work Practices

Summary statistics on work practices are presented for each worker group in Table 11, and over all workers in Figure 4. Overall, 60% of the workers reported that they did not use a dust mask or respirator, 30% reported using a dust mask, and 10% reported using a respirator. Among the eight worker groups, respirator usage was highest for painters and laborers. Relatively few of the workers had received formal training on the proper conduct for R&R in lead-contaminated environments (13%) or had received any educational materials on lead exposures (33%). Of the 293 workers that had performed paint removal during the past 30 days,

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

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
Days performing the activity in last month	25th Percentile	10[a]	0	0	0	0	0	2
	Mean	17.07[b]	2.31	3.84	1.24	6.78	5.54	10.92
	75th Percentile	24	2	5	0	10	10	20
Days performing the activity in Pre-1950 housing in last month	25th Percentile	0	0	0	0	0	0	0
	Mean	10.74	1.40	2.98	0.93	4.38	3.51	6.63
	75th Percentile	20	1	3	0	5	5	10
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.39	0.77	0.44	1.41	1.58	1.70
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	4.1%[d]	64.4%	44.6%	82.6%	30.4%	47.0%	22.6%
	1 to 8 Weeks	20.9%	28.7%	44.8%	14.4%	44.4%	35.4%	41.4%
	More than 8 Weeks	75.0%	6.8%	10.6%	3.1%	25.1%	17.6%	36.1%
Number of years spent performing activity over career	25th Percentile	6	1	1	0	2	0	3
	Mean	13.28	5.15	5.94	2.49	7.10	6.28	10.51
	75th Percentile	20	8	10	2	11	10	15

[a] 25% of all workers responded that they did R&R 10 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 17.07 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 4.1% of workers spent less than one week doing general R&R in the last year.

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

Variable Description	Variable Category	Worker Group									
		Union Carpenter	Non-Union Carpenter	Drywall Worker	Floor Layer	Laborer	Painter	Supervisor	Window Installer	Other	Total
Sample Size		159	105	64	82	56	34	57	14	14	585
Smoke	Don't	64.8%[a]	37.1%	54.7%	48.8%	37.5%	35.3%	66.7%	57.1%	57.1%	52.0%
	Smoke, not on job	5.0%	7.6%	6.3%	9.8%	8.9%	8.8%	0%	14.3%	7.1%	6.7%
	Smoke on job	30.2%	55.2%	39.1%	41.5%	53.6%	55.9%	33.3%	28.6%	35.7%	41.4%
Respirator	Don't Use	57.2%	65.7%	67.2%	70.4%[b]	39.3%	32.4%	68.4%	78.6%	42.9%	59.8%
	Use Dust-mask	38.4%	21.9%	31.3%	22.2%	37.5%	47.1%	26.3%	7.1%	21.4%	30.5%
	Use Respirator	4.4%	12.4%	1.6%	7.4%	23.2%	20.6%	5.3%	14.3%	35.7%	9.8%
Other Occupational Exposures	Yes	30.2%	36.2%	31.3%	8.5%	35.7%	29.4%	19.3%	21.4%	35.7%	27.7%
Hobbies with Pb Exposure	Yes	45.9%	69.5%	59.4%	52.4%	75.0%	70.6%	50.9%	71.4%	64.3%	58.3%
Received Pb Training	Yes	16.2%	16.2%	6.3%	8.5%	16.1%	20.6%	22.8%	14.3%	21.4%	13.2%
Received Educational Material	Yes	38.4%	27.6%	26.6%	26.8%	41.1%	18.2%	50.9%	21.4%	35.7	33.4%
Hours of Cleanup	< 1/2 Hrs/Day	30.8%	4.4%	3.8%	16.7%	18.2%	12.1%	22.5%	24.6%	38.5%	17.7%
	1/2-1 Hrs/Day	34.6%	40.6%	28.3%	50.0%	54.6%	33.3%	57.5%	51.8%	30.8%	44.2%
	1-4 Hrs/Day	26.9%	49.3%	37.7%	30.4%	18.2%	45.5%	20.0%	19.3%	23.1%	30.6%
	>4 Hrs/Day	7.7%	5.8%	30.2%	2.9%	9.1%	9.1%	0.0%	4.4%	7.7%	7.6%

[a] 64.8% of the 159 union carpenters responded that they do not smoke.
[b] Response was missing for one of the 82 workers in the floor layer category, and therefore, total is only 81.

Table 11. Summary of Responses for Questions Pertaining to Worker Practices (continued)

Variable Description	Variable Category	Job Category									
		Union Carpenter	Non-Union Carpenter	Drywall Worker	Floor Layer	Laborer	Painter	Supervisor	Window	Other	Total
Sample Size		159	105	64	82	56	34	57	14	14	585
Paint Removal[(c)]	Dry power-sanding	35.6%	53.1%	59.1%	44.7%	54.1%	51.6%	52.6%	22.2%	45.5%	48.5%
	Dry hand-sanding	66.7%	72.8%	86.4%	42.1%	75.7%	87.1%	89.5%	77.8%	72.7%	72.0%
	Dry scraping	66.2%	80.2%	63.6%	89.5%	86.5%	74.2%	47.4%	88.9%	81.8%	75.8%
	Burning, torching, or a heat gun	15.6%	19.8%	22.7%	26.3%	37.8%	41.9%	5.3%	22.2%	27.3%	24.2%
	Wet-scraping	2.2%	8.6%	22.7%	2.6%	43.2%	6.52%	0%	11.1%	27.3%	12.3%
	Wet-sanding	4.4%	8.6%	13.6%	0%	32.4%	12.9%	0%	0%	18.2%	10.2%
	Chemical stripping	13.3%	25.9%	40.9%	10.5%	29.7%	29.0%	5.3%	22.2%	27.3%	22.5%
	Use dust collector when sanding	11.1%	16.0%	22.7%	21.1%	40.5%	22.6%	21.1%	22.2%	27.3%	21.2%
	Total number of people who performed paint removal	45	81	22	38	37	31	19	9	11	293
Cleanup[(c)]	Broom	100%	98.0%	98.1%	100.0%	98.1%	97.0%	100.0%	92.3%	100.0%	98.8%
	Vacuum	46.8%	69.6%	38.5%	43.5%	55.8%	48.5%	41.0%	69.2%	81.8%	52.3%
	HEPA vacuum	0.9%	2.0%	3.9%	1.4%	19.2%	6.1%	0%	7.7%	45.5%	5.0%
	Wet mop with TSP	1.8%	11.8%	7.7%	4.3%	25.0%	18.2%	2.6%	15.4%	18.2%	9.3%
	Clean power tools using any method	26.1%	42.2%	32.7%	40.6%	55.8%	30.3%	30.8%	69.2%	72.7%	38.4%
	Clean tools using Compressed Air	15.3%	26.5%	7.7%	14.5%	40.4%	15.2%	12.8%	538.5%	63.6%	21.0%
	Total number of people who performed cleanup	111	102	52	69	52	33	39	13	11	482

[(c)] Workers may have checked one or more responses for this question.

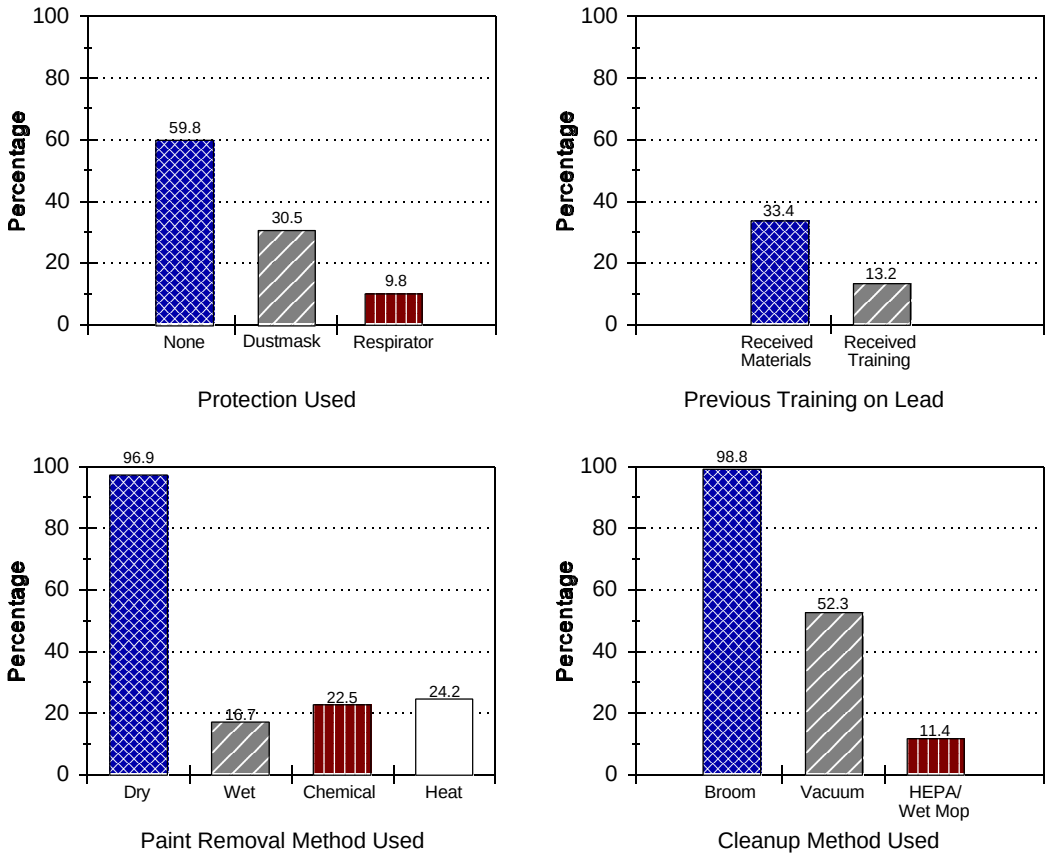

Figure 4. Summary of Worker Practices

over 90% reported using dry methods (power or hand sanding, hand scraping), and only 16% reported using wet methods. Wet methods of paint removal were employed most often by drywall workers and laborers. Of the 482 workers that had performed cleanup during the past 30 days, 99% reported that they had used a broom for cleanup, and only 11% reported using a HEPA vacuum or wet mop methods during cleanup. HEPA vacuum or wet mop methods were employed most often by window installers, painters, and laborers. Approximately 41% of workers smoked while on the job, with higher percentages for laborers, painters, and non-union carpenters. These three worker groups, together with window installers, contained a high percentage of workers (at or above 70%) performing hobbies with potential for lead exposure, and together with drywall workers and union carpenters, contained a high percentage of workers (at or above 30%) with previous non-R&R occupations with potential for lead exposure.

In addition to information on how many days in the past month cleanup was performed, the questionnaire also collected data on cleanup time for a typical day. As shown in Table 11, approximately 62% of the workers performed cleanup for less than one hour per day.

3.5 DESCRIPTIVE STATISTICS OF WORKER BLOOD-LEAD CONCENTRATIONS

Blood samples were obtained from 581 workers. The lead concentration of each sample was measured in at least two separate chemical analyses. The geometric mean blood-lead concentration (in units of µg/dL) among the multiple chemical injection measurements was used to represent the blood-lead concentration of each worker. Table C-4 provides descriptive statistics for the worker blood-lead concentrations.

The distribution of blood-lead concentrations for this sample was skewed; and therefore, a natural log transformation was employed to improve the assumption of normality. Normal and log-normal probability plots are displayed in Figures F-4 and F-5, respectively. Figure 5 shows a histogram of the blood-lead concentrations for the sampled workers. Worker blood-lead concentrations ranged from (below the detection limit of) 1 to 55 µg/dL, with a geometric mean of 4.5 µg/dL. Less than 10% of the workers (51 of 581) had blood-lead concentrations greater than 10 µg/dL, less than 1.5% had blood-lead concentrations greater than 25 µg/dL, and only one worker had a blood-lead concentration greater than 40 µg/dL.

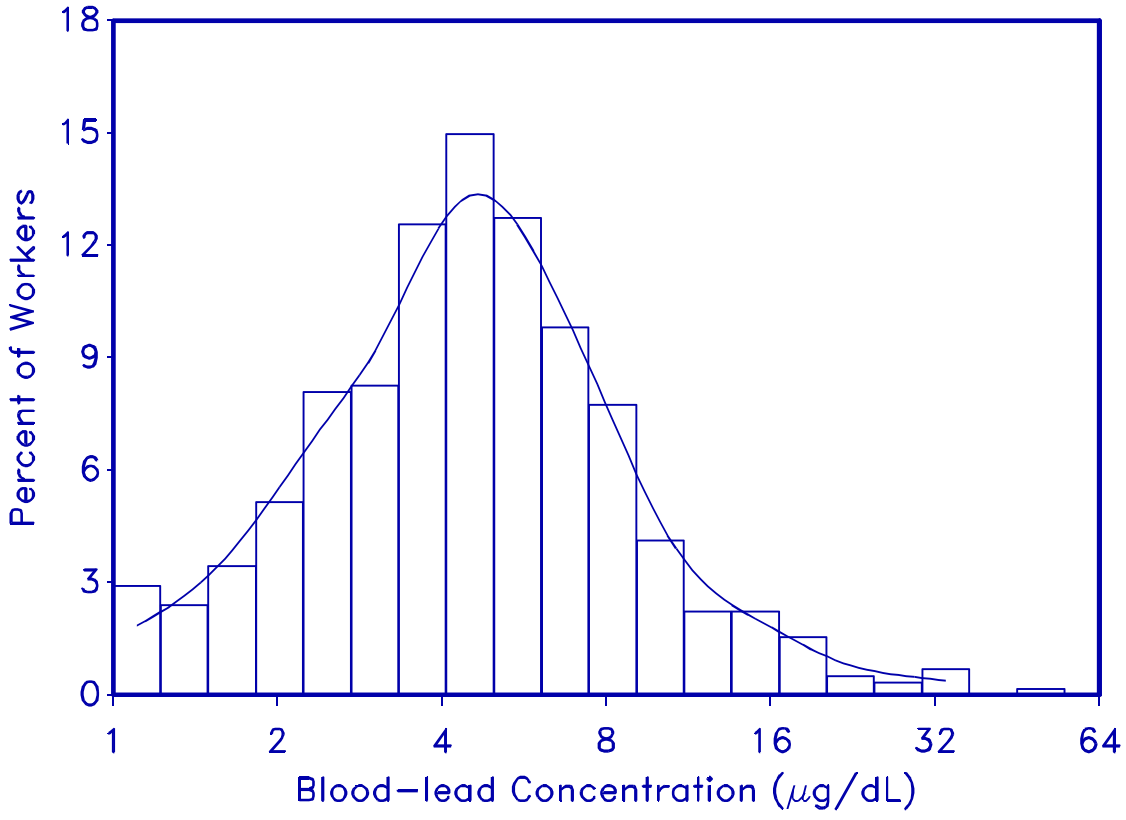

Figure 5. Histogram of Blood-Lead Concentration (Semi-Logarithmic Scale).

Table C-4 also provides descriptive statistics for the blood-lead concentrations for each sampling frame. Estimated 95% confidence intervals for the geometric mean of blood-lead concentrations for each sampling frame are provided in Table 12. Worker blood-lead concentrations were lower in St Louis (in comparison to Philadelphia, p-value <0.0001), and were less for union workers (in comparison to non-union workers, p-value <0.0001). The variability between worker blood-lead concentrations (measured by the log standard deviation) was similar among the sampling frames. Figure F-6 displays side-by-side boxplots of blood-lead concentrations for each sampling frame.

Each worker was assigned to a worker group based on his current job title and job activities. Table C-5 provides descriptive statistics and Figure F-7 displays side-by-side boxplots of blood-lead concentrations for each worker group. Estimated 95% confidence intervals for the geometric mean blood-lead concentration for each worker group are presented in Table 13.

Table 12. 95% Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for Each Sampling Frame

Sampling Frame	N	Geometric Mean (µg/dL)	log Std. Error log (µg/dL)	95% Confidence Interval (µg/dL)
Philadelphia Union	197	5.1	0.044	(4.6, 5.6)
Philadelphia Non-Union	74	5.6	0.072	(4.9, 6.5)
St Louis Union	150	3.0	0.050	(2.7, 3.3)
St Louis Non-Union	160	4.9	0.049	(4.5, 5.4)
All Four Groups Combined	581	4.5	0.027	(4.2, 4.7)

Table 13. 95% Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for Each Worker Group

Worker Group	N	Geometric Mean	95 % Confidence Interval
Union Carpenter	159	4.4	(4.0 , 4.8)
Non-Union Carpenter	104	5.0	(4.5 , 5.7)
Drywall Worker	64	5.8	(5.0 , 6.8)
Floor Layer	81	2.6	(2.3 , 3.0)
Laborer	54	4.9	(4.1 , 5.7)
Painter	34	7.2	(5.8 , 8.8)
Supervisor	57	3.8	(3.2 , 4.4)
Window Installer	14	5.4	(3.9 , 7.4)
Other	14	5.3	(3.9 , 7.3)

3.6 STATISTICAL MODELING RESULTS

3.6.1 Statistical Model Building

Statistical models were used to investigate the relationship between log-transformed worker 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 target activities. The lead exposure variables were constructed for carpet removal, window replacement, HVAC work, large structure removal, paint removal, cleanup, and general R&R work. There were three different periods of exposure captured by the questionnaire for each target activity: short-term exposure, mid-term exposure, and long-term exposure.

The number of days an activity was performed in pre-1950 buildings was selected as the measure of short-term exposure in the statistical models. 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 year. Long-term exposure for each target activity was characterized by the number of years a worker has performed the activity over his career. Thus, a total of 21 variables, one for each combination of target activity and exposure period, were used to characterize the potential lead exposure resulting from R&R.

3.6.1.1 Selection of Ancillary Covariates

Questionnaire information not related to worker group or the conduct of R&R may also have a significant effect on worker blood-lead concentrations. These ancillary variables were divided into two categories:

- Variables related to the conduct of R&R
  - Respirator use
  - General work practices
  - R&R activity in own home
  - Previous lead training and education

- Variables not related to the conduct of R&R
  - Other occupations with potential lead exposure
  - Age of home
  - Hobbies with potential lead exposure
  - Race and ethnicity of worker
  - Age
  - Smoking status
  - Education level

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

Each potential ancillary covariate was classified as being either discrete or continuous. Scatterplots and regression lines were used to characterize the relationships between continuous potential covariates and worker blood-lead concentrations. For each discrete covariate, boxplots of worker blood-lead concentrations (Figures F-8 to F-13) were generated for each level of the response. These boxplots helped identify discrete variables that had a significant relationship with blood-lead, and also provided insight for collapsing the levels of some of the discrete variables. Collapsing the response levels of the discrete variables may provide more power for statistical tests. For example, Question A4 related to worker education level had the following response levels:

(a) Grades 1 through 8
(b) Some High School
(c) High School Graduate
(d) Apprenticeship Training
(e) Some College/Tech School Graduate
(f) College/Tech School

Preliminary boxplots suggested a fundamental division between high school graduates and those who did not finish high school. Therefore, response levels (a) and (b) were collapsed into one category, and response levels (c) through (f) were collapsed into another category (See Figure F-12).

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, two different variables were constructed to reflect the number of other occupations or hobbies a worker had with high potential for lead exposure.

The statistical significance of each candidate covariate on blood-lead concentration is displayed in Table E-1 of Appendix E. Covariates with significant relationships with blood lead were then simultaneously placed into a single model with blood lead. Based on this analysis, the following variables were selected for inclusion in covariate adjusted models:

1. Race
2. Education
3. R&R in Own Home
4. Age of Home
5. Smoking Status
6. Respirator Use

Table 14 provides the geometric mean blood-lead concentration and log(standard deviation) for each level of the selected ancillary covariates.

Table 14. Geometric Mean Blood-lead Concentration and Log (Standard Deviation) for Each Level of the Ancillary Covariates

Variable	Level	Sample Size	Geometric Mean Blood-lead (µg/dL)	
			Mean	Std Dev
Race	White	488	4.26	0.029
	Black	83	5.81	0.071
	Other	10	4.73	0.206
Education	Less than HS	36	6.23	0.109
	Finished HS	545	4.37	0.028
Smoking Status	Non Smoker	303	3.97	0.037
	Smokes, not on Job	39	4.64	0.103
	Smokes on Job	239	5.14	0.042
Age of Home	Post 1978	113	3.48	0.060
	1978 - 1950	232	4.38	0.042
	Pre-1950	236	5.15	0.042
Performed R&R at Home	No	366	4.27	0.034
	Yes	215	4.81	0.045
Used Respirator or Dustmask	No	347	4.12	0.035
	Yes	233	5.04	0.043

3.6.1.2 Selection of the Form of the Model

The paradigm for fitting statistical models presented in Figure 2 was used to investigate the relationship between R&R target activities and worker blood-lead concentrations. Prior to investigating the data, there was no compelling basis for selecting the form of the functional relationship between blood-lead concentrations and measures of potential lead exposure associated with target activities. Therefore, exploratory methods were used to assess these relationships. This involved plotting the data and using robust locally weighted regression. If a functional relationship exists between blood lead and a particular exposure measure, be it linear, quadratic or exponential, the robust locally weighted regression procedure will yield a curve which approximates the functional relationship. Results of the exploratory analyses demonstrated that the relationship between log of blood lead and measures of potential lead exposure associated with each combination of target activity and exposure period could be adequately described by a linear model.

3.6.2 Comparisons Between Blood-Lead Concentrations Among Worker Groups

Geometric mean blood-lead concentration was also estimated for each worker group after adjusting for ancillary covariates. The geometric means are presented in Table 15. The covariate adjusted geometric means utilized a linear combination of the levels of each covariate with weights equal to the percent of workers at each level. The covariate adjusted geometric means

are similar to those unadjusted for covariates for all worker groups except painters. Figure 6 graphs the 95% confidence intervals for the covariate adjusted geometric means.

Table 15. 95% Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for Each Worker Group Based on Covariate Adjusted Model

Worker Group	Geometric Mean	95% Confidence Interval
Union Carpenter	4.5	(4.1 , 5.0)
Non-Union Carpenter	4.8	(4.3 , 5.4)
Drywall Workers	6.1	(5.3 , 7.1)
Floor Layer	2.8	(2.5 , 3.2)
Laborer	4.1	(3.5 , 4.9)
Painter	5.9	(4.8 , 7.3)
Supervisor	4.1	(3.5 , 4.8)
Window Installer	5.8	(4.3 , 7.9)
Other	4.9	(3.6 , 6.7)

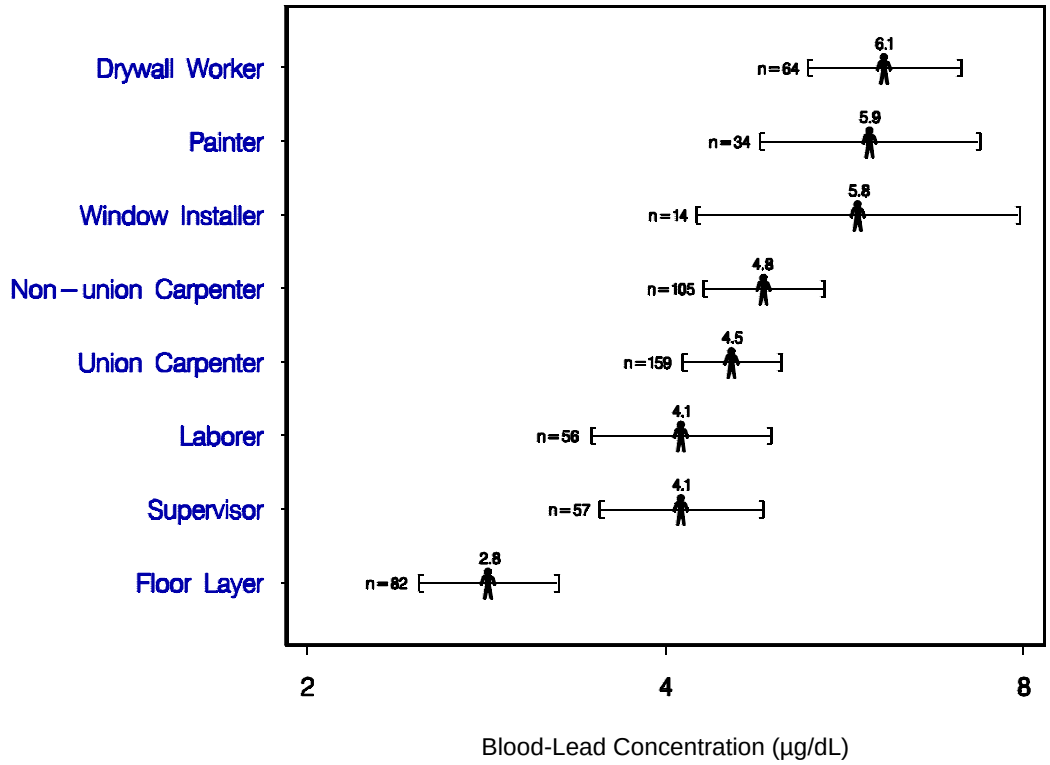

Figure 6. 95% Confidence Intervals for Geometric Mean of Blood-Lead Concentrations for Each Worker Group Based on Covariate Adjusted Model

3.6.3 Relationships Between R&R Target Activities and Worker Blood-Lead Concentrations

The effect of each of the 21 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 E-2. With the exception of carpet removal, there was a statistically significant positive relationship between worker blood-lead concentration and short-term conduct in pre-1950 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 generally positive.

Many of the slope estimates presented in Table E-2 were positive and statistically significant (p-value < 0.05). For each target activity, Table 16 presents the predicted increase in blood-lead concentration for 10 days of work activity in pre-1950 buildings. (Mean number of days of work activity in pre-1950 buildings, as shown in Table 10, was approximately 10 days.) The second column displays predicted blood-lead concentration for each target activity, for workers who performed the activity for zero and ten days in pre-1950 houses during the previous

month. The predicted increases in blood-lead concentration ranged from 0.5 µg/dL for carpet removal to 1.2 µg/dL for HVAC work. The maximum predicted blood-lead concentration associated with 10 days of work in pre-1950 buildings, 5.6 µg/dL, was estimated for HVAC work.

The covariate adjusted effects for each combination of target activity and exposure period were estimated using separate linear regression models. Estimated slopes, standard errors, and p-values are shown in Table E-3. The estimated slopes for target activities were generally positive after adjusting for the effects of selected ancillary covariates. As expected, the magnitudes of the covariate adjusted slopes estimates were generally less than the unadjusted slope estimates.

The predicted increase in blood-lead concentrations, based on the covariate adjusted models, associated with 10 days of work in pre-1950 buildings are presented in the third column of Table 16. The smaller slope estimates for the covariate adjusted models compared to the unadjusted models generally resulted in smaller predicted increases in worker blood-lead concentrations. For example, the predicted increase in blood-lead concentrations associated with 10 days of paint removal was 0.5 µg/dL for the covariate adjusted model compared to 1.1 µg/dL for the unadjusted model. For all activities, the estimated increase in blood-lead concentration from the base level was very small (less than 1 µg/dL) for the covariate adjusted model.

Covariate adjusted models that included all three exposure periods (short-, mid-, and long-term) were also fitted 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 E-4. Parameter estimates in Table E-4 are not consistent across the seven target activities. Short-term exposure (days pre-1950) appeared to dominate for paint removal and cleanup, mid-term exposure (weeks in last year) for window replacement and carpet removal, and long-term exposure (years over career) for large structure removal. For the conduct of R&R work in general, all three exposure periods were significantly associated with blood-lead concentrations. There were no significant relationships

Table 16. Predicted Increase in Blood-Lead Concentration Associated with 10 days of Work in Pre-1950 Buildings

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

Cleanup	4.1 þ 4.7*	4.3 þ 4.6*
General R&R	3.7 þ 4.4*	3.9 þ 4.4*

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

found at all for HVAC work. The inconsistent results of these models may be attributed to the high degree of correlation among the three exposure period measures for each target activity.

3.6.4 Overall Statistical Model for Worker Blood-Lead Concentrations

The right branch of Figure 2 presented the paradigm for developing an overall statistical model. An initial series of models were fitted to the data to assess which of the specific target activities, if any, had the largest impact on blood-lead concentration during each exposure period. For each period of exposure, the effects of all of the target activities (with the exception of general R&R work) were estimated simultaneously using covariate adjusted models. Estimated slopes, standard errors, and p-values are presented in Table E-5.

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 is a result of the strong inter-correlations among the target activity variables.

In Section 3.3, it was observed that target activities varied across the worker groups and in Section 3.6.2 that there were differences in the geometric mean blood-lead concentrations among the nine worker groups. The next series of models assessed which of the specific target activities, if any, have a statistically significant impact on worker blood-lead concentrations after adjusting for the effects of ancillary covariates and worker group. Estimated slopes, standard errors, and p-values are displayed in Table E-6. Although mid-term window replacement had a significant impact on worker blood-lead concentrations, the major result was that virtually no statistically significant relationships were found between target activities and blood lead after adjusting for the effects of the ancillary covariates and worker group.

This result is illustrated in Table 17, which provides general F-tests for the effects of all target activities combined on worker blood-lead concentrations after adjusting for the effects of selected covariates and worker group. The first row shows the R^2 value (12.4%), F-test (8.97) and corresponding p-value (< 0.001) for a model which included only the selected ancillary covariates. The next three rows correspond to models which, for each exposure period, included the ancillary covariates and exposure measures for the six target activities. The combined effect of all six target activities was statistically significant for each exposure period, and accounted for between 1.9 and 5.5% of the variability in worker blood-lead concentrations after adjusting for the covariates. The next 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 12.4% of the variability in blood lead after adjusting for the covariates. The last three rows describe, for each exposure period, the combined effect of all six target activities after adjusting for the effects of ancillary covariates and worker group. The F-test for

the combined exposure measures showed that the combined effects of target activities did not have a significant impact on worker blood-lead concentrations after adjusting for covariates and worker group.

Based on the previously fitted models, the following information was used to develop a final predictive model:

1. Worker group appears to be the most predictive measure of worker blood-lead concentration. Table 17 showed that the partial R^2 for the effect of worker group was 0.124 after adjusting for the effects of the ancillary covariates.

2. The conduct of general R&R work for all three exposure periods was statistically significant when fitted simultaneously in a covariate adjusted model.

3. The combined effect of the six target activities (carpet removal, window replacement, HVAC work, large structure removal, paint removal, and cleanup) did not have a significant impact on worker blood-lead concentration after adjusting for the effects of the ancillary covariates and worker group.

Final Model

The final predictive model fitted to worker blood-lead concentrations was

log(blood lead) = Worker Group + Covariates + (General R&R * Exposure Period)

Estimated parameters, standard errors, and p-values are presented in Table E-7.

This model included an intercept for each worker group and a slope for the effect of performing general R&R in each exposure period. The estimated worker-group intercepts represent the baseline blood-lead concentration for each worker group. Baseline blood-lead concentrations were highest for painters, drywall workers, and window installers, and were lowest for supervisors and floor layers.

Table 17. General F-Tests for the Combined Effects of All Target Activities on Worker Blood-Lead Concentrations, After Adjusting for the Effects of Covariates and Worker Group

Base Model	Variables Under Investigation	R^2	R^2_p	F	P-Value
	Covariates	0.124	----	8.97	<0.001
Covariates	Target Activities (Pre-1950)	0.145	0.024	2.48	0.022
	Target Activities (Weeks)	0.172	0.055	5.42	<0.001
	Target Activities (Years)	0.141	0.019	2.67	0.015
Covariates	Worker Group	0.233	0.124	10.00	<0.001
Covariates + Worker Group	Target Activities (Pre-1950)	0.235	0.003	0.94	0.466
	Target Activities (Weeks)	0.246	0.017	1.56	0.157
	Target Activities (Years)	0.235	0.003	1.19	0.310

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.

The estimated slopes for the conduct of general R&R were positive and statistically significant for each exposure period. Since estimated slopes are the same for all worker groups, differences between worker groups are captured by the estimated intercepts. Thus, the interpretation of this final model is that there are differences in the blood-lead concentrations of different worker groups, and that the amount of general R&R work conducted has the same effect for all workers, regardless of worker group.

The linear relationships between worker blood-lead concentration and conduct of general R&R within each worker group are displayed graphically for short-term exposure, mid-term exposure, and long term exposure in Figures F-14 through F-16, respectively. The fitted line displayed in each graph is based on the common slope estimated for the exposure period. Based on these graphs, it appeared that the assumption of a common slope across the worker groups for the conduct of general R&R in each exposure period was justified.

To illustrate how blood-lead concentration is a function of the amount of general R&R work performed, Table 18 displays the estimated blood-lead concentration (and 95% confidence interval) associated with low, medium, and high exposure indices based on the final model. The low, medium, and high exposure indices were based on the 25th, 50th, and 75th percentiles of questionnaire responses for short-, mid-, and long-term conduct of general R&R. Although the model predicts a 60% increase in blood-lead concentration between the low and high exposure indices, the actual differences in predicted blood-lead concentrations ranged from 1.5 µg/dL for floor layers to 3.0 µg/dL for painters.

Table 18. Predicted Worker Blood-Lead Concentrations Associated with Low, Medium, and High Exposure Indices for Each Worker Group

Worker Group	Low Exposure Index 0 Days Pre-1950 1-4 Weeks in Last Year 5 Years over Career		Medium Exposure Index 10 Days Pre-1950 9-26 Weeks in Last Year 10 Years over Career		High Exposure Index 25 Days Pre-1950 >26 Weeks in Last Year 25 Years over Career	
	Geometric Mean	95% C.I.	Geometric Mean	95% C.I.	Geometric Mean	95% C.I.
Union Carpenter	4.0	(3.5 , 4.5)	4.7	(4.3 , 5.2)	6.4	(5.5 , 7.3)
Non Union Carpenter	3.9	(3.3 , 4.5)	4.6	(4.1 , 5.2)	6.2	(5.3 , 7.1)
Drywall Worker	5.0	(4.3 , 5.9)	6.0	(5.2 , 6.9)	8.1	(6.8 , 9.6)
Floor Layer	2.5	(2.2 , 2.9)	3.0	(2.6 , 3.4)	4.0	(3.4 , 4.8)
Laborer	3.5	(2.9 , 4.2)	4.2	(3.5 , 4.9)	5.6	(4.6 , 6.8)
Other	4.2	(3.1 , 5.8)	5.0	(3.7 , 6.8)	6.8	(4.9 , 9.3)
Painter	5.1	(4.1 , 6.3)	6.0	(4.9 , 7.4)	8.1	(6.4 , 10.2)
Supervisor	3.4	(2.9 , 4.1)	4.1	(3.5 , 4.8)	5.5	(4.6 , 6.6)
Window Installer	4.4	(3.2 , 6.1)	5.2	(3.8 , 7.1)	7.0	(5.1 , 9.6)

Tukey's multiple comparison procedure for unbalanced data was employed to conduct pairwise comparisons between geometric mean blood-lead concentrations predicted for each worker group, based on the covariate-adjusted model. The nine worker groups were separated into three groups, as shown below.

Floor Layer	Supervisor	Laborer	Non-Union Carpenter	Union Carpenter	Window Installer	Painter	Drywall Worker
3.0 µg/dL	4.1 µg/dL	4.2 µg/dL	4.6 µg/dL	4.7 µg/dL	5.2 µg/dL	6.0 µg/dL	6.0 µg/dL

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Mean blood-lead concentrations for floor layers were statistically less than those for the other worker groups. Mean blood-lead concentrations for painters and drywall workers were greater than those for supervisors.

4.0 SUMMARY AND OVERALL CONCLUSIONS

The WCBS surveyed two groups of R&R workers (union carpenters and employees of independent contractors) in two cities (Philadelphia, Pennsylvania, and St. Louis, Missouri). A total of 585 questionnaires and 581 blood samples were collected from R&R workers. The results were utilized to address three objectives:

1. Determine the relationship between blood-lead concentrations and work practices or target activities performed by R&R workers after controlling for other factors that may affect worker blood-lead concentrations.

2. Determine if blood-lead concentrations of R&R workers in specific worker groups differ after adjusting for other factors that may affect worker blood-lead concentrations.

3. Gather information on the types of work activities and work practices in which R&R workers engage.

Overall results for each of these objectives, presented in reverse order, are summarized below.

Questionnaires were collected from a total of 585 workers in the WCBS. The sample of R&R workers consisted primarily of white males between the ages of 30 and 45. The questionnaire captured data on how often each worker conducted specific target activities in any home, as well as in pre-1950 homes, during the past 30 days. The questionnaire results indicated that the sampled workers spent an average of 17 days during the past month on general renovation and remodeling. The workers spent on average of 11 of these 17 days in pre-1950 homes. The questionnaire results indicated that:

1. The workers performed a wide variety of R&R activities, and spent considerable time doing large structure removal and paint removal or surface preparation, activities with potential for creating high dust-lead exposures.

2. The R&R workers were evenly divided between those that worked in residential and nonresidential buildings.

3. 90% of the workers did not use a respirator.

4. 88% of the workers did not use cleanup methods recommended for use in a lead contaminated environment and 98% reported using dry sweeping methods.

5. 66% of the workers had not received any materials on lead hazards and 86% had received no lead exposure training.

Blood samples were successfully collected from 581 of the 585 workers. Worker blood-lead concentrations were generally low: 9.1% were above 10 µg/dL, 3.8% were above 15 µg/dL, 1.2% were above 25µg/dL, and only one worker had a blood-lead concentration greater than 40 µg/dL. The blood-lead results indicated that

6. The distribution of blood-lead concentrations was approximately log-normal with a geometric mean of 4.5 µg/dL and a log standard deviation of 0.659 log(µg/dL).

7. Blood-lead concentrations were significantly different between the sampling frames. This was mostly attributed to lower blood-lead concentrations for the union carpenters in St. Louis.

8. Although geometric mean blood-lead concentrations were low for all of the worker groups, there were significant differences among the worker groups that differentiate the groups with the high mean blood-lead concentrations from those with the low mean blood-lead concentrations. Drywall workers (6.1 µg/dL), painters (5.9 µg/dL), and window installers (5.8 µg/dL) had the highest blood-lead concentrations and floor layers (2.8 µg/dL) had the lowest.

9. Several of the ancillary variables were significantly related to worker blood-lead concentrations. Of all the factors investigated, race, education level, smoking status, age of worker's home, recent R&R work in worker's home, and respirator usage were determined to be significantly related to worker blood-lead concentrations. In general, the estimated effect of each factor was anticipated: smokers, Blacks, non-high school graduates, workers residing in older homes, and workers residing in homes that recently underwent R&R had higher blood-lead concentrations. However, the observed affect associated with respirator usage was opposite of what was anticipated with an increase in mean blood-lead concentration associated with use of a respirator. One possible explanation for this may be that workers who report they wear respirators are much more likely to be exposed to lead-based paint than those who report otherwise.

A series of statistical models were used to investigate the relationship between blood-lead concentration and the conduct of specific R&R activities. Initially, separate models were fitted to the data for each target activity. Based on the separate models fitted to each target activity that adjusted for the ancillary covariates:

10. The number of days worked in pre-1950 buildings in the past month was significantly related to increases in blood-lead concentrations for general R&R work, paint removal, and cleanup. However, the estimated increase in predicted blood-lead concentration associated with performing any of these activities in pre-1950 buildings for 10 days per month was very small (less than 1µg/dL) for all activities.

11. The number of weeks worked in the past year was significantly related to increases in blood-lead concentrations for general R&R work, window replacement, and large structure removal.

12. The number of years worked was significantly related to increases in blood-lead concentrations for general R&R work, window replacement, and large structure removal.

13. Predicted increases in blood-lead concentrations, although sometimes statistically significant, were less than 1 µg/dL for each additional 10 days of work conducted.

A final model was developed that included effects for ancillary covariates, worker group, and conduct of general R&R activity for each of three exposure periods: short-term, mid-term, and long-term. Results of this model indicated that:

14. Much of the statistical association between specific target activities and blood-lead concentrations was also captured by the effects of worker group. In fact, worker group was the most predictive measure of blood-lead concentration.

15. Worker blood-lead concentrations were predicted to be highest for painters, drywall workers, and window installers, and were predicted to be the lowest for floor layers and supervisors.

16. Conduct of general R&R work was significantly related to increases in worker blood-lead concentrations for all three exposure periods.

17. An empirically based index of low potential for lead exposure resulting from conduct of R&R work was estimated to be 0 days worked in pre-1950 buildings in the past month, 1 to 4 weeks worked in the past year, and 5 years of R&R experience. Similarly, an empirically based index of high potential for lead exposure was estimated to be 25 days worked in pre-1950 buildings in the past month, more than 26 weeks worked in the past year, and over 25 years of R&R experience. The increase in worker blood-lead concentrations between a low and high index of potential lead exposure was predicted to be 60%. Although statistically significant, the maximum predicted blood-lead concentration for a high potential for exposure was only 8.1 µg/dL.

To place the results of the WCBS into perspective, the geometric mean blood-lead concentrations of non-Hispanic White and Black workers aged 20-49 were compared to national averages reported in NHANES III. The geometric mean of blood-lead concentrations for the R&R workers were only slightly higher than those reported in NHANES III. Table 19 indicates that the difference in geometric mean blood-lead concentration between R&R workers and the general population was 0.4 µg/dL for non-Hispanic Whites and 1.1 µg/dL for non-Hispanic Blacks.

The results of this study indicated that although R&R workers may be exposed to high levels of lead during the conduct of their work, there was little evidence of elevated blood-lead concentrations among the workers. It is possible that there exist specialized groups of R&R workers who may have higher lead exposures, for example, workers specializing in historic renovations. However, the WCBS study included workers in cities with a documented lead problem who were conducting a significant amount of work in older buildings. In fact, the study was weighted toward highly exposed general R&R workers. Nevertheless, only seven workers out of 581 had a blood-lead concentration greater than 25 µg/dL, and only one worker out of 581 had a blood-lead concentration greater than 40 µg/dL; workers with blood-lead concentrations greater than 40 µg/dL require increased medical surveillance under the interim OSHA rule for lead in construction.

Table 19. Difference in Geometric Mean Blood-Lead Concentration Between WCBS and NHANES III

	WCBS		NHANES III	
Control	Geometric Mean (µg/dL)	95% Confidence Interval	Geometric Mean (µg/dL)	95% Confidence Interval
Non-Hispanic Whites	4.2	(3.9 , 4.4)	3.8	(3.6 , 4.1)
Non-Hispanic Blacks	5.6	(4.8 , 6.4)	4.5	(4.2 , 4.8)

APPENDIX A:
QUESTIONNAIRES

RECORD 01

ID #: [| | | |] 01-04

RECORD #: [0 | 1] 05-06

WORKER EXPOSURE STUDY

TELEPHONE INTERVIEW SCREENER

Hello, my name is _____ and I'm calling for the Environmental Protection Agency about a study of renovation and remodeling workers. You may have received a letter from (your union/the National Association of Home Builders) in the past couple weeks explaining about the study. I'd like a little of your time to ask a few questions about your work. 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 (THANK R AND STOP) .. 2

   07

2. Do you do *hands-on* work? For example, do you do painting; surface preparation such as sanding, scraping, torching or floor refinishing; carpentry; demolition; cleanup or installation? (This does not include administrative or sales work.)

   YES ..... (CONTINUE) 1
   NO (THANK R AND STOP) .. 2

   08

3. 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.

   # DAYS WORKED ..... [| |]

   09-10

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

   NUMBER OF YEARS .... [| |]

   11-12

5. In the last 30 days, how many days did you spend renovating or remodeling homes or buildings built before 1950?

   DAYS IN BLDGS < 1950 .. [| |]

   13-14

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

   DAYS IN HOMES ..... [| |]

   15-16

7. 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. ..... [| |]

   17-18

8A. In the last 30 days, how many days did you spend removing carpets?
DAYS ..... ⌊_⌊_⌋ 19-20

8B. In the last 30 days, how many days did you spend removing windows or door casements?
DAYS ..... ⌊_⌊_⌋ 21-22

8C. In the last 30 days, how many days did you work to maintain, repair or clean heating, ventilation or air conditioning systems?
DAYS ..... ⌊_⌊_⌋ 23-24

8D. In the last 30 days, how many days did you work removing large structures such as making openings for large windows or doorways, tearing down ceilings, putting up walls or removing kitchen cabinets?
DAYS ..... ⌊_⌊_⌋ 25-26

8E. In the last 30 days, how many days did you spend removing paint or preparing surfaces?
DAYS ..... ⌊_⌊_⌋ 27-28

8F. In the last 30 days, how many days did you spend doing the hands-on *dirty* cleanup, where you cleaned up the dirt, dust and debris caused by the renovation and remodeling activities?
DAYS ..... ⌊_⌊_⌋ 29-30
IF 8F = 00, SKIP TO Q9

8G. In the last 30 days, about how many hours in a typical day did you spend doing dirty cleanup work?
DIDN'T DO CLEANUP 1
< ½ HOUR/DAY 2
½ - < 1 HOUR/DAY 3
1 - 4 HOURS/DAY 4
> 4 HOURS/DAY 5
31

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

JOB TITLE: _____ ⌊_⌊_⌋ 32-33

34-35

MAIN ACTIVITIES: _____ ⌊_⌊_⌋

10. Now I'd like to ask you just a few more questions about yourself. How old are you?
AGE ..... ⌊_⌊_⌋ 36-37

11. What is your race and ethnic group? (PROBE FOR HISPANIC ORIGIN)
WHITE, NOT HISPANIC 01
WHITE, HISPANIC 02
BLACK, NOT HISPANIC 03
BLACK, HISPANIC 04
AMERICAN INDIAN 05
ASIAN/PACIFIC ISLANDER ... 06
OTHER ... (SPECIFY) 07
38-39

SPECIFY: _____

12. RECORD GENDER WITHOUT ASKING, IF POSSIBLE. IF NOT, ASK "Are you male or female?"
MALE 1
FEMALE 2
40
END 01

Thank you very much for taking the time to speak with me about your work. If you have any questions or concerns, the study manager, Beth Moore, would be happy to speak with you. You can reach her at (614) 424-4560.

RECORD 01

ID#: ☐-☐-☐☐☐☐ *01-06*

RECORD #: 0 1 *07-08*

DATE: ☐☐-☐☐-☐☐ *09-14*
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. Study staff on duty can provide you with a copy of the letter you were mailed earlier, explaining about the study and how we will use the information you provide.

Thank you for your help in this important research project.

RECORD 01

SECTION A: DEMOGRAPHICS

A1. How old are you?

AGE ..... ☐☐ 15-16

A2. What is your race and ethnic group?

WHITE, NOT HISPANIC ..... ☐ 17-18
WHITE, HISPANIC ..... ☐
BLACK, NOT HISPANIC ..... ☐
BLACK, HISPANIC ..... ☐
AMERICAN INDIAN ..... ☐
ASIAN/PACIFIC ISLANDER ..... ☐
OTHER ... (SPECIFY) ..... ☐

SPECIFY: _____

A3. Are you male or female?

MALE ..... ☐ 19
FEMALE ..... ☐

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

GRADES 1 THROUGH 8 ..... ☐ 20
SOME HIGH SCHOOL ..... ☐
HIGH SCHOOL GRADUATE/GED ☐
APPRENTICESHIP TRAINING ... ☐
SOME COLLEGE/TECH SCHOOL ☐
COLLEGE/TECH SCHOOL GRAD ☐

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

CHILDREN UNDER 6 ... ☐☐ 21-22

A6. Do you belong to the following trade organizations (not including unions)?

	Yes	No	
the National Association of the Remodeling Industry (NARI)?	☐	☐	23
the National Association of Homebuilders?	☐	☐	24

any other trade organizations?

_____ ☐☐ 25-26
(Please write name of other trade organization.) OFFICE USE

_____ ☐☐ 27-28
(Please write name of other trade organization.) OFFICE USE

A7. Do you belong to any of the following unions?	Yes	No	
the United Brotherhood of Carpenters?	☐	☐	29
the International Brotherhood of Electrical Workers?	☐	☐	30
the Laborers International Union of North America?	☐	☐	31
the International Brotherhood of Painters and Allied Trades?	☐	☐	32

any other union? (SPECIFY) _____ ☐☐ 33-34

OFFICE USE

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 B: WORK HISTORY

B1. What is your current job title and what are your main activities at work?

JOB TITLE: _____ ☐☐ 35-36

MAIN ACTIVITIES: _____ ☐☐ 37-38

OFFICE USE

B2. During 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.) _____ days 39-40

B3. During the last 30 days, how many days did you spend renovating or remodeling homes or buildings built before 1950? _____ days 41-42

B4. During the last 30 days, how many days did you work in residential buildings (homes, apartments)? _____ days 43-44

B5. During the last 30 days, how many days did you work in non-residential buildings (offices, schools, government buildings)? _____ days 45-46

RECORD 01

B6. During the last 12 months, how many weeks did you spend doing renovation and remodeling?

- NONE ☐ — 47
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

B7. How many years altogether have you done renovation and remodeling work?

_____ years — 48-49

SECTION C: CARPET REMOVAL

C1. In the last 30 days, how many days did you remove carpet? _____ days 50-51

If you have not removed any carpet in the last 30 days, go to question C4.

C2. In the last 30 days, how many days did you use a respirator while you removed carpet? _____ days 52-53

C3. In the last 30 days, how many days did you remove carpet from homes or buildings that were built before 1950? _____ days 54-55

C4. Altogether in the last 12 months, how many weeks did you remove carpet? 56

- NONE ..... ☐
- LESS THAN 1 WEEK ..... ☐
- 1 - 4 WEEKS ..... ☐
- 5 - 8 WEEKS ..... ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ..... ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ..... ☐

C5. Think about all the years you've done renovation or remodeling. How many of these years did you remove carpet at least some of the time? _____ years 57-58

If you have never removed carpet, go to SECTION D.

C6. Think about all the years you've removed carpet. In an average year, how many weeks did you spend removing carpet? 59

- NONE ..... ☐
- LESS THAN 1 WEEK ..... ☐
- 1 - 4 WEEKS ..... ☐
- 5 - 8 WEEKS ..... ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ..... ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ..... ☐

RECORD 01

SECTION D: WINDOW OR DOOR CASEMENT REPLACEMENT

D1. In the last 30 days, how many days did you remove windows or door casements? _____ days — 60-61

If you have not removed any windows or door casements in the last 30 days, go to question D4.

D2. In the last 30 days, how many days did you use a respirator while you removed windows or door casements? _____ days — 62-63

D3. In the last 30 days, how many days did you remove windows or door casements from homes or buildings built before 1950? _____ days — 64-65

D4. Altogether in the past 12 months, how many weeks did you remove windows or door casements? — 66

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

D5. Think about all the years you've done renovation or remodeling. How many of these years did you remove windows or door casements at least some of the time? _____ years — 67-68

If you have never removed window or door casements, go to SECTION E.

D6. 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? — 69

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

END 01

SECTION E: HEATING, VENTILATION AND AIR CONDITIONING — When you answer these questions, include any work you have done to maintain, repair or clean heating, ventilation or air conditioning systems.

E1. In the last 30 days, how many days did you work on heating, ventilation or air conditioning systems? _____ days *09-10*

If you have not done any work on heating, ventilation or air conditioning systems in the last 30 days, go to question E4.

E2. In the last 30 days, how many days did you use a respirator while you worked on heating, ventilation or air conditioning systems? _____ days *11-12*

E3. In the last 30 days, how many days did you work on heating, ventilation or air conditioning systems in homes or buildings built before 1950? _____ days *13-14*

E4. Altogether in the past 12 months, how many weeks did you work on heating, ventilation or air conditioning systems? *15*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

E5. Think about all the years you've done renovation or remodeling. How many of these years did you work on heating, ventilation or air conditioning systems at least some of the time? _____ years *16-17*

If you have never worked on heating, ventilation or air conditioning systems, go to SECTION F.

E6. Think about all the years you've worked on heating, ventilation or air conditioning systems. In an average year, how many weeks did you spend working on these systems? *18*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

SECTION F: 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
- putting up walls
- removing kitchen cabinets

F1. In the last 30 days, how many days did you remove large structures? _____ days *19-20*

If you have not removed any large structures in the last 30 days, go to question F4.

F2. In the last 30 days, how many days did you use a respirator while you removed large structures? _____ days *21-22*

F3. In the last 30 days, how many days did you remove large structures from homes or buildings built before 1950? _____ days *23-24*

F4. Altogether in the past 12 months, how many weeks did you remove large structures? *25*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

F5. Think about all the years you've done renovation or remodeling. How many of these years did you remove large structures at least some of the time? _____ years *26-27*

If you have never removed large structures, go to SECTION G.

F6. Think about all the years you've removed large structures. In an average year, how many weeks did you spend removing large structures? *28*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

SECTION G: PAINT REMOVAL AND SURFACE PREPARATION — By surface preparation, we mean activities such as sanding, scraping, torching, or floor refinishing.

G1. During the last 30 days, how many days did you remove paint or prepare surfaces? _____ days 29-30

If you didn't remove paint or prepare surfaces at all in the last 30 days, please go to question G6 and continue from there.

G2. During the last 30 days, how many days did you remove paint or prepare surfaces in homes or buildings built before 1950? _____ days 31-32

G3. During the last 30 days, how many days did you use a respirator when you removed paint or prepared surfaces? _____ days 33-34

G4. During the last 30 days when you removed paint or prepared surfaces, how many days did you do this inside? _____ days 35-36

G5. When you removed paint in the last 30 days, how many days did you use the following?

A. dry power sanding? ..... _____ days 37-38

B. dry hand sanding? ..... _____ days 39-40

C. dry scraping? ..... _____ days 41-42

D. burning, torching, or a heat gun? ..... _____ days 43-44

E. wet scraping? ..... _____ days 45-46

F. wet sanding? ..... _____ days 47-48

G. chemical stripping? ..... _____ days 49-50

H. a dust collector when you sanded? ..... _____ days 51-52

G6. During the past 12 months, how many weeks did you spend doing paint removal or surface preparation?

- NONE ☐ — *53*
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

If you have never done paint removal or surface preparation, please go to SECTION H.

G7. Think about all the years you've done renovation and remodeling. 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 — *54-55*

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

- WITHIN THE LAST MONTH ☐ — *56*
- MORE THAN A MONTH AGO ☐
- MORE THAN A YEAR AGO ☐
- MORE THAN 5 YEARS AGO ☐

B. 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?

- NONE ☐ — *57*
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

SECTION H: CLEANUP — By cleanup work, we mean the *hands-on* (dirty) 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.

H1. During the last 30 days, how many days have you spent doing dirty cleanup? _____ days *58-59*

If you didn't do any dirty cleanup activity at all in the last 30 days, please go to question H6 and continue from there.

H2. In the last 30 days, about how many hours in a typical day did you spend doing dirty cleanup? *60*

- LESS THAN ½ HOUR/DAY ☐
- ½ TO LESS THAN 1 HOUR/DAY ☐
- 1 TO 4 HOURS/DAY ☐
- MORE THAN 4 HOURS/DAY ☐

H3. In the last 30 days, how many days did you spend doing dirty cleanup in homes or buildings built before 1950? _____ days *61-62*

H4. In the last 30 days, how many days did you use a respirator while doing dirty cleanup work? _____ days *63-64*

H5. In the last 30 days while you did dirty cleanup, how many days did you...

A. use a broom? ..... _____ days *65-66*

B. use any kind of vacuum? ..... _____ days *67-68*

C. use a HEPA vacuum? ..... _____ days *69-70*

D. use a wet mop with TSP, trisodium phosphate or ledisolve? ..... _____ days *71-72*

E. clean power tools using any method? ..... _____ days *73-74*

F. clean power tools using compressed air? ..... _____ days *75-76*

END 02

H6. During the past 12 months, how many weeks did you spend doing dirty cleanup? *09*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

If you have never done dirty cleanup of any kind, please go to SECTION I.

H7. How many years altogether have you spent doing dirty cleanup work at least some of the time? _____ years *10-11*

A. When was the last time you did any dirty cleanup work? *12*

- WITHIN THE LAST MONTH ☐
- MORE THAN A MONTH AGO ☐
- MORE THAN A YEAR AGO ☐
- MORE THAN 5 YEARS AGO ☐

B. Think about all the years you've done dirty cleanup. In an average year, how many weeks did you spend doing dirty cleanup? *13*

- NONE ☐
- LESS THAN 1 WEEK ☐
- 1 - 4 WEEKS ☐
- 5 - 8 WEEKS ☐
- 9 - 26 WEEKS (ABOUT 3 - 6 MONTHS) ☐
- MORE THAN 26 WEEKS (MORE THAN 6 MONTHS) ☐

SECTION I: GENERAL WORK PRACTICE QUESTIONS

I1. Please answer the following questions about your job in the last 30 days.

A.	How many days did you have water available at the worksite?	_____ days	14-15
B.	How many days did you work at sites that were dusty and dirty?	_____ days	16-17
C.	How many days did you eat at the worksite?	_____ days	18-19
D.	How many days did you wash your hands before you ate?	_____ days	20-21
E.	How many days did you wash your hands before you went home?	_____ days	22-23
F.	How many days did you change your clothes before you went home?	_____ days	24-25
G.	How many days did you change your shoes before you went home?	_____ days	26-27
H.	How many days did you take a radio to the worksite with you?	_____ days	28-29

I2. Do you currently use snuff or chewing tobacco? YES ☐ NO ☐ 30

I3. Do you currently smoke cigarettes? YES ☐ NO ☐ 31

If you do not smoke cigarettes, go to question I4. If you do smoke cigarettes, please answer questions A through C below.

A.	Do you smoke while you work?	YES ☐ NO ☐	32
B.	Do you smoke while on break?	YES ☐ NO ☐	33
C.	Do you carry your cigarettes in your shirt or pants pocket at work?	YES ☐ NO ☐	34

I4. When you used a respirator in the last 30 days, what type did you use? **Check all that apply.**

DIDN'T USE RESPIRATOR ☐	35-36
DUST MASK ☐	37-38
HALF MASK ☐	39-40
FULL FACE MASK ☐	41-42
TYPE C SUPPLIED AIR MASK ☐	43-44
PAPR ☐	45-46
SCBA ☐	47-48

SECTION J: OTHER OCCUPATIONS

Have you ever worked full-time in the following industries?	YES	NO	
1. For a lead abatement contractor?	☐	☐	49
2. In a firing range?	☐	☐	50
3. In a smelter?	☐	☐	51
4. In a battery plant?	☐	☐	52
5. Doing radiator repair?	☐	☐	53
6. As a bridge painter or in bridge demolition?	☐	☐	54
7. In the shipbuilding industry?	☐	☐	55
8. In an oil refinery?	☐	☐	56
9. In paint manufacturing?	☐	☐	57
10. As a welder?	☐	☐	58
11. As a solderer?	☐	☐	59
12. As a lead miner?	☐	☐	60
13. In a lead mill?	☐	☐	61
14. In a scrap and waste material company?	☐	☐	62

For each job you answered "YES" to above, please fill out a line on the following table.

Line # of job (from table above)	What was your job and most important duties?	When was the last time you worked in this industry?				
		Within the last month	More than a month ago	More than a year ago	More than 5 years ago	
☐☐	_____	☐	☐	☐	☐	63-67
☐☐	_____	☐	☐	☐	☐	68-72
☐☐	_____	☐	☐	☐	☐	73-77

END 03

SECTION K: 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.

K1. 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? *09*

- NEW CONSTRUCTION ..... ☐
- NOT NEW BUT BUILT AFTER 1978 ..... ☐
- BUILT BETWEEN 1950 AND 1978 ..... ☐
- BUILT BEFORE 1950 ..... ☐

K2. Have any room additions or any major remodeling changes been made to your home in the last 12 months? *10*

- YES ..... ☐
- NO ..... ☐

If no additions or changes have been made to your home in the last 12 months, leave questions A through F blank and continue with SECTION L.

A. Was the inside of the house remodeled in the last 12 months? *11*

- YES ..... ☐
- NO ..... ☐

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

- YES ..... ☐
- NO ..... ☐

C. Was paint stripped or sanded during the remodeling? *13*

- YES ..... ☐
- NO ..... ☐

D. Did the remodeling include major work on the kitchen or the bathroom? *14*

- YES ..... ☐
- NO ..... ☐

E. Did you do any of the work yourself? *15*

- YES ..... ☐
- NO ..... ☐

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

SPECIFY: _____ ☐☐ *16-17*

F. Did you live in the house while the work was being done? *18*

- YES ..... ☐
- NO ..... ☐

SECTION L: NON-WORK ACTIVITIES

		Yes	No	
L1.	Do you do any of the following?			
a.	Shoot guns at an indoor firing range?	☐	☐	19
b.	Cast lead into bullets or fishing sinkers?	☐	☐	20
c.	If you go fishing more than 10 times a year, do you crimp your sinkers onto your line with your teeth?	☐	☐	21
d.	Refinish, restore or repaint old cars or bicycles?	☐	☐	22
e.	Refinish furniture?	☐	☐	23
f.	Work on old metal radiators?	☐	☐	24
g.	Dismantle car or truck batteries?	☐	☐	25
h.	Paint with artist's paints?	☐	☐	26
i.	Work with stained glass?	☐	☐	27
j.	Work with ceramics?	☐	☐	28
k.	Eat out of imported ceramic dishes or decorated pottery?	☐	☐	29

SECTION M: MEDICAL HISTORY

M1.	Have you ever been diagnosed by a health care professional as having an elevated lead level in your blood?	YES ☐ NO ☐	30
M2.	In the last 12 months, have you been diagnosed by a health care professional as having anemia?	YES ☐ NO ☐	31
M3.	Has anyone else living in your household ever had their blood tested for lead? **Check all that apply.**	YES, OTHER ADULT ☐ YES, CHILD ☐ NO ☐	32 33 34
M4.	Has anyone else living in your household ever been identified by a health care professional as having an elevated blood lead level? **Check all that apply.**	YES, OTHER ADULT ☐ YES, CHILD ☐ NO ☐	35 36 37
M5.	Do you take calcium supplements?	YES ☐ NO ☐	38

M6. Do you use any of these medicines: Azarcon, greta, liga, maria luisa, alarcon, coral, rueda or pay-loo-ah? — YES ☐ NO ☐ — 39

M7. Have you ever been shot by a gun? — YES ☐ NO ☐ — 40

SECTION N: PREVIOUS TRAINING

N1. Have you ever received any training about how to reduce potential lead exposures at work? — YES ☐ NO ☐ — 41

If you have never had any lead training, please continue with question N2.

A. Who provided this training? **Check all that apply.**

- EMPLOYER ☐ — 42-43
- UNION ☐ — 44-45
- LOCAL OR STATE HEALTH DEPT. ☐ — 46-47
- PRIVATE COMPANY ☐ — 48-49
- FEDERAL AGENCY ☐ — 50-51
- COLLEGE OR UNIVERSITY ☐ — 52-53
- SOMEONE ELSE (SPECIFY) ☐ — 54-55

SPECIFY: _____

N2. Have you ever received any pamphlets or other information about how to reduce potential lead exposures in the workplace from any of the following groups?

	Yes	No	
a. A trade organization, such as NARI?	☐	☐	56
b. Union newsletters?	☐	☐	57
c. Trade magazines?	☐	☐	58
d. Supplier pamphlets?	☐	☐	59
e. Federal government, such as EPA	☐	☐	60
f. Non-profit or advocacy organization	☐	☐	61
g. Any other source? If yes, please specify on line below.			62

SPECIFY: _____

RECORD 04

N3. Have you ever had the water in your home tested for lead? YES ☐ NO ☐ 63

N4. Do you run your tap water for a minute before taking a drink? YES ☐ NO ☐ 64

N5. Has your home ever been tested for lead paint? YES ☐ NO ☐ 65

N6. Do you think that lead poses a potential problem for you at work? YES ☐ NO ☐ 66

N7. Are there other ways you think you may be exposed to lead that we haven't asked about? 67

_____

_____

N8. Is there anything else you'd like to tell us, or do you have any additional comments you would like to make? 68

_____

_____

END 04

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, you can call John Egel at 1-800-444-5234.

PLEASE RETURN THIS QUESTIONNAIRE TO THE STUDY MANAGER

If you would like the results of this study when it is complete, please call John Egel at 1-800-444-5234 to request them.

APPENDIX B:
ASSESSMENT OF LABORATORY QUALITY CONTROL DATA

Appendix B

Assessment of Laboratory Quality Control Data

Quality control activities were conducted on this project in order to assure the accuracy and reliability of the data. The assessment of the overall quality of the data was performed by the Senior Quality Assurance Officer of Midwest Research Institute using statistical quality control (SQC) procedures. The quality control data from the blood analyses for lead were evaluated using one or more statistical techniques (e.g., Gaussian distribution, ANOVA statistics, or Shewhart performance charts).

This section evaluates the data in terms of the data quality indicators as defined in the QAPjP. These indicators are the data quality objectives (DQOs) for the program and measurement quality objectives (MQOs) for the analytical procedures. Finally, the analytical results are assessed using the data obtained from the various quality control and performance evaluation samples.

1. DATA QUALITY OBJECTIVES

The analytical objective of the study was to determine the levels of lead in blood samples obtained from R&R workers. Using these data, the primary objective was to determine the relationship between blood-lead levels and work practices performed by R&R workers in specific work groups or work activities. To achieve the analytical objective of assuring that the data will permit an assessment of the correlation between R&R activities and actual exposure, the analytical data must meet the quantitative QA objectives of precision, accuracy, and completeness, and the qualitative QA objectives of representativeness and comparability.

With the selection of standard analytical methodology having known and acceptable criteria of performance for method detection limit, precision, and accuracy, the basic analytical objectives were met for this project. The quantitative objective for completeness required to achieve a specific statistical level of confidence also was achieved with 100% of the samples collected and shipped to the laboratory where they were to be analyzed. By using an acceptable and validated standard analytical method for blood-lead analysis, the analytical results are considered to be representative of lead levels in this population and comparable to the results of other similar studies.

2. MEASUREMENT QUALITY OBJECTIVES

The analytical methodology selected for the analysis of blood samples for lead was expected to provide quantifiable lead levels based on the expected amount of sample to be collected. To ensure the accuracy and reliability of the data generated during the analytical process, a series of internal quality control samples and CDC performance samples were included as part of the analytical design. These quality control and performance samples (Table B-1) with

proposed criteria were designed to allow not only a controlling mechanism for the procedure during the analytical process but also to provide the means to evaluate the results from each set of analyses and to assess the quality of the data.

Table B-1. Quality Control and CDC Performance Samples

Sample Identification	MQO Accuracy	MQO Precision	Type of Quality Control Sample	Lead Conc. µg/dL	Mean Recovery	Control Limits
Blank	< 1.0 µg/dL		Matrix modifier	0.0	-0.08	1.59
BioRad 1	±25%	±10%	Continuing calibration Reference material samples	5.0 - 8.3	99.74	58 - 142
BioRad 2	±25%	±10%	Continuing calibration Reference material samples	24.4 - 24.5	95.24	72 - 118
BioRad 3	±25%	±10%	Continuing calibration Reference material samples	55.4	95.98	81 - 111
New York State SRM	±10%		Calibration verification	16.0	98.25	68 - 130
NIST SRM 995a	±10%		Calibration Check Standard	13.53	101.0	79 - 122
CDC RS 590	±20%		Blind performance	9.0	93.35	77 - 110
CDC RS 991	±20%		Blind performance	23.3	98.72	89 - 109
CDC RS 1394	±20%		Blind performance	41.1	102.6	91 - 114

The results from the internal quality control samples and the external performance samples show that the selected method provided quantifiable lead levels that were accurate and reliable. The internal quality control samples were used during the analytical process as a control mechanism. The precision criteria were met for the majority of the internal quality control samples analyzed. Of those samples that did not meet the precision criteria, all were reanalyzed. The accuracy criteria were met for the internal quality control samples with the exception of six occasions or control situations. In two of the six control situations occurring during the analytical process, the process was terminated and restarted because the quality controls sample results were outside the acceptance criteria. In three of the six situations, the preceding and subsequent quality control samples were acceptable; therefore, the analytical process was continued. The samples analyzed between the two acceptable quality control samples were individually reviewed and either repeated in another batch or accepted with explanation and corrective action. The last control situation resulted from a shift of the control posture of the calibration verification reference (New York State SRM). These control situations and the control posture for all of the quality control and performance samples are discussed under data assessment (3.0).

3. DATA ASSESSMENT

Six quality control samples and three CDC performance evaluation samples were evaluated using a statistical evaluation program based on Gaussian distribution (Tables B-2 through B-10) and Shewhart control charts (Figures B-1 through B-10). Of the nine performance charts, five charts (BioRad-2, BioRad-3, CDC RS 590, CDC RS 991, and CDC RS 1394) show that the analytical process was in control for the specific level of lead. The other four charts indicated different control situations during the analytical phase of the project. These situations are discussed below.

The low level BioRad-1 (5.0 to 8.3 µg/dL) reference material quality control sample shows a broader accuracy range (58% to 142%) than had been expected (±25%) due largely to an observation (216%) on 22 November 1994. However, on that day, the failure of that quality control sample resulted in stopping the analytical sequence and restarting the analysis. When this sample is deleted, the variability is reduced from a standard deviation of 14.6% to a standard deviation of 10.4 and the accuracy range is reduced to ±30%, close to laboratory expectations and in compliance with QAPjP data quality objectives of ±30% for spiked samples. Moreover, over 95% of the BioRad-1 samples fell within ±25% of the certified concentration of the reference material.

The NIST SRM (13.53 µg/dL) used as the continuing calibration check was determined to have a broader accuracy range (79% to 122%) than originally considered (±10%). The accuracy range for the NIST SRM is consistent with the CDC RS 590 (9.0 µg/dL) and the BioRad-2 (24.4 to 24.5 µg/dL) ranges. The accuracy is consistent with the fact that it is a matrix SRM rather than a calibration standard that is used in similar analytical methods. In view of these facts, the accuracy range should be considered consistent with other procedures using matrix SRM material with an accuracy acceptance range of ±25%. In addition the accuracy range was calculated including a 22 November 1994 sample (62.31%) that resulted in stopping the analytical sequence and restarting the analysis, as well as a 15 November 1994 sample (62.31%) that was determined to be caused by a bad burn as discussed below. Deletion of these two samples results in an accuracy range of ±12%.

The normal instrument detection limit for the GFAA analysis is approximately 1 µg/dL. However, the results for the matrix modifier (blank) indicate a standard deviation of 1.59. A review of the data for the matrix modifier blanks indicated that four of the 288 samples were unusually large. Two of the four samples resulted in the analytical sequence being stopped and reanalysis of the samples. The other two samples were rejected because of their large difference from a replicate analysis of the same sample. When these four samples are deleted, the standard deviation is reduced to 0.64 resulting in an IDL of 1.27. Since all of the calibration standards and quality control samples were blood matrices, the MDL (3 x noise level) and method quantitation level (MQL = 5 x noise level) were also evaluated. The resultant MDL and MQL were 1.9 µg/dL and 3.2 µg/dL, respectively, for this procedure. These results are consistent with the results of the duplicate analyses (presented in Section 3.2.2.2). The log standard deviation of the duplicate blood draws was 0.0677. Assuming a lognormal distribution and a geometric mean of 4.5 µg/dL

(the mean blood-lead concentration in the study), the standard deviation of the sampling and analysis method is 0.31 which agrees with the expected precision of the method.

The last performance chart control situation occurred on the calibration verification quality control sample (NY State SRM). The control limits for the NY State SRM (16 µg/dL) show an accuracy range of ±31%. However, due to a shift in the control posture of the quality control sample, there are actually two ranges. The first range is for the analytical period from 23 September 1994 to 15 December 1994, where the mean recovery was 93.4%, and the accuracy range was 83.4% to 103.4%. The second range is for the analytical period from 15 December through 30 December 1994, where the mean recovery was 116.8% and the analytical range 106.8% to 126.8%. Each range by itself was within the acceptable criterion; however, the shift in control posture is unacceptable. The control posture of the NIST SRM (13.35µg/dL) was also reviewed and compared with the NY State SRM results. Although there was no shift in control posture for the NIST SRM, the data show a mean that has increased consistently over the analytical sequence. The NIST data are supportive of the shift in control posture for the NY State SRM. The analytical results, based on the calibration curves from 15 December through 30 December 1994, should be flagged as having potentially high bias.

As discussed earlier under 2.0, there are six individual control situations. There also are four blanks that are above the IDL. Each of these situations were reviewed by the laboratory and corrective actions taken. For two of these situations on 22 November 1994, the failure of the BioRad-1 (216%) and NIST (62.31%) quality control samples resulted in stopping the analytical sequence and restarting the analysis.

On 23 September and 11 November 1994, one of the BioRad-2 quality control samples for each analytical run failed (125.6% and 70.35%, respectively). The quality control samples, both prior and subsequent, were within their respective control criteria. After investigation by the laboratory, the results for these standards were flagged as being outside of the normal data set, and the samples analyzed between the acceptable standards were accepted as valid.

The fifth situation occurred on 15 November 1994 for one of the NIST quality control samples. The result (62.31%) for this sample was determined to be caused by a bad second analytical burn (analysis). The result was flagged as such, and no further action was taken.

The last situation was uncorrected by the laboratory because it occurred on one of the blind performance evaluation samples (CDC RS 590). The result for the CDC RS 590 was 76.1%, which was outside of the statistical control limits (77 to 110%) but within the preset control criterion of ±20% (73% to 113%). No further action is required on these data.

For the matrix modifier (method blank), there were four analyses that had results greater than the IDL. Two of these results were from a single analysis with the second analytical result falling below the IDL; therefore, these are considered to be acceptable (showing no possible interference). The other two results were from a replicate analyses where both were above the IDL. These occurred on 22 November 1994 and were part of a normal analytical system shutdown when it is shown not to meet the QC criteria. The analytical sequence was restarted

with calibration standards followed by matrix modifier, and the samples analyzed after the instrument failed QC criteria were then reanalyzed.

4. SUMMARY

The overall assessment of the data indicates that the data are accurate and reliable. The data meet the DQOs and MQOs as defined in the QAPjP with only the exceptions flagged in this section.

Table B-2. **ESA Internal Quality Control Sample Statistics Report for the Matrix Modifier Blank**

Column Name: Matrix Modifier

Number of column points:	288
Number of valid values:	288
Number of missing value:	0
Number of negative value:	166
Number of positive value:	119
Number of zero:	3
Maximum:	22.0900000
Minimum:	-1.97000000
Sum of raw value:	-23.4600000
Sum of absolute value:	170.040000
Arithmetic mean:	-0.0814583333
Geometric mean:	0.000000000
Quadratic mean:	1.58723707
Harmonic mean:	0.000000000
Absolute mean:	0.590416667
Median:	-0.0800000000
Sum of squares:	725.564600
Variance:	2.52144107
Standard deviation:	1.58790462
Absolute deviation:	0.583909144
Standard error:	0.0935681769
95 % confidence interval:	
[-0.265625218 , 0.102708551]	
99 % confidence interval:	
[-0.324086927 , 0.161170260]	
Coeff. of variance:	-1949.34582
Skewness:	10.0738714
Coeff. of skewness:	5.03693571
Kurtosis:	132.385783
Coeff. of kurtosis:	135.385783

Percentiles:

10 percentile:	-1.31000000
25 percentile:	-0.410000000
50 percentile:	-0.0800000000
75 percentile:	0.180000000
90 percentile:	0.430000000

Quartiles:

First quartile:	-0.410000000
Second quartile:	-0.0800000000
Third quartile:	0.180000000

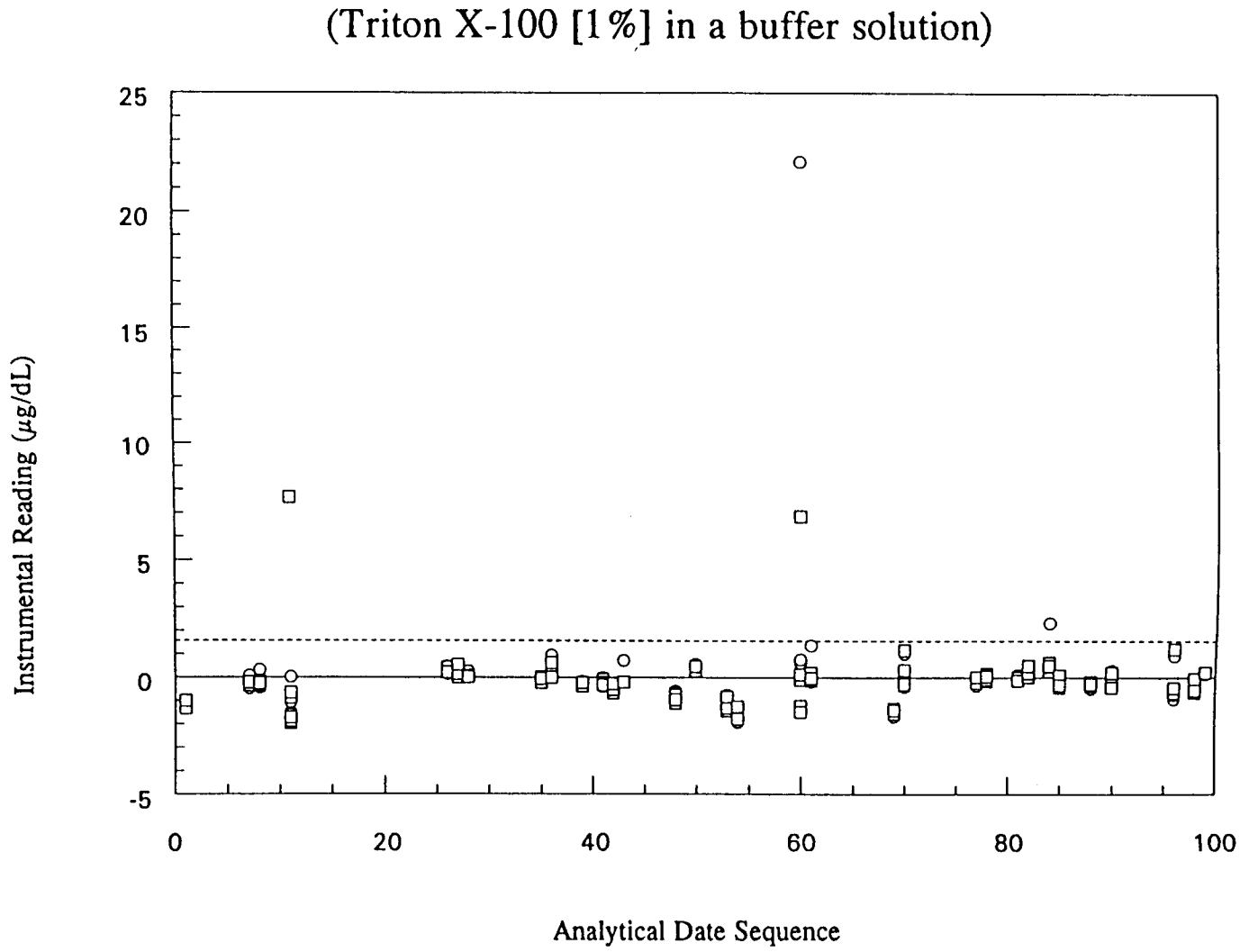


Figure B-1. ESA Matrix Modifier (Blank).

Table B-3. ESA Internal Quality Control Sample Statistics Report for BioRad-1

```
    Column Name : RECOVERY
 Number of column points: 132
  Number of valid values: 131
 Number of missing value: 1
Number of negative value: 0
Number of positive value: 131
          Number of zero: 0
              Maximum:          216.111111
              Minimum:          73.8202247
     Sum of raw value:          13066.4411
Sum of absolute value:          13066.4411
      Arithmetic mean:          99.7438252
       Geometric mean:          98.9031773
       Quadratic mean:          100.799016
        Harmonic mean:          98.1887767
        Absolute mean:          99.7438252
               Median:          97.1910112
       Sum of squares:         1331017.8553
             Variance:          213.238749
   Standard deviation:          14.6026966
   Absolute deviation:          8.67560181
       Standard error:          1.27584353
95 % confidence interval:
      [97.2197214 , 102.267929]
99 % confidence interval:
      [96.4085450 , 103.079105]
   Coeff. of variance:          14.6402011
              Skewness:          3.93842938
   Coeff. of skewness:          1.96921469
              Kurtosis:          28.6586439
   Coeff. of kurtosis:          31.6586439

  Percentiles:
        10 percentile:          86.6292135
        25 percentile:          93.9887640
        50 percentile:          97.1910112
        75 percentile:          102.777778
        90 percentile:          115.900000

  Quartiles:
       First quartile:          93.9887640
      Second quartile:          97.1910112
       Third quartile:          102.777778
```

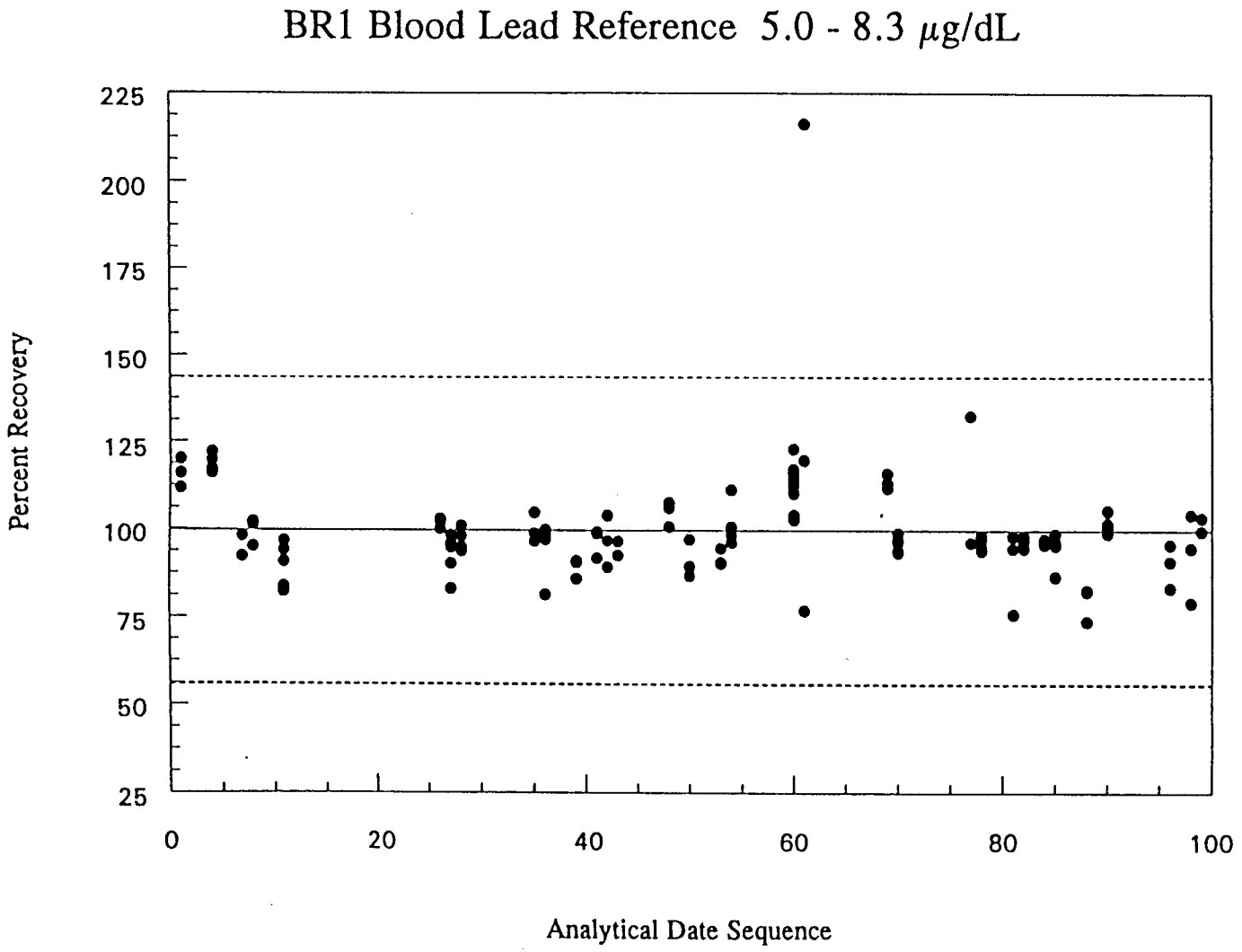


Figure B-2. ESA Internal Quality Control Sample (5.0 to 8.3 µg/dL).

Table B-4. ESA Internal Quality Control Sample Statistics Report for BioRad-2

```
   Column Name : RECOVERY
 Number of column points: 72
  Number of valid values: 72
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 72
          Number of zero: 0
                 Maximum:          125.571429
                 Minimum:          70.3469388
     Sum of raw value:             6857.24624
Sum of absolute value:             6857.24624
      Arithmetic mean:             95.2395311
       Geometric mean:             94.9479326
       Quadratic mean:             95.5361114
        Harmonic mean:             94.6574073
        Absolute mean:             95.2395311
               Median:             94.3979592
       Sum of squares:            657154.6983
             Variance:             57.3772166
   Standard deviation:             7.57477502
   Absolute deviation:             4.79680046
       Standard error:            0.892695797
95 % confidence interval:
      [93.4595462 , 97.0195159]
99 % confidence interval:
      [92.8766869 , 97.6023752]
   Coeff. of variance:             7.95339386
              Skewness:            0.731306870
   Coeff. of skewness:             0.365653435
              Kurtosis:             4.41858805
   Coeff. of kurtosis:             7.41858805

  Percentiles:
        10 percentile:             88.4221311
        25 percentile:             91.8852459
        50 percentile:             94.3877551
        75 percentile:             97.3469388
        90 percentile:             102.356557

  Quartiles:
       First quartile:             91.8852459
      Second quartile:             94.3877551
       Third quartile:             97.3469388
```

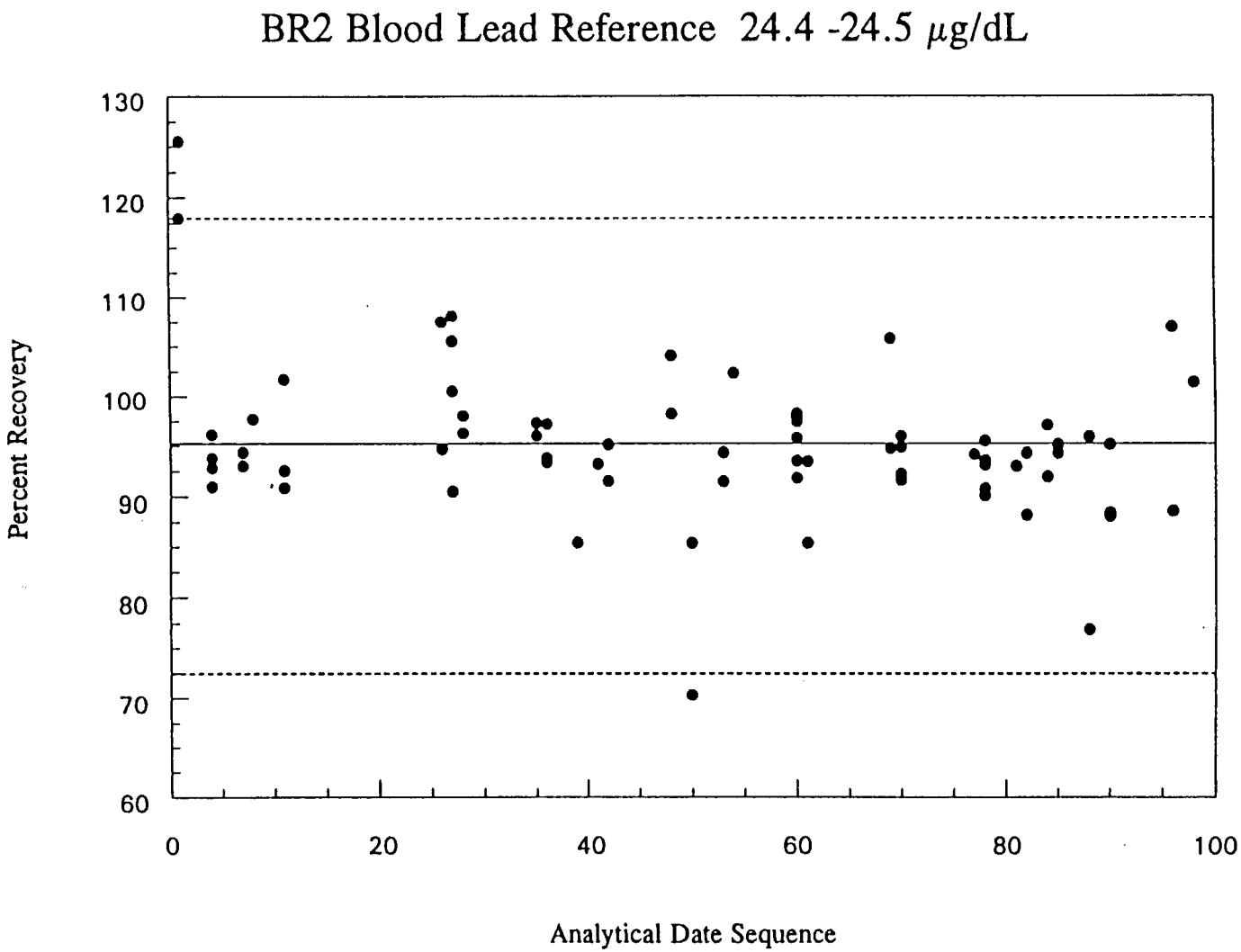


Figure B-3. ESA Internal Quality Control Sample (24.4 to 24.5 µg/dL).

Table B-5. ESA Internal Quality Control Sample Statistics Report for BioRad-3

```
   Column Name : RECOVERY
 Number of column points: 71
  Number of valid values: 71
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 71
          Number of zero: 0
              Maximum:          106.317690
              Minimum:          76.0649819
     Sum of raw value:          6814.83201
Sum of absolute value:          6814.83201
      Arithmetic mean:          95.9835495
       Geometric mean:          95.8493468
       Quadratic mean:          96.1133426
        Harmonic mean:          95.7101037
        Absolute mean:          95.9835495
               Median:          96.0486891
       Sum of squares:          655881.9990
             Variance:          25.2890439
   Standard deviation:          5.02882132
   Absolute deviation:          3.65195459
       Standard error:          0.596811291
95 % confidence interval:
      [94.7932469 , 97.1738521]
99 % confidence interval:
      [94.4032499 , 97.5638491]
   Coeff. of variance:          5.23925334
             Skewness:          -0.728428036
   Coeff. of skewness:          -0.364214018
             Kurtosis:          2.18955629
   Coeff. of kurtosis:          5.18955629

  Percentiles:
        10 percentile:          90.8052434
        25 percentile:          93.2116105
        50 percentile:          96.0486891
        75 percentile:          98.3801498
        90 percentile:          102.481949

  Quartiles:
       First quartile:          93.2116105
      Second quartile:          96.0486891
       Third quartile:          98.3801498
```

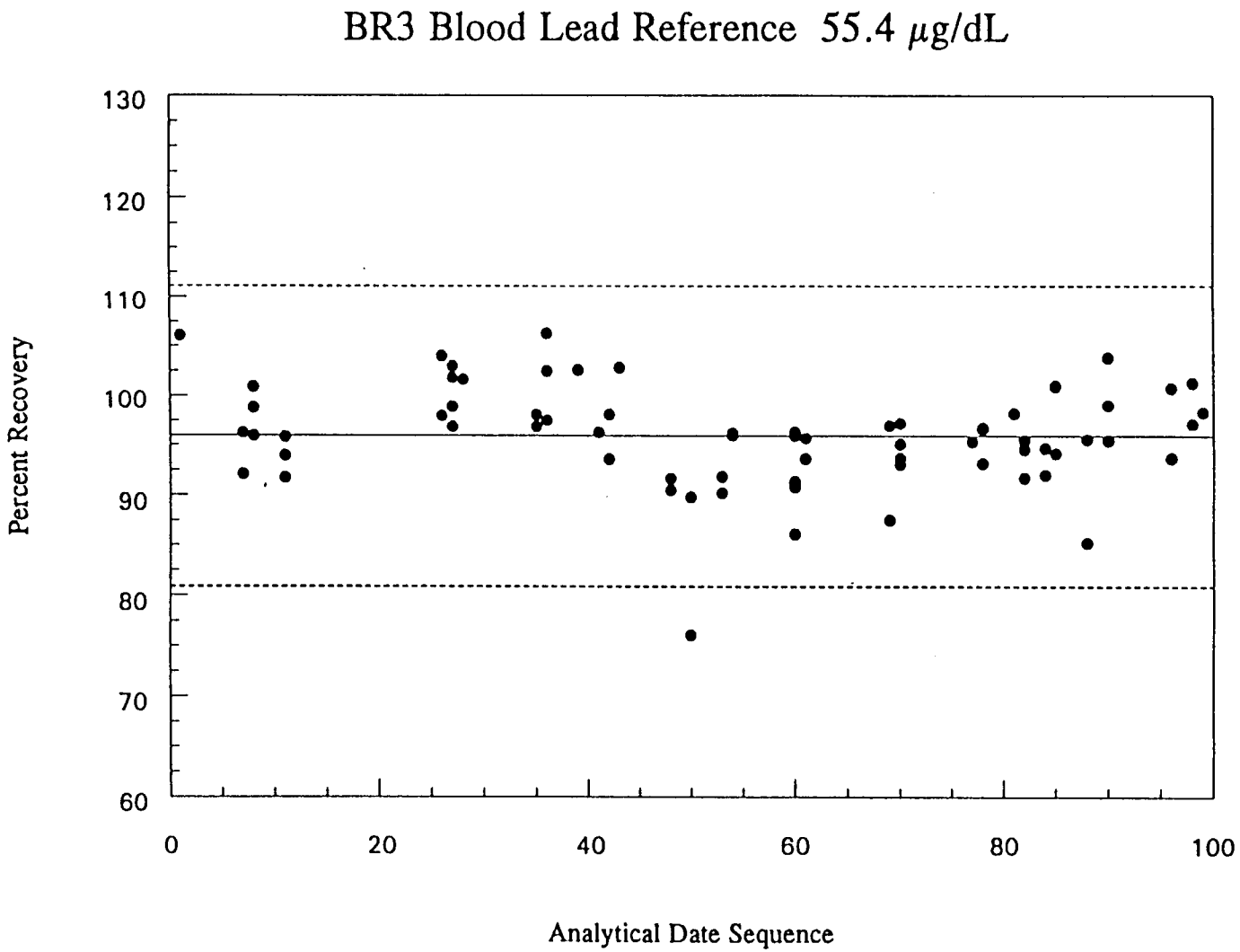


Figure B-4. ESA Internal Quality Control Sample (55.4 µg/dL).

Table B-6. ESA Internal Quality Control Sample Statistics Report for New York State SRM

```
   Column Name : RECOVERY
 Number of column points: 43
  Number of valid values: 43
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 43
          Number of zero: 0
                 Maximum:          121.281250
                 Minimum:          86.7812500
     Sum of raw value:             4225.13542
Sum of absolute value:             4225.13542
      Arithmetic mean:             98.2589632
       Geometric mean:             97.7589271
       Quadratic mean:             98.7925362
        Harmonic mean:             97.2933080
        Absolute mean:             98.2589632
                Median:             94.2500000
       Sum of squares:            419678.5040
             Variance:             107.644731
   Standard deviation:             10.3751979
   Absolute deviation:             8.25766180
       Standard error:             1.58220284
95 % confidence interval:
      [95.0659486 , 101.451978]
99 % confidence interval:
      [93.9900751 , 102.527851]
   Coeff. of variance:             10.5590345
              Skewness:             1.06031767
   Coeff. of skewness:            0.530158836
              Kurtosis:           -0.317295166
   Coeff. of kurtosis:             2.68270483

  Percentiles:
        10 percentile:             88.4375000
        25 percentile:             91.2812500
        50 percentile:             94.2500000
        75 percentile:             100.437500
        90 percentile:             114.562500

  Quartiles:
       First quartile:             91.2812500
      Second quartile:             94.2500000
       Third quartile:             100.437500
```

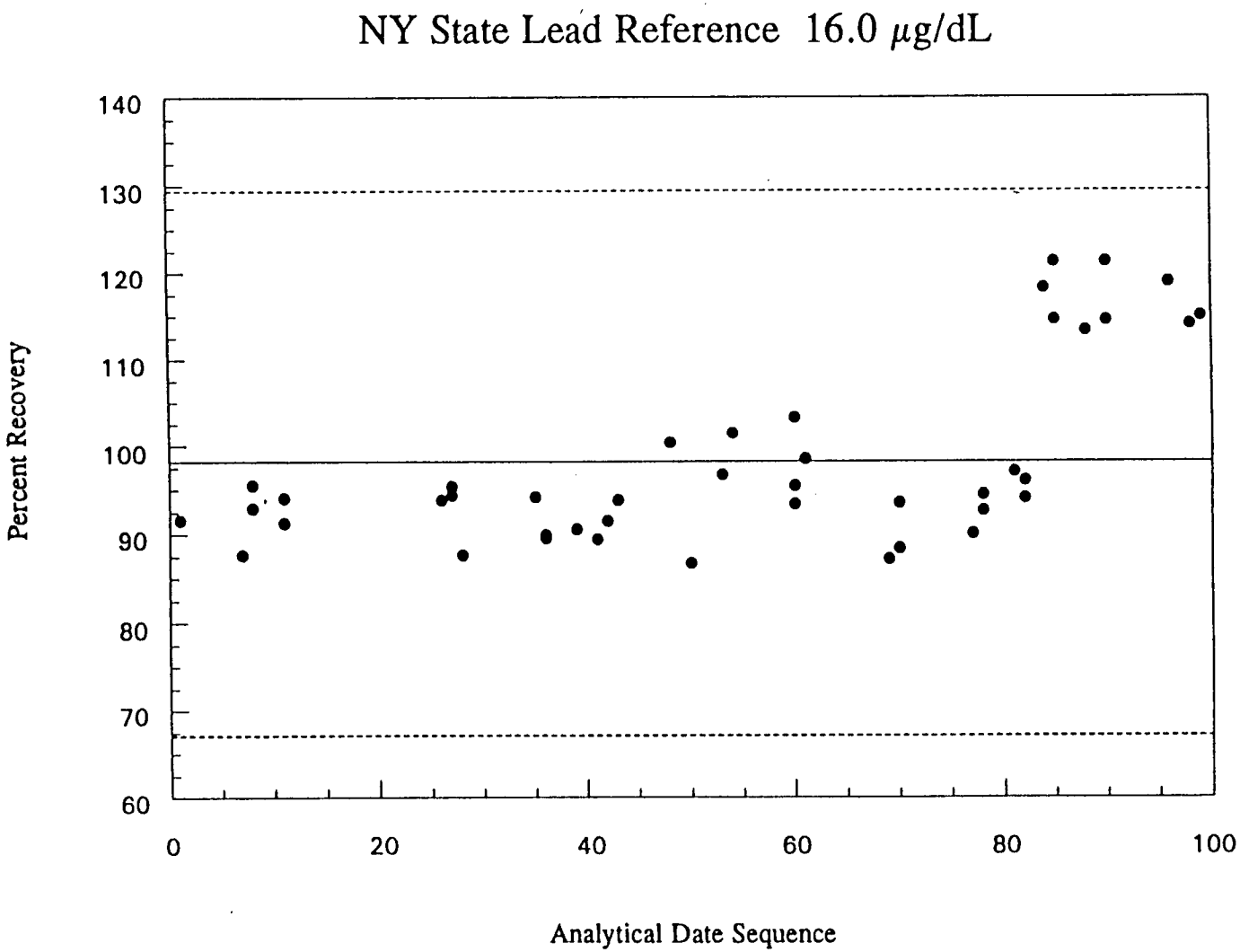


Figure B-5. ESA Initial Calibration Verification (16.0 µg/dL).

Table B-7. ESA Internal Quality Control Sample Statistics Report for NIST SRM

```
   Column Name : RECOVERY
 Number of column points: 189
  Number of valid values: 189
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 189
          Number of zero: 0
                 Maximum:          119.586105
                 Minimum:          59.0785908
     Sum of raw value:             19088.8087
Sum of absolute value:             19088.8087
      Arithmetic mean:             100.998988
       Geometric mean:                    NAN
       Quadratic mean:             101.253634
        Harmonic mean:             100.380741
        Absolute mean:             100.998988
                Median:             100.406504
       Sum of squares:            1937684.4096
             Variance:              51.7768622
   Standard deviation:              7.19561410
   Absolute deviation:              4.92037472
       Standard error:             0.523403909
95 % confidence interval:
      [99.9664885 , 102.031487]
99 % confidence interval:
      [99.6369693 , 102.361006]
   Coeff. of variance:              7.12444179
              Skewness:             -1.70068007
   Coeff. of skewness:            -0.850340037
              Kurtosis:              9.12367233
   Coeff. of kurtosis:              12.1236723

  Percentiles:
        10 percentile:             94.9741316
        25 percentile:             97.8196600
        50 percentile:             100.406504
        75 percentile:             105.210643
        90 percentile:             109.312639

  Quartiles:
       First quartile:             97.8196600
      Second quartile:             100.406504
       Third quartile:             105.210643
```

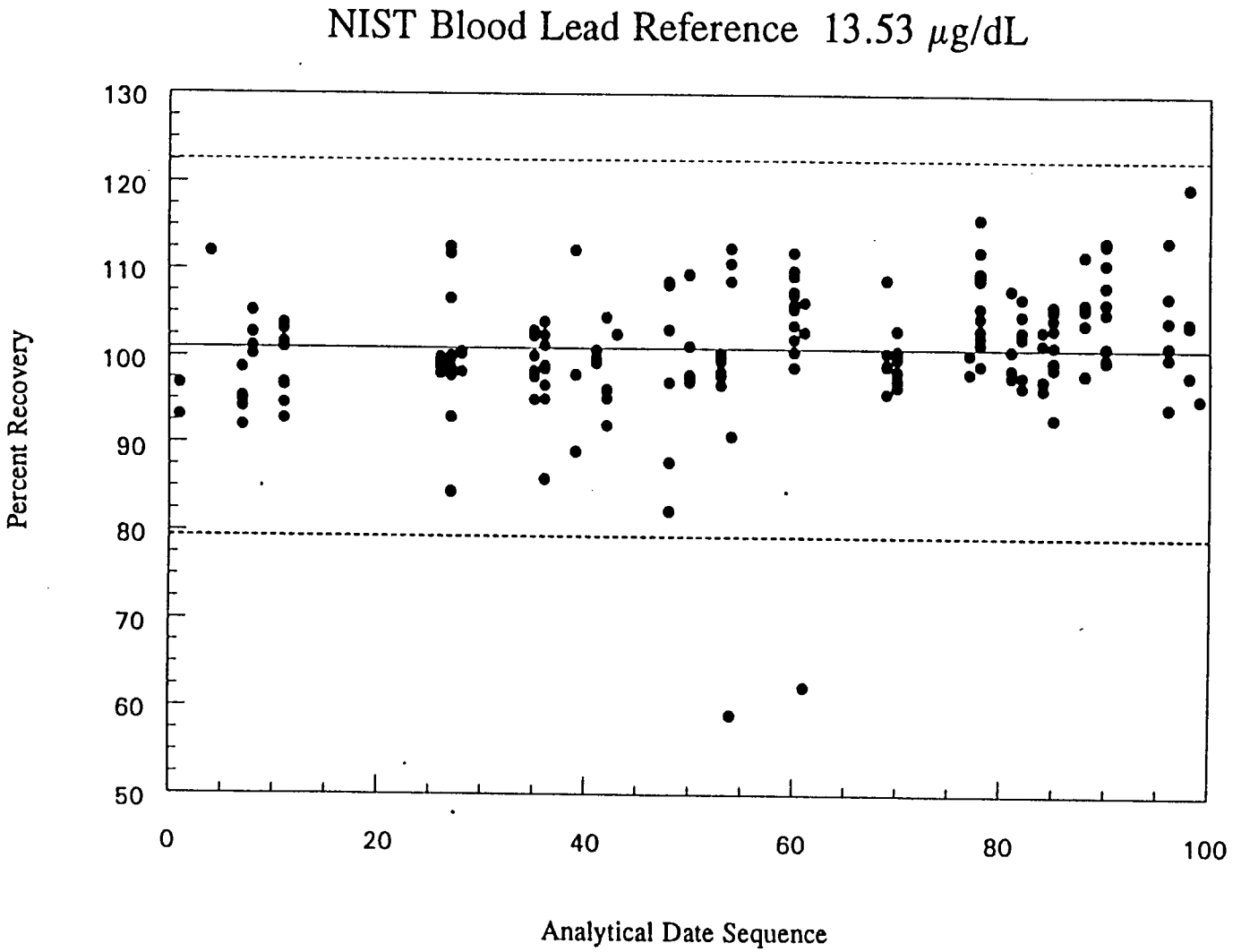


Figure B-6. ESA Internal Quality Control Sample (13.53 µg/dL).

Table B-8. ESA Performance Evaluation Sample Statistics Report for CDC RS 590 (9.0 μg/dL)

```
   Column Name : RECOVERY
 Number of column points: 35
  Number of valid values: 35
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 35
          Number of zero: 0
               Maximum:          104.944444
               Minimum:          76.0833333
     Sum of raw value:           3267.41667
Sum of absolute value:           3267.41667
      Arithmetic mean:           93.3547619
       Geometric mean:           93.1909478
       Quadratic mean:           93.5109210
        Harmonic mean:           93.0188233
        Absolute mean:           93.3547619
               Median:           94.8333333
       Sum of squares:          306050.2323
             Variance:           30.0390380
   Standard deviation:           5.48078808
   Absolute deviation:           4.04340136
       Standard error:          0.926422274
95 % confidence interval:
      [91.4720453 , 95.2374785]
99 % confidence interval:
      [90.8271166 , 95.8824072]
   Coeff. of variance:           5.87092503
              Skewness:         -0.996913625
   Coeff. of skewness:         -0.498456813
              Kurtosis:           1.48435599
   Coeff. of kurtosis:           4.48435599

  Percentiles:
        10 percentile:           86.1666667
        25 percentile:           91.0833333
        50 percentile:           94.8333333
        75 percentile:           97.1388889
        90 percentile:           97.7777778

  Quartiles:
       First quartile:           91.0833333
      Second quartile:           94.8333333
       Third quartile:           97.1388889
```

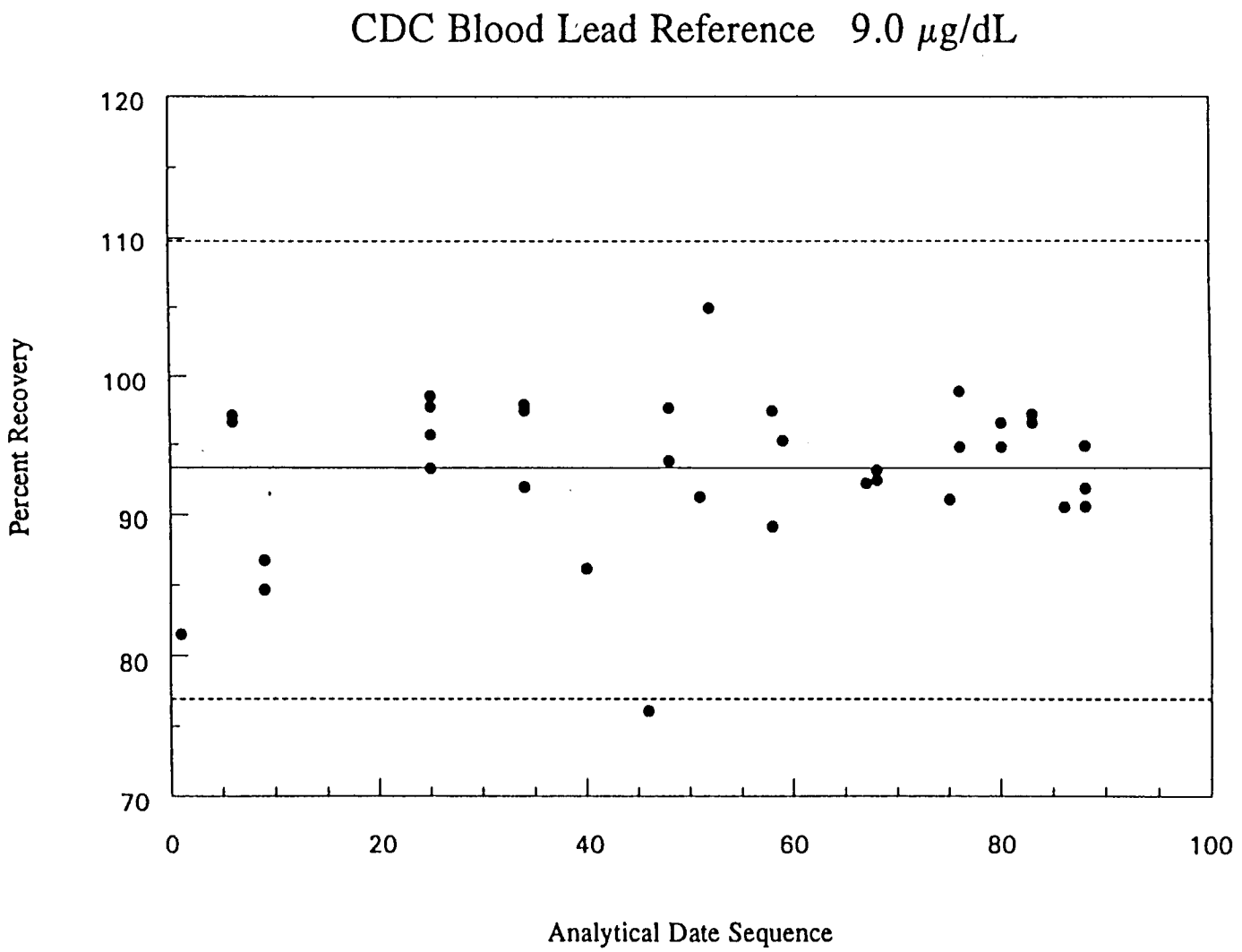


Figure B-7. ESA Performance Evaluation Sample (9.0 µg/dL).

Table B-9. ESA Performance Evaluation Sample Statistics Report for CDC RS 991 (23.3 μg/dL)

```
    Column Name : RECOVERY
 Number of column points: 35
  Number of valid values: 35
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 35
          Number of zero: 0
                 Maximum:          107.263948
                 Minimum:          90.5793991
     Sum of raw value:             3455.31984
Sum of absolute value:             3455.31984
      Arithmetic mean:             98.7234241
       Geometric mean:             98.6687853
       Quadratic mean:             98.7781267
        Harmonic mean:             98.6141893
        Absolute mean:             98.7234241
               Median:             98.4334764
      Sum of squares:              341499.1409
             Variance:             11.1215997
   Standard deviation:             3.33490625
   Absolute deviation:             2.47177350
       Standard error:            0.563702042
95 % confidence interval:
      [97.5778438 , 99.8690045]
99 % confidence interval:
      [97.1854227 , 100.261426]
   Coeff. of variance:              3.37802936
              Skewness:            0.138362618
   Coeff. of skewness:           0.0691813088
              Kurtosis:            0.492721042
   Coeff. of kurtosis:             3.49272104

  Percentiles:
        10 percentile:             94.4527897
        25 percentile:             97.1351931
        50 percentile:             98.4334764
        75 percentile:             100.407725
        90 percentile:             102.167382

  Quartiles:
       First quartile:             97.1351931
      Second quartile:             98.4334764
       Third quartile:             100.407725
```

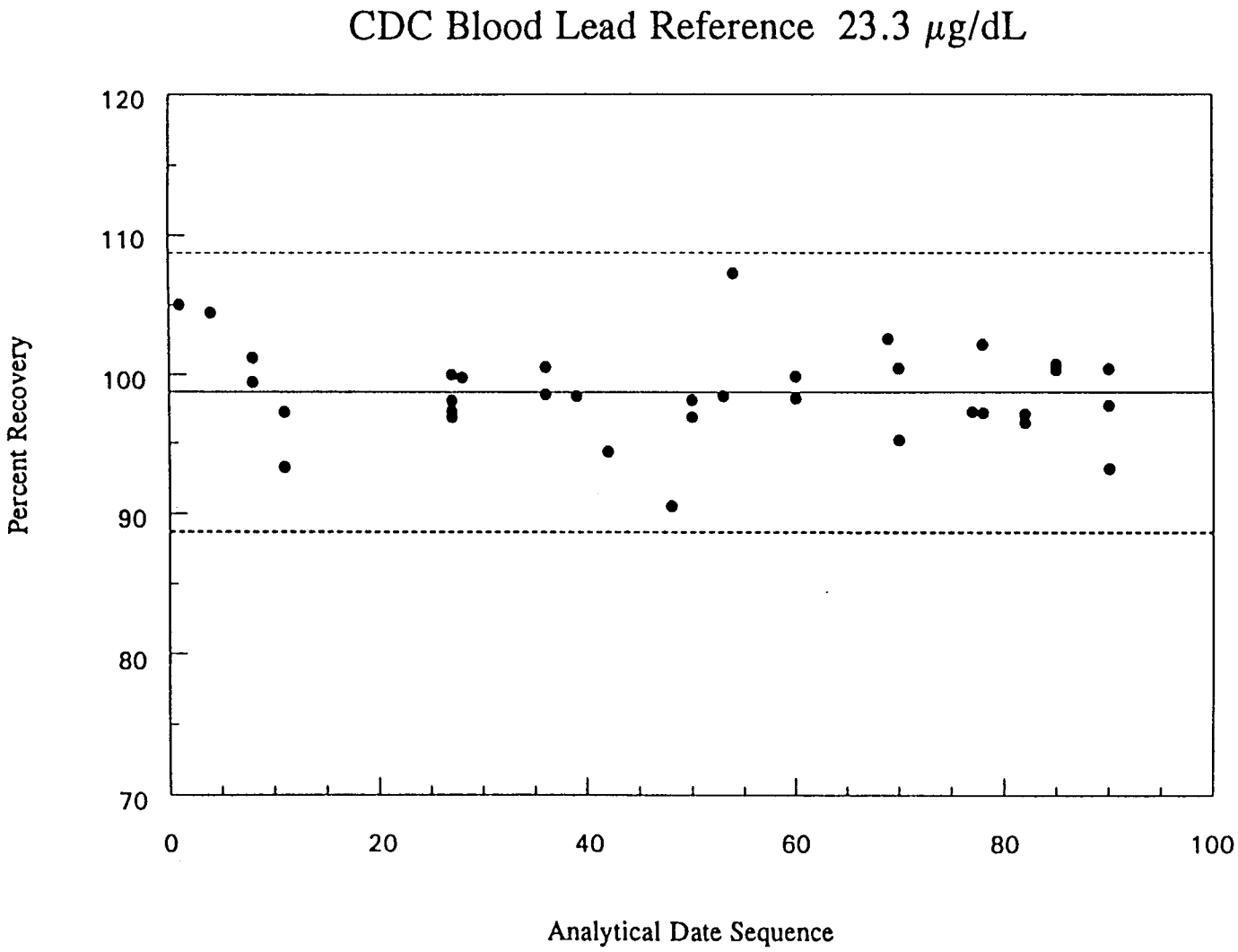


Figure B-8. ESA Performance Evaluation Sample (23.3 µg/dL).

Table B-10. ESA Performance Evaluation Sample Statistics Report for CDC RS 1394 (41.1 μg/dL)

```
Column Name : RECOVERY
Number of column points: 35
Number of valid values: 35
Number of missing value: 0
Number of negative value: 0
Number of positive value: 35
Number of zero: 0
Maximum: 109.482968
Minimum: 93.3333333
Sum of raw value: 3592.04988
Sum of absolute value: 3592.04988
Arithmetic mean: 102.629997
Geometric mean: 102.563833
Quadratic mean: 102.695513
Harmonic mean: 102.497027
Absolute mean: 102.629997
Median: 103.406326
Sum of squares: 369122.8947
Variance: 13.8478871
Standard deviation: 3.72127492
Absolute deviation: 3.04425245
Standard error: 0.629010267
95 % confidence interval:
[101.351694 , 103.908299]
99 % confidence interval:
[100.913808 , 104.346185]
Coeff. of variance: 3.62591352
Skewness: -0.323345875
Coeff. of skewness: -0.161672938
Kurtosis: -0.366972074
Coeff. of kurtosis: 2.63302793

Percentiles:
10 percentile: 97.1715328
25 percentile: 100.206813
50 percentile: 103.406326
75 percentile: 105.182482
90 percentile: 106.429440

Quartiles:
First quartile: 100.206813
Second quartile: 103.406326
Third quartile: 105.182482
```

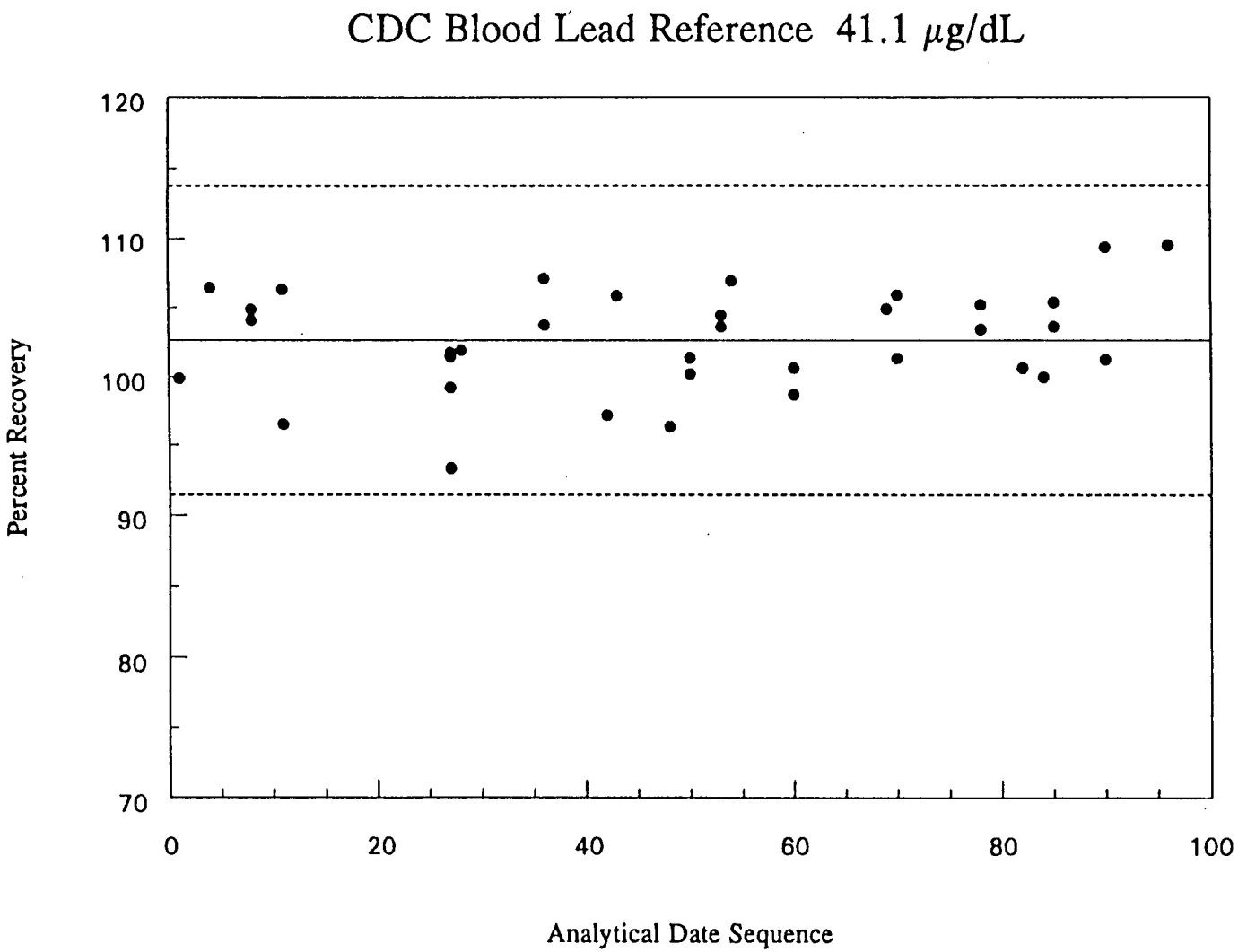


Figure B-9. ESA Performance Evaluation Sample (41.1 µg/dL).

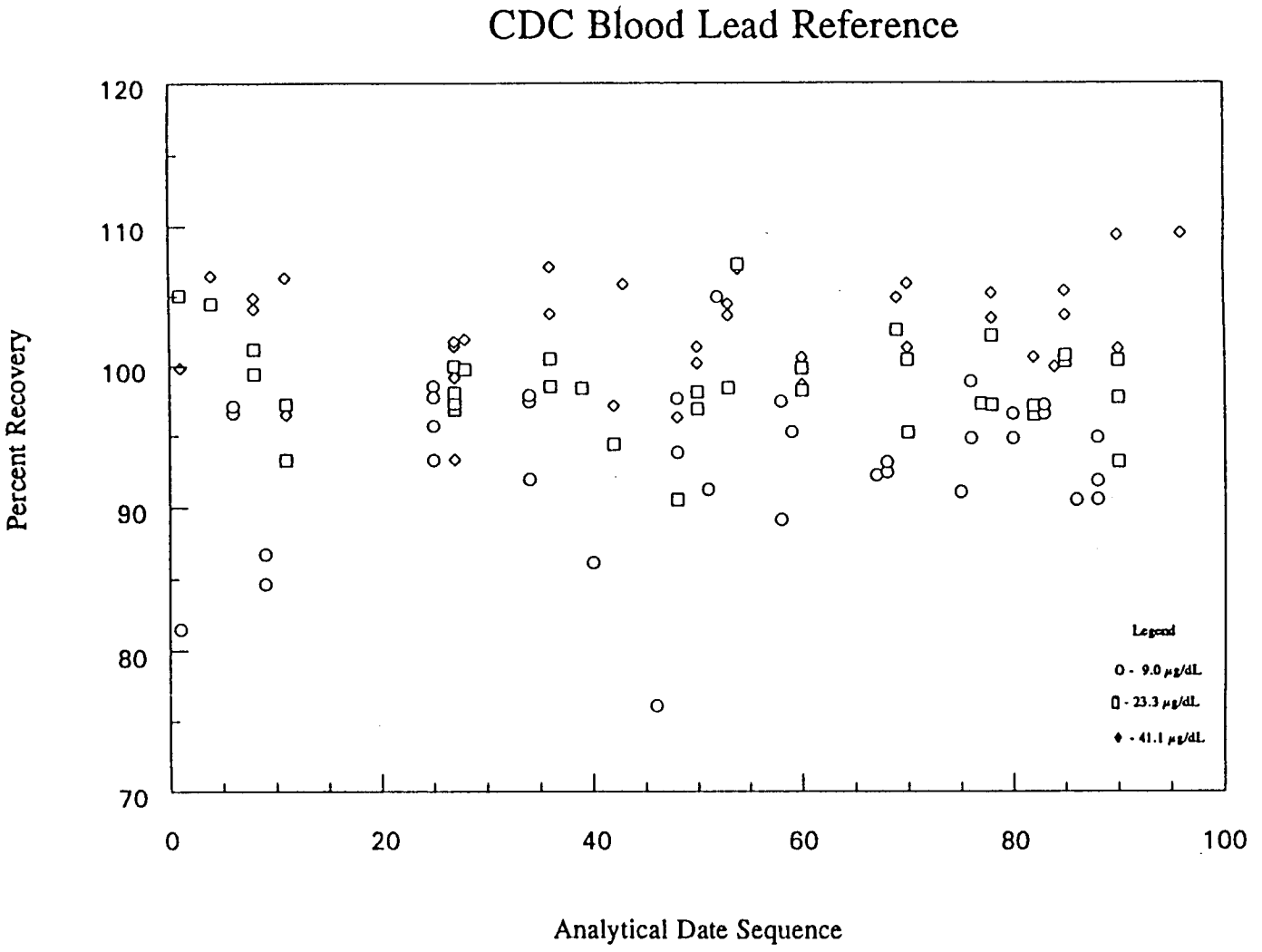


Figure B-10. ESA Performance Evaluation Sample.

APPENDIX C:
DESCRIPTIVE STATISTICS TABLES

Table C-1. Descriptive Statistics of Lead Concentrations for CDC Quality Control Reference Samples

CDC Reference Number	Known Value	N	Min (µg/dl)	25th Percentile (µg/dl)	Median (µg/dl)	75th Percentile (µg/dl)	Max (µg/dl)	Geometric Mean (µg/dl)	log Std. Dev. log(µg/dl)
590	9.0	30	7.4	8.3	8.6	8.8	9.5	8.4	0.056
991	23.3	30	21.8	22.7	23.0	23.4	25.0	23.0	0.031
1394	41.1	30	38.4	41.4	42.6	43.5	45.1	42.3	0.037

Table C-2. Descriptive Statistics of Log Standard Deviations Between Duplicate Blood Draws for Each Sampling Frame

Sampling Frame	N	Min log(µg/dl)	25th Percentile log(µg/dl)	Median log(µg/dl)	75th Percentile log(µg/dl)	Max log(µg/dl)	Mean log(µg/dl)
Philadelphia Union	25	0.006	0.010	0.020	0.035	0.113	0.031
Philadelphia Non-Union	8	0.003	0.008	0.016	0.031	0.097	0.026
St Louis Union	19	0.000	0.000	0.025	0.080	0.504	0.076
St Louis Non-Union	21	0.000	0.017	0.028	0.042	0.109	0.037
All Four Groups Combined	73	0.000	0.009	0.020	0.042	0.504	0.044

Table C-3. Descriptive Statistics of Log Standard Deviations Among Multiple Chemical Analyses for Each Sampling Frame

Sampling Frame	N	Min log(µg/dl)	25th Percentile log(µg/dl)	Median log(µg/dl)	75th Percentile log(µg/dl)	Max log(µg/dl)	Mean log(µg/dl)
Philadelphia Union	197	0.00	0.006	0.016	0.035	0.267	0.030
Philadelphia Non-Union	74	0.00	0.00	0.015	0.031	0.243	0.028
St Louis Union	149	0.00	0.010	0.031	0.062	0.485	0.051
St Louis Non-Union	160	0.00	0.006	0.020	0.036	0.325	0.031
All Four Groups Combined	580	0.00	0.005	0.019	0.040	0.485	0.036

Table C-4. Descriptive Statistics of Blood-Lead Concentrations for Each Sampling Frame

Sampling Frame	N	Min (µg/dl)	25th Percentile (µg/dl)	Median (µg/dl)	75th Percentile (µg/dl)	Max (µg/dl)	Geometric Mean (µg/dl)	log Std. Dev. log(µg/dl)	n>10
Philadelphia Union	197	1.55	3.80	5	6.60	55.25	5.10	0.517	14
Philadelphia Non-Union	74	1.00	3.80	5.08	8.45	26.2	5.61	0.657	12
St Louis Union	150	1.00	1.95	3.03	4.50	13.80	3.02	0.592	3
St Louis Non-Union	160	1.00	2.95	4.73	7.95	36.25	4.90	0.727	22
All Four Groups	581	1.00	2.90	4.50	6.60	55.25	4.46	0.659	52

Table C-5. Descriptive Statistics of Blood-Lead Concentrations for Each Worker Group

Worker Group	N	Min (µg/dl)	25th Percentile (µg/dl)	Median (µg/dl)	75th Percentile (µg/dl)	Max (µg/dl)	Geometric Mean (µg/dl)	log Std. Dev. log(µg/dl)	n>10
Union Carpenter	159	1.00	3.10	4.50	6.25	32.60	4.37	0.579	9
Non-Union Carpenter	104	1.05	3.28	5.00	8.03	26.20	5.03	0.665	15
Drywall Worker	64	1.80	4.50	5.65	7.23	24.45	5.85	0.484	5
Floor Layer	81	1.00	1.95	2.75	3.85	6.65	2.63	0.497	0
Laborer	54	1.00	3.55	4.80	7.15	55.25	4.86	0.716	5
Other	14	1.00	3.50	4.68	6.45	21.40	5.30	0.829	3
Painter	34	1.00	4.75	7.15	8.80	36.25	7.17	0.781	7
Supervisor	57	1.10	2.55	4.05	4.95	13.60	3.75	0.524	3
Window Installer	14	1.65	2.55	5.55	10.40	15.65	5.37	0.778	4

APPENDIX D:
ADDITIONAL QUESTIONNAIRE TABLES

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

Job Title	Main Activity
Main Activities for Carpenter Classification	
	GENERAL CARPENTRY-(CONSTRUCTION REMODELING, ALL PHASES, FRAMING, HANDYMAN)
	GENERAL CARPENTRY-(CONSTRUCTION REMODELING, ALL PHASES, FRAMING, HANDYMAN)
Carpenter	CUSTOM WOOD WORKING
Carpenter	PRE-HUNG DOOR ASSEMBLER
Carpenter	ROOF SPRAYING, SIDING
	INSULATION OF THE CEILING AND SIDING AND CONCRETE
	PUNCH LIST WORK ON NEW CONSTRUCTION
	RENOVATION OF WATER PLANT BUILDINGS
	TENANT REMODEL DEMOLITION AND RECONSTRUCTION
Carpenter	REMODEL NEW GROCERY STORE AND INSTALL NEW COMM FREEZER
	WORKING AT HOME
	BUILDING- SCAFFOLDING/HOUSING WORK
	METAL ROCK, MILLWORK, CABINETRY
	WORKED ON FURNITURE
	ROOF AND WALL FRAMING
	BUILDING NEW HOMES
Carpenter	BUILDING MAINTENANCE COMP. WIRING
Maintenance	BUILDING MAINTENANCE COMP. WIRING
Man	ROOFS TO RATHSKELLERS, ALL PHASES
	FINISH WORK
	OUT HURT
	CONCRETE FORM WORK/RENOVATION
	NEW RENOVATIONS
Carpenter	NEW RENOVATIONS
Owner	NEW RENOVATIONS
Contractor	REMODELING APARTMENTS/HOMES
	INTERIOR RENOVATIONS
Carpenter	INTERIOR RENOVATIONS
Owner	INSTALL- CORIAN COUNTERTOPS, KITCHEN, AND BATHS
	WEATHERIZATION
	REPAIR WATER AND ELECTRIC
	FIT UP FOR STORES AND OFFICES
	SUB-CONTRACTOR
	CARPENTER/ELECTRICIAN
	HOME MAINTENANCE
	FURNITURE AND REMODELING
	HANGING METAL PANELS
	REMODELED KITCHEN AND BATHS
Main Activities for Drywall Worker Classification	
	HANGS SHEET ROCK- DRYWALL
	DRYWALL, METAL STUDS, DOOR FRAMES
	DRYWALL AND INTERIOR FINISH
	ACOUSTIC CEILINGS & DRYWALL/INSULATION
	INTERIOR WALLS AND CEILINGS
	DRYWALL, CONCRETE, RENOVATIONS
	DRYWALL- SETTING DOORBUCKS

Table D-1. Main Activities and Job Titles for Each Worker Group (continued)

Job Title	Main Activity
Main Activities for Floor Layer Classification	
	INSTALL FLOORS (CARPET, TILE, VINYL, HARDWOOD, VICTORIAN, PARQUET, MARBLE) FLOOR SURFACE PREPARATION (SAND, SCRAPE, TEAR UP, FINISH, PREP UNDERLAYMENT, REMOVAL) TEACHES FLOOR LAYING INSTALLING & PAINTING ASTROTURF CUTTING CARPET AND VINYL
Main Activities for Laborer Classification	
Laborer Laborer Laborer Laborer Laborer	PRE-HUNG DOOR ASSEMBLER ROOF SPRAYING, SIDING GUTTING WINDOWS CLEANS UP REMODEL NEW GROCERY STORE AND INSTALL NEW COMM FREEZER DEMOLITION/INSTALLATION GUTTING INTERIORS, DEMOLITION NEW RENOVATIONS INTERIOR RENOVATIONS LABOR PLUMBING, ELECTRICAL, DRYWALL, INSULATION BREAKING DOWN FLOORS AND WALLS REMOVING AND PLACING SIDING CLEAN UP-ELECTRICAL WIRING, SHEETROCKING, FIRE/WATER DAMAGE BRING IN AND TAKE OUT MATERIALS
Main Activities for Other Classification	
Mill Worker	CUSTOM WOOD WORKING COOLING TOWERS CLEAN RESTROOM AND OTHER CLEANING DUTIES SHOPWORK, ASSEMBLY , SANDING, GLUING, ETC. BUILDING STEEL CONVEYOR/BUILDING MACHINES UNEMPLOYED PLUMBING AND HEATING CUTTING STONE TO BE PUT IN PLACE LINING AND SETTING (BRICK LAYER) PRINT DETOX LEAD FROM HOME TEACHING STUDENTS
Main Activities for Painter Classification	
Painter	ROOF SPRAYING, SIDING CUTTING GRASS, PAINTING PAINT STRUCTURES, HOUSES REMODELING/PAINTING PAINTING, REPAIRING, CLEANING PAINTING AND PULLING UP CARPET

Table D-1. Main Activities and Job Titles for Each Worker Group (continued)

Job Title	Main Activity
Main Activities for Supervisor Classification	
	SUPERVISOR (JOB MANAGEMENT, ESTIMATING), RUN WORK AND WORKERS INSPECTS CARPENTRY WORK (REMODELING AND NEW WORK) OFFICE DUTIES JOB LAYOUT
Main Activities for Window Installer Classification	
	INSTALLATION OF WINDOWS, DOORS, WALLS, ETC. WINDOWS- TEAR DOWN AND REPAIR

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

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
UNION CARPENTER								
Days performing the activity in last month	25th Percentile	5[a]	0	0	0	0	0	0
	Mean	14.90[b]	0.84	3.04	0.38	6.42	1.84	6.88
	75th Percentile	22	1	5	0	10	2	12
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	0	0	0	0	0	0	0
	Mean	8.65	0.36	2.35	0.22	3.57	0.68	3.96
	75th Percentile	15	0	3	0	5	0	5
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.09	0.27	0.04	1.01	0.43	0.79
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	5.0%[d]	87.4%	45.9%	91.8%	25.8%	72.3%	38.4%
	1 to 8 Weeks	25.2%	12.6%	47.2%	7.5%	51.6%	24.5%	49.7%
	More than 8 Weeks	69.8%	0%	6.9%	0.6%	22.6%	3.1%	11.9%
Number of years spent performing activity over career	25th Percentile	5	0	1	0	2	0	2
	Mean	12.74	3.21	6.56	1.71	7.77	4.13	8.75
	75th Percentile	18	3	10	1	13	5	15

[a] 25 percent of all workers responded that they did R&R 5 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 14.90 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 5 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
NON-UNION CARPENTER								
Days performing the activity in last month	25th Percentile	17[a]	0	2	0	3	1	5
	Mean	20.38[b]	1.82	5.58	1.68	8.70	7.19	13.68
	75th Percentile	24	3	9	1	13	12	20
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	7	0	0	0	0.5	0	1
	Mean	14.91	1.29	4.19	1.26	6.56	5.51	9.67
	75th Percentile	20	2	5	1	10	10	20
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.25	0.67	0.24	1.16	0.99	1.74
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	0%[d]	60.0%	15.2%	63.8%	11.4%	19.0%	8.6%
	1 to 8 Weeks	12.4%	36.2%	66.7%	31.4%	50.5%	56.2%	40%
	More than 8 Weeks	87.6%	3.8%	18.1%	4.8%	38.1%	24.8%	51.4%
Number of years spent performing activity over career	25th Percentile	6	1	3	1	5	3	6
	Mean	13.26	5.91	8.85	5.22	9.70	8.93	12.08
	75th Percentile	18	10	14	7	14	15	17

[a] 25 percent of all workers responded that they did R&R 17 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 20.38 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 0 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
DRYWALL WORKER								
Days performing the activity in last month	25th Percentile	10[a]	0	0	0	1	0	2
	Mean	17.84[b]	1	2.05	0.75	8.28	3.58	8.31
	75th Percentile	25	1	3	0	14.5	3.5	15
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	0	0	0	0	0	0	0
	Mean	11.33	1.20	1.52	0.52	5.53	2.61	5.83
	75th Percentile	20	0	1.5	0	9	0	7.5
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.06	0.22	0.45	1.05	0.63	0.88
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	0%[d]	78.1%	57.8%	90.6%	26.6%	60.9%	32.8%
	1 to 8 Weeks	14.1%	21.9%	39.1%	9.4%	45.3%	32.8%	51.6%
	More than 8 Weeks	85.9%	0%	3.1%	0%	28.1%	6.3%	15.6%
Number of years spent performing activity over career	25th Percentile	7	0	1	0	2	0	1
	Mean	13.59	2.78	4.56	1.61	8	4.34	8.19
	75th Percentile	19	2.5	5.5	1	13	5.5	12

[a] 25 percent of all workers responded that they did R&R 10 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 17.84 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 0 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
FLOOR LAYER								
Days performing the activity in last month	25th Percentile	7[a]	0	0	0	0	0	5
	Mean	14.79[b]	5.79	0.57	0.61	0.74	8.28	14.53
	75th Percentile	23	10	0	0	0	20	24
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	0	0	0	0	0	0	0
	Mean	5.21	1.93	0.45	0.32	0.24	2.0	3.25
	75th Percentile	6	3	0	0	0	2	5
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.07	0.18	0	0	1.17	0.91
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	13.4%[d]	18.3%	91.5%	96.3%	84.1%	42.7%	13.4%
	1 to 8 Weeks	25.6%	50.0%	7.3%	1.2%	14.6%	24.4%	24.4%
	More than 8 Weeks	61.0%	31.7%	1.2%	2.4%	1.2%	32.9%	62.2%
Number of years spent performing activity over career	25th Percentile	8	4	0	0	0	0	6
	Mean	15.32	11.67	1.67	1.12	1.38	6.90	13.01
	75th Percentile	21	17	1	0	1	12	20

[a] 25 percent of all workers responded that they did R&R 7 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 14.79 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 13.4 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
LABORER								
Days performing the activity in last month	25th Percentile	12[a]	0	1.50	0	3	0	10
	Mean	18.02[b]	4.82	6.95	3.95	10.04	8.57	16.64
	75th Percentile	24.5	7	10	7	15	14.5	25
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	5	0	0	0	0.50	0	3
	Mean	13.73	3.68	6.38	3.64	7.20	7.54	12.46
	75th Percentile	20	4.5	10	5	13	12.5	20
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	2.13	3.71	2.45	4.50	4.30	5.27
	75th Percentile	[c]	0	3	1.5	6.5	5	8
Number of Weeks spent performing activity in last year	Less than 1 Week	0%[d]	46.4%	25.0%	62.5%	17.9%	23.2%	3.6%
	1 to 8 Weeks	26.8%	44.6%	53.6%	28.6%	51.8%	55.4%	39.3%
	More than 8 Weeks	73.2%	8.9%	21.4%	8.9%	30.4%	21.4%	57.1%
Number of years spent performing activity over career	25th Percentile	5.5	1	1	0	2	1	4
	Mean	10.38	4.63	4.93	2.11	5.38	5.92	8.92
	75th Percentile	15	6	7	2	8	10	13

[a] 25 percent of all workers responded that they did R&R 12 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 18.02 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 0 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
PAINTER								
Days performing the activity in last month	25th Percentile	13[a]	0	0	0	0	7	5
	Mean	18.38[b]	2.88	4.76	0.82	5.91	14.09	13.18
	75th Percentile	22	3	5	0	10	20	20
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	10	0	0	0	0	3	3
	Mean	14.18	3.06	3.97	0.82	3.65	10.91	11.09
	75th Percentile	20	2	4	0	5	20	20
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.97	1.15	0.50	2.24	7.09	4.82
	75th Percentile	[c]	1	0	0	3	15	5
Number of Weeks spent performing activity in last year	Less than 1 Week	2.9%[d]	58.8%	41.2%	82.4%	35.3%	11.8%	5.9%
	1 to 8 Weeks	26.5%	32.4%	44.1%	14.7%	44.1%	32.4%	38.2%
	More than 8 Weeks	70.6%	8.8%	14.7%	2.9%	20.6%	55.9%	55.9%
Number of years spent performing activity over career	25th Percentile	5	1	1	0	1	4	2
	Mean	11.12	3.76	4	1.97	4.91	9.44	8.94
	75th Percentile	15	5	5	1	8	15	15

[a] 25 percent of all workers responded that they did R&R 13 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 18.38 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 2.9 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
SUPERVISOR								
Days performing the activity in last month	25th Percentile	9[a]	0	0	0	0	0	0
	Mean	16.21[b]	0.71	2.56	0.46	6.84	1.60	5.28
	75th Percentile	22	1	3	0	10	2	8
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	0	0	0	0	0	0	0
	Mean	8.19	0.16	1.07	0.05	3.09	0.56	2.21
	75th Percentile	14	0	1	0	5	0	2
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0	0.23	0.07	0.98	0.21	0.35
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	1.8%[d]	75.4%	45.6%	87.7%	17.5%	70.2%	35.1%
	1 to 8 Weeks	19.3%	24.6%	50.9%	12.3%	50.9%	26.3%	45.6%
	More than 8 Weeks	78.9%	0%	3.5%	0%	31.6%	3.5%	19.3%
Number of years spent performing activity over career	25th Percentile	9	1	1	0	3	0	7
	Mean	15.21	4.68	7.72	2.60	9.37	6.70	12.70
	75th Percentile	20	9	14	3	15	10	18

[a] 25 percent of all workers responded that they did R&R 9 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 16.21 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 1.7 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
WINDOW INSTALLER								
Days performing the activity in last month	25th Percentile	21[a]	0	7	0	2	0	20
	Mean	22.43[b]	2.07	14.14	2.14	10.86	6.71	19.14
	75th Percentile	22	2	21	0	21	10	24
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	20	0	5	0	2	0	8
	Mean	19.50	1.86	11.14	1.93	9.57	6.07	16.86
	75th Percentile	22	2	16	0	20	10	22
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	1	2.29	1.57	1.57	2.36	1.64
	75th Percentile	[c]	0	0	0	0	0	0
Number of Weeks spent performing activity in last year	Less than 1 Week	7.1%[d]	85.7%	7.1%	85.7%	28.6%	35.7%	14.3%
	1 to 8 Weeks	7.1%	7.1%	35.7%	7.1%	35.7%	28.6%	21.4%
	More than 8 Weeks	85.7%	7.1%	57.1%	7.1%	35.7%	35.7%	64.3%
Number of years spent performing activity over career	25th Percentile	7	0	4	0	5	0	6
	Mean	15.14	4.43	9.79	3	10.93	6.29	13.14
	75th Percentile	20	6	17	0	17	14	20

[a] 25 percent of all workers responded that they did R&R 21 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 22.43 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 7.1 percent of workers spent less than one week doing general R&R in the last year.

Table D-2. (continued)

Variable Description	Statistic	Target Activities						
		General R&R	Carpet Removal	Window Replacement	HVAC Work	Large Structure	Paint Removal	Cleanup
OTHER								
Days performing the activity in last month	25th Percentile	10[a]	0	0	0	1	1	2
	Mean	17.71[b]	3.43	7.29	6.14	9.79	9.93	13.43
	75th Percentile	25	4	15	10	15	20	25
Days performing the activity in Pre- 1950 housing in last month	25th Percentile	3	0	0	0	0	0	0
	Mean	13.57	3.14	6.14	4	6.86	8.50	10.71
	75th Percentile	25	2	5	5	10	15	20
Days using a respirator while performing activity	25th Percentile	[c]	0	0	0	0	0	0
	Mean	[c]	0.64	1.07	1.14	4.93	6.14	3.64
	75th Percentile	[c]	0	0	0	10	5	5
Number of Weeks spent performing activity in last year	Less than 1 Week	14.3%[d]	64.3%	35.7%	57.1%	21.4%	28.6%	28.6%
	1 to 8 Weeks	21.4%	28.6%	50.0%	21.4%	42.9%	50.0%	28.6%
	More than 8 Weeks	64.3%	7.1%	14.3%	21.4%	35.7%	21.4%	42.9%
Number of years spent performing activity over career	25th Percentile	10	0	1	1	2	2	4
	Mean	13.50	2.29	6.29	4.64	8.21	7.92	12.29
	75th Percentile	20	3	10	6	14	10	20

[a] 25 percent of all workers responded that they did R&R 10 days or less over the past 30 days.
[b] Mean number of days spent doing R&R in the past 30 days was 17.71 over all workers.
[c] Did not ask this question for general R&R activity.
[d] 14.3 percent of workers spent less than one week doing general R&R in the last year.

Table D-3. Frequency Tables of Days Activity Performed Versus Days Performed in pre-1950 Buildings for Each Target Activity

RENOVATION AND REMODELING

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	0	0	0	0	0	0
	0	0	35	0	0	1	36
	1-5	0	26	27	3	0	56
	6-10	0	13	17	35	4	69
	>10	2	76	58	38	250	424
	TOTAL	2	150	102	76	255	585

CARPET REMOVAL

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	1	0	0	0	0	1
	0	0	315	0	0	0	315
	1-5	1	82	114	1	2	200
	6-10	0	8	17	7	4	36
	>10	0	4	4	10	15	33
	TOTAL	2	409	135	18	21	585

WINDOW REPLACEMENT

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	0	0	0	0	0	0
	0	0	247	0	0	0	247
	1-5	1	60	155	1	2	219
	6-10	1	11	11	33	1	57
	>10	0	4	4	9	45	62
	TOTAL	2	322	170	43	48	585

Table D-3. Frequency Tables of Days Activity Performed Versus Days Performed in pre-1950 Buildings for Each Target Activity (continued)

HVAC

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	0	0	0	0	0	0
	0	0	457	0	0	0	457
	1-5	1	31	59	1	0	92
	6-10	0	1	3	12	0	16
	>10	0	0	3	2	15	20
	TOTAL	1	489	65	15	15	585

LARGE STRUCTURE REMOVAL

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	0	0	0	0	0	0
	0	0	196	0	0	0	196
	1-5	0	51	116	2	0	169
	6-10	1	23	14	38	1	77
	>10	1	29	16	8	89	143
	TOTAL	2	299	146	48	90	585

PAINT REMOVAL AND SURFACE PREPARATION

Number of Days Activity	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
	Missing	0	0	0	0	0	0
	0	0	275	0	0	0	275
	1-5	0	43	91	1	0	135
	6-10	0	16	7	27	2	52
	>10	2	19	17	12	73	123
	TOTAL	2	353	115	40	75	585

Table D-3. Frequency Tables of Days Activity Performed Versus Days Performed in pre-1950 Buildings for Each Target Activity (continued)

CLEANUP							
	Pre-1950 Activity						
	Freq.	Missing	0	1-5	6-10	>10	TOTAL
Number of Days Activity	Missing	1	0	0	0	0	1
	0	0	97	0	0	0	97
	1-5	0	57	111	3	1	172
	6-10	0	20	15	27	1	63
	>10	2	36	49	23	142	252
	TOTAL	3	210	175	53	144	585

APPENDIX E:
STATISTICAL MODELS TABLE

Table E-1. Summary of Relationships Between Discrete Covariates and Blood-Lead Concentrations

Categorical Covariate Description (Levels)	Combined		Philadelphia Union		Philadelphia Non-union		St. Louis Union		St. Louis Non-union	
	F[a]	P-value[b]	F	P-value	F	P-value	F	P-value	F	P-value
Smoking status (No/Yes)	20.59	<0.001	11.34	<0.001	17.68	<0.001	15.65	<0.001	0.35	0.554
Smoking status (No/Yes, but not on job/Yes, on job)	10.71	<0.001	6.70	0.002	8.81	<0.001	8.32	<0.001	1.49	0.230
Previous training	0.34	0.562	0.74	0.390	2.32	0.132	1.84	0.177	0.72	0.400
Room additions (No/Yes)	4.40	0.036	0.47	0.494	0.39	0.532	0.57	0.452	0.19	0.665
Room additions (No/Contracted/Self-performed)	2.35	0.097	1.32	0.269	1.34	0.267	0.57	0.564	0.29	0.749
Age of home (Pre-/Post-1950)	19.30	<0.001	0.086	0.770	0.25	0.620	11.58	<0.001	6.79	0.010
Age of home (Pre-1950/1950-1978/Post-1978)	14.37	<0.001	0.391	0.677	0.22	0.801	7.56	<0.001	5.59	0.005
Race (White/Black/Other)	8.16	<0.001	0.124	0.883	0.14	0.867	11.29	<0.001	1.95	0.146
Race (all levels)	3.09	0.005	0.114	0.952	0.28	0.921	7.48	<0.001	1.38	0.250
Educational level (At most High School/More than High School)	10.01	0.002	0.923	0.338	6.8	0.011	6.91	0.009	0.51	0.477
Educational level (all levels)	2.50	0.030	1.88	0.115	4.33	0.002	1.76	0.140	0.25	0.942
Respirator use (None/Dustmask/Respirator)	6.90	0.001	4.62	0.033	1.05	0.357	1.82	0.165	1.93	0.149
Respirator use (None/Respirator)	4.43	0.036	2.36	0.097	0.82	0.367	1.38	0.241	2.89	0.091
Non-work activities (hobbies)	0.26	0.610	1.07	0.303	0.20	0.652	3.35	0.069	0.02	0.892

[a] F-values represent test statistics for analysis-of-variance of covariate on log-blood concentrations.
[b] P-values measure influence of covariate. P-values < 0.05 indicate significant covariate effect.

Table E-1. (continued)

Categorical Covariate Description (Levels)	Combined		Philadelphia Union		Philadelphia Non-union		St. Louis Union		St. Louis Non-union	
	F[a]	P-value[b]	F	P-value	F	P-value	F	P-value	F	P-value
Other occupations	6.71	0.010	0.18	0.675	3.63	0.061	7.27	0.008	0.69	0.409
Runs water before drinking	3.78	0.052	0.64	0.427	0.93	0.338	3.73	0.055	0.24	0.622
Takes radio to worksite	0.98	0.403	1.54	0.204	0.17	0.919	0.81	0.490	0.58	0.631
Changes shoes before going home	0.18	0.911	1.28	0.283	0.25	0.862	0.78	0.505	1.49	0.221
Changes clothes before going home	0.22	0.877	0.39	0.760	1.19	0.321	0.07	0.975	0.34	0.798
Washes before going home	1.24	0.293	1.18	0.319	0.94	0.426	2.05	0.110	0.37	0.772
Washes before eating	0.38	0.769	0.81	0.488	0.02	0.996	0.16	0.923	1.50	0.216
Eats at worksites	1.78	0.149	0.23	0.874	0.53	0.662	0.42	0.736	2.22	0.088
Dirty worksites	0.60	0.616	0.89	0.449	0.10	0.959	4.54	0.005	0.04	0.987
Uses water at worksite	0.24	0.870	0.32	0.810	0.17	0.917	0.64	0.590	0.78	0.505

[a] F-values represents test statistics for analysis-of-variance of covariate on log-blood concentrations.
[b] P-values measure influence of covariate. P-values < 0.05 indicate significant covariate effect.

Table E-1. (Continued)

Continuous Covariate Description	Combined		Philadelphia Union		Philadelphia Non-union		St. Louis Union		St. Louis Non-union	
	F[a]	P-value[b]	F	P-value	F	P-value	F	P-value	F	P-value
Worker's age	29.11	<0.001	12.81	<0.001	12.68	<0.001	12.17	<0.001	6.23	0.014
Number of non-work activities (hobbies)	0.32	0.570	0.71	0.400	0.03	0.866	6.75	0.010	0.35	0.553
Number of other occupational hazards	3.37	0.067	0.21	0.645	0.07	0.799	6.25	0.013	0.001	0.971
Days radio taken to worksite	1.96	0.162	3.00	0.084	0.37	0.543	1.76	0.186	0.30	0.583
Days change shoes before going home	0.46	0.500	3.53	0.062	0.18	0.675	0.0001	0.992	3.37	0.068
Days change clothes before going home	2.34	0.127	0.002	0.970	3.26	0.075	0.73	0.394	0.52	0.474
Days wash before going home	0.09	0.761	2.01	0.157	0.06	0.802	0.07	0.787	1.36	0.246
Days wash before eating	0.10	0.751	2.71	0.101	1.13	0.291	0.21	0.649	1.79	0.183
Days eat at worksite	1.70	0.192	0.59	0.445	0.47	0.500	0.40	0.531	1.15	0.286
Days worksite dirty	1.65	0.200	1.00	0.319	0.54	0.463	4.63	0.033	0.03	0.870
Days water available at worksite	1.65	0.200	1.76	0.186	0.06	0.814	1.31	0.254	0.16	0.685

[a] F-values represent test statistics for regression F-test of covariate on log blood concentrations..
[b] P-values measure influence of covariate. P-values < 0.05 indicate significant covariate effect.

Table E-2. Summary of Univariate Relationships Between Conduct of Target Activity and Blood-Lead Concentrations for each Target Activity (Unadjusted)

Target Activity	Days of Pre-1950 Activity			Weeks in Last Year			Years of Activity		
	€	se(€)	P-value	€	se(€)	P-value	€	se(€)	P-value
Renovation and Remodeling	0.0187	0.0027	<0.001	0.1155	0.0215	<0.001	0.0078	0.0032	0.017
Carpet Removal	0.0100	0.0077	0.190	-0.0388	0.0217	0.074	-0.0019	0.0041	0.646
Window Replacement	0.0177	0.0051	<0.001	0.1125	0.0198	<0.001	0.0124	0.0041	0.003
HVAC Work	0.0243	0.0083	0.003	0.0666	0.0259	0.010	0.0104	0.0054	0.056
Large Structure	0.0136	0.0040	<0.001	0.0630	0.0174	<0.001	0.0135	0.0041	<0.001
Paint Removal	0.0219	0.0043	<0.001	0.0249	0.0169	0.143	0.0063	0.0036	0.083
Cleanup	0.0138	0.0031	<0.001	-0.0044	0.0175	0.802	0.0008	0.0033	0.803

Table E-3. Summary of Univariate Relationships Between Conduct of Target Activity and Blood-Lead Concentrations for each Target Activity (Adjusted for Ancillary Covariates)

Target Activity	Days of Pre-1950 Activity			Weeks in Last Year			Years of Activity		
	€	se(€)	P-value	€	se(€)	P-value	€	se(€)	P-value
Renovation and Remodeling	0.0135	0.0027	<0.001	0.1124	0.0205	<0.001	0.0090	0.0031	0.004
Carpet Removal	-0.0096	0.0079	0.227	-0.0654	0.0210	0.002	-0.0041	0.0040	0.298
Window Replacement	0.0088	0.0051	0.084	0.0854	0.0194	<0.001	0.0112	0.0039	0.004
HVAC Work	0.0055	0.0084	0.515	0.0167	0.0256	0.514	0.0066	0.0052	0.204
Large Structure	0.0070	0.0039	0.073	0.0412	0.0169	0.015	0.0130	0.0039	0.001
Paint Removal	0.0108	0.0044	0.015	-0.0037	0.0165	0.824	0.0028	0.0034	0.411
Cleanup	0.0067	0.0032	0.039	-0.0278	0.0168	0.099	0.0009	0.0031	0.768

Table E-4. Summary for Each Target Activity of the Covariate Adjusted Relationship Between Blood-Lead Concentration and the Combined Effect of All Three Exposure Period Measures.

Target Activity	Days of Pre-1950 Activity			Weeks in Last Year			Years of Activity			R^2
	€	se(€)	P-value	€	se(€)	P-value	€	se(€)	P-value	
Renovation and Remodeling	0.0093	0.0029	0.001	0.0810	0.0219	<0.001	0.0068	0.0030	0.026	0.190
Carpet Removal	0.0055	0.0094	0.557	-0.0754	0.0278	0.007	0.0021	0.0045	0.636	0.136
Window Replacement	-0.0110	0.0064	0.086	0.0979	0.0273	<0.001	0.0036	0.0045	0.427	0.156
HVAC Work	0.0087	0.0107	0.419	-0.0177	0.0369	0.631	0.0071	0.0062	0.254	0.129
Large Structure	0.0027	0.0047	0.568	0.0155	0.0217	0.475	0.0109	0.0043	0.012	0.145
Paint Removal	0.0137	0.0054	0.011	-0.0376	0.0218	0.085	0.0037	0.0039	0.338	0.135
Cleanup	0.0125	0.0036	<0.001	-0.0622	0.0196	0.002	0.0016	0.0032	0.620	0.142

Note: There are a total of seven models being fitted in this Phase. Each model represents a single target activity and contains all three measures of potential lead exposure (short term, intermediate, and long term). Thus the Table reads across the rows.

Table E-5. Summary for Exposure Period of the Covariate Adjusted Relationship Between Blood-Lead Concentration and the Combined Effect of All Six Target Activities Exposure Variables.

	Days of Pre-1950 Activity			Weeks in Last Year			Years of Activity		
Target Activity	€	se(€)	P-value	€	se(€)	P-value	€	se(€)	P-value
Carpet Removal	-0.0227	0.0088	0.010	-0.0538	0.0238	0.024	-0.0059	0.0050	0.233
Window Replacement	0.0037	0.0062	0.553	0.0876	0.0232	<0.001	0.0079	0.0063	0.210
HVAC Work	0.0045	0.0089	0.613	0.0058	0.0279	0.836	-0.0008	0.0066	0.898
Large Structure	0.0040	0.0048	0.407	0.0068	0.0197	0.732	0.0110	0.0060	0.068
Paint Removal	0.0116	0.0051	0.024	0.0021	0.0183	0.910	0.0025	0.0046	0.590
Cleanup	0.0023	0.0040	0.557	-0.0293	0.0197	0.136	-0.0056	0.0045	0.217
R^2	0.145			0.172			0.141		

Note: There are a total of four models being fitted in this Phase. Each model represents a single period of exposure (Short-Term, Mid-Term and Long-Term) and contains all six target activities. Thus the Table reads down the three columns.

Table E-6. Summary for Exposure Period of the Relationship Between Blood-Lead Concentration and the Combined Effect of All Six Target Activities Exposure Variables, After Adjusting for the Effects of Covariates and Worker Group

	Days of Pre-1950 Activity			Weeks in Last Year			Years of Activity		
Target Activity	€	se(€)	P-value	€	se(€)	P-value	€	se(€)	P-value
Carpet Removal	-0.0130	0.0085	0.130	0.0205	0.0267	0.442	0.0107	0.0054	0.048
Window Replacement	0.0031	0.0061	0.608	0.0683	0.0245	0.005	0.0032	0.0062	0.605
HVAC Work	0.0080	0.0087	0.361	-0.0059	0.0281	0.834	-0.0038	0.0064	0.555
Large Structure	-0.0018	0.0047	0.700	-0.0335	0.0208	0.108	-0.0012	0.0060	0.846
Paint Removal	0.0086	0.0052	0.099	-0.0040	0.0188	0.830	-0.0002	0.0045	0.959
Cleanup	0.0015	0.0039	0.707	-0.0080	0.0200	0.691	0.0007	0.0044	0.870
R^2	0.235			0.246			0.235		

Note: There are a total of four models being fitted in this Stage. Each model represents a single period of exposure (Short-Term, Mid-Term and Long-Term) and contains all six target activities. Thus the Table reads down the three columns.

Table E-7. Parameter Estimates for Final Model

Variable Category	Variable	Effect on log (Blood Pb)	Standard Error	P-Value
Worker Group	Union Carpenter	0.961	0.145	<0.001
	Non-Union Carpenter	0.929	0.156	<0.001
	Drywall Worker	1.198	0.159	<0.001
	Floor Layer	0.499	0.150	<0.001
	Laborer	0.832	0.163	<0.001
	Other	1.024	0.209	<0.001
	Painter	1.202	0.164	<0.001
	Supervisor	0.811	0.163	<0.001
	Window Installer	1.058	0.213	<0.001
Covariates	Race: Black	0.190	0.080	0.017
	Race: Other	-0.052	0.185	0.780
	Education: Finished High School	-0.223	0.104	0.032
	Smokes	0.162	0.101	0.108
	Smokes While Working	0.223	0.052	<0.001
	Age of Home: Pre 1950	0.212	0.069	0.002
	Age of Home: Pre 1978 (Post 1950)	0.134	0.067	0.045
	Performed R&R on Own House	0.054	0.050	0.283
	Use of Respirator or a Dustmask	0.123	0.051	0.016
General R&R	Days of R&R in Pre 1950 Buildings	0.0059	0.0029	0.041
	Weeks of R&R in Last Year	0.0685	0.0213	0.001
	Years of R&R over Career	0.0093	0.0029	0.002

APPENDIX F:
ADDITIONAL FIGURES

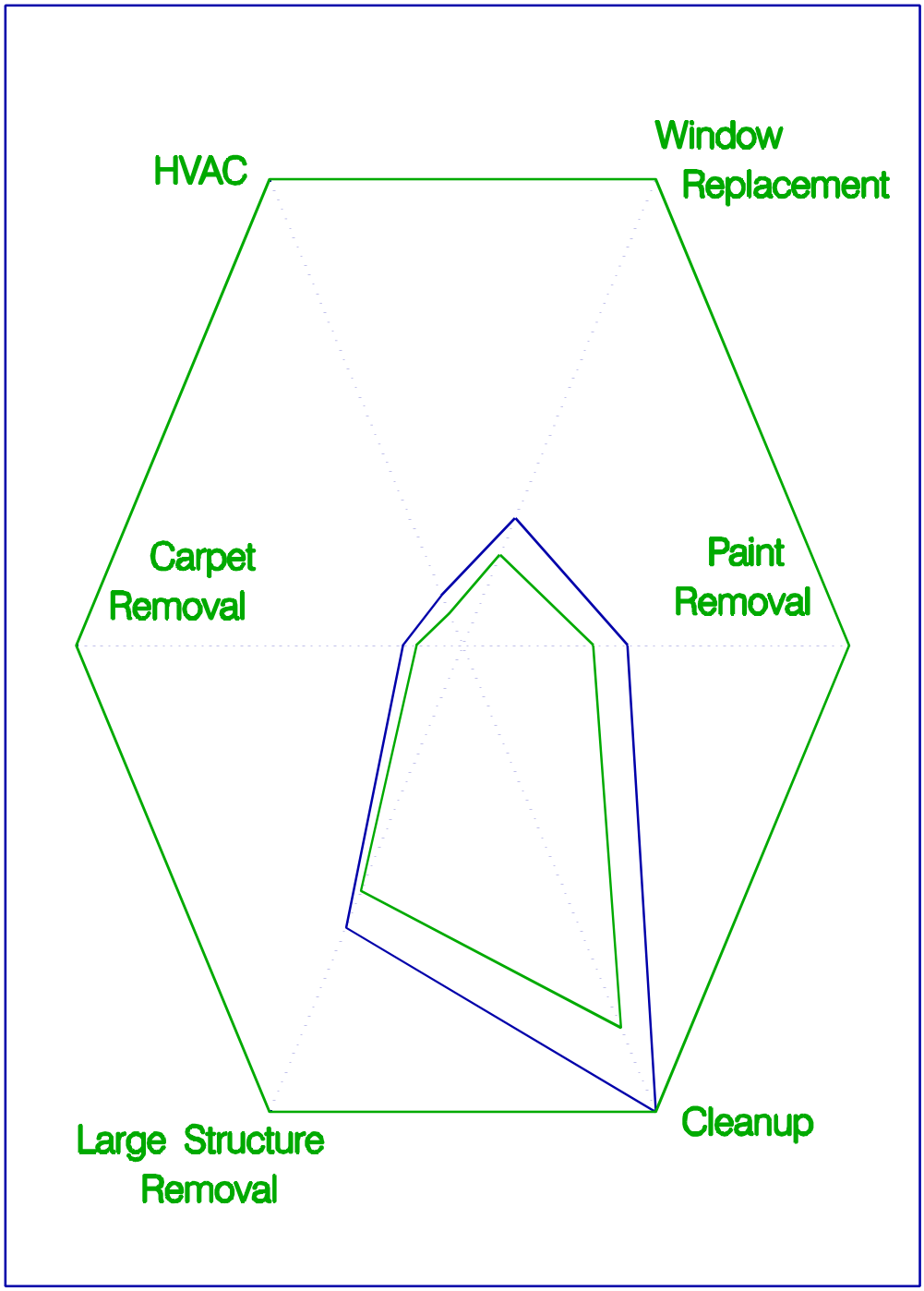


Figure F-1. Average Number of Days Spent Conducting Each Target Activity for Participants Versus Nonparticipants.*

* The maximum possible length of each axis is 20 days. The outer polygon represents the average number of days activity was performed during the past 30 work days for participants. The inner polygon presents the average number of days activity was performed for non-participants.

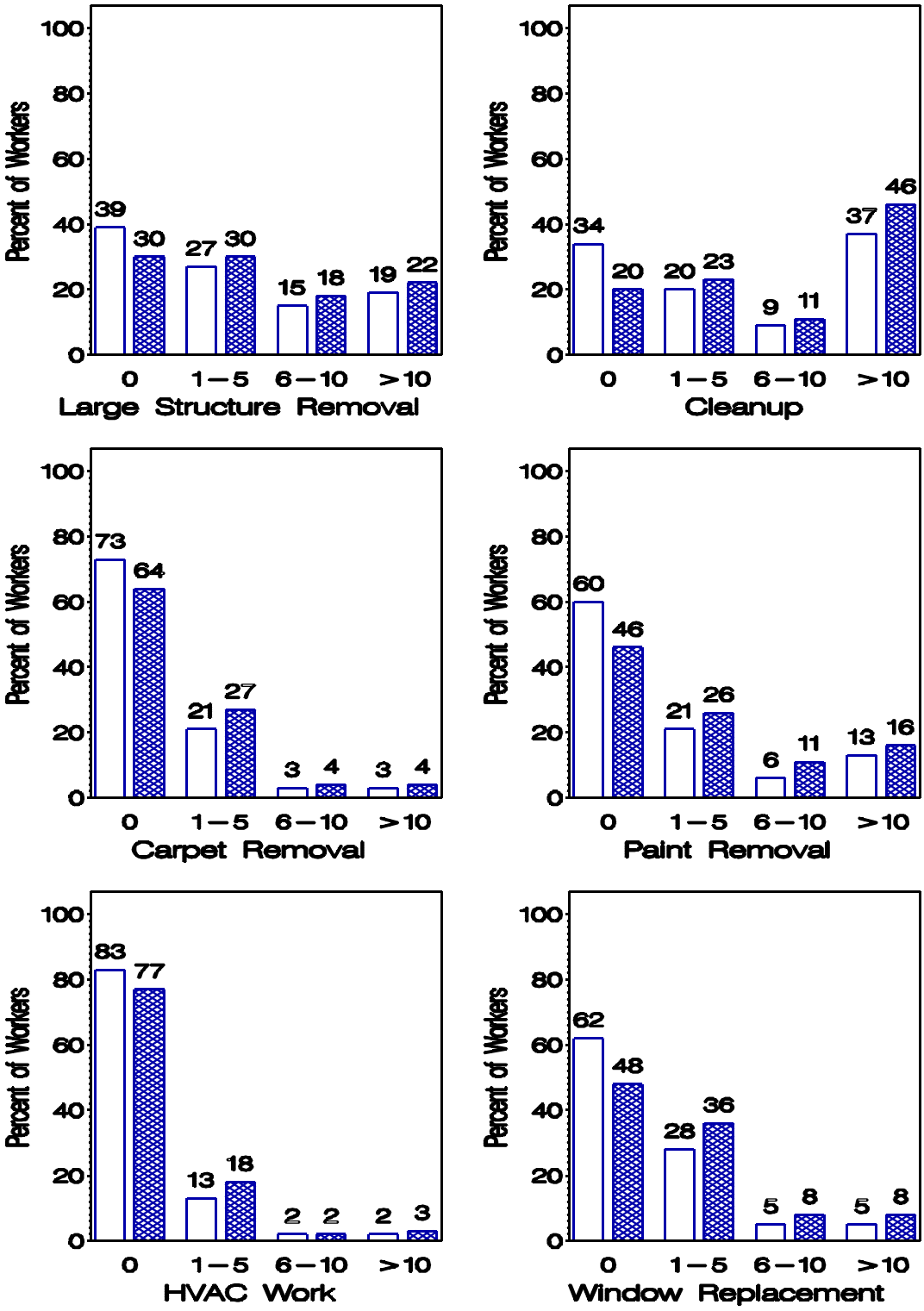


Figure F-2. Days in Last Month Spent Conducting Specific Target Activities for Participants (shaded) Versus Nonparticipants.

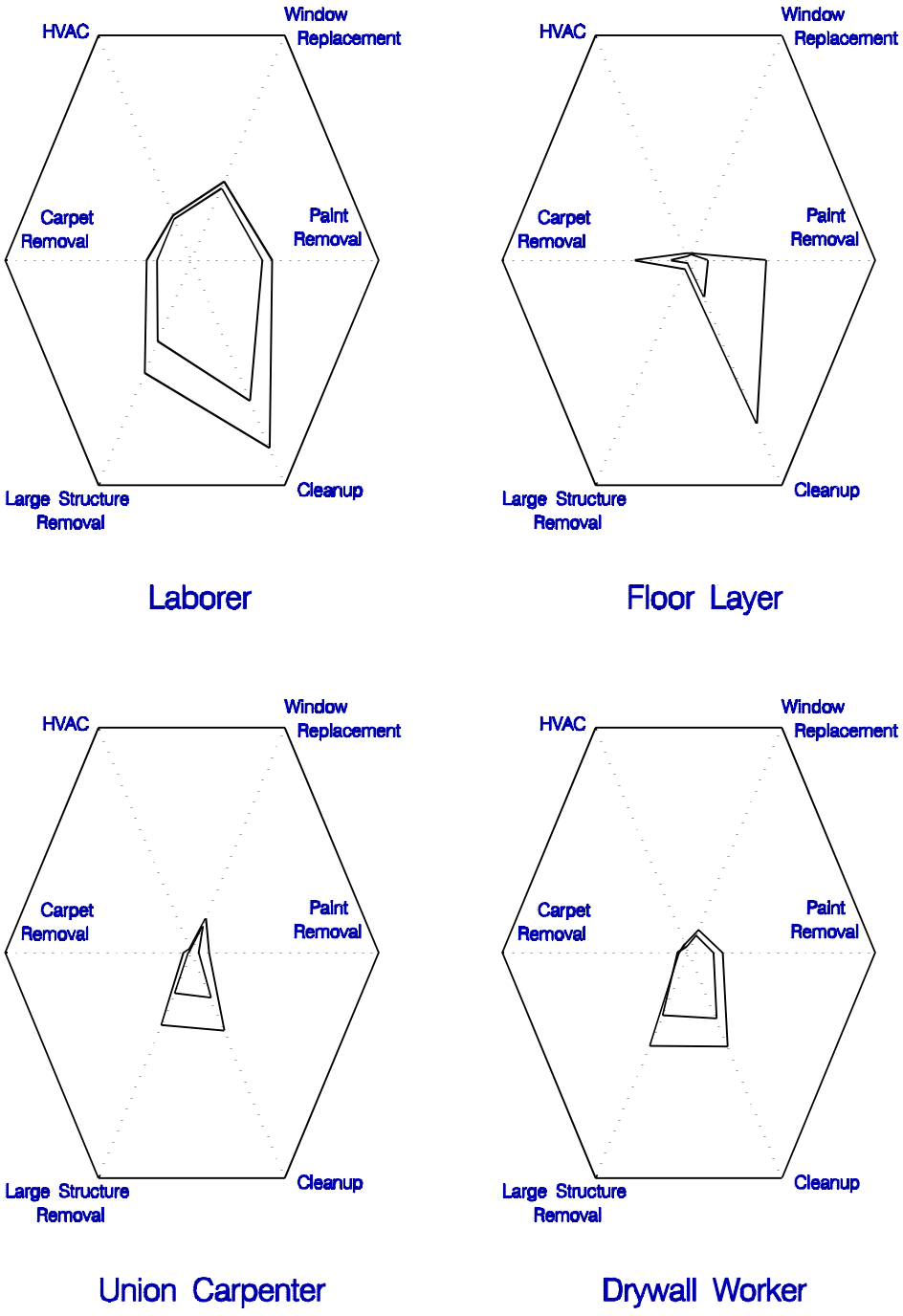


Figure F-3. Average Number of Days Spent Conducting Each Target Activity for Each Worker Group.*

* There are two polygons shown in each graph, and each polygon has six vertices, one for each target activity. Each vertex of the outer polygon represents the average number of days the activity was performed during the past 30 days, and each vertex of the inner polygon denotes the average number of days the activity was performed in pre-1950 buildings. The border of the graphs represent 20 days of work activity. The closer a vertex is to the border, the more that particular target activity was performed.

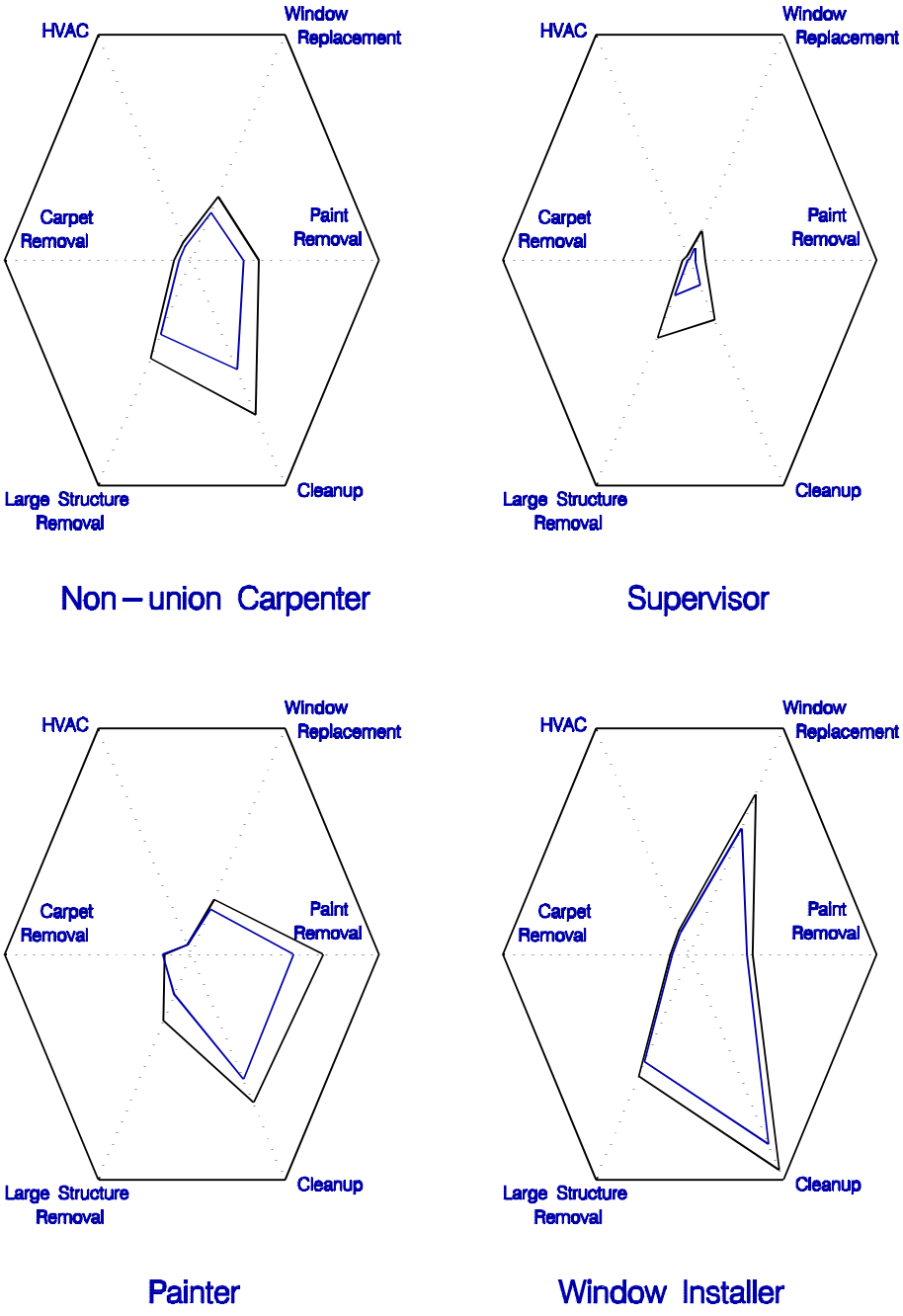


Figure F-3. (continued).*

* There are two polygons shown in each graph, and each polygon has six vertices, one for each target activity. Each vertex of the outer polygon represents the average number of days the activity was performed during the past 30 days, and each vertex of the inner polygon denotes the average number of days the activity was performed in pre-1950 buildings. The border of the graphs represent 20 days of work activity. The closer a vertex is to the border, the more that particular target activity was performed.

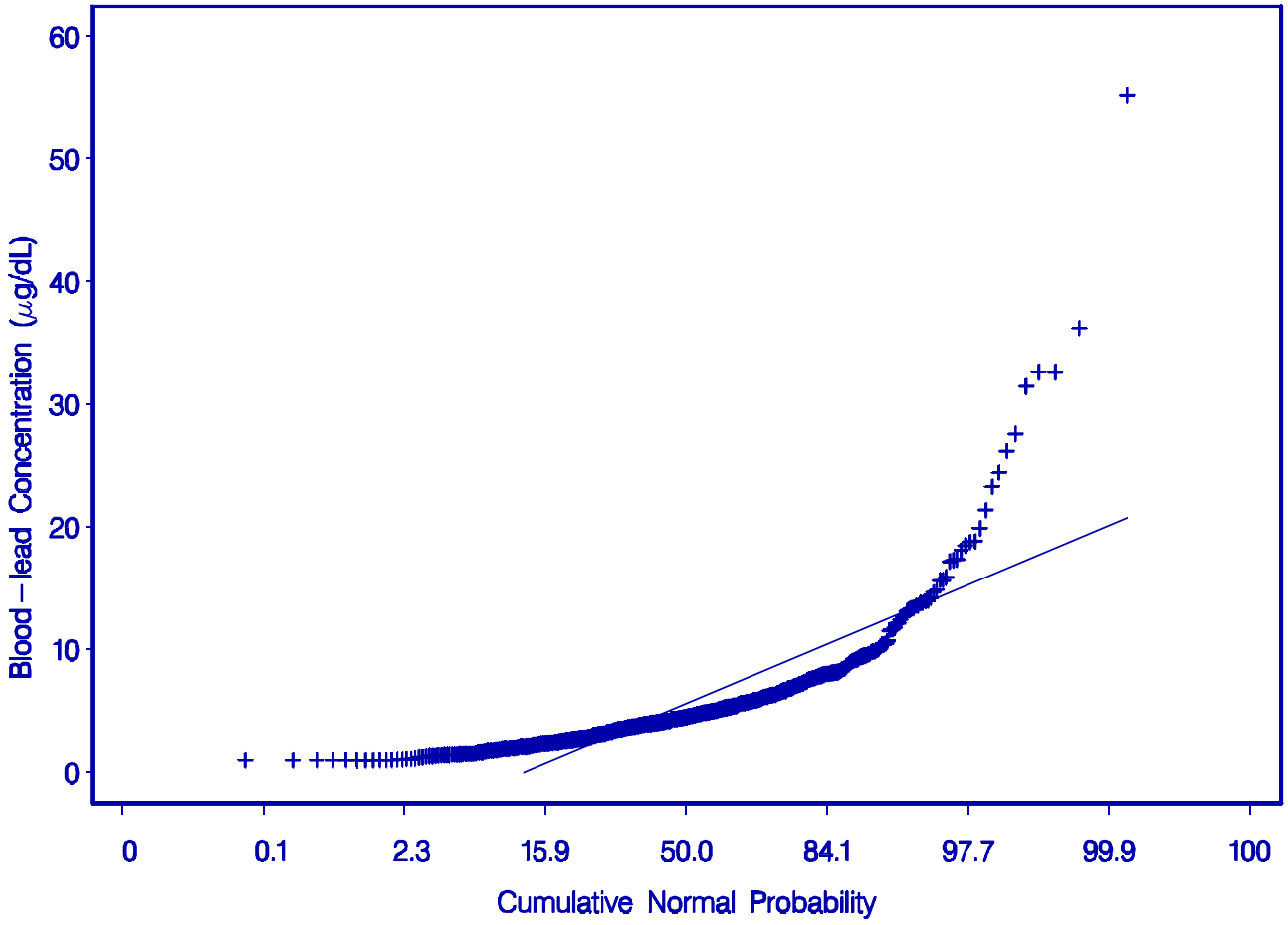


Figure F-4. Normal Probability Plot of Blood-Lead Concentrations.*

* Straight line indicates normality.

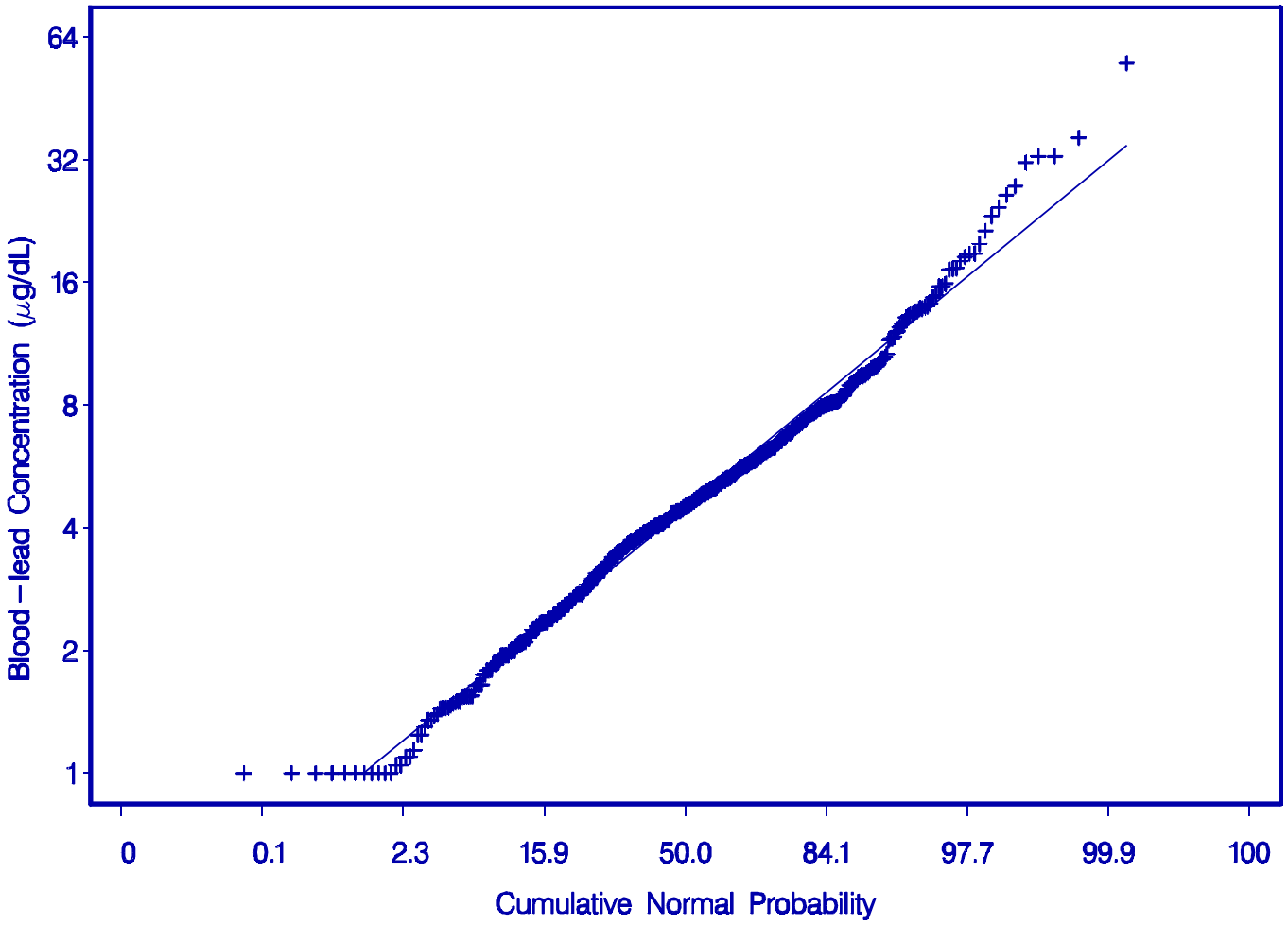


Figure F-5. Semi-log Probability Plot of Blood-Lead Concentrations.*

* Straight line indicates log-normality.

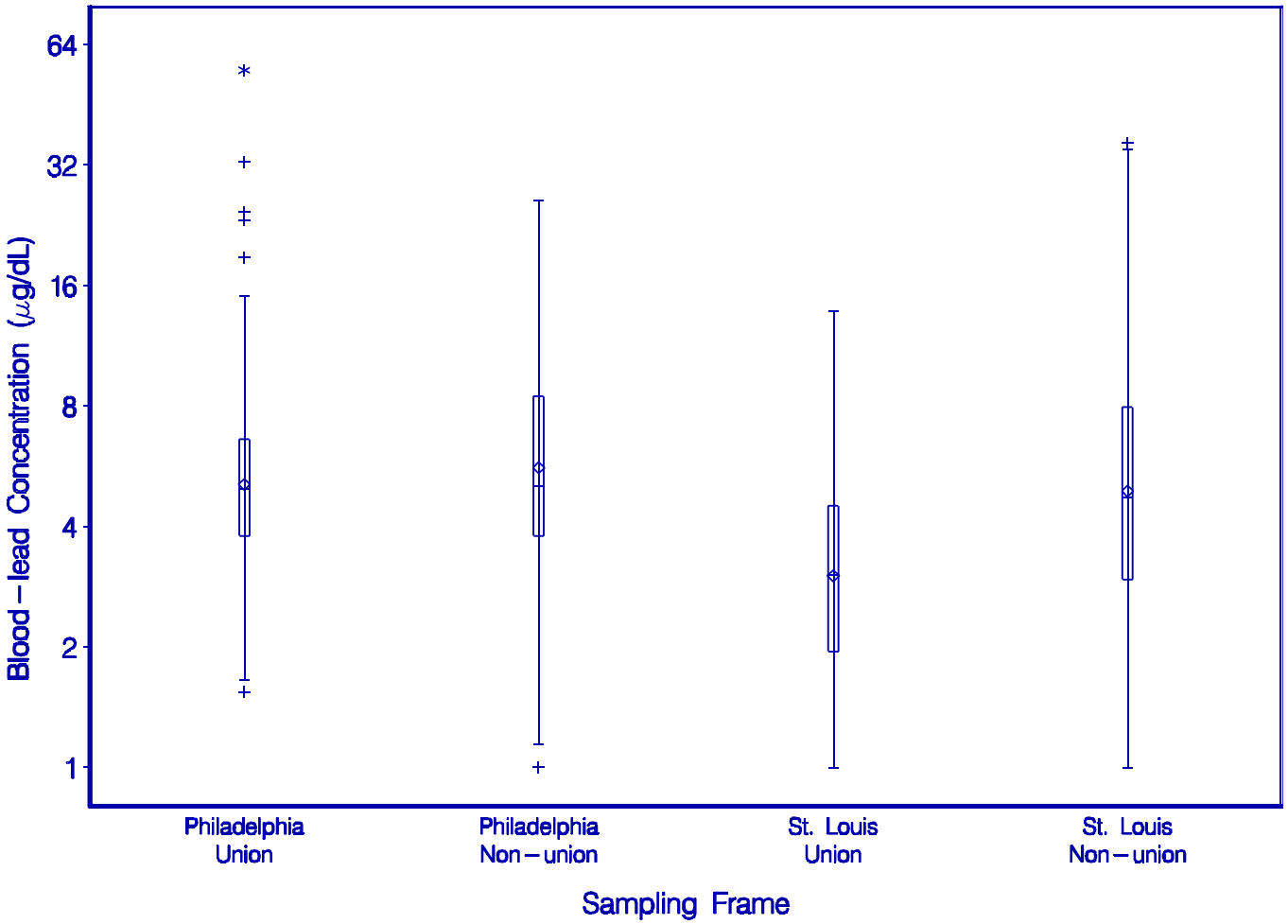


Figure F-6. Boxplot of Blood-Lead Concentrations for Each Sampling Frame.

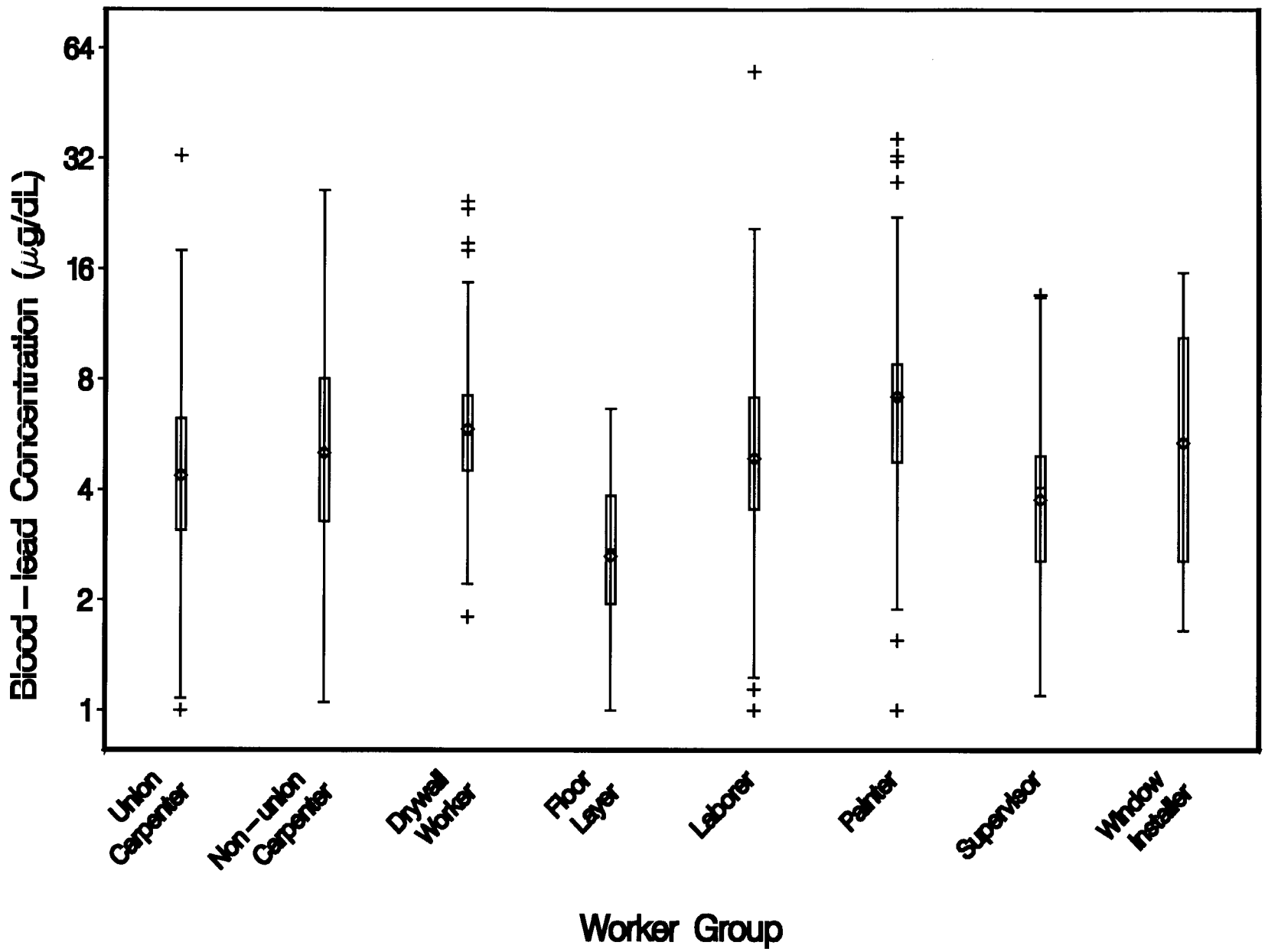


Figure F-7. Boxplot of Blood-Lead Concentration for Each Worker Group.

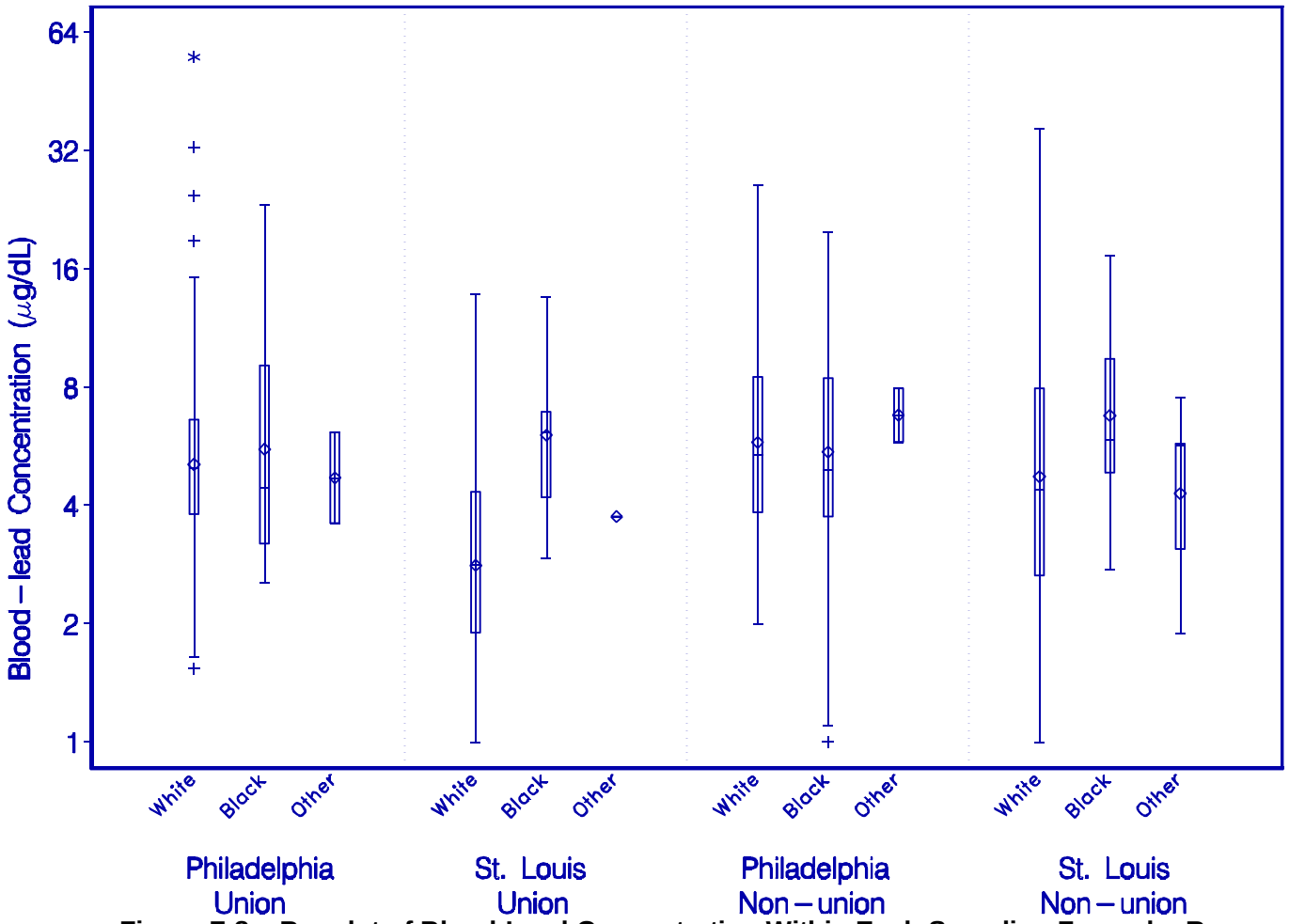


Figure F-8. Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Race.

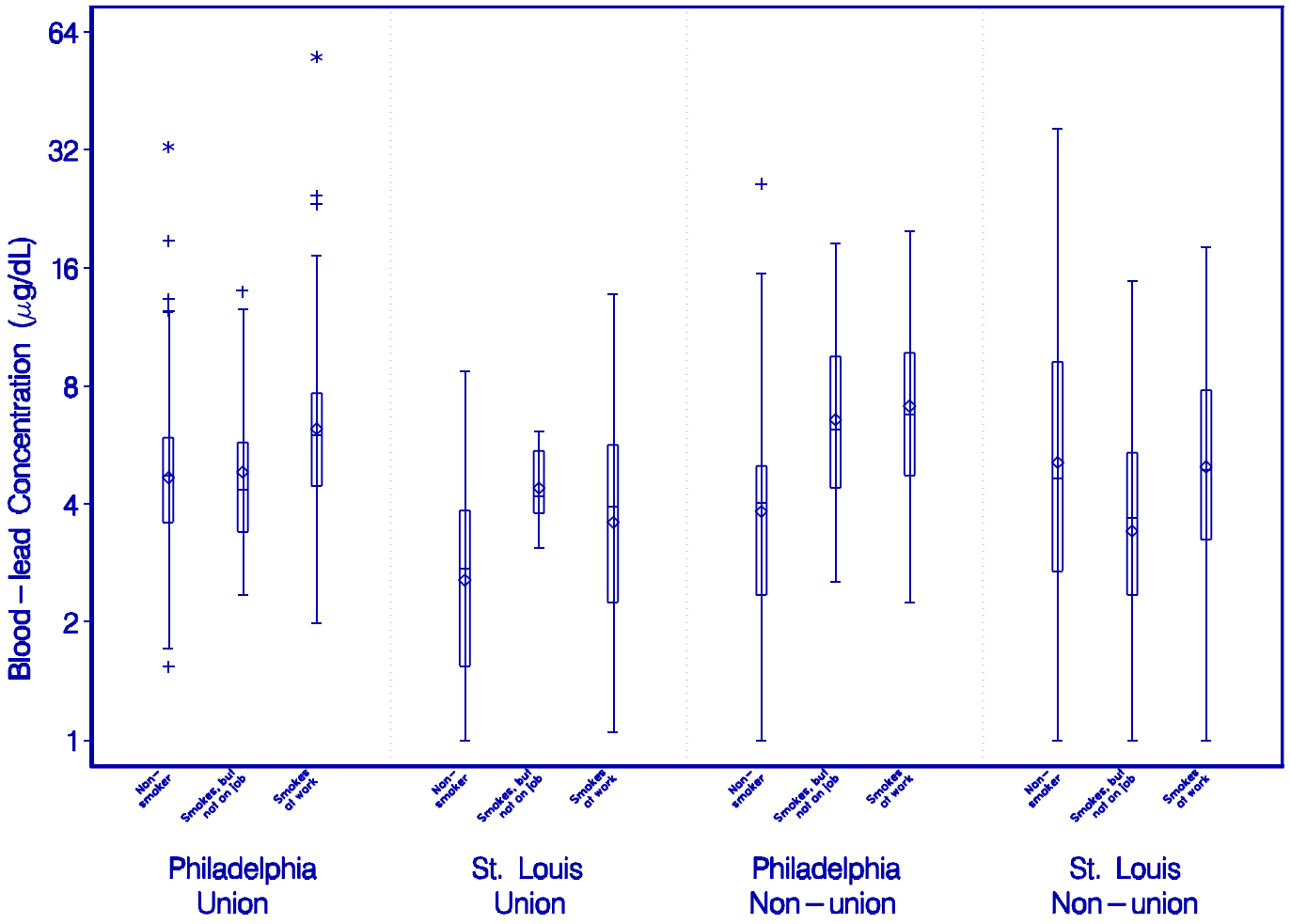


Figure F-9. Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Smoking Status.

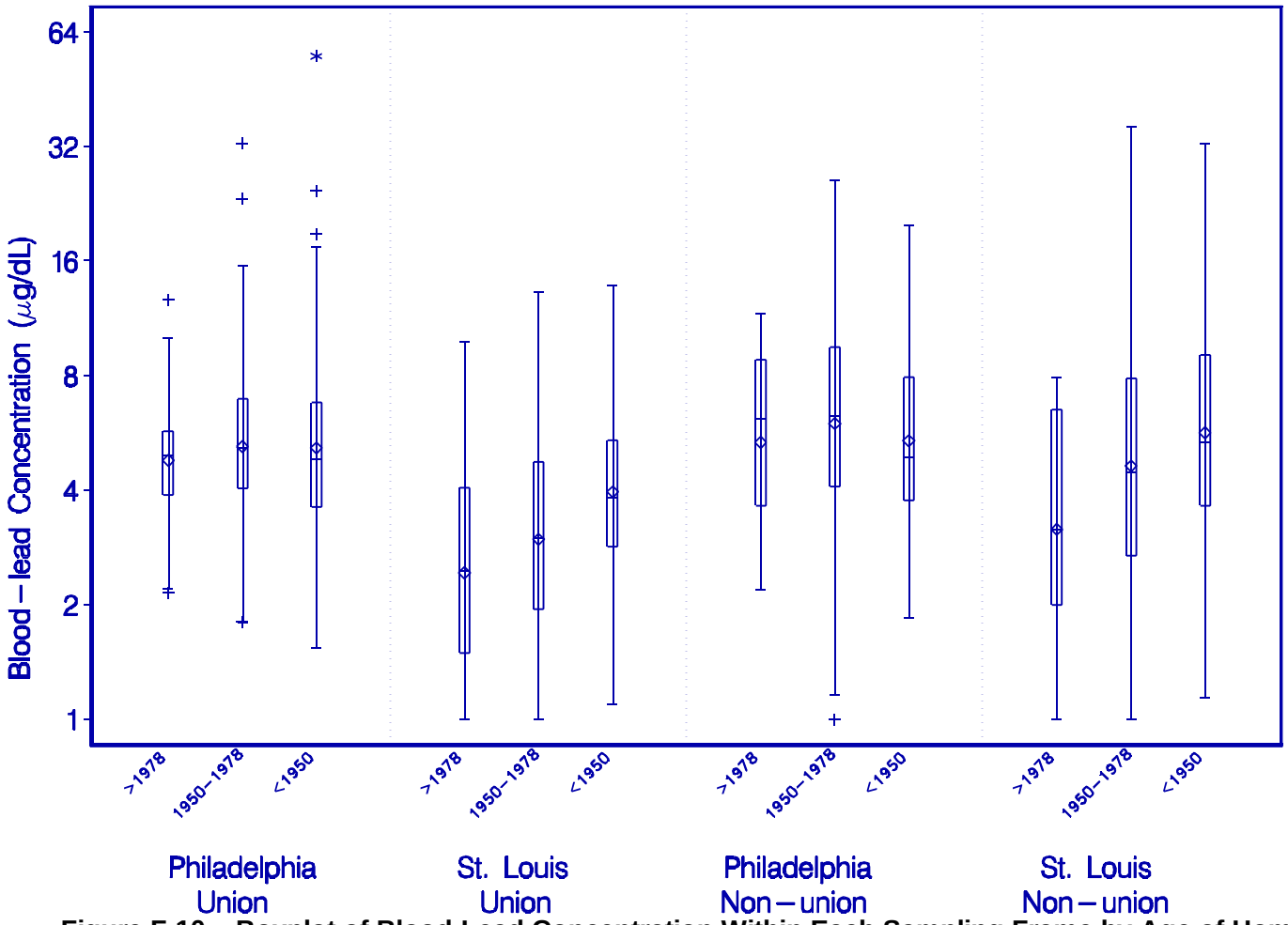


Figure F-10. Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Age of Home.

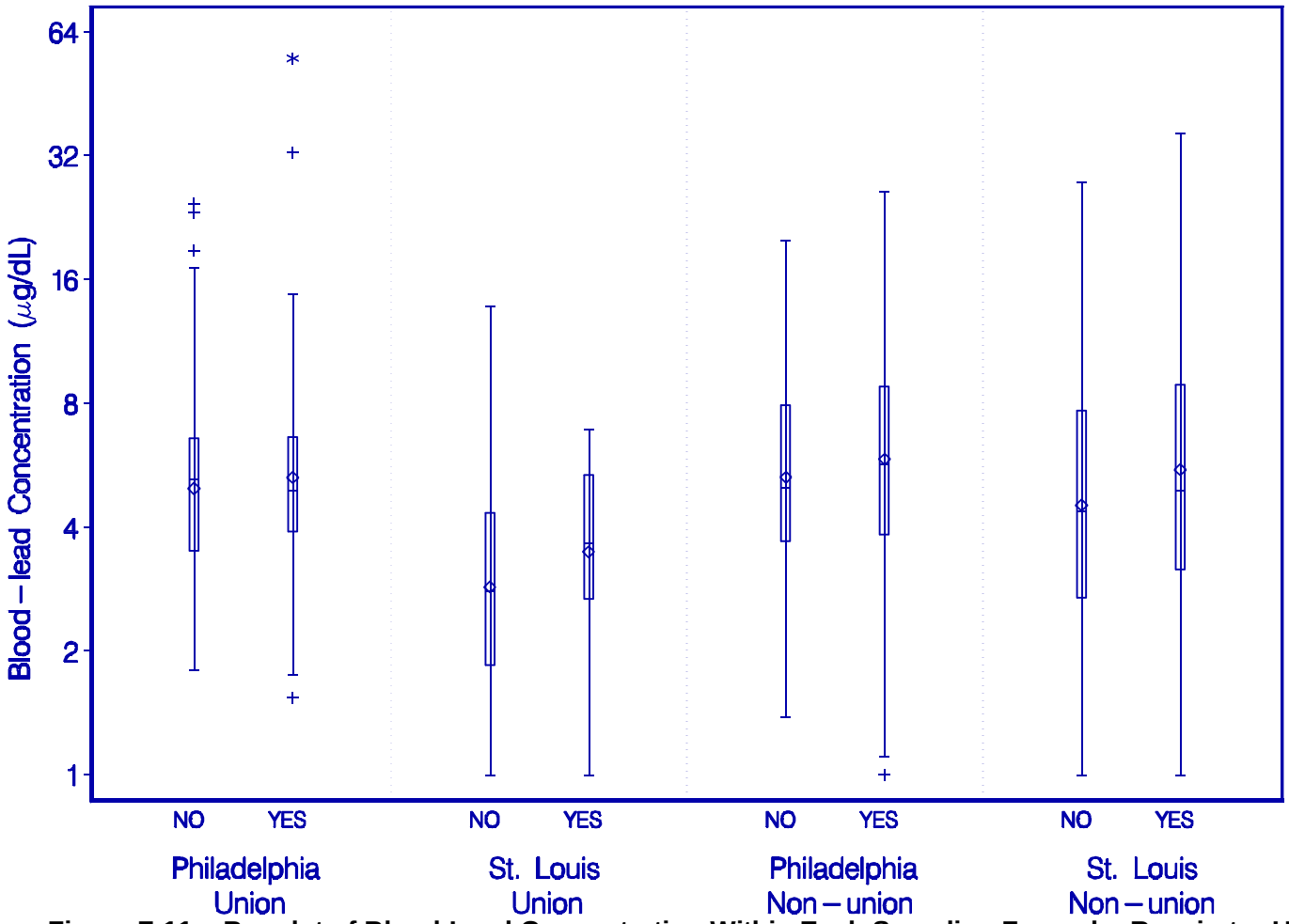


Figure F-11. Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Respirator Use.

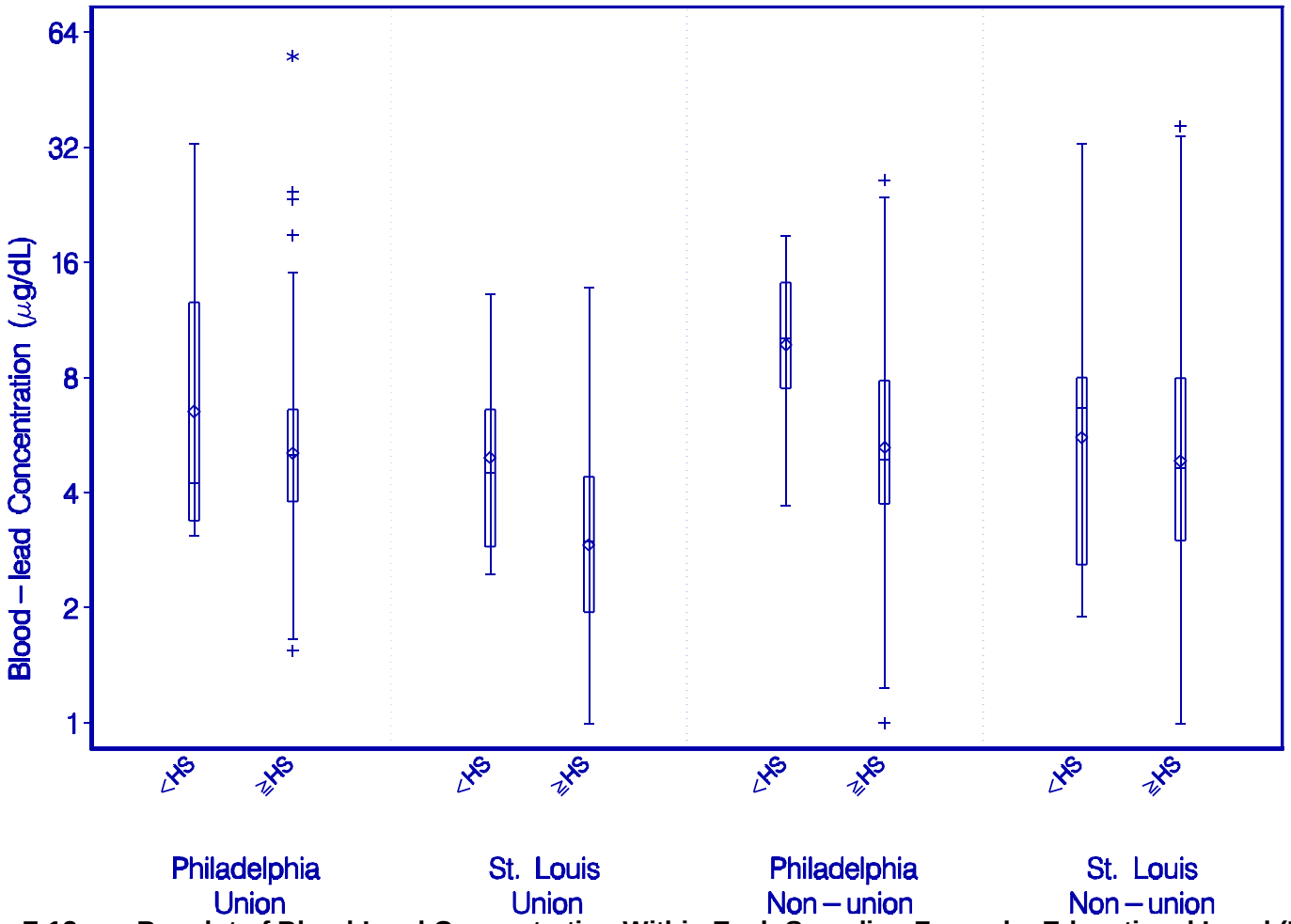


Figure F-12. **Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Educational Level (HS Indicates High School).**

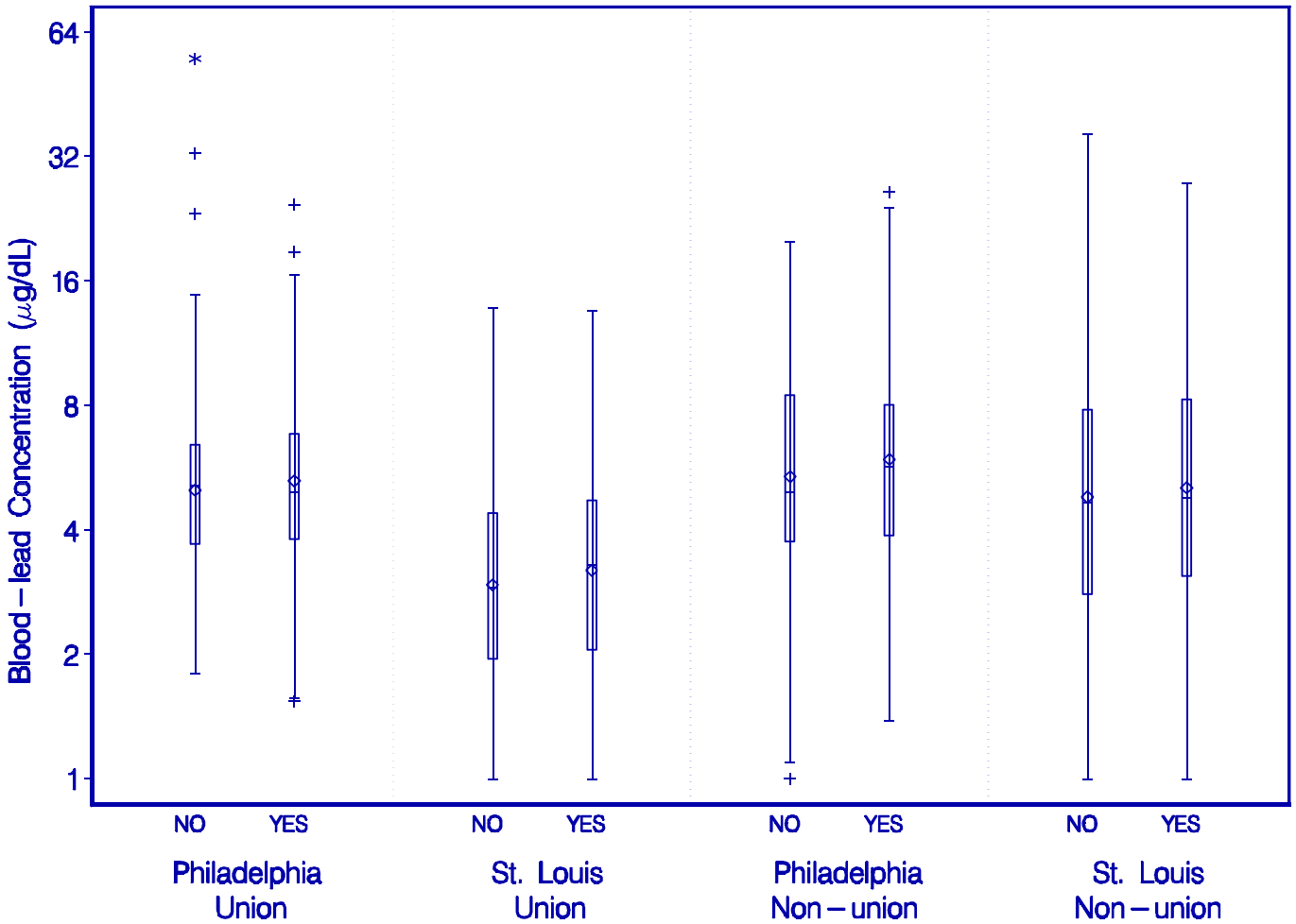


Figure F-13. Boxplot of Blood-Lead Concentration Within Each Sampling Frame by Incidence of Home Renovation/Remodeling in Last Year.

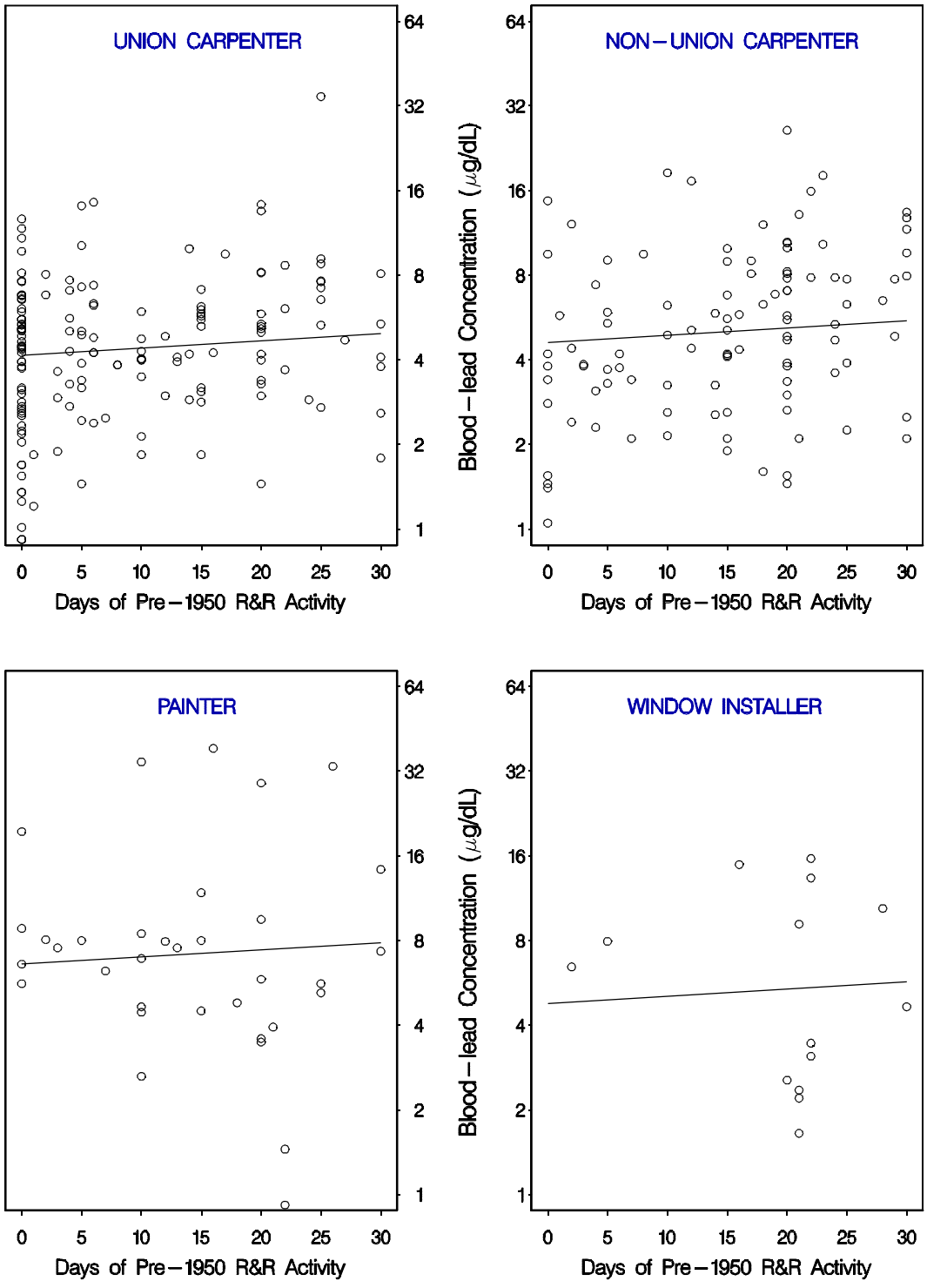


Figure F-14. Modeled Relationship Between Blood-Lead Concentration and Days in Last Month for Each Job Category of Pre-1950 R&R Activity.

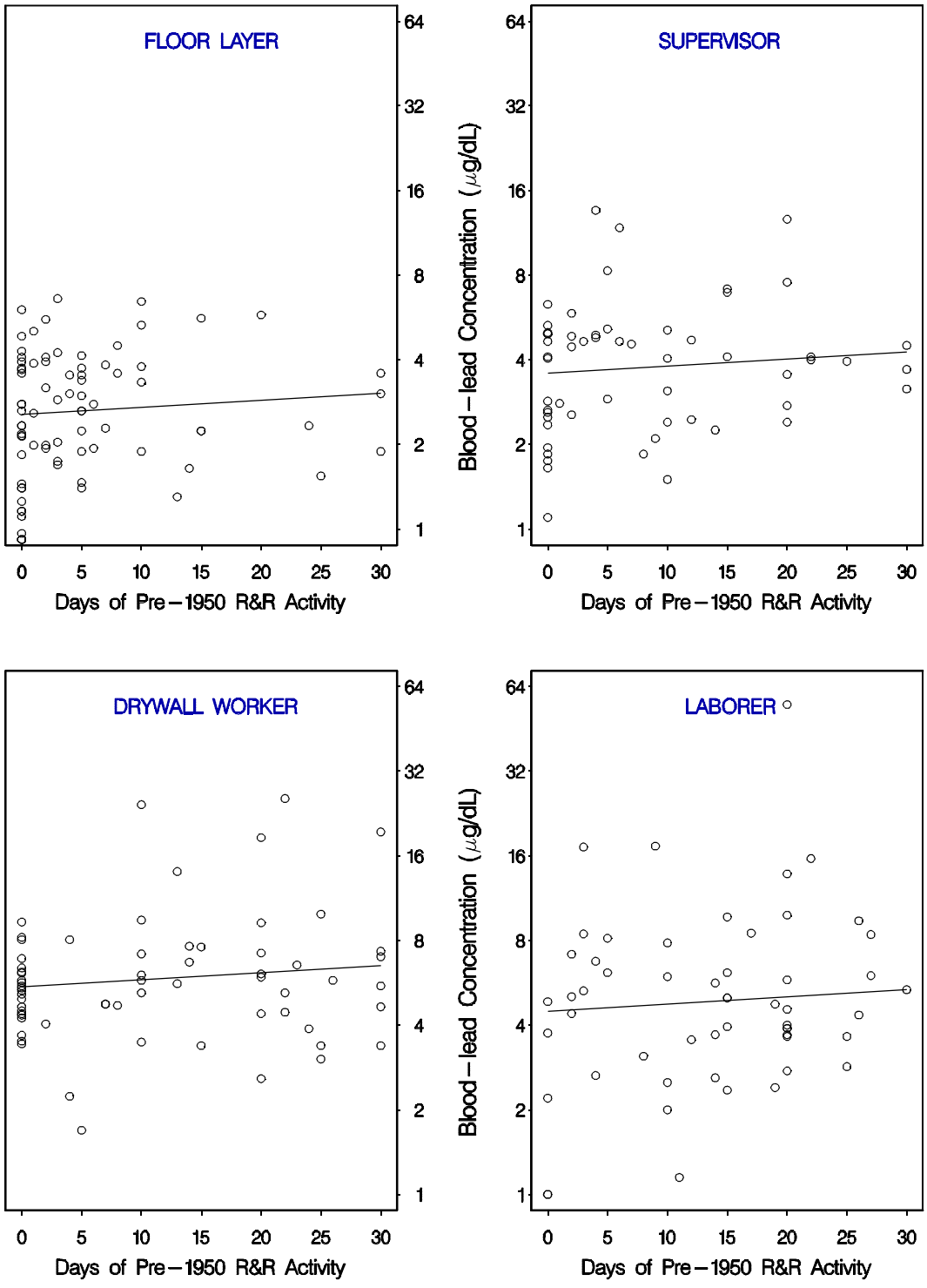


Figure F-14. (continued).

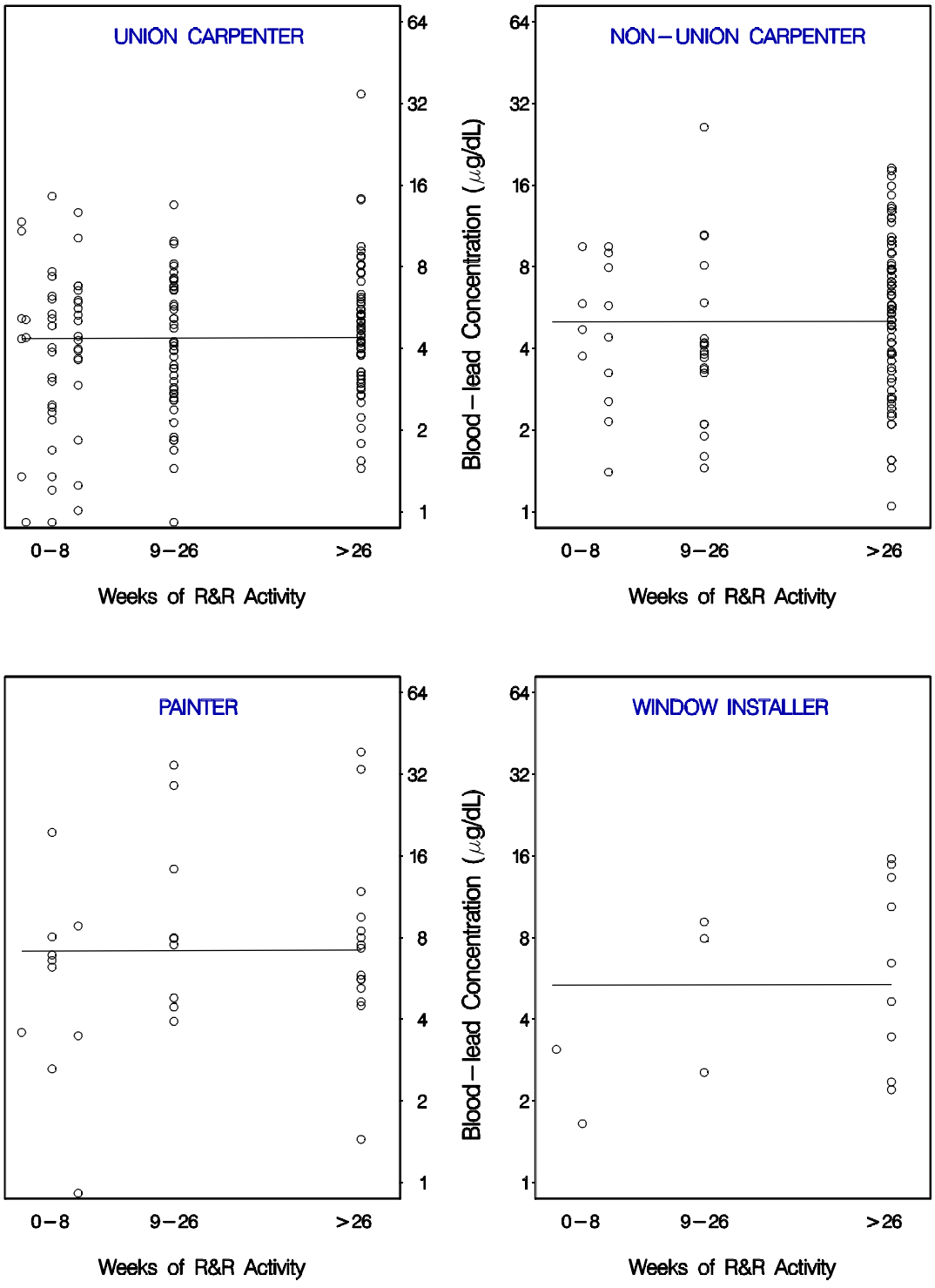


Figure F-15. Modeled Relationship Between Blood-Lead Concentration and Weeks in Last Year of General R&R Activity for Each Job Category.

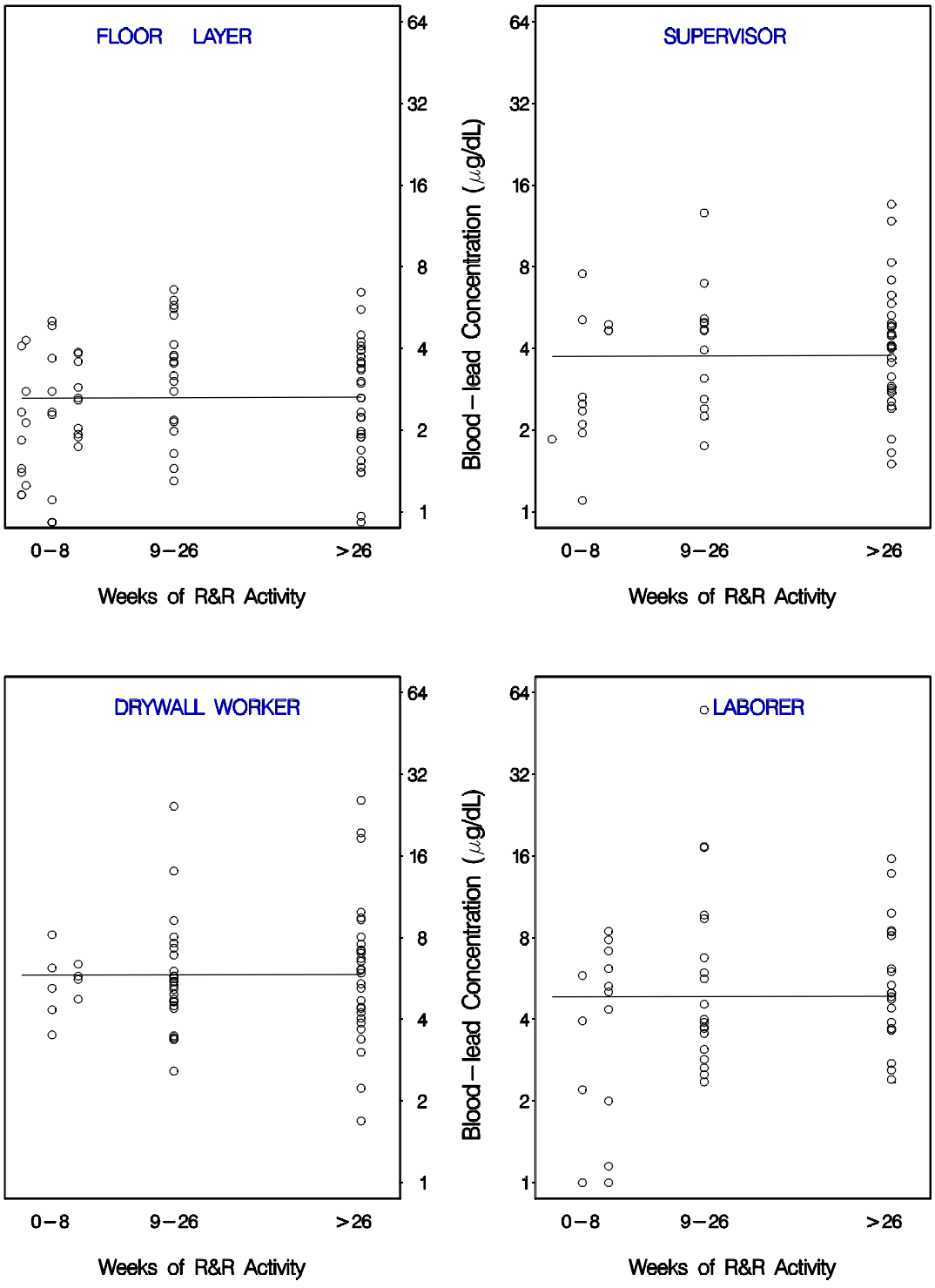


Figure F-15. (continued).

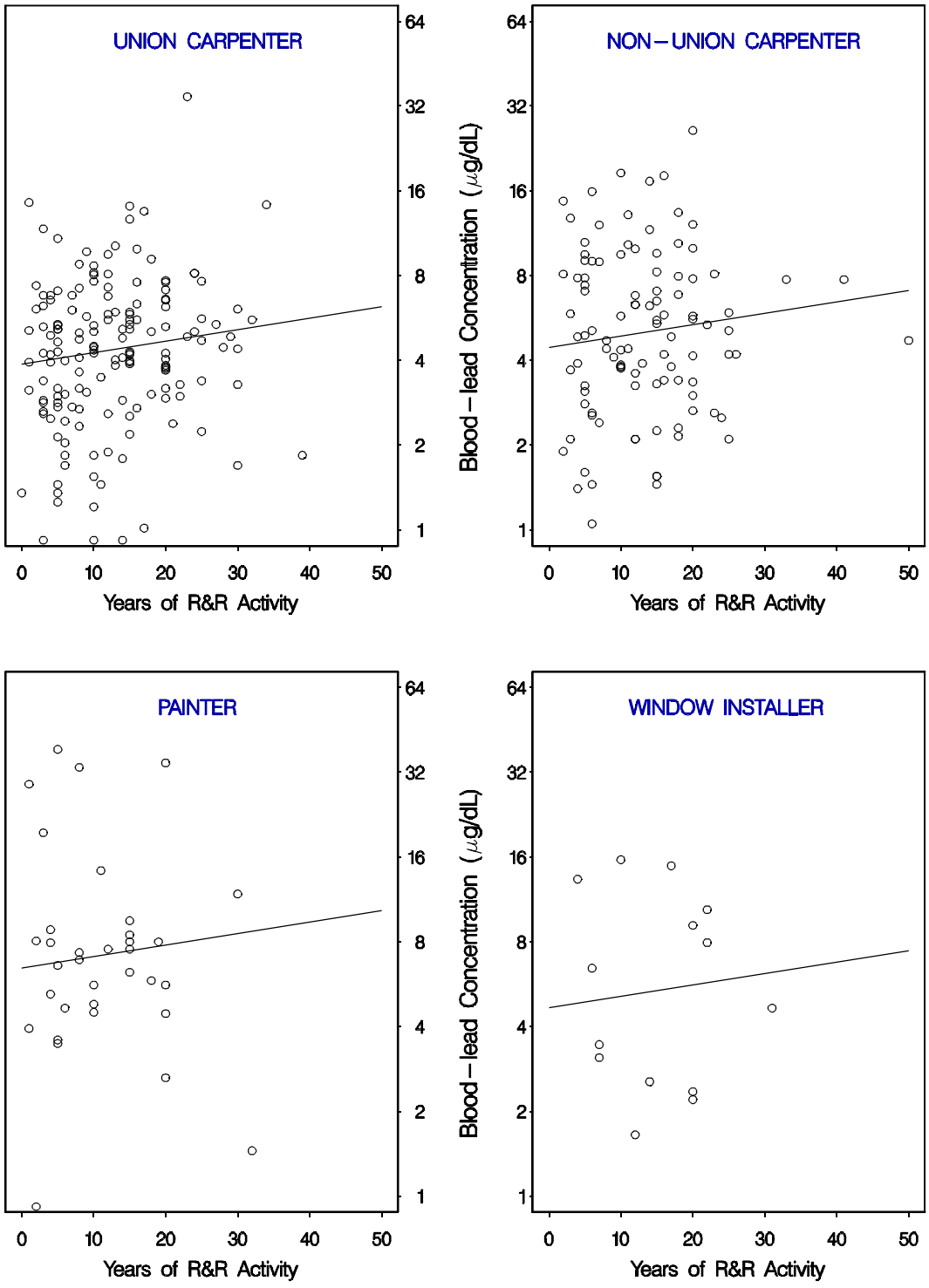


Figure F-16. Modeled Relationship Between Blood-Lead Concentration and Years of General R&R Activity for Each Job Category.

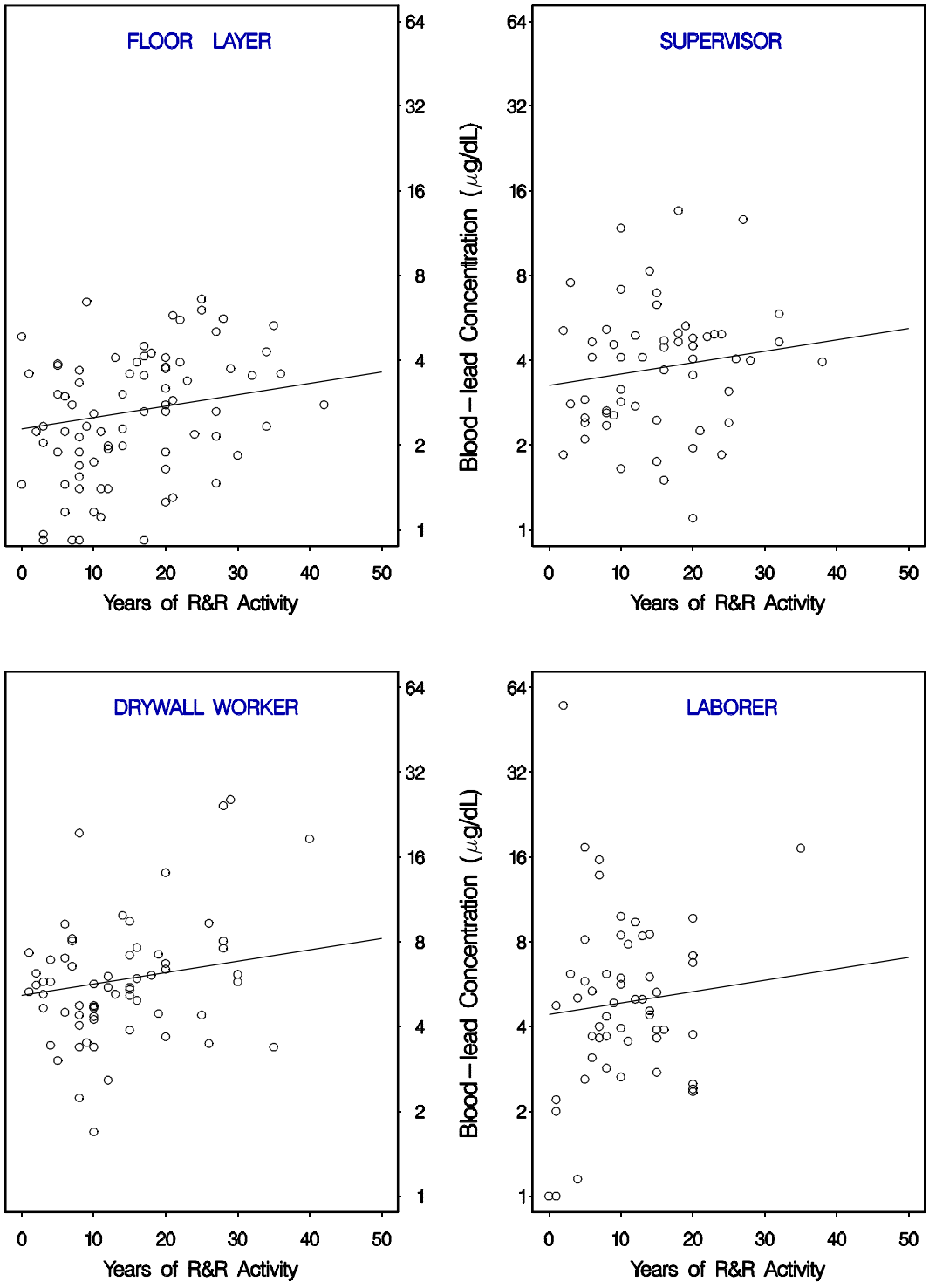


Figure F-16. (continued).

APPENDIX G:
HUMAN SUBJECTS APPROVAL AND INFORMED CONSENT

ASSURANCE OF CONFIDENTIALITY OF SURVEY DATA

Statement of Policy

SRA is firmly committed to the principle that the confidentiality of individual data obtained through SRA's surveys must and shall be protected. The principle holds true whether or not any specific guarantee of confidentiality was given at time of interview, or whether or not there are specific contractual obligations to the client. When guarantees have been given or contractual obligations regarding confidentiality have been entered into, they may impose additional requirements which are to be strictly adhered to by you.

Procedures for Maintaining Confidentiality

A. You shall sign this assurance of confidentiality. This assurance may be supplemented by another comparable assurance for a particular project.

B. You shall keep completely confidential the names of respondents and/or study subjects, all information or opinions collected in the course of conducting work, and any information about respondents and/or study subjects otherwise learned, directly or indirectly, during work. You shall exercise reasonable precaution to prevent access by others to all survey data not in their possession or under their control and responsibility.

C. Unless specifically instructed otherwise for a particular project, you, upon encountering a respondent or information pertaining to a respondent whom you know personally, shall immediately cease the activity and contact your supervisor for further instructions.

Pledge of Confidentiality

A. I hereby certify that I have carefully read and will cooperate fully with the above procedures on confidentiality. I will keep confidential all information arising from surveys concerning individual respondents and/or study subjects to which I gain access. I will not discuss, disclose, disseminate or provide access to survey data and identifiers except as specifically authorized by SRA for a particular contract. I will devote my best efforts to ensure that there is compliance with the required procedures by any personnel whom I supervise. I understand that violation of this pledge is sufficient grounds for disciplinary action, including immediate dismissal. I also understand that violation of the privacy rights of individuals through such unauthorized discussion, disclosure, dissemination, or access may make me subject to criminal or civil penalties. I give my personal pledge that I shall abide by this assurance of confidentiality.

B. I shall not, during or after my employment with SRA, for any reason whatsoever, unless I receive express written permission from an SRA officer, reproduce, copy, disclose or divulge to anyone, directly or indirectly, any information or knowledge relating to the past, present or future business operations or internal structure of any project conducted by SRA.

C. I acknowledge and agree that all files, records, reports, manuals, memoranda, notebooks, documents, correspondence, and all other information or records and similar items relating to the business or SRA, whether prepared by me or otherwise coming into my possession, are, and shall remain, the exclusive property of SRA, and shall be promptly delivered to SRA upon demand by an SRA Officer.

7. SIGNATURE. I have read and understand and agree to abide by the provisions contained in this memorandum, and have received a copy of this memorandum which is hereby acknowledged, I understand that a copy, signed by me, will be placed in my employment file.

Accepted:
Survey Research Associates, Inc.

By:_____(SEAL) Name: _____
Duly Authorized Agent (Please print)

Date:_____ Signature:_____(SEAL)

SS#:

Address:_____

_____

MIDWEST RESEARCH INSTITUT
425 Volker Bouleva
Kansas City, Missouri 641
Telephone (816) 753-76
Telefax (816) 753-84

June 30, 1994

Mr. Daniel Reinhart
U.S. Environmental Protection Agency
Technical Programs Branch, 7404
East Tower
401 M Street, SW
Washington, DC 20460

Subject: Contract No. 68-DO-0137, MRI Project No. 9803-A, Work Assignment 4-14, MRI Project No. 9803-A 14.

Dear Mr. Reinhart:

I have reviewed the work to be carried out under the above contract and am in agreement with the action of the Battelle Human Subjects Review Committee and the SRA Internal Review Board. These actions grant authorization for Battelle to proceed on EPA's Worker Characterizations and Blood-lead Study Under Work Assignment No. 4-14 of MRI contract No. 68-D0-0137 with the EPA.

Please call me at (816) 753-7600, Ext. 1184 if you have any questions.

MRI HSC Assurance Identification No.: M1051
IRB Identification No.: 01

Eugene G. Podrebarac, Ph.D.
Chairman, Human Subjects Committee

June 30, 1994
Date

/hs

c: Paul Constant
9803-A 4-14

Project Number B-512208-07 (1031)

Battelle
. . . Putting Technology To Work

Internal Distribution

D Snediker/J Greenway
P Brusky
J Manuel

Date June 23, 1994

To John Menkedick

From David Snediker/HSC Chairman

Subject **EPA/Worker Characterization and Blood Lead Study**

HSC No. = 0010.2
Project No. = G301106-1414

On June 23, 1994, the HSC Committee received and reviewed the pre-screen letters submitted in response to our follow-up memo dated May 9, 1994. Your compliance adequately addressed our concerns. Therefore, *final authorization has been granted* for this study to proceed.

No changes, amendments, or addenda may be made to this protocol or to the informed consent form without Committee re-review and approval. You, as project manager, or your designate, are responsible for *promptly* informing Phyllis Brusky, HSC Secretary, Ext. 6536, if:

- Adverse consequences are encountered in the course of the project.
- New information becomes available which could change the actual or perceived risk associated with the project.
- A change in the scope of work alters the nature of human subject participation in the project.

The Committee must review all changes and new information to determine if the program, protocol, or informed consent form should be modified, discontinued, or should continue as approved.

If I can be of further assistance, please contact me at Ext. 4-4633.

DS:jlg

:final.app

OMB No. 9000-
Approved for use through 7/

Protection of Human Subjects
Assurance Identification/Certification/Declaration
(Common Federal Rule)

POLICY: Research activities involving human subjects may not be conducted or supported by the Departments and Agencies adopting the Common Rule (56FR28001, June 18, 1991) unless the activities are exempt from or approved in accordance with the common rule. See Section 101(b) the common rule for exemptions. Institutions submitting applications or proposals for support must submit certification of appropriate Institutional Review Board (IRB) review and approval to the Department or Agency in accordance with the common rule.

Institutions with an assurance of compliance that covers the research to be conducted on file with the Department, Agency, or the Department of Health and Human Services (HHS) should submit certification of IRB review and approval with each application or proposal unless otherwise advised by the Department or Agency. Institutions which do not have such an assurance must submit an assurance and certification of IRB review and approval within 30 days of a written request from the Department or Agency.

1. Request Type	2. Type of Mechanism	3. Application or Proposal Identification No. *(If known)*
☒ ORIGINAL ☐ FOLLOWUP ☐ EXEMPTION	☐ GRANT ☒ CONTRACT ☐ FELLOWSHIP ☐ COOPERATIVE AGREEMENT ☐ OTHER:	Contract No. 68-02-0139 Subcontract No. 257-9801-1

4. Title of Application or Activity	5. Name of Principal Investigator, Program Director, Fellow, or Oc
RcR Worker Characterization and Blood-lead Study	Ronald G. Menton

6. Assurance Status of this Project *(Respond to one of the following)*

☒ This Assurance, on file with the Department of Health and Human Services, covers this activity:

Assurance identification no. M- 1221 IRB identification no. 01

☐ This Assurance, on file with *(agency/dept.)* _____ covers this activity.

Assurance identification no. _____ IRB identification no. _____ *(If applicable)*

☐ No assurance has been filed for this project. This institution declares that it will provide an Assurance and Certification of IRB review and approva upon request.

☐ *Exemption Status:* Human subjects are involved, but this activity qualifies for exemption under Section 101 (b), paragraph _____.

7. Certification of IRB Review *(Respond to one of the following IF you have an Assurance on file)*

☐ This activity has been reviewed and approved by the IRB in accordance with the common rule and any other governing regulations or subparts o

(date) June 23, 1994 by: ☒ Full IRB Review or ☐ Expedited Review.

☐ This activity contains multiple projects, some of which have not been reviewed. The IRB has granted approval on condition that all projects coven by the common rule will be reviewed and approved before they are initiated and that appropriate further certification will be submitted.

8. Comments

9. The official signing below certifies that the information provided above is correct and that, as required, future reviews will be performed and certification will be provided.

10. Name and Address of Institution

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

11. Phone No. *(with area code)*	12. Fax No. *(with area code)*
614) 424-4633	(614) 424-7274

13. Name of Official	14. Title
Dr. David K. Snediker	Chair, Battelle-Columbus Human Subjects Committee

15. Signature David K Snediker

16. Date June 24, 1993

thorized for local reproduction

OPTIONAL FORM 310 (9
Sponsored by HHS/PHS

Received 5/20/94

SRA Survey Research Associates, Inc.

6115 Falls Road, Baltimore, Maryland 21209 (410) 377-5660

May 18, 1994

Ron Menton, Ph.D.
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201-2693

Dear Dr. Menton:

As IRB Chairperson I have reviewed the modified consent form and protocol that you provided for the study entitled, "Worker Characterization and Blood-Lead Study" and have determined that this study has now received final approval.

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,

Elizabeth E. Hogue

Elizabeth E. Hogue
IRB Chairperson

STUDY ID: _____

ENVIRONMENTAL PROTECTION AGENCY WORKER CHARACTERIZATION AND BLOOD-LEAD STUDY OF RENOVATION AND REMODELING WORKERS

INFORMED CONSENT DOCUMENT

The U.S. Environmental Protection Agency (EPA) has contracted with Battelle, Survey Research Associates (SRA) and Midwest Research Institute (MRI) to study the lead exposure hazard associated with renovation and remodeling. The objectives of this study are to (1) characterize the relationship (if any) between renovation and remodeling activities 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 which includes information relevant to lead exposures on a) work history (both current and long term); b) personal characteristics and habits related to lead exposures; c) non-work activities; d) medical history related to lead exposures; and e) previous training or 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 one hour 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 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 measurement 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 participants' names and their participant identification number will not be released outside of SRA.

If you have any questions or comments regarding this study, or if you experience any difficulties as a result of participation in this study, please contact: Ms. Beth Moore, Battelle Memorial Institute, 505 King Avenue, Columbus Ohio 43201. Her phone number is (614) 424-4560.

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

May 11, 1994

Mr. John Moran
Laborers' International Union of North America
905 16th Street, N.W.
Washington, D.C. 20006-1765

Dear Mr. Moran:

Thank you for returning my call. I appreciate your interest in EPA's Renovation and Remodeling (R&R) Study even though you are very busy with other matters. Enclosed is a document that covers in detail the Worker Characterization and Blood-lead Study (WCBS); one of two field studies that comprise the EPA R&R Study. We will call you again in the next week to continue our conversation on the WCBS, discuss our needs, and to answer any questions you may have.

The continued success of EPA's WCBS depends on the input and cooperation of individuals such as yourself and the Laborer's International Union of North America. Your earlier comments had a direct impact on revisions made to the questionnaire which was pretested in April 1994, with the help of the United Brotherhood of Carpenters and Joiners of America. We are planning to pretest the telephone screening questionnaire and begin constructing our sampling frames in the next few weeks. In addition, we are anticipating receipt of OMB approval by the end of this month which means we could be out in the field as early as June 1, 1994. As we are moving toward implementation of the field study, we are looking forward to an increased role and participation of the Laborer's International Union of North America. Please feel free to call me at (614)424-4560 or Ron Menton at (614)424-7165 if you have any questions about the study.

Sincerely,

Beth E. Moore

Beth E. Moore
Statistics and Data
Analysis Systems

BEM:mk

Enclosure

June 13, 1994

John Moran, Executive Director
National Health and Safety Fund
Laborer's Union International

Dear John,

We were disappointed not to have been able to meet with you while we were in Washington on June 6. We do appreciate the time Bill Kijola spent with us to discuss the Worker Characterization and Blood-lead Study (WCBS).

This study is not looking for any renovation and remodeling jobs. The WCBS is looking to recruit field workers belonging to the laborer's union to: 1) complete a questionnaire and 2) have a blood sample taken. Completion of the questionnaire and having a blood sample taken will take approximately 1 hour of a person's time. Each participant will be compensated $50.00 for participating.

In our last phone conversation, you had indicated that the local unions would not be cooperative if we were to call them and ask for a copy of their membership list. Bill also confirmed this with us. I thought I had understood you to say that you could provide us with the membership lists in the cities of interest if I sent you a memo stating that as a request. Could you please let me know as soon as possible if that is true or whether I have misunderstood you. If this is not feasible, I would ask to get a random sample from the membership lists or work out another compromise.

We have not pursued going through the AGC or other avenues to locate labor union members. If we need to be go through the AGC or another means to locate labor union members, we would appreciate any help you can provide. Our time frame for getting started on the study is getting very close and we need to decide how we are going to recruit workers from your union.

We believe our recruitment success depends on your cooperation and support of the study. If you do not feel you can help us, we may forego including the laborer's union in our study.

I look forward to hearing back from you sometime this week to discuss our needs and yours with respect to the WCBS. You may call me at (614) 424-4560.

Sincerely,

Beth E. Moore

Beth E. Moore
Statistics and Data Analysis Systems

cc: Dan Reinhart, EPA

June 24, 1994

Mr. John Moran, Executive Director
Laborers' International Union of North America
National Health and Safety Fund
905 16th Street, N.W.
Washington, D.C. 20006-1765

Dear Mr. Moran:

The United States Congress passed the Residential Lead-Based Paint Hazard Reduction Act in 1992. Part of this act requires the Environmental Protection Agency (EPA) to conduct a study of lead exposures among renovation and remodeling (R&R) workers, such as those belonging to the Laborer's Union. Two research firms, Battelle and Midwest Research Institute, are assisting EPA with the study, referred to as the Worker Characterization and Blood-lead Study (WCBS). The objectives of the study are to:

1. Determine the relationship between blood-lead levels and work practices or activities performed by R&R workers.

2. Determine if blood-lead levels of R&R workers in specific worker groups differ.

3. Gather information on the types of work activities that various categories of R&R workers engage in, and the personal background and behavioral information relevant to their potential lead exposures.

EPA will use the results of this study to prepare training and certification guidelines that may affect R&R workers who are performing activities involving lead-based paint. These guidelines cannot be properly constructed if this study does not succeed.

A random sample of workers belonging to the Laborers' Union from St. Louis and, most likely, Philadelphia are needed to participate in this study. Your cooperation in providing to us the names, addresses and phone numbers of *at least* 450 members in St. Louis and 450 members in Philadelphia will assist us in locating participants for the study. We anticipate needing to contact 450 members from each city in an effort to get 100 to participate.

A phone call will be made to determine a worker's eligibility for the study. If a worker meets the criteria of the study (i.e. currently does or has done hands-on renovation work in homes or buildings built prior to 1950), he will be asked to come to a central location to complete a questionnaire and have a blood sample taken. This will take approximately 1 hour of his time. He will be compensated $50.00 for participating.

We believe our recruitment success and results of the study depend on your cooperation and support. I look forward to hearing back from you this week to discuss our needs and yours with respect to the WCBS. You may call me at (614)424-4560.

Sincerely,

Beth E. Moore

Beth E. Moore
Statistics and Data
Analysis Systems

BEM:mk

LABORERS' HEALTH & SAFETY FUND OF NORTH AMERICA

October 17, 1994

Ronald G. Menton, Ph.D.
Statistics and Data Analysis Systems
Battelle
505 King Avenue
Columbus, OH 43201-2693

Dear Mr. Menton:

Your letter of September 13, 1994 to John Moran with a copy to me is acknowledged. John and I have discussed the matter of the EPA sponsored R&R Worker characterization and Blood-lead Study which Battelle is conducting and your requested participation of members of the Laborers' International Union of North America in that study.

The attachment to your letter, the Informed Consent Document, is one which we have been seeking for some months. John informs me that both your office and EPA committed to providing this form to him months ago. The form does not bear an OMB approval number, a matter which John discussed with Mr. Reinhart.

We remain concerned about the study protocol and the fact that you will only "attempt" to get the results of the individual blood-lead analysis to the participating worker according to the Consent Document. Further, there is no indication that you will bear responsibility for reporting elevated blood-leads to the state registry. Indeed, earlier discussions on that matter indicated the intent to select the cities for the study in states which did not have reporting requirements.

Accordingly, we do not feel that it is the best interest of LIUNA members to participate in the study under the current study protocol. As a result, we will not recommend participation to the International Union.

Sincerely,

Brian M. McQuade

Brian M. McQuade
Executive Director

BMc:sz

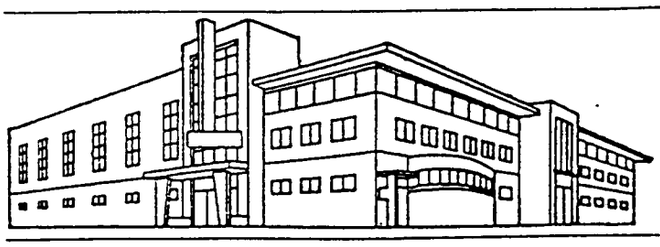
cc: John Moran

HEADQUARTERS: 905-16th Street, NW • Washington, D.C. 20006-1765 • (202) 628-5465 • Fax: (202) 628-2613

Affiliated with the United Brotherhood of Carpenters and Joiners of America, AFL-CIO

Carpenters' District Council of Greater Saint Louis, AFL-CIO

Carpenters' Building
1401 Hampton Avenue
St. Louis, Mo. 63139-3199
314-644-4800



Terry Nelson
Executive Secretary-Treasurer

Dear Member:

Two research companies, Battelle and MidWest Research Institute, are assisting EPA with a study, the Worker Characterization and Blood-lead Study (WCBS), that looks at lead exposures among remodeling field workers. The study will examine the possible relationship between lead levels in the blood and work practices performed by renovation and remodeling workers. EPA will use the results of this study to prepare training and certification guidelines that may directly affect you and your fellow workers.

The United Brotherhood of Carpenters and Joiners of America supports this study. As Executive Secretary-Treasurer of the St. Louis District Council, I also support this study and strongly encourage you to participate in the study.

A Battelle representative may call you in the next week to ask you a few brief questions. The representative may also ask you to schedule a time to come to the Carpenters' Hall to complete a questionnaire and have a blood sample taken. You will be paid $50.00 for completing the questionnaire and having a blood sample taken.

We are counting on you to help us collect this important information for EPA. Your participation will make a difference to union carpenters everywhere. If you have any questions about the study, call John Egel at Battelle: (314) 993-5234 or toll free (800) 444-5234. Thank you in advance for your cooperation.

Sincerely and fraternally,

Terry Nelson

TERRY NELSON
Executive Secretary-Treasurer

TN/lp

PHONE:
215/568-1634

UNITED BROTHERHOOD OF CARPENTERS AND JOINERS OF AMERICA

METROPOLITAN DISTRICT COUNCIL

PHILADELPHIA, DELAWARE, CHESTER, MONTGOMERY AND BUCKS COUNTIES

FAX:
215/568-0293

EDWARD CORYELL
PRESIDENT-BUSINESS MANAGER

FRANCIS J. LAFFEY
SECRETARY-TREASURER

OFFICE

PHILADELPHIA, PENNSYLVANIA

CARPENTERS' BUILDING

1803 SPRING GARDEN STREET, PHILADELPHIA, PA 19130-3816

September 22, 1994

Dear Member:

Two research companies, Battelle and MidWest Research Institute, are assisting the Environmental Protection Agency with a study, which is called the "Worker Characterization and Blood-lead Study (WCBS)". Its purpose is to investigate how exposure to lead affects workers in the Home Renovation field.

The study will examine the possible relationship between lead levels in the blood and the work practices of our Council's renovation and remodeling Carpenters. EPA will use the results of this study to prepare Training and Certification Guidelines that may directly affect you and your fellow workers in the future.

A list of our Carpenters who have done this type of work has been supplied to the Organization conducting this study. Certain members will be selected at random from this list to receive this letter.

The General Office of our United Brotherhood is sponsoring this Program through our National Health & Safety Fund. Our Metropolitan District Council also supports it, and we strongly encourage you to participate in the study if you are contacted.

> A Battelle representative may call you some evening in the next week to ask you a few short questions. The representative may also ask you to come to the Carpenters' Building, at 1803 Spring Garden Street, Philadelphia, PA, to complete a questionnaire and have a blood sample taken. You will be paid $50.00 for completing the questionnaire and for submitting the blood sample. This appointment will be scheduled after 5:30 PM, if you are working on the date selected.

If you are selected, we are counting on you to help us collect this important information for the EPA. Your participation will make a real difference to Union Carpenters everywhere.

If you have any questions about the study call Business Agent Seanus Boyle at the Council Office at 215/569-1634.

Thank you in advance for your cooperation.

Fraternally,

EDWARD CORYELL
President-Business Manager

EC:mnm

10104 OLD OLIVE STREET ROAD • ST. LOUIS, MO 63141-1509 • (314) 994-7700 • FAX (314) 432-7185

home builders association
of greater saint louis

August 22, 1994

Dear HBA Member:

Two research companies, Battelle and MidWest Research Institute, are assisting EPA with a study, the Worker Characterization and Blood-lead Study (WCBS), that will look at lead exposures among remodeling field workers. The study will examine the possible relationship between the possible relationship between blood-lead levels and work practices performed by renovation and remodeling workers. EPA will use the results of this study to prepare training and certification guidelines that may affect you and your workers.

The NAHB Remodelors Council supports this study and encourages your cooperation so that you can have an impact on the EPA's upcoming policy. You can help by taking just a few minutes to provide the names, addresses and phone numbers of your field workers. Use the enclosed FIELD WORKER INFORMATION sheet and FAX or mail in the next three days to:

Mr. John Egel
Battelle/Survey Research Associates
401 N. Lindbergh, Ste. 330
St. Louis, MO 63141
FAX: 314-993-5163

The enclosed page, Summary of the WCBS, briefly explains how your remodeling workers would be involved in the study if they choose to participate. If you are in a one-person shop, and would like to participate yourself in the study, or feel your subcontractors would be interested in participating, please call Mr. Egel. If you have any questions or cannot return the FIELD WORKER INFORMATION sheet in the next three days, please call John Egel at (314) 993-5234. Thank you for your cooperation.

Sincerely,

James P. Quinley, CGR
Chairman, NAHB Remodelors Council

ST. LOUIS GATEWAY TO THE GOLD
U.S. OLYMPIC FESTIVAL '94
ARCH • PATRON
hba

Summary of the Worker Characterization and Blood-lead Study

Battelle and MidWest Research Institute (MRI) are assisting the United States Environmental Protection Agency (U.S. EPA) in planning and implementing the Worker Characterization and Blood-lead Study (WCBS) which is a component of EPA's research on lead exposures associated with renovation and remodeling (R&R). The WCBS is a targeted field study of lead exposures for three workers groups: union carpenters, union laborers, and non-union, independent carpenters. The data collected include: 1) telephone screening questionnaire, 2) self-administered questionnaire, and 3) blood samples to be analyzed for lead concentration. The results of this study will help EPA to prepare guidelines for training and certification of R&R workers.

Rather than comprising a nationally representative sample, this study will target these three worker groups in just two cities: St. Louis and Milwaukee. The two cities were selected because of support and cooperation of local union leadership, and because a large number of children with elevated blood-lead levels have been found in both cities.

The first step in recruiting workers to participate in the study is to contact their employer. You were randomly selected from a membership list of employers provided to us by your local NAHB Remodelors Council Chairman. By completing and returning the enclosed EMPLOYEE INFORMATION sheet, we can begin to randomly select workers to call. Other employers will be submitting EMPLOYEE INFORMATION sheets to us, so not all employees will be selected and called.

Employees that are selected will receive a letter in the mail that gives them a brief summary of the study, informs them that the NAHB and their employer have endorsed the study, and lets them know that they will be receiving a phone call from a Battelle representative. When the Battelle representative calls, the employee will be asked to answer a few questions and may also be asked to participate in the main study. Participation in the main study requires that the employee come to a central location to complete a questionnaire and have a blood sample taken. Employees are compensated $50.00 for completing the questionnaire and giving a blood sample.

hba newsletter

ROUTE TO:

Volume 10, No. 8 April 13, 1994 FAX# 432-7185 HBA Phone 994-7700

St. Louis Selected for Lead Study .... EPA is working with NAHB in a blood lead level study to provide statistical data in lead levels in blood, specifically of those who work in the remodeling industry .... Data could have a tremendous impact on rules and regs coming from EPA .... 100 volunteers from this area needed for study .... Will involve a **confidential** blood test and completion of a survey .... Volunteers will receive $50 for participating .... Only requirement is the participant must have worked on a remodeling project within 30 days of test .... Preliminary data show that blood lead levels are lower than anticipated .... Lack of participation will mean no data, and tougher regs for employers and employees in lead abatement .... Call Jim Kuhn at Consolidated Construction at 647-9077 if you and/or your employees can help. HBA staff contact: Roxanne Radunzel.

BAT·TELLE
NEWS RELEASE

Celebrating 75 Years

Contact:
Robin Yocum
Telephone 614-424-5544

Will Kopp
Telephone 614-424-7984

No. 82-94

November 17, 1994

For Immediate Release

BATTELLE CONDUCTING STUDY IN PHILADELPHIA TO EXAMINE LEVELS OF LEAD IN REMODELERS

Battelle is conducting a study of home improvement workers and carpenters in the Philadelphia area to determine if home remodelers have been exposed to lead.

The study was mandated by Congress in October 1992. Battelle is conducting the study for the U.S. Environmental Protection Agency.

Battelle is attempting to survey between 225-250 union and non-union carpenters by Dec. 15. Participants are asked to fill out a questionnaire and allow a blood sample to be taken. Participants receive $50.

"What we're trying to determine is whether any particular work activities or practices are associated with elevated blood-lead levels," said Battelle researcher Ronald Menton, who is heading the study.

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.

Menton said the survey is being conducted in Philadelphia and St. Louis because they are older cities with higher documented instances of elevated blood-lead levels in children. Older urban homes tend to have more lead in paints, dust, and plumbing.

Carpenters ingest lead through airborne particles in the work place. Carpenters can reduce the likelihood of suffering from lead exposure, Menton said, by taking simple precautions, such as:

(MORE)

- Wearing a respirator
- Wetting down surfaces before working
- Avoiding dry power sanding
- Sealing off work areas
- Washing hands before eating

Although the study involves union and non-union workers, Menton said the study needs to recruit more non-union workers.

"We've worked with the United Brotherhood of Carpenters and Joiners and received tremendous cooperation," Menton said. "But, we need to look at both union and non-union workers.

"If work activities differ between union and non-union workers, then lead exposure also may differ. Union carpenters tend to be more specialized than a non-union, residential remodelers. The independent handyman often performs a variety of jobs in a diverse range of buildings."

Anyone interested in participating in the study should call 800-444-5234.

Battelle serves industry and government by developing, commercializing, and managing technology. With a wide range of scientific and technical capabilities, Battelle puts technology to work for clients in 30 countries.

# # #

St. Louis Post Dispatch 12/6/94

BRIEFS
REGION

MISSOURI

LAMBERT FIELD INQUIRY

Tapes Show Cessna Pilot Was Told To Stop

The pilot of the Cessna that crossed into the path of a Trans World Airlines jet at Lambert Field last month acknowledged a flight controller's order to stop but kept moving, federal investigators have found.

Investigators for the National Transportation Safety Board discovered the new information in listening to taped conversations between the control tower and the Cessna pilot, said Alan Pollock, a spokesman for the board.

In addition, investigators found that the TWA plane, an MD-82, was traveling down Runway 30 Right around 125 mph, or 25 mph faster than previously believed, Pollock said.

The Cessna, a charter plane, rolled onto Runway 30 Right about 10:03 p.m. on Nov. 22. The TWA pilot, Rick Carr, swerved to avoid a head-on collision, and the TWA's wing sliced open the Cessna. The Cessna's pilot and a passenger were killed.

ST. LOUIS COUNTY

Port Authority Makes Plans For Riverboat

The St. Louis County Port Authority says it hopes by mid-April to recommend to the County Council a developer and operator of a riverboat gambling facility on the authority's property in Lemay.

The County Council will select the developer-operator. Council members got the responsibility when voters in November agreed to allow riverboat gambling in the unincorporated area.

Vernon "Bud" Schertel, chairman of the Port Authority Board of Commissioners, said he hopes a decision can be made quickly so the developer could have most of the construction season to build a facility.

The authority plans to send out requests for qualifications of developer-operators this week with replies due by Jan. 6.

ST. PETERS

Hate Crime May Be Civil Rights Issue

The FBI has launched a preliminary investigation to determine whether any civil rights violations occurred in St. Peters over the weekend. A pickup was torched in front of a house in Millwood subdivision, and the owner's house was painted with a swastika and the words "White Power."

The victim, who is white, said he believed the vandalism occurred because his children play with the children of a black family down the street.

FBI spokesman Michael Roman said Tuesday that the agency's report would be forwarded to the Justice Department, which would decide whether to prosecute any suspects.

WELLSTON

Officials Approve Private Detention Facility

Wellston officials, meeting Tuesday night, approved the St. Louis area's first privately owned and operated detention center on the site of an abandoned foundry. It is expected to open in about a year.

Former Missouri Lt. Gov. Ken Rothman is a partner in Secured Housing Inc., which will begin construction of the $6 million facility this spring in the 1400 block of Ogden Avenue, south of the Moog Industries plant.

The facility will house people awaiting trial on misdemeanor federal and state charges or on municipal charges, and others serving sentences of up to one year.

The Wellston City Council voted 5-0 at the end of a long public hearing that drew about 100 participants. Four people who live near the site objected.

But council members said the estimated 70 new jobs and $200,000 in taxes to be paid each year by the facility justified the approval.

LEAD-EXPOSURE STUDY

St. Louis Carpenters Sought For Survey

Scientists conducting a federal study of lead exposure say they need help from carpenters and home-improvement workers.

Scientists with Battelle, a research company based in Columbus, Ohio, are surveying union and non-union carpenters and remodelers in St. Louis and Philadelphia as part of a study for the federal Environmental Protection Agency.

The two cities were chosen because they have a history of high blood-lead levels in children.

Battelle researchers want to survey about 250 union and non-union carpenters by Dec. 15, but they are having difficulty recruiting non-union workers, Menton said. Participants will be asked to fill out a questionnaire and allow a blood sample to be taken. Each will receive $50.

The St. Louis portion of the study is run by Survey Research Associates, a Battelle subsidiary, at 401 N. Lindbergh Boulevard. Anyone interested in participating can call 1-800-444-5234.

Yes! You Can Make a Difference
St. Louis Selected for Lead Level Study

Soon you will receive a letter from the National Association of Home Builders and the HBA of Greater St. Louis regarding member participation in a lead blood level study. The results of this study will have a great impact in the rules and regulations developed by EPA for lead abatement. Other studies have indicated that remodeling and abatement work do not affect a field worker's lead level.

Your help is needed to make the study a success.

Watch your mail for a letter from Jim Quinley, Chairman, NAHB Remodelors Council.

8/16/94

St. Louis Selected to Take Part in Lead Study

by Roxanne Radunzel
Staff V.P./Association Services

St. Louis has been selected for lead based paint testing by the EPA, to be conducted by Battelle, a national research firm. The goal of the study is to show the correlation between renovation and remodeling field work and actual human exposure to lead. The NAHB Remodelors Council is fully supporting the testing.

In October 1992, the U..S. Congress passed the Residential Lead-Based Paint Hazard Reduction Act. This act falls under the jurisdiction of the Environmental Protection Agency (EPA) to set the guidelines and any requirements for working with lead based paint in remodeling and renovation projects.

As part of the legislation, the EPA is required to conduct a study of lead exposures among remodeling field workers. It is hoped that this research will indicate the lead based paint risk to remodeling/rehab field workers. The EPA attempted to locate other existing sources of data for the study, but none addressed the lead hazard (in terms of a health effect) associated with remodeling and renovation activity. A painting trade association has conducted a smaller sampling which did not indicate a lead problem with field workers. However, the format and size of the sampling is not adequate for the EPA's needs.

Volunteers for Christmas in April wear masks as they scrape peeling lead-based paint from their designated home.

The objectives of the St. Louis study are to:

- ▶Determine the relationship between blood-lead levels and work practices or activities performed by remodeling and renovation field workers (after including potential confounding factors such as personal hobbies with lead exposure, etc.).
- ▶Determine if blood-lead levels of remodeling and renovation workers in specific worker groups differ.
- ▶Gather information on the types of work activities and work practices in which various categories of remodeling and renovation workers engage.

Participants will be asked to complete a questionnaire and submit to a blood test. The individual results of the testing will be kept confidential. All participants will receive $50 for the testing. All types of field workers, illustrating a range of lead exposure, are needed for the testing. The results of the test will determine the extent to which field workers are exposed to lead. The EPA will then use the results to set forth guidelines or determine guidelines that are not needed.

Member participation is needed to make this research successful. Without definite data, the EPA will develop worker guidelines without regard to the true impact of lead in the remodeling and renovation industry. Your level of participation is limited to giving the Battelle research company a list of your field workers' names, addresses, and phone numbers for follow-up. The testing is done on the employees' time.

You should have already received in the mail a letter briefly outlining the program and asking for a list of employees. If you have not yet responded, please do so by contacting John Egel at Battelle, Survey Research Associates at (314) 993-5234. Egel will be able to answer any questions you may have about the survey process, or assist you in getting a worker information sheet prepared.

The final results of the survey will be known within 6 months of survey completion, with the EPA using the results in the final report. **It is up to St. Louis to make a difference in the outcome of this report by participating in the survey research!** □

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA 747-R-96-006	2.	3. Recipient's Accession No.
4. Title and Subtitle Lead Exposure Associated with Renovation and Remodeling Activities: Worker Characterization and Blood-Lead Study			5. Report Date May 1997 6.
7. Author(s) Menton, R.G., Menkedick, J.R., Schulman, J., Strauss, W.J., Egel, J.N., Lowry, L.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Battelle Memorial Institute 505 King Avenue Columbus, Ohio 43201-2693 and Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) 68-D5-0008 (G)
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics 401 M Street, S.W. Washington, D.C. 20460			13. Type of Report & Period Covered Technical Report 14.

15. Supplementary Notes
In addition to the authors listed above, the following staff were major contributors to the study: Patsy Henderson, Beth Burkhart, Halsey Boyd, and Karen Christie of Battelle; and Paul Constant and Jack Balsinger of MRI.

16. Abstract (Limit 200 words)

The U.S. Environmental Protection Agency, in response to the Residential Lead Based Paint Hazard Reduction Act of 1992 (Title X) conducted a study of lead exposure associated with renovation and remodeling (R&R) activities. This report presents the results of one of the principle data collection efforts of the study: the Worker Characterization and Blood-Lead Study (WCBS). The WCBS collected blood-lead measurements and questionnaire information from 585 R&R workers in two cities. Questionnaire results include the type and frequency of renovation work conducted, worker protection and clean-up methods, and lead training. Blood-lead concentrations were generally low, with only 7 out of 581 workers above 25 µg/dL and only one out of 581 above 40 µg/dL. The geometric mean blood-lead concentration for all workers was 4.5 µg/dL. Statistical models were fit to the data to assess the effect of worker groups, the amount of R&R activity conducted, and significant covariates.

17. Document Analysis

a. Descriptors
Lead-based paint, lead hazards, renovation and remodeling, blood-lead measurements, work habits, worker certification, worker survey

b. Identifiers/open-ended Terms
Lead, renovation and remodeling, worker exposure, blood-lead, Title X

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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