

National Survey of Lead and Allergens in Housing

FINAL REPORT

Volume I: Analysis of Lead Hazards

Revision 6.0

Prepared for:

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This work was conducted under HUD Contract Number C-OPC-21356.

April 18, 2001

Table of Contents

<u>Chapter</u>	<u>Page</u>
EXECUTIVE SUMMARY	ES-1
1. INTRODUCTION	1-1
1.1 Background	1-1
1.2 Survey Objectives	1-3
1.2.1 Technical Note on the Survey Weights.....	1-4
1.3 Report Organization	1-4
2. SURVEYED HOUSING POPULATION	2-1
3. LEAD-BASED PAINT (LBP) HAZARDS IN HOUSING.....	3-1
3.1 Definition of Lead-Based Paint (LBP) Hazards.....	3-1
3.2 Prevalence of Lead-Based Paint Hazards in Housing	3-2
3.3 Significant LBP Hazards with Alternate Threshold for Soil Lead Hazards	3-9
3.4 Prevalence of Lead-Related Occupations or Hobbies.....	3-12
4. LEAD-BASED PAINT (LBP) IN HOUSING	4-1
4.1 Prevalence of Lead-Based Paint	4-1
4.2 Prevalence of Deteriorated Lead-Based Paint	4-5
4.3 Paint Lead Loadings in Housing	4-8
4.4 Comparison of Prevalence of Lead-Based Paint (LBP) to the 1990 LBP Survey.....	4-16
4.5 Amount of Lead-Based Paint in Housing	4-18
5. DUST LEAD IN HOUSING.....	5-1
5.1 Prevalence of Dust Lead in Housing.....	5-1
5.2 Dust Lead Loadings in Housing.....	5-2
5.3 Association between Dust Lead Hazards and LBP Paint Condition	5-16
6. RESIDENTIAL SOIL LEAD.....	6-1
6.1 Prevalence of Residential Soil Lead, All Sampled Locations	6-1
6.2 Association Between Soil Lead and Exterior Paint Condition	6-7
6.3 Prevalence of Bare Soil Lead in Children's Play Areas	6-8
6.4 Prevalence of Bare Soil Lead in the Rest of the Yard	6-11
6.5 Comparison of Prevalence of Soil Lead to the 1990 LBP Survey.....	6-13

7.	SOURCES OF ERROR IN THE NATIONAL SURVEY DATA	7-1
7.1	Statistical Concepts and Terminology	7-1
7.2	Potential for Nonresponse Bias	7-2
7.2.1	Analysis of Completion and Response Rates.....	7-2
7.2.2	Comparison of “Hard to-Recruit” Versus “Easy-to-Recruit” HUs	7-7
7.3	Correcting for Classification Bias Due to Measurement Error.....	7-10
7.3.1	Measurement Error – Paint XRF Measurements	7-10
7.3.2	Measurement Error – Dust Lead Measurements.....	7-17
7.3.3	Measurement Error – Soil Lead Measurements.....	7-27
7.4	Quality of Field Data Collection and Analysis	7-32
7.4.1	Field Data Collection	7-32
7.4.2	Laboratory Quality Control Samples	7-35
7.4.3	Laboratory Selection Quality Assurance	7-35
7.5	Paint Testing Quality Assurance.....	7-36

List of Appendices

APPENDIX A	COMPARISON OF FINDINGS ON LBP HAZARDS WITH RESPECT TO <i>DE MINIMIS</i> HAZARDS UNDER THE HUD LEAD SAFE HOUSING RULE AND THE 1995 HUD <i>GUIDELINES</i>	A-1
APPENDIX B	COMPARISON OF PROTOCOLS FOR THE HUD 1990 SURVEY OF LEAD-BASED PAINT (LBP) AND THE HUD NATIONAL SURVEY OF LEAD AND ALLERGIES IN HOUSING	B-1

List of Tables

Table ES.1	Summary Estimates of Prevalence of Lead-Based Paint and Lead-Based Paint Hazards	ES-2
Table 2.1	Characteristics of the Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS).....	2-4
Table 3.1	Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics.....	3-3
Table 3.2	Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building	3-5

Table 3.3	Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 years of Age by Type of Hazard	3-6
Table 3.4	Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule	3-10
Table 3.5	Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule	3-10
Table 3.6	Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 years of Age by Type of Hazard. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule	3-12
Table 3.7a	Prevalence of Housing Units with Selected Lead-Related Characteristics	3-14
Table 3.7b	Prevalence of Selected Lead-Related Characteristics in Homes with Significant LBP Hazards	3-14
Table 4.1	Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU) Characteristics	4-2
Table 4.2	Prevalence of Lead-Based Paint (LBP) by Location in the Building	4-5
Table 4.3	Prevalence of Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP) by Location in the Building	4-6
Table 4.4	Distribution of Housing Units (HUs) with Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP) by Construction Year	4-7
Table 4.5	Distribution of Paint Lead Loading by Location in the Building	4-9
Table 4.6	Distribution of Paint Lead Loading by Location in the Building and Construction Year	4-10
Table 4.7	Estimated Empirical Distribution Parameters of Paint Lead Loadings by Interior Component Types	4-15
Table 4.8	Estimated Empirical Distribution Parameters of Paint Lead Loadings by Exterior Component Types	4-15
Table 4.9	Percentage of Components with Lead-Based Paint by Component Type And HU Age	4-16
Table 4.10	Comparison of the Prevalence of Lead-Based Paint to the 1990 LBP Survey	4-16
Table 4.11	Amount of LBP by Painted Component	4-19
Table 5.1	Prevalence of Housing Units with a Dust Lead Hazard Somewhere in the Home	5-2
Table 5.2a	Distribution of Maximum Dust Lead Loadings by Surface	5-3
Table 5.2b	Distribution of Average Dust Lead Loadings by Surface	5-5
Table 5.2c	Comparison of Dust Lead Hazards for the HUD 1995 Guidelines and the HUD Lead Safe Housing Rule	5-6
Table 5.3	Distribution of Dust Lead Loading by Room and Surfaces	5-7
Table 5.4a	Maximum Floor Dust Lead Loading by Year of Construction	5-8
Table 5.4b	Maximum Window Sill Dust Lead Loading by Year of Construction	5-9
Table 5.4c	Maximum Window Trough Dust Lead Loading by Year of Construction	5-10
Table 5.5a	Maximum Floor Dust Lead Loadings by Household Income	5-11
Table 5.5b	Maximum Window Sill Lead Dust Loadings by Household Income	5-12
Table 5.5c	Housing Units with Lead Dust from Window Troughs Above Thresholds by Household Income	5-13

Table 5.6	Estimated Empirical Distribution Parameters of Dust Lead Loadings by Surface Types	5-16
Table 5.7	Association Between Dust Lead Hazards and Presence and Condition of Interior Lead-Based Paint	5-17
Table 6.1	Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations, All Sampled Locations	6-2
Table 6.2	Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentrations, All Sampled Locations	6-3
Table 6.3	Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations by Construction Year, All Sampled Locations	6-4
Table 6.4	Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentration by Construction Year, All Sampled Locations	6-5
Table 6.5	Estimated Empirical Distribution Parameters of Soil Lead Concentrations by Sample Site	6-7
Table 6.6	Association Between Bare Soil Lead Concentration and Presence of Significantly Deteriorated Exterior LBP, All Sampled Locations	6-8
Table 6.7	Distribution of Maximum Soil Lead Concentrations in Children's Play Areas	6-9
Table 6.8	Distribution of Maximum Soil Lead Concentration in Children's Play Areas, by Construction Year	6-10
Table 6.9	Association Between Bare Soil Lead Concentration and Presence of Significantly Deteriorated Exterior LBP, in Children's Play Areas.....	6-11
Table 6.10	Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard	6-12
Table 6.11	Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard, by Construction Year.....	6-13
Table 6.12	Comparison of the Prevalence of Lead-Contaminated Bare Soil in the National Survey and the 1990 LBP Survey	6-14
Table 7.1	National Survey Completion Rates by 1990 Census Block Group Characteristics	7-6
Table 7.2	National Survey Mean Percents for Completed and Noncompleted Housing Units by 1990 Census Block Group Characteristics	7-7
Table 7.3	Comparison of "Easy-to-Recruit" Respondents Versus "Hard-to-Recruit" Respondents by Reported Housing Characteristics.....	7-8
Table 7.4	Regression Model Used for Different Categories of Homes	7-22
Table 7.5	Regression Model Used for Different Categories of Homes	7-28

List of Figures

Figure 3.1	Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) by Hazard Characteristic (HUD Lead Safe Housing Rule).....	3-7
Figure 3.2	Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) with Children Under Age 6 by Hazard Characteristic (HUD Lead Safe Housing Rule).....	3-8
Figure 3.3	Prevalence of Significant LBP Hazards, Soil Lead Threshold at 2,000 ppm and at 1,200 ppm.....	3-9

Figure 4.1	Presence and Condition of LBP by Construction Year.....	4-8
Figure 4.2	Box Plots for Paint Lead (XRF) Measurements by Room Type.....	4-12
Figure 4.3	Box Plots for Paint Lead (XRF) Measurements by Interior Components	4-13
Figure 4.4	Box Plots for Paint Lead (XRF) Measurements by Exterior Components	4-14
Figure 5.1	Box Plots for Dust Lead Loadings by Room	5-14
Figure 5.2	Box Plots for Dust Lead Loadings by Surface.....	5-15
Figure 6.1	Box Plots for Lead in Soil Samples by Sample Site	6-6
Figure 7.1	Original and Replicate XRF Readings on the Same Component.....	7-12
Figure 7.2	Relative Median Paint Lead Loading by Construction Year of the Home and Substrate	7-13
Figure 7.3	Relative Median Paint Lead Loading by Construction Year of the Home and Region	7-14
Figure 7.4	Relative Median Paint Lead Loading by Component Type and Room Type	7-15
Figure 7.5	Relative Median Paint Lead Loading by Component Condition, Metro Status, Presence of Pets, Overall Cleanliness, and Air Condition Use in the Last Month.....	7-16
Figure 7.6	Relative Median Floor Dust Lead Loadings Estimated from Regression, by Construction Year Category and Floor Cover in the Sampled Room	7-18
Figure 7.7	Relative Median Soil Lead Concentrations Estimated from Regression, by Construction Year Category and Region	7-19
Figure 7.8	Cumulative Distribution of the Maximum Floor Dust Lead Loading for Homes	7-21
Figure 7.9	Median Window Dust Lead Loading Estimated from Regression by Different Factors in the Regression Model	7-23
Figure 7.10	Cumulative Distribution of the Maximum Within-Home Window Sill Dust Lead Loading	7-25
Figure 7.11	Cumulative Distribution of the Maximum Within-Home Window Trough Dust Lead Loading	7-26
Figure 7.12	Relative Median Soil Lead Concentrations Estimated from Regression, by Construction Year Category and Sample Location	7-29
Figure 7.13	Median Soil Lead Concentrations Estimated from Regression, by Construction Year Category and Region.....	7-30
Figure 7.14	Cumulative Distribution of the Maximum Soil Lead Concentration for All Homes	7-31

EXECUTIVE SUMMARY

The National Survey of Lead and Allergens in Housing (referred to as the National Survey or NSLAH) was conducted under the sponsorship of the Department of Housing and Urban Development (HUD) and the National Institute of Environmental Health Sciences (NIEHS) to assess children's potential household exposure to lead and allergens. The National Survey measured the levels of lead in dust, soil, and paint, the prevalence of hazardous levels of lead, and levels and patterns of various indoor allergens in dust in homes. Volume I includes the findings for lead hazards, and describes lead levels in dust, soil, and paint in the nation's housing by age, type, geographical location, and exposed populations. This Executive Summary refers to the standards of HUD's new "Lead Safe Housing Rule" on Federally-owned and -assisted housing.¹ Appendix A compares the National Survey findings using these current standards with the guidance provided in HUD's 1995 *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* ("Guidelines"). The definition of lead-based paint is the same for both (1.0 mg/cm²), while the definition of lead-based paint hazard has changed in accordance with advances in scientific understanding and statutory changes.

Results: Extent of Lead-Based Paint and Lead-Based Paint Hazards in Housing

An estimated 38 million² homes (40 percent of all homes) in the United States have lead-based paint somewhere in the building. Of these, 20 million homes have lead-based paint present on both interior and exterior surfaces, 9 million homes have lead-based paint only on the interior, and another 9 million homes have lead-based paint only the exterior.

Although a large number of homes have lead-based paint, most of them have relatively small surface areas of it. The average home with lead-based paint has an estimated 259 square feet of interior lead-based paint and 996 square feet of exterior lead-based paint.

An estimated 26 million (27 percent) homes have significant lead-based paint hazards somewhere in the building or on the premises; this is similar to earlier HUD estimates of 24 million homes. Based on the HUD Lead Safe Housing Rule, a home is said here to have a significant lead-based

¹ Title 24 of the Code of Federal Regulations, Part 35 was issued September 15, 1999 in Volume 64 of the Federal Register, pages 50140-50231, and is effective September 15, 2000. It implements sections 1012 and 1013 of the Residential Lead-Based Paint Hazard Reduction Act of 1992, which is Title X of the Housing and Community Development Act of 1992 (P.L. 102-550). A copy is available on the Internet at www.hud.gov/lea.

² The 95 percent confidence intervals for the estimates are presented in the main body of the report.

paint hazard if one or more of the following conditions exists: lead-based paint with deterioration larger than *de minimis* levels specified in the Lead Safe Housing Rule,³ dust lead loadings at or above specified thresholds on floors or window sills;⁴ bare soil in children's play areas above specified thresholds; or more than 9 square feet of bare soil in the rest of the yard with lead concentrations at or above specified thresholds.⁵

Of the 16.4 million homes with one or more children under age 6, an estimated 5.7 million (34 percent) have significant lead-based paint hazards. Of all 4.8 million homes with household incomes under \$30,000 and one or more children under age 6, an estimated 1.6 million (34 percent) have significant lead-based paint hazards. Thus, one in three homes with young children among the residents have significant lead-based paint hazards. Table ES.1 summarizes these basic estimates of the prevalence of lead-based paint and significant lead-based paint hazards.

Table ES.1 Summary Estimates of Prevalence of Lead-Based Paint and Lead-Based Paint Hazards

Housing Unit Characteristic ¹	Number of Housing Units (millions)	Number of Housing Units with Lead-Based Paint (millions)	Number of Housing Units with Significant Lead-Based Paint hazards (millions)
Total housing units	95.7	37.9	25.5
One or more children under age 6	16.4	5.3	5.7
One or more children under age 6, less than \$30,000/year household income	4.8	1.4	1.6

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

³ The *de minimis* levels for LBP deterioration are in Section 35.1350(d) of the Lead Safe Housing R rule. These levels are: deterioration of more than 20 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or deterioration of to more than 10% of the total surface area of interior small surface area components types (window sills, baseboards, trim). These are the same levels used in the U.S. Environmental Protection Agency's lead hazard standards rule implementing the Toxic Substance Control Act's section 403.

⁴ The floor and window sill dust lead loading thresholds are dust on floors with greater than or equal to 40 µg/ft² lead and dust on window sills with greater than or equal to 250 µg/ft² lead. They are in the HUD Lead Safe Housing rule and in the EPA Rule *Identification of Dangerous Levels of Lead*; 40 CFR Part 745, January 5, 2001.

⁵ The thresholds for bare, lead-contaminated soil are more than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years. These thresholds are in the HUD Lead Safe Housing Rule. The EPA Rule *Identification of Dangerous Levels of Lead* has the same threshold for children's play areas, but a threshold of 1,200 ppm for the rest of the yard.

Of the 26 million homes with significant lead-based paint hazards, an estimated 17 million have interior dust lead hazards, 14 million have deteriorated lead-based paint at or above *de minimis* levels and 6 million have soil lead hazards.

Dust lead levels above the Lead Safe Housing Rule's standards are associated with the presence of interior lead-based paint. An estimated 29 million homes have some interior lead-based paint, of which 39 percent have dust lead levels above the Lead Safe Housing Rule's standards. In contrast, only 6 percent of the 67 million homes without interior lead-based paint have dust levels above the Lead Safe Housing Rule's standards.

Soil lead levels above the Lead Safe Housing Rule's standards are associated with the presence of deteriorated lead-based paint. While 13 percent of the 14 million homes with deteriorated lead-based paint above *de minimis* levels have lead in bare soil at or above 2,000 parts per million, only 2 percent of the 82 million homes free of such deteriorated lead-based paint have bare soil lead above this threshold.

Survey Design and Methodology

The principal lead-related purpose of the National Survey of Lead and Allergens in Housing was to develop a scientific description of the existing lead levels in paint, dust, and soil in the nation's housing. Additional objectives were to obtain data to: (1) estimate the number and percent of homes with dust and soil lead levels above selected thresholds; (2) identify sources of lead in dust in housing, e.g., paint and soil; (3) permit future analyses of lead hazard control strategies and costs, e.g., quantities of deteriorated painted surfaces; and (4) permit future analyses for regulation, policy, and guidance that minimize regulatory and program implementation burden.

The target population included approximately 96 million homes, out of the of the 112 million total homes in the nation, including single- and multi-family buildings and manufactured housing units, e.g., mobile homes and trailers. Homes built in all age categories were included. Vacant housing, group quarters, and hotels and motels were excluded for operational reasons. Housing where children were not permitted to live, e.g., elderly care facilities, were excluded because the primary interest was in children's exposure to lead. Thus, 16 million units out of 112 million total units were excluded from this survey.

The main field survey was conducted in 1998-1999, with an augmentation of the soil sampling in 2000. A nationally-representative sample of 1,984 homes was drawn from 75 clusters (each a metropolitan statistical area (MSA) or a cluster of counties) called *primary sampling units* (PSUs).⁶ A total of 831 eligible homes were recruited and completed the survey.

Four rooms were randomly selected for environmental sample collection and testing from each of four room types: kitchen, common living areas, bedrooms (preferably those occupied by children), and other rooms. In each of these four rooms floor, window sill, and window trough dust samples were collected, painted surfaces were measured for lead content, and the condition of painted surfaces was assessed. Outside the building, soil samples were taken and exterior painted surfaces were tested. A floor dust sample was collected in the interior common area of multi-family buildings.

Measurements of lead in paint were made by State- or EPA-certified lead-based paint inspectors using an XRF analyzer and a protocol based on the 1997 *Guidelines*' inspection procedure. The instrument model used does not require making substrate corrections, nor have an inconclusive range, both of which involve destructive sampling of painted surfaces. One XRF reading was made per painted component in each room, approximately in the center of a randomly selected quadrant of the total building component surface area.

Single wipe dust samples were collected by the technique described in ASTM E 1728-95.⁷ Floor dust samples were collected in the center of the largest open floor area in the room. The floor samples in the major entrance and interior common area were collected approximately six inches away from the center of the doorway. One-square-foot templates were used for floor samples. Window sill and trough samples were collected from a random, openable window in each selected room. The entire area was wiped for window sill and trough samples (up to two square feet). All dust samples were analyzed by flame atomic absorption spectrophotometry, using the Environmental Protection Agency's (EPA's) SW-846 method 3050 digestion method and the American Industrial Hygiene Association's *Environmental Lead Laboratory Accreditation Program* (ELLAP) proficiency testing procedures.

Soil sampling was conducted in accordance with core sampling procedures described in the 1995 HUD *Guidelines*. Only the top one-half inch of each soil core, i.e., that portion most accessible to children, was included in the sample. Where necessary, grass or leaf covering was gently removed

⁶ A PSU is a metropolitan statistical area (MSA) or a cluster of counties.

⁷ ASTM E 1728-95. (1995b). *Standard practice for the field collection of settled dust samples using wipe sampling methods for lead determination by atomic spectrometry techniques*. American society of Testing and Materials, Philadelphia, PA.

before taking the core. Soil samples were taken outside the building at the major entrance, and along the dripline and mid-yard area of two sides of the building. Soil samples were collected from children's play areas in a subsample of 375 homes. Soil samples were analyzed by inductively-coupled plasma atomic emission spectroscopy, using the SW-846 digestion method and the ELLAP proficiency testing procedures.

Conclusion

This most recent HUD survey shows that the number of housing units with lead-based paint has declined from 64 million in 1990 to 38 million ten years later. Despite this decline, one in three homes with resident children under 6 years old have significant lead-based paint hazards.

1. INTRODUCTION

The National Survey of Lead and Allergens in Housing (referred to here as the National Survey) was conducted under the sponsorship of the Department of Housing and Urban Development (HUD) and the National Institute of Environmental Health Sciences (NIEHS) to assess children's potential household exposure to lead and allergens, i.e., to estimate the levels of lead in dust, soil, and paint, the prevalence of hazardous levels of lead, and levels and patterns of various indoor allergens (allergy-inducing substances) in dust in homes. Combining the goals of HUD and NIEHS into a single survey saved significant public funds, reduced the survey response burden on the public, and substantially reduced the time required to obtain the data needed by both agencies for their ongoing primary and secondary prevention activities.

This report, Volume I, includes the findings for lead hazards, and describes lead levels in dust, soil, and paint in the nation's housing by age, type, geographical location, and exposed populations. In addition, the report estimates the number and percent of homes with dust and soil lead levels above selected thresholds, especially thresholds in HUD's Lead Safe Housing Rule (24 CFR Part 35 et al., *Requirements for Notification, Evaluation and Reduction of Lead-Based Paint Hazards in Federally Owned Residential Property and Housing Receiving Federal Assistance*, effective September 15, 2000) and in the *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* (referred to as HUD 1995 *Guidelines*), as amended by the 1997 revision to its chapter 7 on lead-based paint inspection.

1.1 Background

Lead is a toxin that affects the central nervous system and is particularly damaging to the developing nervous system of young children and fetuses. High blood lead levels can result in convulsions, mental retardation, and even death. Research has shown that even low lead levels can have serious health consequences. These include reduced intelligence and short-term memory, slower reaction times, poorer hand-eye coordination, reduced height, hearing problems and numerous behavioral problems.⁸

⁸ National Academy of Sciences (1993). *Measuring lead exposure in infants, children, and other sensitive populations*. National Academy Press, Washington, DC.

Although there are many sources of lead in the environment, including drinking water, food, emissions from gasoline combustion, and industrial emissions, it is clear that lead-based paint (LBP) plays a major role in high blood lead levels among children today. Research indicates that dust and soil may be the most significant pathways for low-level lead exposure, and that LBP is the major important source of household dust lead.^{9,10}

The fundamental purpose of the Residential Lead-Based Paint Hazard Reduction Act of 1992, which is Title X of the Housing and Community Development Act of 1992 (P.L. 102-550) is prevention, i.e., to find and mitigate LBP hazards in homes before children are poisoned. In Sections 1051 and 1052(10), Congress required HUD to conduct research on risk reduction strategies from household-based lead exposure, and to assess the effectiveness of lead hazard evaluation activities, respectively. The National Survey was undertaken to provide current information needed for regulatory and policy decisions and for assessment of the effectiveness of lead hazard reduction strategies, e.g., lead information disclosure during housing sale or lease transactions and certification of LBP professionals.

In 1989-1990, HUD sponsored a national survey of LBP in housing (referred to as the 1990 LBP Survey). The primary objective of that survey was to estimate the prevalence of LBP in housing - not to address the presence of lead-based hazards in the housing.¹¹ Since 1990, there have been advances in the understanding of the sources and pathways of lead transport and exposure, advances in the protocols for collecting samples of paint and dust for lead contamination, and improvements in the understanding of the susceptibility of children to the effects of lead exposure in the intervening years. For example, it is now understood that lead-contaminated house dust from LBP is most often the primary lead hazard for children.^{12,13,14} Also, HUD now recommends, and HUD and EPA require in their regulations, the use of dust wipe sampling as opposed to the vacuum sampling employed in the 1990 LBP

⁹ Bornschein, R., Hammond, P.B., Dietrich, et al. (1985a). The Cincinnati prospective study of low-level lead exposure and its effects on child development: Protocol and status report. *Environ. Res.* 38:4-18.

¹⁰ Bornschein, R., Succop, P., Dietrich, et al. (1985b). *The influence of social and environmental factors on dust lead, hand lead, and blood lead levels in young children.* *Environ. Res.* 38:108-118.

¹¹ In Title X of the Housing and Community Development Act of 1992 (P.L. 102-550), the term "lead-based paint hazard" means any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects as established by the appropriate Federal agency.

¹² Clark, S., Bornschein, R., Succop, P., et al. (1985). *Conditions and type of housing as an indicator of potential environmental lead exposure and pediatric blood lead levels.* *Environ. Res.* 38, pp. 46-53.

¹³ Centers for Disease Control and Prevention (1991). *Preventing Lead Poisoning in Young Children.* Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA.

¹⁴ Lanphear, B.P., et al. (1995). *The Relation of Lead-Contaminated House Dust and Blood Lead Levels Among Urban Children, Final Report.* Report to the U.S. Department of Housing and Urban Development.

Survey. In addition, the 1990 survey data are dated because the housing stock has continued to evolve as older houses are renovated, repaired and/or demolished. Thus, it may not serve as an appropriate estimate for evaluation of current LBP hazard reduction strategies. Finally, the 1990 LBP Survey excluded certain housing categories such as manufactured housing, and housing built after 1979 (i.e., after the Consumer Product Safety Commission's ban on lead-containing residential paint went into effect).

The National Survey has updated HUD's 1990 LBP Survey and will enable an assessment of progress in making the U.S. housing stock lead-safe. Further, it provides current baseline information needed for regulatory and policy decisions and for assessment of the effectiveness of lead hazard reduction strategies currently under development.

1.2 Survey Objectives

HUD's principal lead-related purpose for the National Survey was to develop a scientific description of the existing lead levels in dust, soil, and paint in the Nation's housing. In addition, the survey of lead hazards in homes collected data to:

- i. Estimate the number and percent of homes with dust and soil lead levels above selected thresholds.
- ii. Identify likely sources of lead in dust in housing, e.g., paint and soil.
- iii. Permit future analyses of lead hazard control strategies and costs, e.g., quantities of deteriorated painted surfaces.
- iv. Permit future analyses for regulation, policy, and guidance that minimize regulatory and program implementation burden.

In order to meet the survey objectives, a nationally-representative sample of 1,984 housing units (HUs) was drawn from 75 clusters called *primary sampling units* (PSUs).¹⁵ A general three-stage sample design was utilized to accomplish these goals as efficiently as possible. A total of 831 eligible HUs were recruited into the survey. In each recruited HU, samples of dust and soil were collected and

¹⁵ A PSU is a metropolitan statistical area (MSA), county, or cluster of counties that have a minimum population of 15,000 and do not cross Census region boundaries.

painted surfaces were tested. (See Volume II: *Design and Methodology* for details on design and data collection protocols.)

1.2.1 Technical Note on the Survey Weights

Paint lead measurements, dust samples and general area soil samples were collected from all 831 homes in the sample. In contrast, data on the presence of children's play areas and play area soil samples were collected from a nationally representative statistical subsample of 375 homes in the sample. Consequently, two sets of survey sampling weights have been developed: one for the full sample of 831 surveyed homes; and one for the subsample of 375 homes with play area soil lead data. The construction of these weights is described in Volume II. Both sets of weights are unbiased; they will both produce unbiased national estimates to characterize the target population of all 95.7 million occupied housing units in the U.S. where children are permitted to live. However, the play area subsample, being smaller, will have wider confidence intervals than the full sample. Throughout this report, national estimates that involve play area soil lead data (including estimates of lead-based paint hazard) are based on the 375 home subsample and its survey sampling weights, while estimates that do not involve play areas are based on the full 831 home sample and its weights.

1.3 Report Organization

The report for the National Survey consists of two volumes: Volume I presents the major lead hazard findings. Volume II presents the survey design and methodology. The findings on bedroom allergens are presented in a separate Volume.

There are seven chapters in Volume I, including this introduction. Descriptions of each chapter are as follows:

- Chapter 2 describes the population surveyed and compares the survey population to Current Population Survey (CPS) and American Housing Survey (AHS) populations.
- Chapter 3 presents the estimates of the prevalence of significant LBP hazards in housing, based on the findings presented in Chapters 4, 5 and 6 for paint, dust, and soil, respectively. The association between lead in each of the matrices (paint, dust, soil) is presented, as well as the prevalence of lead-related occupations and hobbies among housing residents.

- Chapter 4 presents the estimates of the prevalence and amount of LBP and deteriorated LBP in housing, including paint lead loadings in housing.¹⁶ Relevant estimates are compared with the findings of the 1990 LBP Survey.
- Chapter 5 presents the estimates of the prevalence of lead-contaminated dust in housing, including the dust lead loadings and the association between interior dust lead and LBP condition. Relevant estimates are compared with the findings of the 1990 LBP Survey.
- Chapter 6 presents the estimates of the prevalence of residential soil lead, including soil lead concentrations and the association between soil lead and exterior LBP condition. Relevant estimates are compared with the findings of the 1990 LBP Survey.
- Chapter 7 examines the quality of the data and the resulting quality of projected national estimates. In order to do this, the chapter addresses nonresponse rates and classification bias due to measurement error. A summary of field data collection quality control activities is also provided.

¹⁶ Throughout the volume, the concepts of lead loading and lead concentration are used. Lead in paint and dust are reported as loadings, while lead in soil is reported as a concentration. For paint, lead loading is the number of milligrams of lead per square centimeter of painted surface (mg/cm^2). For dust, lead loading is the number of micrograms of lead per square foot of wiped surface ($\mu\text{g}/\text{ft}^2$). Soil is reported as the number of micrograms of lead per gram of soil ($\mu\text{g}/\text{g}$), equivalent to parts per million (ppm).

2. SURVEYED HOUSING POPULATION

The National Survey of Lead and Allergens in Housing (NSLAH) population included the national housing stock of permanently-occupied, noninstitutional housing units (HUs), including multi-family buildings and manufactured HUs, i.e., mobile homes and trailers. Homes built in all age categories in all 50 states and the District of Columbia were included. Homes built before 1978 were included to update and expand upon the findings of the 1990 LBP Survey. Homes built in 1978 or after were included to verify the assumption that newer homes have minimal lead hazards, based on the 1978 ban of lead-based paint (LBP) for residential use. Vacant housing, group quarters, hotels and motels, military bases, and short-term housing were excluded for operational reasons and are consistent with exclusions under the Lead Safe Housing Rule. Housing where children were not permitted to live, e.g., elderly care facilities, were excluded because the primary interest of the survey was in children's exposure to lead and allergens. However, a home was not excluded simply because a child was not currently residing in the home at the time of the survey. With these exclusions, the eligible national housing stock consisted of approximately 96 million housing units.

A nationally-representative sample of 1,984 HUs was drawn from 75 clusters called *primary sampling units* (PSUs).¹⁷ A total of 831 eligible HUs were recruited and completed the survey. Table 2.1 presents the national estimates for selected characteristics of the survey population, including year of construction, geographic region, degree of urbanization, presence of children under age 6 and age 18, tenure, income, poverty, government support, race, and ethnicity.¹⁸ All estimates presented are weighted national estimates as discussed in Volume II. Most results reported in Chapters 3 and 6 include data from play area soil samples and are therefore restricted to the 375 eligible HUs in 40 PSUs from which play area samples were collected. Chapter 7 of this volume presents an extensive discussion of the potential effect of nonresponse bias.

One important measure of the representativeness of the National Survey is to examine how the distributions of the housing characteristics, socioeconomic and demographic factors compare to national distributions. National distributions were obtained from the 1997 American Housing Survey (AHS) and the 1998 and 1999 Current Population Surveys (CPS). The weighted percent distribution of

¹⁷ See Volume II for description of PSUs.

¹⁸ Cross comparisons of two variables, e.g., Region by Construction Year and Poverty by Urbanization, result in cells containing 30 or fewer HUs. Caution is recommended in the interpretation of these results.

the National Survey sample by race, ethnicity, income, presence of a child under 18,¹⁹ Census region, year of construction, single family vs. multi-family, metropolitan status, and tenure (owned vs. rented) were compared with that of the available AHS and CPS data.²⁰

The 95 percent confidence intervals for the National Survey sample estimate were found to contain the AHS or CPS estimate for most of the available statistics. Slight differences in estimates were observed as follows:

- The 1997 AHS estimate of 35 percent of all homes being in the South is slightly lower than the survey estimate of 36 percent to 39 percent of all homes being in the South.
- The 1997 AHS estimate of 37 percent of all homes having children under age 18 is slightly lower than the survey estimate of 38 percent to 39 percent of all homes.
- The 1998 CPS estimate of 26 percent of all household incomes falling in the \$0-19,999 range is slightly higher than the survey estimate of 17 percent to 24 percent of all households in this income range.
- The 1998 CPS estimate of 85 percent of all households not in poverty is slightly higher than the survey estimate of 77 percent to 83 percent of all households not in poverty.

A few items should be noted which affect the comparability of the estimates and may explain the above observed differences. The first is that the target population for the National Survey excludes housing that excludes children, whereas the AHS and CPS estimates include such housing. Second, the cut-offs used for defining urbanization were not exactly the same for the NSLAH and the CPS. The NSLAH used a cut-off of 2,100,000 while the CPS used 2,500,000. This difference explains why the CPS estimates fall just outside the confidence intervals for the NSLAH. That is why this comparison is not mentioned in the above listing of differences. Third, for the income and poverty comparisons, the CPS uses the family size and income to determine poverty status, whereas the National Survey has used household size and income.²¹ National Survey estimates of any particular income class are also deflated due to the 9 percent of respondents whose income level is unknown. Similarly, there are 6 percent of respondents whose poverty status is unknown. Fourth, race and ethnicity are based on

¹⁹ While we were most interested in children under the age of six years for lead, we were also interested in all children up to age 18 for allergen exposures. Comparative data from the AHS are only available for children under age 18 in the household. For the same reason, post-stratification for this survey was based on children under age 18.

²⁰ If AHS or CPS data are not listed in Table 2.1, e.g., for One or More Children Under Age 6, they were not available in these sources.

²¹ Family size includes all related people living in a housing unit. Household size includes all people living the housing unit, whether or not they are related to each other. Thus household size tends to be larger than family size. The 1999 CPS reports an average household size of 3.17 and an average family size of 2.62.

the youngest household member for the National Survey, while the AHS bases these data on the first householder identified over the age of 18. Fifth, the most recent AHS available is for 1995 and 1997, thus the AHS data is slightly out of date as compared to the National Survey. Finally, there is a small amount of sampling error in both the AHS and CPS estimates, and in the standard error estimates for all three surveys. The standard error for both AHS estimates (percent of homes in the south, percent of homes with children under age 18) is approximately 0.25%.²² The difference between the NSLAH and AHS estimates is still statistically significant for both variables. CPS standard errors are of a comparable magnitude to those for the AHS (similar sample sizes and designs) and also do not affect the statistical significance of the results.

²² American Housing Survey 1997, Appendix D, <http://www.census.gov/hhes/www/housing/ahs/meth.html>.

Table 2.1 Characteristics of the National Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS)

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99) ³
	Estimate (000)	Estimate (%) ¹	Lower 95% CI ² (%)	Upper 95% CI (%)			
Total Housing Units⁴	95,688	100%			831		
Construction year:							
1978-1998	29,774	31%	30%	32%	220	30%	
1960-1977	27,874	29%	28%	30%	267	30%	
1940-1959	20,564	21%	20%	23%	186	20%	
Before 1940	17,476	18%	17%	20%	158	20%	
Region:							
Northeast	19,290	20%	19%	22%	155	20%	
Midwest	22,083	23%	22%	24%	196	24%	
South	35,474	37%	36%	39%	277	35%	
West	18,841	20%	18%	21%	203	21%	
Urbanization:²³							1999
MSA equal to or above 2 million population	26,814	28%	24%	32%	276		55%
MSA below 2 million population	45,753	48%	43%	53%	417		23%
Non-MSA	23,121	24%	19%	30%	138		23%
One or more children under age 6	16,402	17%	15%	19%	184		
Refusal/Don't Know ⁵	352				5		
One or more children under age 18	36,994	39%	38%	39%	398	37%	
Refusal/Don't Know	290				3		
Housing Unit Type:							
Single family	82,651	86%	84%	89%	705	88%	
Multi-family	13,037	14%	11%	16%	126	12%	
Tenure:							1999
Owner-occupied	66,232	69%	65%	73%	539		67%
Renter-occupied	29,074	30%	27%	34%	289		33%
Refusal/Don't Know	381				3		
Household Income (\$30,000):							1998
Less than \$30,000/year	33,830	35%	30%	41%	309		40%
Equal to or more than \$30,000/year	56,111	59%	54%	63%	482		60%
Refusal/Don't Know	5,747				40		

²³ The cut-off used with survey data was actually metropolitan statistical areas (MSAs) of 2,100,000 while the available CPS cut-off is 2,500,000. This difference in definitions explains the slight discrepancy in the findings.

Table 2.1 **Characteristics of the Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS) (continued)**

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99) ³
	Estimate (000)	Estimate (%)	Lower 95% CI (%)	Upper95% CI (%)			
Household Income (\$20,000):							1998
\$0-19,999/year	19,359	20%	17%	24%	189		26%
\$20-39,999/year	25,855	27%	23%	31%	228		27%
\$40-59,999/year	19,316	20%	16%	25%	152		19%
Equal to or more than \$60,000/year	22,890	24%	20%	28%	203		28%
Refusal/Don't Know	8,268				59		
Government Support:							
Government support	4,809	5%	3%	7%	54		
No Government support	86,070	90%	88%	92%	733		
Refusal/Don't Know	4,809	5%			44		
Poverty:							1998
In poverty	13,221	14%	11%	16%	137		15%
Not in poverty	76,336	80%	77%	82%	651		85%
Refusal/Don't Know	6,130	6%			43		
Race:							
White	77,005	80%	78%	83%	622	83%	
African American	10,365	11%	9%	13%	116	12%	
Other ⁶	6,571	7%	5%	8%	77	6%	
Refusal/Don't Know	1,746	2%			16		
Ethnicity:							
Hispanic/Latino	7,434	8%	6%	10%	86	9%	
Not Hispanic/Latino	87,008	91%	88%	93%	736	91%	
Refusal/Don't Know	1,246	1%			9		
Region by Construction year:							
<i>Northeast</i>	19,290	20%	19%	22%	155		
1978-1998	4,358	5%	3%	6%	30		
1960-1977	3,754	4%	3%	5%	30		
1940-1959	4,261	5%	4%	5%	36		
Before 1940	6,917	7%	6%	8%	59		
<i>Midwest</i>	22,083	23%	22%	24%	196		
1978-1998	4,801	5%	4%	6%	41		
1960-1977	6,283	7%	6%	7%	55		
1940-1959	5,899	6%	5%	7%	47		
Before 1940	5,101	5%	5%	6%	53		
<i>South</i>	35,474	37%	36%	39%	277		
1978-1998	14,447	15%	14%	17%	95		
1960-1977	11,261	12%	11%	12%	96		
1940-1959	6,320	7%	6%	7%	57		
Before 1940	3,445	4%	3%	4%	29		

Table 2.1 **Characteristics of the Survey Population, with Comparisons to the American Housing Survey (AHS) and the Current Population Survey (CPS) (continued)**

HU Characteristic	National Survey Estimates				HUs in sample	AHS (1997)	CPS (1998-99) ³
	Estimate (000)	Estimate (%)	Lower 95% CI (%)	Upper95% CI (%)			
<i>West</i>	18,841	20%	17%	21%	203		
1978-1998	6,169	6%	5%	8%	54		
1960-1977	6,536	7%	6%	7%	85		
1940-1959	4,124	4%	3%	6%	47		
Before 1940	2,013	2%	1%	3%	17		
Poverty by Urbanization:							
<i>MSA equal to or above 2 million population</i>	26,814	28%	24%	32%	276		
In poverty	2,962	3%	2%	4%	35		
Not in poverty	22,005	23%	19%	27%	226		
Refusal/Don't Know	1,847	2%			15		
<i>MSA below 2 million population</i>	45,753	48%	43%	53%	417		
In poverty	6,996	7%	5%	9%	75		
Not in poverty	35,786	37%	34%	41%	323		
Refusal/Don't Know	2,971	3%			19		
<i>Non-MSA</i>	23,121	24%	19%	30%	138		
In poverty	3,264	3%	2%	5%	27		
Not in poverty	18,544	19%	14%	25%	102		
Refusal/Don't Know	1,313	1%			9		

¹ All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

² CI = 95% confidence interval for the estimated number or percent.

³ Current Population Survey (CPS) data was taken from either 1998 or 1999 CPS, as indicated by the boldface year at the top of each section of the column.

⁴ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ Refusals and "don't know" responses by survey respondents.

⁶ "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

3. LEAD-BASED PAINT (LBP) HAZARDS IN HOUSING

Chapter 3 presents the estimates of the prevalence of lead-based paint (LBP) hazards in housing, based on the findings presented in Chapters 4, 5, and 6. The associations between lead in each of the matrices (paint, dust, soil) are presented. In addition, the prevalence of lead-related behaviors, occupations, and hobbies among housing residents is presented. No comparison is made with the dust lead findings of the 1990 LBP Survey because the concept of hazard from the earlier survey is not comparable to the definitions in use today. The effect of measurement error on the estimates is discussed in Section 7.3.

As will be seen below, the definition of lead-based paint hazard involves lead-contaminated soil in children's play areas. Therefore, as described in Chapter 1 and Volume II, estimates in this chapter of the prevalence of significant LBP hazards are based on the play area subsample and its survey sample weights. A few tables in this chapter are independent of the presence or absence of lead-contaminated soil in children's play areas; such tables are therefore based on the full sample and have a footnote indicating that the basis is the full sample.

3.1 Definition of Lead-Based Paint (LBP) Hazards

The number of housing units (HUs) classified as having a LBP hazard depends on the definition employed in such classification. Under Title X, a LBP hazard is defined as "any condition that causes exposure to lead from lead-contaminated dust; bare, lead contaminated soil; LBP that is deteriorated; or LBP present on accessible surfaces, friction surfaces, or impact surfaces." Several operational definitions have been developed since Title X was enacted. They involve varying thresholds for lead-contaminated dust and soil and deteriorated LBP. This report focuses on *significant lead-based paint (LBP) hazards*, defined in accordance with the HUD Lead Safe Housing Rule (24 CFR 35). If any of the following situations exist in a home, then a significant LBP hazard exists in the home under this definition:

- Deteriorated LBP – LBP with deterioration larger than the *de minimis* levels per Section 35.1350(d) of the Lead Safe Housing rule, viz., deterioration of more than 20 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or damage to more than 10% of the total surface area of

interior small surface area components types (window sills, baseboards, trim).²³ LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm² or

- Lead-contaminated dust – Dust on floors with greater than or equal to 40 µg/ft² lead, dust on window sills with greater than or equal to 250 µg/ft² lead²⁴; or
- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

The findings in the body of this report are based on this definition of a LBP hazard. Comparative statistics for alternative definitions of LBP hazards are presented in Appendix A.

3.2 Prevalence of Significant Lead-Based Paint Hazards in Housing

An estimated 26 million (± 5 million²⁵) or 27 percent ($\pm 6\%$) of housing units in the United States have significant LBP hazards. Table 3.1 presents the number and percentage of housing units with significant LBP hazards by selected characteristics, including housing unit age²⁶, region of the country, the presence of a resident child under six years of age, degree of urbanization, measures of household income, race, ethnicity, and housing unit type.

Homes in Northeastern and Midwestern states are more likely to have significant LBP hazards than homes in Southern or Western states. An estimated 43 percent ($\pm 12\%$) of homes in the Northeast have significant LBP hazards, while the estimates are 17 percent ($\pm 9\%$) and 19 ($\pm 14\%$) percent for homes in the South and West, respectively. Older homes are more likely to have significant LBP hazards than newer homes. An estimated 10 percent ($\pm 9\%$) of homes built between 1960 and 1977 have significant LBP hazards, but the percentage increases to 51 percent ($\pm 12\%$) for homes built between

²³ Intact LBP present on accessible surfaces, friction surfaces, or impact surfaces were not included in the definition of LBP hazard for the estimates presented in this report because this information was not specifically collected for each component.

²⁴ Window trough dust is not considered in the definition of a LBP hazard under the HUD Lead Safe Housing Rule.

²⁵ All confidence intervals are at the 95% level for the estimated number or percent.

²⁶ In the interpretation of the data by housing unit age, it is important to keep the source of the data in mind. Residents were asked the year their home was constructed. If a resident could not report the exact year, he/she was asked to report the construction year in ranges: 1978-1998, 1960-1977, 1946-1959, 1940-1945, and 1939 or before. Over 40% of respondents provided the construction year of their home in this secondary manner. For the purposes of the data analyses in this report, the midpoints of the ranges were assigned as the year of construction, viz., 1988, 1968, 1953, 1943, and 1922, respectively. The year 1922 is not the midpoint of the pre-1940 range; it is the median construction year for pre-1940 housing, according to the 1995 AHS. For these reasons, housing unit age is reported in the four ranges given in Table 3.1; finer breakdowns should be interpreted cautiously.

1940 and 1959, and to 67 percent ($\pm 17\%$) for homes built before 1940. A similar pattern of results was found for homes with children under age 6 categorized by age of construction.

Table 3.1 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics

HUD Lead Safe Housing Rule: Significant LBP Hazards ¹								
Characteristic	All HUs (000) ²	No. of HUs with Significant LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied HUs	95,688	25,517	20,410	30,623	27%	21%	32%	375
Region:								
Northeast	19,290	8,260	5,904	10,616	43%	31%	55%	95
Midwest	22,083	7,606	5,691	9,521	34%	26%	43%	102
South	35,474	6,082	3,161	9,003	17%	9%	25%	111
West	18,841	3,569	1,003	6,135	19%	5%	33%	67
Construction Year:								
1978-1998	29,774	425	0	1,222	1%	0%	4%	88
1960-1977	27,874	2,843	317	5,370	10%	1%	19%	111
1940-1959	20,564	10,501	7,996	13,006	51%	39%	63%	97
Before 1940	17,476	11,747	8,771	14,723	67%	50%	84%	79
One or More Children Under Age 6:								
All HU ages	16,402	5,652	3,758	7,546	34%	23%	46%	83
HUs built 1978-1998	5,847	364	0	1,127	6%	0%	19%	25
HUs built 1960-1977	5,098	371	0	987	7%	0%	19%	20
HUs built 1940-1959	3,055	2,662	1,554	3,770	87%	51%	123%	22
HUs built before 1940	2,401	2,255	502	4,007	94%	21%	167%	16
Housing Unit Type:								
Single family	82,651	23,204	17,794	28,614	28%	22%	35%	319
Multi-family	13,037	2,313	0	5,143	18%	0%	39%	56
Occupant Status:								
Owner-occupied	62,232	16,013	12,647	19,380	26%	20%	31%	254
Renter-occupied	29,074	9,503	5,906	13,100	33%	20%	45%	119
Refusal/Don't Know ⁵	381							2
Household Income:								
Less than \$30,000/year	33,830	13,998	8,938	19,057	41%	26%	56%	145
Equal to or more than \$30,000/year	56,111	10,060	7,151	12,970	18%	13%	23%	211
Refusal/Don't Know	5,747							19
One or More Children Under Age 6:								
All Income Categories	16,402	5,652	3,758	7,546	34%	23%	46%	83
Less than \$30,000/year	4,791	1,646	0	3,460	34%	0%	72%	28
Equal to or more than \$30,000/year	11,236	4,006	1,797	6,214	36%	16%	55%	52
Refusal/Don't Know	375							3

**Table 3.1 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by
Selected Characteristics (continued)**

HUD Lead Safe Housing Rule: Significant LBP Hazards ¹								
Characteristic	All HUs (000) ²	No. of HUs with Significant LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Government Support:								
Government support	4,809	822	10	1,634	17%	0%	34%	25
No government support	86,070	23,571	19,114	28,028	27%	22%	33%	327
Refusal/Don't Know	4,809							23
Poverty:								
In Poverty	13,221	5,053	2,542	7,565	38%	19%	57%	54
Not in Poverty	76,336	18,669	14,396	22,942	24%	19%	30%	300
Refusal/Don't Know	6,130							21
Race:								
White	77,005	19,164	14,972	23,356	25%	19%	30%	285
African American	10,365	2,317	665	3,969	22%	6%	38%	45
Other ⁶	6,571	2,631	0	5,734	40%	0%	87%	35
Refusal/Don't Know	1,746							10
Ethnicity:								
Hispanic/Latino	7,434	3,635	700	6,569	49%	9%	88%	31
Not Hispanic/Latino	87,008	20,841	16,734	24,948	24%	19%	29%	337
Refusal/Don't Know	1,246							7

¹ Significant LBP hazard as defined in text and HUD Lead Safe Housing Rule.² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.³ All percentages are calculated with the "All HUs" column in each row used as the denominator.⁴ CI = 95% confidence interval for the estimated number or percent.⁵ Refusals and "don't know" responses by survey respondents.⁶ "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

More homes with lower income occupants have significant LBP hazards than homes where occupants have higher incomes. An estimated 41 percent ($\pm 15\%$) of households with less than \$30,000/year income have significant LBP hazards, compared with 18 percent ($\pm 5\%$) of households in the \$30,000/year or above income level.

Government-supplied housing may have fewer lead-based paint hazards than housing without Government support. An estimated 17 percent of Government-supported housing had significant lead-based paint hazards, compared to 27 percent of housing without Government support.

Table 3.2 presents the number of homes with significant LBP hazards by location in the building—either interior or exterior, or both.

Table 3.2 Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building

HUD Lead Safe Housing Rule: Significant LBP Hazards							
LBP Hazard Location	Number of HUs ¹ (000)			Percent of HUs ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI	
Interior only	10,861	6,865	14,857	11%	7%	16%	47
Both Interior and Exterior	7,965	4,891	11,040	8%	5%	12%	39
Exterior only	6,690	3,635	9,745	7%	4%	10%	29
Anywhere	25,517	20,440	30,594	27%	21%	32%	115
No Significant LBP Hazard	70,171	65,094	75,248	73%	68%	79%	260
Total HUs	95,688			100%			375

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

Table 3.3 presents data for the presence of significant LBP hazards in homes by type of hazard, for all homes in the National Survey's target population and for homes with one or more children under the age of 6 years. The percentages for each "All HUs" row of Table 3.3 show the percent of all HUs with the component of significant LBP hazard, while the percentages in each "HUs w/Child Under 6" row of Table 3.3 show the percent of all HUs with a child under age 6 with that component of significant LBP hazard.

Figures 3.1 and 3.2 show the proportion of each significant LBP hazard attributable to each type of hazard, for all homes and for homes in the National Survey's target population with one or more children under the age of 6 years.

Table 3.3 Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 Years of Age by Type of Hazard

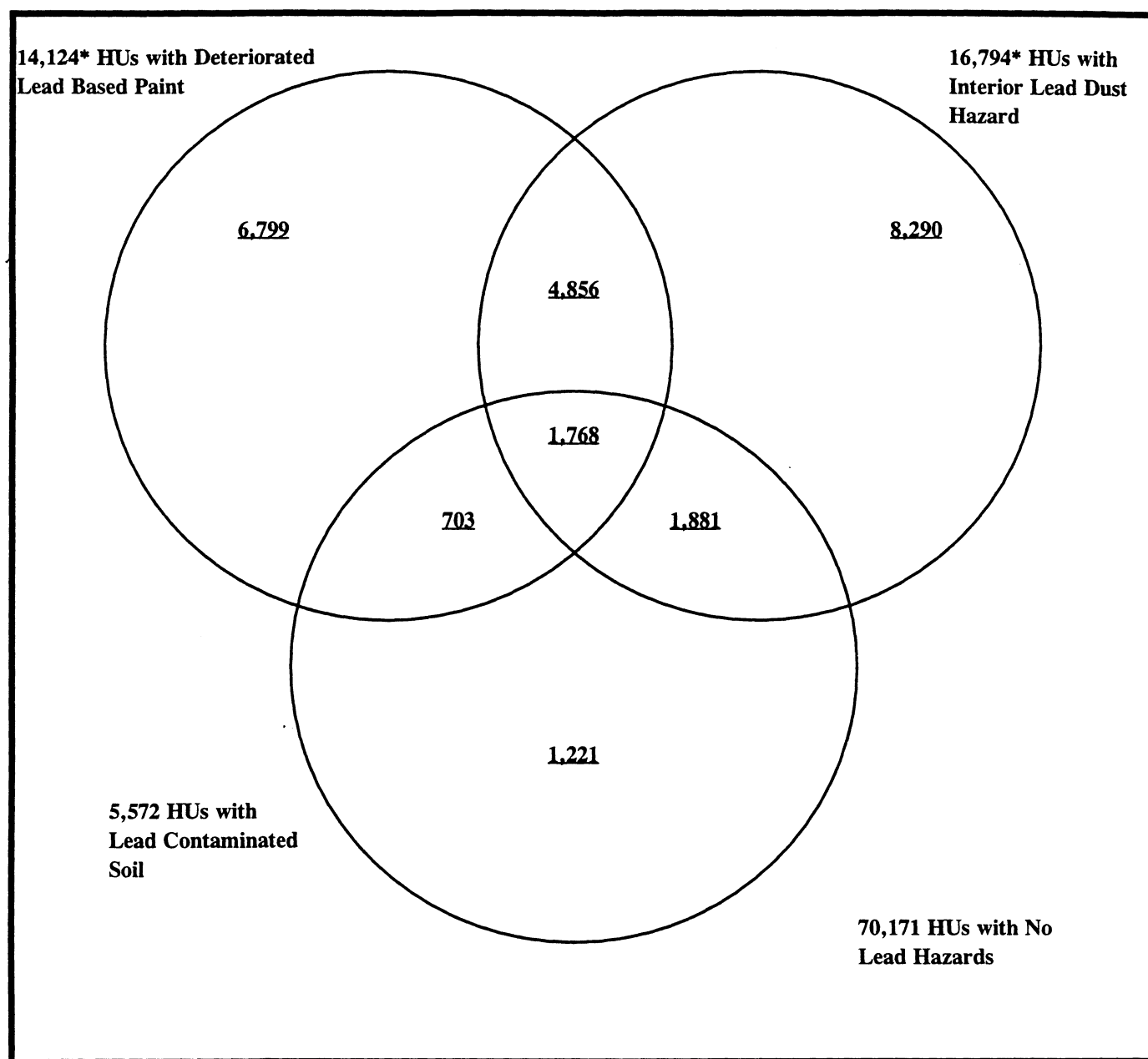
HUD Lead Safe Housing Rule: Significant LBP Hazards						
Type of Hazard	Number of HUs ¹ (000)			Percent of HUs ² (%)		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Significantly Deteriorated Lead Based Paint						
All HUs	14,124	10,666	17,582	15%	11%	18%
HUs w/ Child Under 6	3,521	1,576	5,467	21%	10%	33%
Interior Lead Dust						
All HUs	16,794	12,169	21,420	18%	13%	22%
HUs w/ Child Under 6	3,637	1,636	5,638	22%	10%	34%
Lead Contaminated Soil						
All HUs	5,572	2,487	8,657	6%	3%	9%
HUs w/ Child Under 6	1,419	0	3,057	9%	0%	19%
Any LBP Hazard						
All HUs	25,517	20,410	30,623	27%	21%	32%
HUs w/ Child Under 6	5,652	3,758	7,546	34%	23%	46%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (19,577) as the denominator, or as applicable.

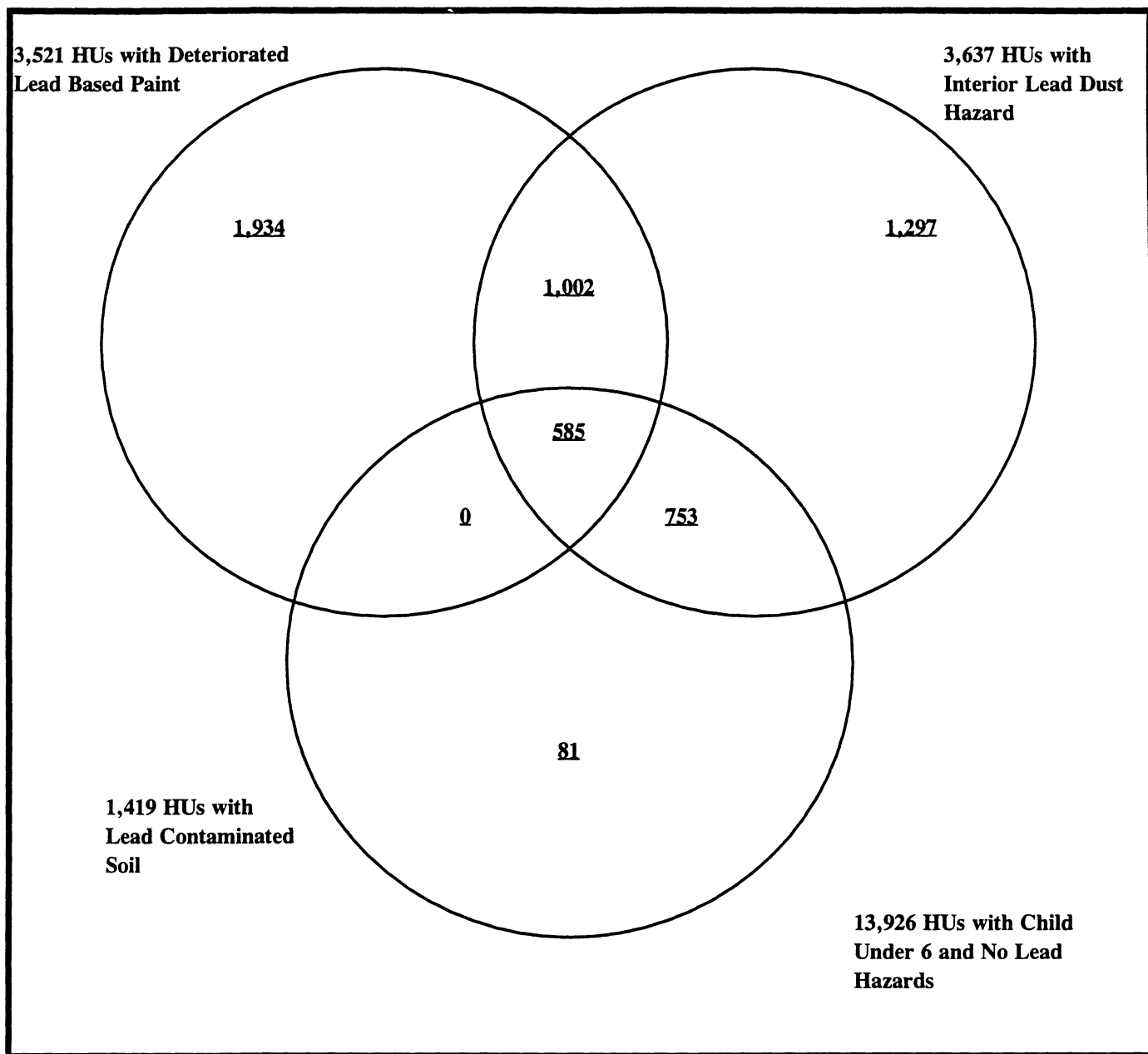
³ CI = 95% confidence interval for the estimated number or percent.

Figure 3.1 Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) by Hazard Characteristic (HUD Lead Safe Housing Rule)



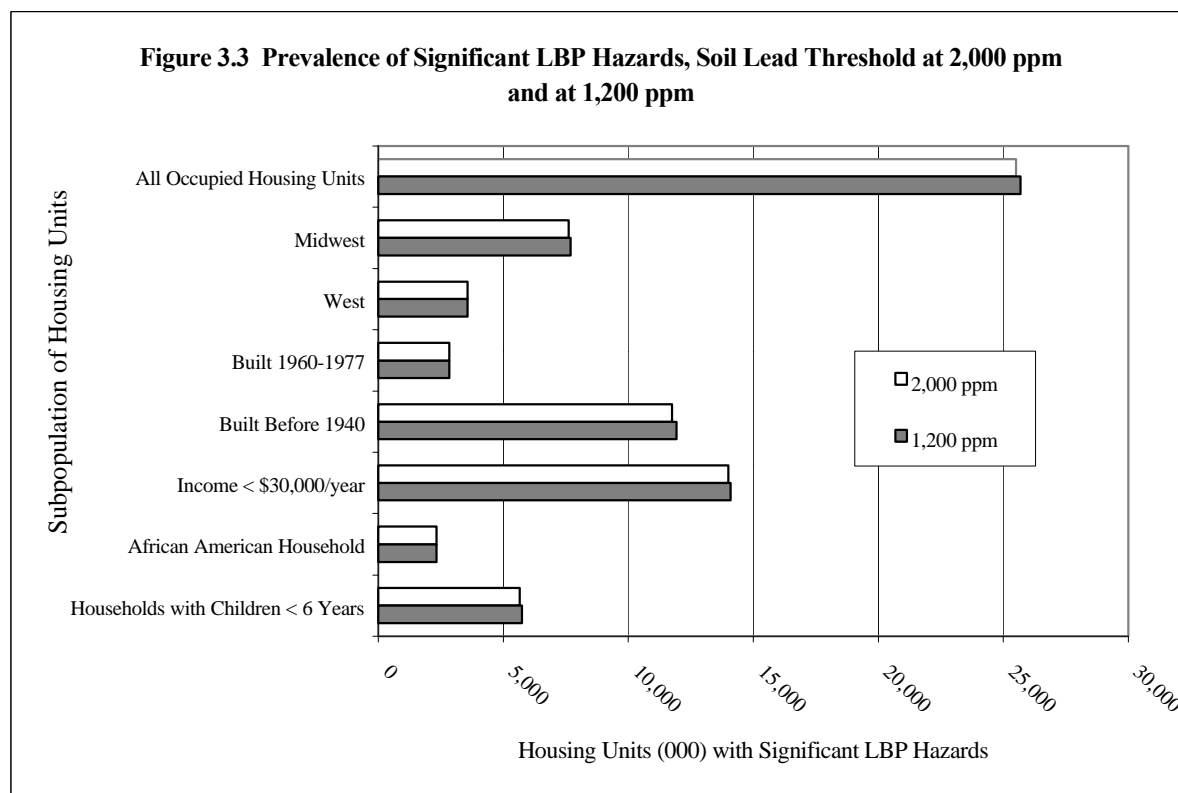
* Includes a small number of cases with unknown soil lead levels

Figure 3.2 Significant Lead-Based Paint (LBP) Hazards in Housing Units (HUs) with Children Under Age 6 by Hazard Characteristic (HUD Lead Safe Housing Rule)



3.3 Significant LBP Hazards with Alternate Threshold for Soil Lead Hazards

The EPA Identification of Dangerous Levels of Lead Rule, (40 CFR 745), issued under Section 403 of the Toxic Substances Control Act, contains a different definition of soil lead hazard than that contained in the HUD Lead Safe Housing Rule. The EPA Section 403 rule uses 1,200 ppm as the threshold for soil lead concentrations outside of children's play areas, rather than 2,000 ppm. To explore the implications of this difference, this section reproduces Tables 3.1, 3.2, and 3.3, as Tables 3.4, 3.5, and 3.6, respectively, for the alternate soil lead threshold. A comparison of Tables 3.4, 3.5, and 3.6 with Tables 3.1, 3.2, and 3.3 shows that the proposed change would result in a very slight increase in the number of housing units with LBP hazards, in the range of zero to one percent for all estimates²⁷. A summary of this comparison is presented in Figure 3.3, which presents the estimated number of housing units with LBP Hazards for selected subpopulations and for the two soil lead concentration thresholds. The data in Figure 3.3 are taken from Tables 3.1 – 3.6.



²⁷ In comparing Tables 3.2 and 3.5, it is to be noted that all rows depend on the presence of both interior and exterior LBP hazards, and may therefore have different estimates in the two tables.

Table 3.4 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule

EPA Section 403 Rule: Significant LBP Hazards ¹								
Characteristic	All HUs (000) ²	Number of HUs with Signif. LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied HUs	95,688	25,698	20,697	30,699	27%	22%	32%	375
Region:								
Northeast	19,290	8,350	6,162	10,537	43%	32%	55%	95
Midwest	22,083	7,697	5,885	9,509	35%	27%	43%	102
South	35,474	6,082	3,178	8,986	17%	9%	25%	111
West	18,841	3,569	1,018	6,120	19%	5%	32%	67
Construction Year:								
1978-1998	29,774	425	0	1,217	1%	0%	4%	88
1960-1977	27,874	2,843	331	5,355	10%	1%	19%	111
1940-1959	20,564	10,501	8,011	12,992	51%	39%	63%	97
Before 1940	17,476	11,928	9,068	14,789	68%	52%	85%	79
One or More Children Under Age 6:								
All HU ages	16,402	5,743	3,886	7,601	35%	24%	46%	83
HUs built 1978-1998	5,847	364	0	1,122	6%	0%	19%	25
HUs built 1960-1977	5,098	371	0	983	7%	0%	19%	20
HUs built 1940-1959	3,055	2,662	1,561	3,764	87%	51%	123%	22
HUs built before 1940	2,401	2,346	589	4,103	98%	25%	171%	16
Housing Unit Type:								
Single family	82,651	23,385	18,113	28,657	28%	22%	35%	319
Multi-family	13,037	2,313	-	5,126	18%	0%	39%	56
Occupant Status:								
Owner-occupied	62,232	16,013	12,666	19,361	26%	20%	31%	254
Renter-occupied	29,074	9,684	6,160	13,209	33%	21%	45%	119
Refusal/Don't Know ⁵	381							2
Household Income:								
Less than \$30,000/year	33,830	14,089	9,079	19,100	42%	27%	56%	145
Equal to or more than \$30,000/year	56,111	10,150	7,341	12,958	18%	13%	23%	211
Refusal/Don't Know	5,747							19
One or More Children Under Age 6:								
All Income Categories	16,402	5,743	3,886	7,601	35%	24%	46%	83
Less than \$30,000/year	4,791	1,738	0	3,504	36%	0%	73%	28
Equal to or more than \$30,000/year	11,236	4,006	1,810	6,201	36%	16%	55%	52
Refusal/Don't Know	375							3
Government Support:								
Government support	4,809	914	90	1,737	19%	2%	36%	25
No government support	86,070	23,661	19,288	28,033	27%	22%	33%	327
Refusal/Don't Know	4,809							23

Table 3.4 Prevalence of Housing Units with Significant Lead-Based Paint (LBP) Hazards, by Selected Characteristics. Alternative Soil Lead Threshold at 1,200 ppm per EPA 403 Rule (continued)

EPA Section 403 Rule: Significant LBP Hazards ¹								
Characteristic	All HUs (000) ²	No. of HUs with Significant LBP Hazards (000)			Percent of HUs with Significant LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Poverty:								
In Poverty	13,221	5,145	2,623	7,666	39%	20%	58%	54
Not in Poverty	76,336	18,759	14,614	22,903	25%	19%	30%	300
Refusal/Don't Know	6,130							21
Race:								
White	77,005	19,345	15,265	23,425	25%	20%	30%	285
African American	10,365	2,317	665	3,969	22%	6%	38%	45
Other ⁶	6,571	2,631	0	5,734	40%	0%	87%	35
Refusal/Don't Know	1,746							10
Ethnicity:								
Hispanic/Latino	7,434	3,635	718	6,552	49%	10%	88%	31
Not Hispanic/Latino	87,008	21,022	17,034	25,010	24%	20%	29%	337
Refusal/Don't Know	1,246							7

¹ Significant LBP hazard as defined in text and HUD Lead Safe Housing Rule.² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.³ All percentages are calculated with the "All HUs" column in each row used as the denominator.⁴ CI = 95% confidence interval for the estimated number or percent.⁵ Refusals and "don't know" responses by survey respondents.⁶ "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.**Table 3.5 Prevalence of Significant Lead-Based Paint (LBP) Hazards by Location in the Building. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule**

EPA Section 403 Rule: Significant LBP Hazards							
LBP Hazard Location	Number of HUs ¹ (000)			Percent of HUs ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI	
Interior Only	10,416	6,296	14,536	11%	7%	15%	44
Both Interior and Exterior	8,411	5,090	11,731	9%	5%	12%	42
Exterior Only	6,871	3,832	9,911	7%	4%	10%	31
Anywhere	25,698	20,726	30,670	27%	22%	32%	117
No LBP Hazard	69,990	65,018	74,962	73%	68%	78%	258
Total HUs	95,688			100%			375

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.² All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.³ CI = 95% confidence interval for the estimated number or percent.

Table 3.6 Prevalence of Significant Lead-Based Paint (LBP) Hazards in Housing Units with a Child under 6 Years of Age by Type of Hazard. Alternative Soil Lead Threshold at 1,200 ppm per EPA Section 403 Rule

HUD Lead Safe Housing Rule: Significant LBP Hazards						
Type of Hazard	Number of HUs ¹ (000)			Percent of HUs ² (%)		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Deteriorated Lead-Based Paint						
All HUs	14,124	10,666	17,582	15%	11%	18%
HUs w/ Child Under 6	3,521	1,576	5,467	18%	8%	28%
Interior Lead Dust						
All HUs	16,794	12,169	21,420	18%	13%	22%
HUs w/ Child Under 6	3,637	1,636	5,638	19%	8%	29%
Lead Contaminated Soil						
All HUs	6,460	3,122	9,799	7%	3%	10%
HUs w/ Child Under 6	1,511	0	3,108	9%	0%	19%
Any LBP Hazard						
All HUs	25,517	20,410	30,623	27%	21%	32%
HUs w/ Child Under 6	5,652	3,758	7,546	29%	19%	39%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (16,402) as the denominator, or as applicable.

³ CI = 95% confidence interval for the estimated number or percent.

3.4 Prevalence of Lead-Related Occupations or Hobbies

Table 3.7a presents the number and percent of all U.S. households in which at least one occupant engages in a lead-related occupation or hobby. Data for home cleanliness and clutter categories are also presented. Table 3.7b presents the same data for homes with significant LBP hazards. As described below, all of these estimates are likely to overstate the number of households that may have contributions to lead in dust from these behaviors.

An estimated 24 percent ($\pm 3\%$) of households report that at least one occupant engages in a listed lead-related occupation, e.g., construction or renovation work, lead industry work, automotive repair or radiator work, or firing range work²⁸. This may be elevated above the actual estimate of people who may bring lead home due to the fact that many people in the construction business only work with

²⁸ A respondent was considered to be engaged in a lead-related occupation if they worked on any of the following activities in the previous six months: building demolition, paint removal (including sanding or scraping), plumbing, sandblasting, battery manufacturing or salvage work, explosive or ammunition work, foundry work, glass work, lead smelter work, oil refinery work, car radiator repair, making or splicing cable, work at a firing range or police work, welding or torch cutting, or other lead-related industry work.

new construction or in projects which that do not involve disturbing LBP, dust-lead hazards or soil-lead hazards. Similarly, a person working in a lead-related industry may have an administrative position and have no lead exposure at all.

An estimated 41 percent ($\pm 5\%$) report that at least one occupant engages in a potentially lead-related hobby at home, e.g., making bullets or sinkers, furniture or home renovation, stained glass, pottery, or making jewelry.²⁹ Among homes with significant LBP hazards, 30 percent ($\pm 13\%$) report that at least one occupant engages in a potentially lead-related hobby. These may be high estimates of the number of homes where lead dust is actually generated since some of these people may generally or always use lead-free materials in their hobbies.

Home cleanliness has been associated with lead dust levels.³⁰ About half of all homes were found to be clean (59%) and organized (43%), using the criteria in this survey. Homes with significant LBP hazards in their interiors were generally somewhat less clean and organized; the percentage of clean homes is 36%, 21% lower than the general population, and the percentage of organized homes is 32%, 12% lower than the general population.

²⁹ A respondent was counted as engaged in a potentially lead-related activity at home if they had participated in any of the following activities in the previous six months: make bullets or fishing sinkers, paint cars or bicycles, reload bullets, target shoot, hunt, remove paint from any part of the house, remove paint from furniture, sand or paint any part of the house, solder pipes or metal, solder electronic parts, use artists' paint (jewelry, pictures), work with stained glass, or work with pottery or glazes. However, painting and renovation work on homes built after 1978 were excluded from these estimates.

³⁰ NCLSH (1998). *Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program, Fifth Interim Report*, March 1998, Prepared for the U.S. Department of Housing and Urban Development by the National Center for Lead-Safe Housing.

Table 3.7a Prevalence of Housing Units with Selected Lead-Related Characteristics

Lead Related Behavior	Number of HUs (000) ¹			Percent of HUs (%) ²			HUs in Sample
	Estimate ³	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Lead Related Occupation	22,673	19,732	25,615	24%	21%	27%	203
Lead Related Hobby	39,281	35,020	43,543	41%	36%	46%	347
Cleanliness							
House Appears Clean	56,058	51,887	60,228	59%	54%	63%	462
Some Evidence of Cleaning	25,347	21,417	29,277	26%	22%	31%	237
No Evidence of Cleaning	9,646	7,577	11,714	10%	8%	12%	86
Clutter							
Clutter Organized	41,158	37,650	44,666	43%	40%	46%	347
Average Amount of Clutter	38,601	35,663	41,539	40%	37%	43%	336
No Organization	11,045	8,859	13,231	12%	9%	14%	100
Total HUs	95,688						831

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

³ Estimates are based on the full weighted sample.

⁴ CI = 95% confidence interval for the estimated number or percent.

Table 3.7b Prevalence of Selected Lead-Related Characteristics in Homes with Significant Interior LBP Hazards

Lead Related Behavior	Number of HUs (000) ¹			Percent of HUs (%) ²			HUs in Sample
	Estimate ³	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Lead Related Occupation	3,355	1,564	5,146	18%	8%	27%	20
Lead Related Hobby	5,639	3,153	8,124	30%	17%	43%	29
Cleanliness							
House Appears Clean	6,737	2,876	10,599	36%	15%	56%	35
Some Evidence of Cleaning	8,447	3,060	13,833	45%	16%	74%	34
No Evidence of Cleaning	2,778	754	4,801	15%	4%	26%	13
Clutter							
Clutter Organized	6,016	2,345	9,687	32%	12%	52%	27
Average Amount of Clutter	8,684	3,687	13,681	46%	19%	73%	38
No Organization	3,262	1,162	5,361	17%	6%	29%	17
Total HUs	18,827						86

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units with significant interior LBP hazard (18,827) as the denominator. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

4. LEAD-BASED PAINT (LBP) IN HOUSING

Chapter 4 presents estimates of the prevalence, location, and amount of lead-based paint (LBP) and deteriorated LBP in housing, including paint lead loadings in housing. Relevant estimates are compared with the findings of the 1990 LBP Survey. All estimates in this chapter are based on the full, weighted sample of 831 housing units.

Under both the Lead Safe Housing Rule and the *Guidelines*, LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wall-paper over paint) that contains lead equal to or greater than 1.0 mg/cm². The estimates for deteriorated LBP and significantly deteriorated LBP are presented in Section 4.2. Under the Lead Safe Housing Rule, LBP is considered to be deteriorated if there is any deterioration. It is considered to be significantly deteriorated if the deterioration exceeds the *de minimis* thresholds given in the definition of a significant LBP hazard presented in Chapter 3.

4.1 Prevalence of Lead-Based Paint

An estimated 38 million (± 3 million³¹) or 40 percent ($\pm 4\%$) of housing units (HUs) in the United States have LBP on either the interior or exterior painted surfaces, or both. Table 4.1 presents the number and percentage of housing units with LBP by selected characteristics, including year of construction³², geographic region, degree of urbanization, presence of children under age 6, tenure, income, government support, race, ethnicity, and poverty.

As expected, older homes are more likely to have LBP than newer homes. An estimated 24 percent ($\pm 6\%$) of homes built between 1960 and 1977 have LBP, but the percentage increases to 69 percent ($\pm 9\%$) for homes built between 1940 and 1959, and to 87 percent ($\pm 5\%$) for homes built before 1940. Table 4.1 indicates that 5 to 8 percent of homes built after 1977 have LBP. This estimate is likely to be somewhat high, for two reasons. First, housing unit age is based on the residents' reports. Some residents, especially renters, may have reported their homes as being newer than they actually are. There

³¹ All confidence intervals are at the 95% level for the estimated number or percent.

³² In the interpretation of the data by housing unit age, it is important to keep the source of the data in mind. Residents were asked the year their home was constructed. If a resident could not report the exact year, he/she was asked to report the construction year in ranges: 1978-1998, 1960-1977, 1946-1959, 1940-1945, and 1939 or before. Over 40% of respondents provided the construction year of their home in this secondary manner. For the purposes of the data analyses in this report, the midpoints of the ranges were assigned as the year of construction, viz., 1988, 1968, 1953, 1943, and 1922, respectively. The year 1922 is not the midpoint of the pre-1940 range; it is the median construction year for pre-1940 housing, according to the 1995 AHS. For these reasons, housing unit age is reported in most tables in the four ranges given in Table 3.1; finer breakdowns should be interpreted cautiously.

were a few homes in the survey in which an examination of all of the data collected from a home presented a picture that suggested that the home may be older than reported by the respondent. In no case was the respondent's reported age overridden in the analyses. Second, most of the homes in the sample built after 1977 that had LBP had only one or two components with LBP. In approximately one-third of these homes, the substrate of the one painted component in the home may have interfered with the reading (these included painted metal, ceramic, or stone substrates which may contain lead, but paint was not scraped to measure bare substrate for this purpose).³³

Table 4.1 Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU) Characteristics

HU Characteristic	All HUs (000)	Number of HUs with LBP (000)			Percent of HUs with LBP (%) ¹			HUs in Sample
		Estimate	Lower 95% CI ²	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Housing Units³	95,688	37,897	34,521	41,272	40%	36%	43%	831
Construction Year:								
1989-1998	10,378	9,864	7,132	12,596	5%	0%	14%	61
1978-1988	19,397	17,880	15,184	20,575	8%	3%	13%	159
1960-1977	27,874	6,577	4,875	8,280	24%	18%	30%	267
1940-1959	20,564	14,171	12,203	16,139	69%	60%	77%	186
Before 1940	17,476	15,117	13,532	16,702	87%	82%	91%	158
Region:								
Northeast	19,290	10,600	8,306	12,895	55%	46%	64%	155
Midwest	22,083	11,748	10,546	12,950	53%	48%	59%	196
South	35,474	9,607	7,762	11,451	27%	22%	32%	277
West	18,841	5,942	4,747	7,137	32%	25%	38%	203
Region:								
Northeast								
HUs built 1978-1998	4,358	76	0	225	2%	0%	5%	30
HUs built 1960-1977	3,794	1,478	348	2,609	39%	9%	69%	31
HUs built 1940-1959	4,221	3,089	2,179	3,999	73%	52%	95%	35
HUs built before 1940	6,917	5,957	5,187	6,728	86%	75%	97%	59
Midwest								
HUs built 1978-1998	4,801	533	0	1,134	11%	0%	24%	41
HUs built 1960-1977	6,283	1,771	872	2,670	28%	14%	42%	55
HUs built 1940-1959	5,899	4,785	4,011	5,559	81%	68%	94%	47
HUs built before 1940	5,101	4,658	3,888	5,429	91%	76%	100%	53
South								
HUs built 1978-1998	14,447	1,197	0	2,436	8%	0%	17%	95
HUs built 1960-1977	11,261	1,914	1,216	2,612	17%	11%	23%	96
HUs built 1940-1959	6,320	3,431	2,329	4,532	54%	37%	72%	57
HUs built before 1940	3,445	3,065	2,676	3,453	89%	78%	100%	29

³³ The XRF analyzer used for the study corrected for substrate interferences, but any actual lead in the substrate would be measured.

**Table 4.1 Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU)
Characteristics (continued)**

HU Characteristic	All HUs (000)	Number of HUs with LBP (000)			Percent of HUs with LBP (%) ¹			HUs in Sample
		Estimate	Lower 95% CI ²	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
West								
HUs built 1978-1998	6,169	225	0	473	4%	0%	8%	54
HUs built 1960-1977	6,536	1,414	816	2,011	22%	12%	31%	85
HUs built 1940-1959	4,124	2,866	1,715	4,017	69%	42%	97%	47
HUs built before 1940	2,013	1,437	376	2,498	71%	19%	100%	17
Urbanization:								
MSA equal or above 2 million population	26,814	9,681	7,550	11,812	36%	30%	42%	276
MSA below 2 million Population	45,753	17,390	14,026	20,754	38%	32%	44%	417
Non-MSA	23,121	10,826	7,458	14,193	47%	35%	59%	138
Housing Unit Type:								
Single family	82,651	34,081	30,874	37,289	41%	37%	45%	705
Multi-family	13,037	3,815	2,470	5,160	29%	20%	39%	126
Tenure:								
Owner-occupied	66,232	25,172	22,400	27,943	38%	35%	41%	539
Renter-occupied	29,074	12,409	9,538	15,281	43%	35%	50%	289
Refusal/Don't Know ⁴	381							3
Income:								
Less than \$30,000/year	33,830	15,007	11,604	18,411	44%	37%	52%	309
Equal to or more than \$30,000/year	56,111	20,815	17,745	23,885	37%	32%	42%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6								
<i>All Income Categories</i>	16,402	5,328	4,048	6,609	32%	26%	39%	184
Less than \$30,000/year	4,791	1,375	784	1,965	29%	16%	41%	61
Equal to or more than \$30,000/year	11,236	3,820	2,579	5,061	34%	23%	45%	117
Refusal/Don't Know	375							6
One or More Children Under Age 6:								
<i>All HU Ages</i>	16,402	5,328	4,048	6,609	32%	26%	39%	184
HUs built 1978-1998	5,847	202	0	436	3%	0%	7%	56
HUs built 1960-1977	5,098	876	416	1,337	17%	8%	26%	61
HUs built 1940-1959	3,055	1,997	1,341	2,654	65%	44%	87%	40
HUs built before 1940	2,401	2,253	1,426	3,079	94%	59%	100%	27
Government Support:								
Government support	4,809	1,741	678	2,805	36%	16%	56%	54
No government support	86,070	33,871	30,681	37,062	39%	36%	43%	733
Refusal/Don't Know	4,809							44

**Table 4.1 Prevalence of Lead-Based Paint (LBP) by Selected Housing Unit (HU)
Characteristics (continued)**

HU Characteristic	All HUs (000)	Number of HUs with LBP (000)			Percent of HUs with LBP (%) ¹			HUs in Sample
		Estimate	Lower 95% CI ²	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Race:								
White	77,005	30,945	28,037	33,853	40%	37%	44%	622
African American	10,365	4,228	2,767	5,689	41%	30%	52%	116
Other ⁵	6,571	1,913	1,015	2,811	29%	17%	41%	77
Unknown	1,746							16
Ethnicity:								
Hispanic/Latino	7,434	3,329	2,044	4,614	45%	31%	59%	86
Not Hispanic/Latino	87,008	33,830	30,436	37,223	39%	35%	42%	736
Refusal/Don't Know	1,246							9
Poverty by Urbanization:								
<i>MSA equal or above 2 Million population</i>								
In poverty	2,962	1,205	735	1,674	41%	25%	57%	35
Not in poverty	22,005	7,758	5,957	9,559	35%	27%	43%	226
<i>MSA below 2 million Population</i>								
In poverty	6,996	3,795	2,248	5,341	54%	32%	76%	75
Not in poverty	35,786	12,455	9,722	15,188	35%	27%	42%	323
<i>Non-MSA</i>								
In poverty	3,264	1,362	310	2,414	42%	9%	74%	27
Not in poverty	18,544	8,684	5,071	12,297	47%	27%	66%	102
Refusal/Don't Know if in Poverty	6,131							43

¹ All percentages are calculated with the "all HUs" on the left most column of each row as the denominator.

² CI = 95% confidence interval for the estimated number or percent.

³ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁴ Refusals and "don't know" responses by survey respondents.

⁵ "Other" race includes Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

The data also suggest that homes in northeastern and midwestern states are more likely to have LBP than homes in southern or western states. An estimated 55 percent and 53 percent of homes in the Northeast and Midwest have LBP, while the estimates are 27 percent and 32 percent for homes in the South and West, respectively. This finding can be explained by the fact that homes in the Northeast and Midwest are older.

An estimated 5.3 million (± 1.3 million) or 32 percent ($\pm 6\%$) of homes with children under the age of 6 years have lead-based paint, although children are eligible to live in the estimated 38 million homes with lead-based paint. Homes with children under age 6 showed the same relationship between HU age and the presence of LBP as do all homes.

The differences among LBP prevalence by urbanization, single family versus multi-family housing, occupant status, household income, race, ethnicity, and poverty crossed with urbanization do not appear to be significant in that the confidence intervals overlap. Likewise, there were no differences in LBP prevalence when urbanization was crossed by construction year, or one or more children under age 6 was crossed by construction year. Thus, these cross-comparisons are not presented in Table 4.1.

Table 4.2 presents the number of homes with LBP by location in the building – either interior or exterior, or both. About one-half of homes with lead-based paint have it on both interior and exterior surfaces (21% of all homes, or 53% of homes with LBP anywhere in the building).

Table 4.2 Prevalence of Lead-Based Paint (LBP) by Location in the Building

LBP Location	Number of HUs ¹ with LBP (000)			Percent of HUs with LBP (%) ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	8,609	6,102	11,116	9%	6%	12%	77
Both Interior and Exterior	20,260	17,961	22,558	21%	19%	24%	181
Exterior Only	9,028	6,535	11,521	9%	7%	12%	80
<i>Subtotal – LBP anywhere in Building</i>	37,897	34,521	41,272	40%	36%	43%	338
No LBP in Building	57,791	54,624	60,959	60%	57%	64%	493
<i>Total HUs</i>	95,688			100%			831

¹ “Housing units” include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

4.2 Prevalence of Deteriorated Lead-Based Paint

Although there are many homes with LBP, the condition of the paint is important in determining whether a hazard exists. Except during renovations, maintenance, or other activities that could disturb it, intact lead-based paint is believed to pose little immediate risk to occupants. However, significantly deteriorated lead-based paint may present an immediate danger to occupants, especially to young children. Table 4.3 presents the number and percentage of HUs with deteriorated LBP and significantly deteriorated LBP by location in the building - either interior or exterior, or both.

**Table 4.3 Prevalence of Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP)
by Location in the Building**

a. Deteriorated LBP							
Location	Number of HUs¹ with Deteriorated LBP (000)			Percent² of HUs with Deteriorated LBP(%)			HUs in Sample
	Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	4,180	2,851	5,509	4%	3%	6%	39
Both Interior and Exterior	6,236	4,661	7,811	7%	5%	8%	62
Exterior Only	7,009	4,922	9,097	7%	5%	10%	61
Total with Deteriorated LBP	17,425	14,816	19,735	18%	15%	21%	162
No Deteriorated LBP	78,263	75,953	80,572	82%	79%	84%	669
TOTAL	95,688			100%			831
b. Significantly Deteriorated LBP							
Location	Number of HUs¹ with Significant Deteriorated LBP (000)			Percent² of HUs with Significant Deteriorated LBP(%)			HUs in Sample
	Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	2,629	1,692	3,566	3%	2%	4%	28
Both Interior and Exterior	3,487	2,132	4,842	4%	2%	5%	34
Exterior Only	7,518	5,357	9,679	8%	6%	10%	65
Total with Significantly Deteriorated LBP	13,634	10,928	16,341	14%	11%	17%	127
No Significantly Deteriorated LBP	82,053	79,347	84,760	86%	83%	89%	704
TOTAL	95,688			100%			831

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

An estimated 17 million (± 2 million) or 18 percent ($\pm 2\%$) of housing units in the United States have deteriorated LBP. The deteriorated LBP is only on the exterior for approximately 40 percent of the homes with deteriorated LBP. An estimated 14 million (± 3 million) or 14 percent ($\pm 3\%$) of housing units in the United States have *significantly* deteriorated LBP. Roughly 55 percent of these homes have significant deterioration only on exterior surfaces. Twenty percent of these homes have the significantly deteriorated LBP only on interior surfaces.

Table 4.4 presents the number and percentage of housing units with deteriorated and significantly deteriorated LBP by construction year. The data suggest that older homes are more likely to have deteriorated LBP than newer homes. Only 3% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 32% for homes built between 1940 and 1959, and to

56% for homes built before 1940. Only 2% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 25% for homes built between 1940 and 1959, and to 44% for homes built before 1940.

Table 4.4 Distribution of Housing Units (HUs) with Deteriorated and Significantly Deteriorated Lead-Based Paint (LBP) by Construction Year

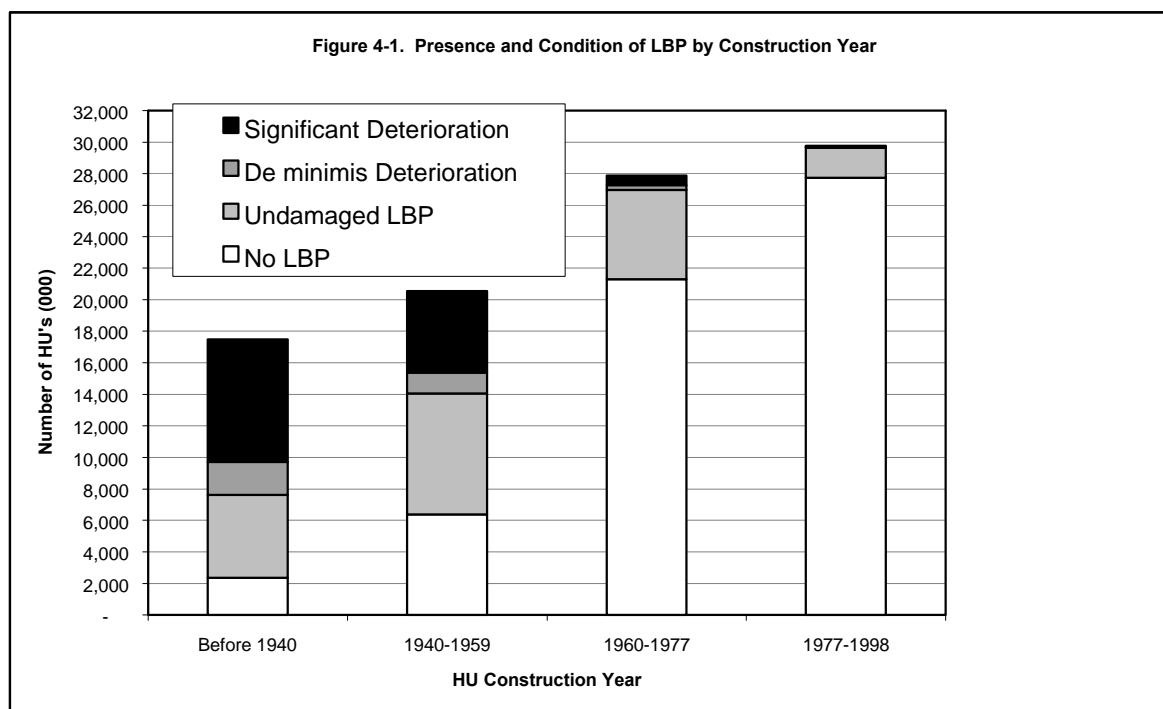
a. Deteriorated LBP							
Construction Year	Total HUs (000)²	Number of HUs with Deteriorated LBP (000)			Percent of HUs with Deteriorated LBP (%)¹		
		Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
1978-1998	29,774	139	0	330	0%	0%	1%
1960-1977	27,874	910	235	1,586	3%	1%	6%
1940-1959	20,564	6,510	4,603	8,418	32%	22%	41%
Before 1940	17,476	9,866	8,111	11,620	56%	46%	66%
Total HUs	95,688	17,425	15,222	19,628	18%	16%	21%
b. Significantly Deteriorated LBP							
Construction Year	Total HUs (000)²	No. of HUs with Significantly Deteriorated LBP (000)			Percent of HUs with Significantly Deteriorated LBP (%)¹		
		Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
1978-1998	29,774	83	0	238	0%	0%	1%
1960-1977	27,874	610	97	1,122	2%	0%	4%
1940-1959	20,564	5,190	3,387	6,993	25%	16%	34%
Before 1940	17,476	7,752	6,048	9,456	44%	35%	54%
Total HUs	95,688	13,635	9,893	16,582	14%	10%	17%

¹ Percentages may not total 100% due to rounding.

² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

³ CI = 95% confidence interval for the estimated number or percent.

Figure 4.1 is a bar chart that summarizes the above survey data on deteriorated and significantly deteriorated LBP by construction year. It graphically displays the downward trends in the prevalence of LBP in homes and of damaged LBP in homes.



4.3 Paint Lead Loadings in Housing

Table 4.5 presents the distribution of the highest lead paint loading by location in the building for selected thresholds: 0.3, 0.6, 0.8, 1.0, 1.3, 4.0, and 10.0 mg/cm². By definition, paint with less than 1.0 mg/cm² is not LBP; thus, the first four categories represent paint that is considered not to be LBP. The majority of the surfaces tested did not contain lead-based paint: In 70 percent of HUs the highest interior readings, and in 69 percent of HUs the highest exterior readings were below 1.0 mg/cm². Fourteen percent of HUs had at least one paint sample with 10 mg/cm² or more of lead-based paint.

Table 4.5 Distribution of Paint Lead Loading by Location in the Building

Maximum Paint Lead Loading in HU ³	Interior (% HUs) ¹			Exterior (% HUs)			Anywhere (% HUs)		
	Estimate	Lower 95% CI ²	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
GT 0 mg/cm ²	100%	100%	100%	100%			100%		
GE 0.3 mg/cm ²	51%	47%	55%	42%	39%	46%	62%	58%	67%
GE 0.6 mg/cm ²	37%	34%	39%	35%	32%	38%	47%	44%	50%
GE 0.8 mg/cm ²	31%	29%	34%	32%	29%	36%	42%	39%	45%
GE 1.0 mg/cm ²	30%	27%	33%	31%	27%	34%	40%	36%	43%
GE 1.3 mg/cm ²	26%	24%	29%	29%	26%	33%	36%	33%	40%
GE 4.0 mg/cm ²	17%	14%	20%	18%	15%	22%	24%	20%	27%
GE 10.0 mg/cm ²	9%	7%	12%	10%	8%	13%	14%	11%	17%
TOTAL HUs	100%			100%			100%		

¹ All percentages are calculated with total housing units (95,688) as the denominator. "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² CI = 95% confidence interval for the estimated number or percent.

³ GT equals "greater than." GE equals "greater than or equal to."

Table 4.6 presents the distribution of paint lead loadings by location in the building and construction year for the selected thresholds. This clearly demonstrates the effectiveness of the reduction from 1940 to 1980 in the amount of lead added to commercial residential paint. An estimated 87 percent of housing reported as built before 1940 had at least one lead measurement somewhere in the house at 1.0 mg/cm², or above. This decreased to 24 percent of housing reported as built between 1960 and 1977, and to 7 percent of housing reported as built since 1978. The same pattern holds for very high lead levels, with 55 percent of pre-1940 homes having some lead above 10 mg/cm² but only 1 percent for post-1977 housing.³⁴ These differences would be even greater but for major paint removals, renovations, demolitions of older houses, and other causes of elimination of old paint.

³⁴ It should be noted that the 1 percent of homes built in 1978-1998 with a maximum paint lead loading above 10.0 mg/cm² may be a result of respondent error in reporting the date of home construction. The year reported by the respondent was never modified.

Table 4.6 Distribution of Paint Lead Loading by Location in the Building and Construction Year

Largest Paint Lead Loading in the Housing Unit	Percent of HUs with LBP ¹⁻²				
	Year of Construction				
	1978-1998	1960-1977	1940-1959	Before 1940	Subtotal
Interior					
GT 0 mg/cm ²	100%	100%	100%	100%	100%
GE 0.3 mg/cm ²	23%	39%	77%	91%	51%
GE 0.6 mg/cm ²	9%	21%	59%	83%	37%
GE 0.8 mg/cm ²	6%	16%	48%	80%	31%
GE 1.0 mg/cm ²	4%	16%	46%	79%	30%
GE 1.3 mg/cm ²	3%	12%	41%	72%	26%
GE 4.0 mg/cm ²	1%	6%	19%	60%	17%
GE 10.0 mg/cm ²	1%	2%	7%	38%	9%
TOTAL	100%	100%	100%	100%	100%
Exterior					
GT 0 mg/cm ²	100%	100%	100%	100%	100%
GE 0.3 mg/cm ²	11%	31%	69%	81%	42%
GE 0.6 mg/cm ²	7%	18%	64%	76%	35%
GE 0.8 mg/cm ²	4%	16%	61%	73%	32%
GE 1.0 mg/cm ²	3%	13%	59%	72%	31%
GE 1.3 mg/cm ²	3%	11%	56%	71%	29%
GE 4.0 mg/cm ²	0%	6%	28%	56%	18%
GE 10.0 mg/cm ²	0%	2%	10%	41%	10%
TOTAL	100%	100%	100%	100%	100%
Anywhere in Building					
GT 0 mg/cm ²	100%	100%	100%	100%	100%
GE 0.3 mg/cm ²	30%	57%	89%	95%	62%
GE 0.6 mg/cm ²	15%	31%	80%	89%	47%
GE 0.8 mg/cm ²	10%	26%	70%	88%	42%
GE 1.0 mg/cm ²	7%	24%	69%	87%	40%
GE 1.3 mg/cm ²	5%	18%	65%	84%	36%
GE 4.0 mg/cm ²	1%	10%	34%	73%	24%
GE 10.0 mg/cm ²	1%	3%	14%	55%	14%
TOTAL	100%	100%	100%	100%	100%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² GT equals "greater than." GE equals "greater than or equal to."

Figures 4.2 through 4.4 are a series of boxplots of the distributions of the paint lead measurements recorded in the survey. Figure 4.2 shows the distribution of the lead in paint measurements by room type: kitchen, common living area (e.g., living room, den), bedroom, other room (e.g., bathroom, office), and exterior.³⁵ Overall, the largest lead in paint readings were taken on the

³⁵ Paint and dust lead loading data is presented in box plot form. Each boxplot shows a univariate data distribution, for example, the dust samples collected from a specific location (e.g., entrance floor). The box in the boxplot represents the middle 50 percent of the data; the bottom of the box gives the 25th percentile; the top gives the 75th percentile; and the horizontal line inside the box gives the median or 50th percentile. The vertical lines extending from the top and bottom of the box reach to the largest and smallest observations, respectively, except for outliers.

exterior of the homes. Of interior rooms, the kitchen had the highest lead in paint readings. Figure 4.3 shows the distribution of the lead in paint measurements by interior component type. The largest interior lead in paint readings were taken on window, door, and trim components. Figure 4.4 shows the distribution of the lead in paint measurements by exterior component type. The largest exterior lead in paint readings were taken on window and other components. The other category included chimneys and miscellaneous painted components purposively selected by the technician in addition to the required components.

Tables 4.7 and 4.8 present selected parameters of the distributions of paint lead loadings by interior and exterior component types, corresponding to the boxplots in Figures 4.2 and 4.3, respectively. Tables 4.7 and 4.8 also present the geometric means and standard deviations. All of the distributions in Tables 4.7 and 4.8 are right-skewed and thus cannot be fitted by normal distributions. A better model would be the lognormal distribution. Chapter 7 includes a discussion of fitting models to these data.

Outliers are not plotted. Data sets approximating a normal distribution will produce a symmetrical boxplot. From this display of the data, it is possible to visually compare lead loadings in all of the sample locations inside the dwellings simultaneously.

Figure 4.2 Box Plots for Paint Lead (XRF) Measurements by Room Type

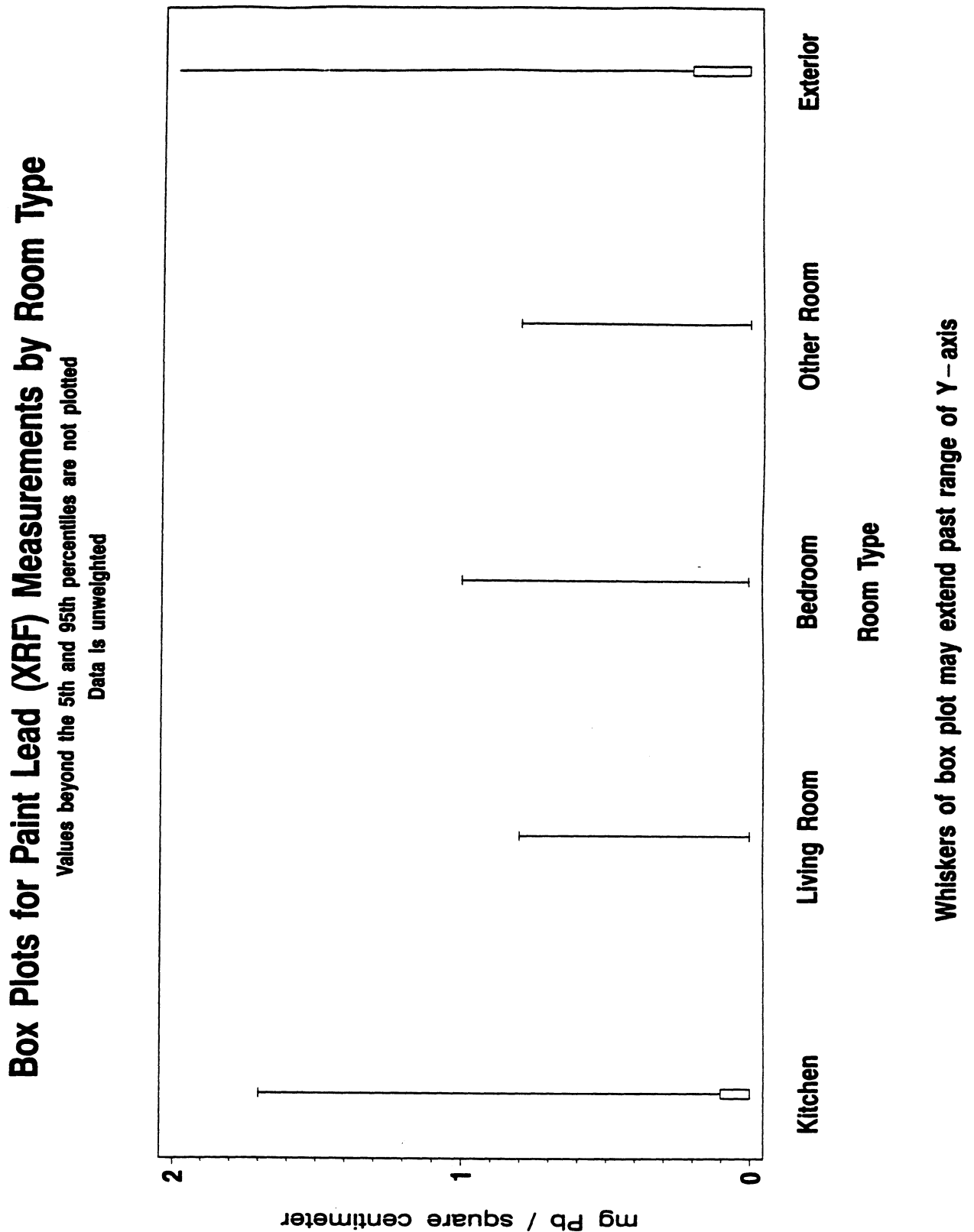


Figure 4.3 Box Plots for Paint Lead (XRF) Measurements by Interior Components

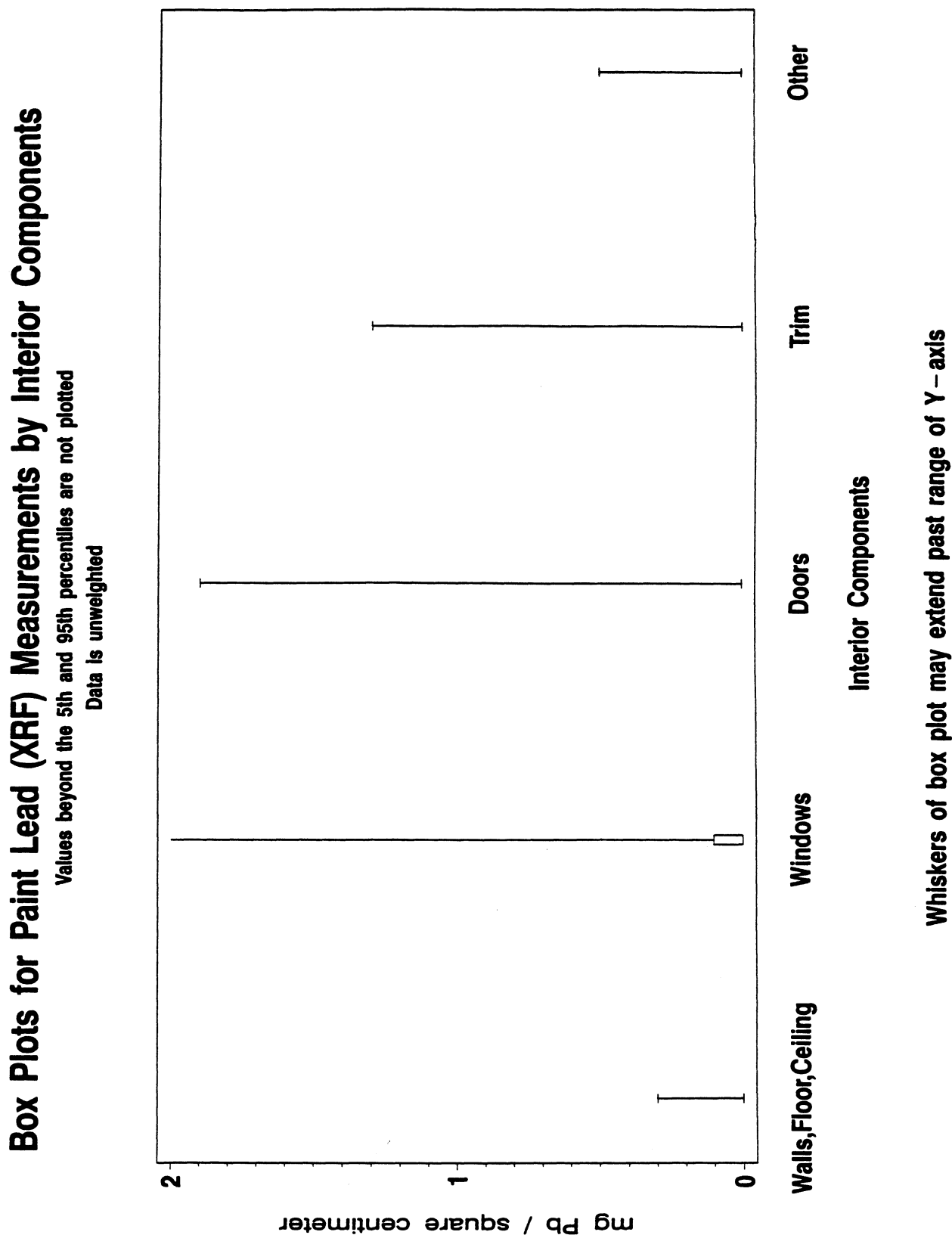


Figure 4.4 Box Plots for Paint Lead (XRF) Measurements by Exterior Components

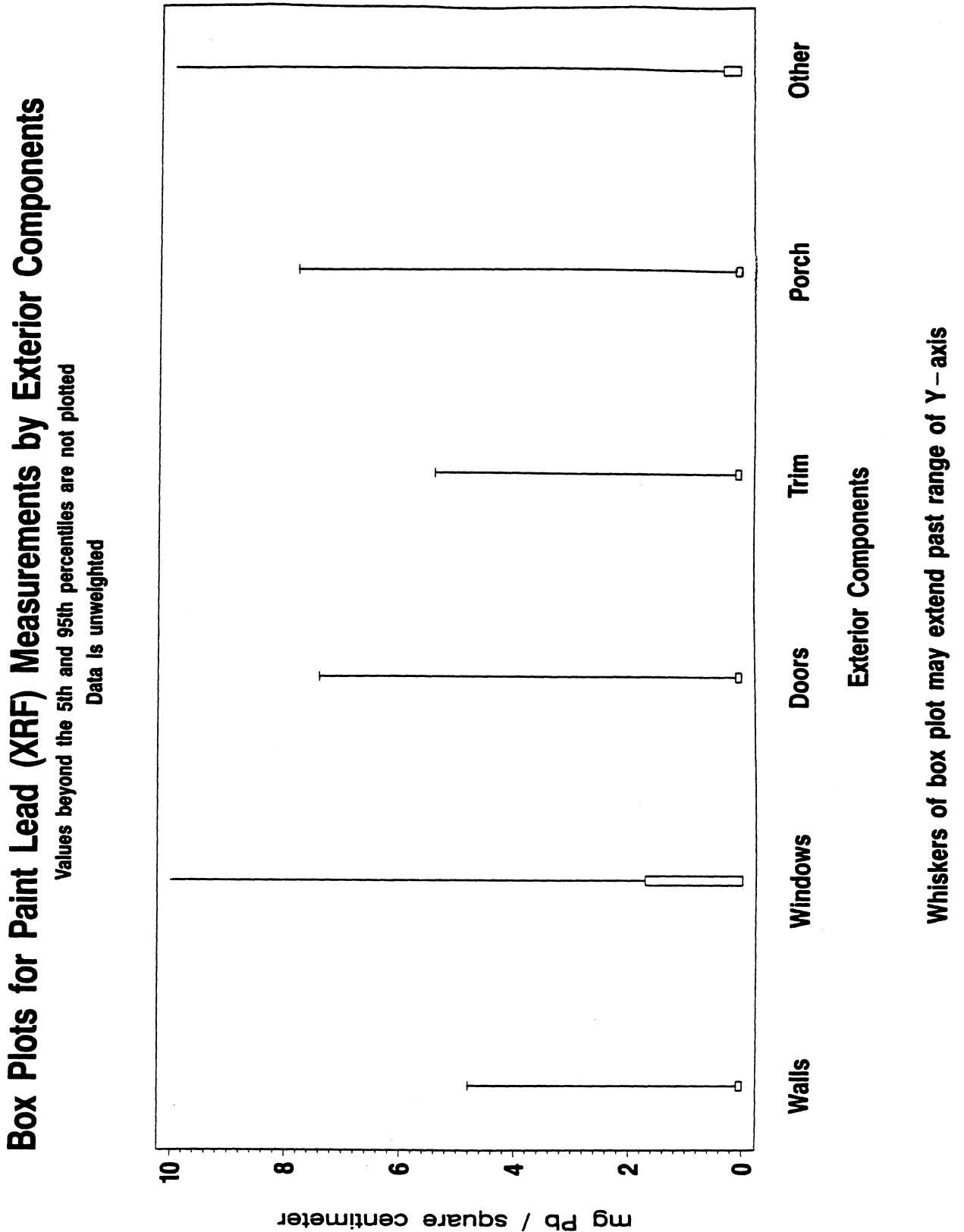


Table 4.7 Estimated Empirical Distribution Parameters of Paint Lead Loadings by Interior Component Types

	Walls, Floors, Ceilings	Windows	Doors	Trim	Other
	mg/cm²	mg/cm²	mg/cm²	mg/cm²	mg/cm²
Arithmetic Mean	0.2	0.9	0.5	0.5	0.4
Arithmetic Standard Deviation	1.5	3.4	2.5	2.3	2.6
25 th Percentile	0.0	0.0	0.0	0.0	0.0
Median	0.0	0.0	0.0	0.0	0.0
75 th Percentile	0.0	0.1	0.0	0.0	0.0
90 th Percentile	0.1	1.3	0.4	0.2	0.2
95 th Percentile	0.3	6.0	1.9	1.4	0.5
Number of Readings	14,876	5,513	4,596	2,578	2,686

The geometric mean and geometric standard deviation are not meaningful due to the large number of zero XRF readings.

Table 4.8 Estimated Empirical Distribution Parameters of Paint Lead Loadings by Exterior Component Types

	Walls	Windows	Doors	Trim	Porch	Other
	mg/cm²	mg/cm²	mg/cm²	mg/cm²	mg/cm²	mg/cm²
Arithmetic Mean	0.9	2.5	1.2	1.1	1.1	1.6
Arithmetic Standard Deviation	3.4	6.2	4.4	4.5	3.9	5.1
25 th Percentile	0.0	0.0	0.0	0.0	0.0	0.0
Median	0.0	0.0	0.0	0.0	0.0	0.0
75 th Percentile	0.1	1.7	0.1	0.1	0.1	0.3
90 th Percentile	1.9	7.7	2.4	1.8	2.2	3.3
95 th Percentile	4.8	15.3	7.4	5.4	7.8	10.7
Number of Readings	2,008	781	1,398	446	698	250

The geometric mean and geometric standard deviation are not meaningful due to the large number of zero XRF readings.

Table 4.9 summarizes the data in Tables 4.7 and 4.8 by presenting the percentage of components with LBP by component type and housing unit age. Table 4.9 shows the expected trends and differences: exterior components are more likely to be leaded than interior components; interior walls are least likely to have LBP; and older homes have more LBP than newer homes.

Table 4.9 Percentage of Components with Lead-Based Paint by Component Type and HU Age

Component Type		Year of Construction			
		1978-1998	1960-1977	1940-1959	Before 1940
Interior	Walls, Floors Ceilings	0%	1%	2%	7%
	Windows	1%	2%	6%	21%
	Doors	0%	1%	7%	22%
	Trim	0%	2%	4%	15%
	Other	0%	1%	2%	12%
Exterior	Walls	0%	9%	18%	34%
	Windows	0%	12%	30%	41%
	Doors	2%	5%	29%	33%
	Trim	3%	8%	16%	24%
	Porch	1%	7%	25%	28%
	Other	0%	8%	37%	37%

4.4 Comparison of Prevalence of Lead-Based Paint (LBP) to the 1990 LBP Survey

Table 4.10 compares the prevalence of LBP and deteriorated LBP found in the National Survey (restricted to pre-1980 construction) with the prevalence found in the 1990 LBP Survey, which was similarly restricted³⁶. The National Survey shows fewer total homes built before 1980. This is partly due to the fact that housing where children could not live was excluded from the current survey. There has also been a loss of homes built before 1980 due to demolition.

Table 4.10 Comparison of the Prevalence of Lead-Based Paint¹ to the 1990 LBP Survey

	1990 LBP Survey		Current National Survey (Pre-1980 HUs)	
	Number (000)	Percent (%)	Number (000)	Percent (%)
Total HUs Built Before 1980	77,177	100%	68,756	100%
HUs with LBP	64,059	83%	34,195	50%
Interior LBP	48,986	63%	26,184	38%
Exterior LBP	56,495	73%	27,373	40%
HUs with Deteriorated LBP ¹	14,354	19%	14,962	22%
Interior Deteriorated LBP	5,596	7%	7,281	11%
Exterior Deteriorated LBP	9,657	13%	11,784	17%

¹ Deteriorated LBP is as defined in the 1995 *Guidelines*.

³⁶ A comparison of the protocols for the two surveys is presented in Appendix B.

A lower percentage of pre-1980 homes were found with LBP during the current National Survey (50% versus 83% found in 1990). This was not unexpected because there has been renovation, remodeling, demolition, and paint removal activities in the intervening years.

The number of homes with LBP was expected to decrease between 1990 and 1999, primarily due to demolition, renovation and remodeling of older homes. For homes built around the same time, the percentage of homes with LBP was also expected to decrease between 1990 and 1999, primarily due to renovation and remodeling of older homes. However, the difference between the 1990 and 1999 survey estimates of the number and percentage of homes with LBP is greater than might be expected from these sources. Factors that might explain the differences include:

- **Demolition.** Demolition of older homes reduces the number of homes with LBP over time.
- **Renovation, Remodeling, and Remediation.** Removal of surfaces with LBP during renovation and remodeling reduces both the number and percentage of homes by age with LBP. Covering (encapsulating) surfaces with LBP reduces the quantity of lead directly accessible to occupants and reduces the XRF reading on the surface. The lower XRF readings result in fewer homes classified as having LBP. Although additional coats of paint are expected to reduce XRF readings, the effect of painting is expected to be small.
- **XRF Models.** XRF measurements from the 1999 survey are more precise than those from the 1990 survey. The less precise XRF instrument used in the 1990 survey was more likely to misclassify a surface as having LBP and thus increases the estimated number of surfaces with LBP.
- **XRF Calibration Procedures.** The calibration of the XRF instrument used for the 1990 survey was checked at paint loadings of 0.6 and 3.0 mg lead per sq.cm. The 1990 XRF readings were recalibrated based on these checks. The calibration of the XRF instrument used for the 1999 survey was checked at paint loadings of 0.0 and 1.0 mg lead per sq.cm. The difference in the calibration procedures and the assumptions required for the re-calibration of the 1990 XRF readings have an unknown effect of the estimated number of homes with LBP.
- **Sample Design.** The two surveys used slightly different criteria and sampling methods for selected the sampled homes. The primary difference being that the 1999 survey excluded homes where children were excluded, some of which may have been included in the 1990 survey.
- **Within-home Data Collection Procedures.** The two surveys had different criteria and procedures for within-home data collection. The 1999 survey collected measurements in more rooms within the sampled homes than the 1990 survey (4 to 6 rooms vs. 2 rooms). Within the sampled rooms the 1999 survey also collected more measurements.

The larger number of measurements in the 1999 survey would tend to increase the number of homes classified as having LBP, other factors being equal, contrary to the observed difference.

- **Sampling Error.** The confidence intervals provide an indication of the expected range of the survey estimates if other samples had been selected.

Approximately the same percentage of homes with LBP had deteriorated LBP in both surveys (22% versus 19% found in 1990). The slight increase in the percentage of homes with deteriorated LBP was expected, because homes are now ten years older. In addition, the definitions of deteriorated LBP were different for the two studies. In the 1990 LBP Survey, deteriorated interior LBP was defined as more than 5 square feet of deteriorated interior lead-based paint, with a similar definition for exterior lead-based paint. Table 4.10 uses the 1995 HUD *Guidelines* definition of deteriorated LBP, as given in Chapter 3, for the comparison.

4.5 Amount of Lead-Based Paint in Housing

Table 4.11 presents estimates of the amounts of LBP by architectural component type. An estimated 7.4 billion square feet of painted interior surfaces are covered with LBP. This represents 2 percent of the area of painted interior surfaces in all homes. Although 2 percent of paint on walls, floors, and ceilings is lead-based, the area of these LBP-coated components accounts for 67 percent of all interior surfaces with LBP.³⁷ Conversely, paint on window and door system components is more likely to contain LBP, but the total surface area of LBP on these components is only 21 percent of the area of all interior painted surfaces.

An estimated 29.2 billion square feet of painted exterior surfaces are covered with LBP. This represents 22 percent of the area of painted exterior surfaces in all homes. Wall siding accounts for most (67%) of the surface area of LBP.

Although a large number of homes have LBP, most of them have relatively small areas of LBP. The average home has 259 square feet of interior LBP and 996 square feet of exterior LBP.

³⁷ For comparison, a room 10 feet by 12 feet with an 8 foot ceiling has a wall area of 352 square feet and a combined wall, ceiling and floor area of 592 square feet.

Table 4.11 Amount of LBP by Painted Component

Component	National Total Amount of LBP		Average Amount LBP Per Housing Unit with LBP (square feet)
	Millions of sq ft	Percent of All Paint on Component	
<i>INTERIOR:</i>			
Wall, Floor, Ceiling	4,993	2%	173
Window	687	9%	24
Door	911	6%	32
Trim	499	5%	17
Cabinets, Chimney, Beams	388	2%	13
TOTAL	7,448	2%	259
<i>EXTERIOR:</i>			
Wall	26,706	18%	912
Window	365	28%	12
Door	446	14%	15
Trim	556	12%	19
Porch	1,086	21%	37
TOTAL	29,159	22%	996

5. DUST LEAD IN HOUSING

Chapter 5 presents estimates of the prevalence of lead-contaminated dust in housing, including the dust lead loadings and the association between interior dust lead and exterior LBP condition. No comparison is made with the dust lead findings of the 1990 LBP Survey because the vacuum technique employed in the earlier study is not comparable to the wipe technique used in the National Survey. All estimates in this chapter are based on the full, weighted sample of 831 housing units.

5.1 Prevalence of Dust Lead in Housing

Table 5.1 presents the prevalence of all homes and homes with one or more children under 6 years of age with a dust lead hazard somewhere in the home,³⁸ as defined by the HUD Lead Safe Housing Rule. The HUD Lead Safe Housing Rule defines a dust lead hazard as greater than or equal to 40 $\mu\text{g}/\text{ft}^2$ lead on floors or 250 $\mu\text{g}/\text{ft}^2$ lead on window sills. There is no longer a hazard level defined for dust lead on window troughs. The earlier HUD 1995 *Guidelines* considered lead in dust to be a hazard when dust on floors had greater than 100 $\mu\text{g}/\text{ft}^2$ lead, dust on window sills had greater than 500 $\mu\text{g}/\text{ft}^2$ lead, or dust on window troughs had greater than 800 $\mu\text{g}/\text{ft}^2$ lead.

Using the HUD Lead Safe Housing Rule definition of dust lead hazard, an estimated 16 percent ($\pm 2\%$ ³⁹) of all homes have a dust lead hazard somewhere in the home, and 3 percent ($\pm 1\%$) of all homes have both a child under 6 years of age and a dust lead hazard.

³⁸ The maximum lead dust loading on any surface tested (floor, window sill, and window trough) in the home was used to determine whether a dust lead hazard existed.

³⁹ All confidence intervals are at the 95 percent level for the estimated number or percent.

Table 5.1 Prevalence of Housing Units with a Dust Lead Hazard Somewhere in the Home

HU Category ¹	Number of HUs (000)			Percent of HUs(%) ²		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
HUs with Lead Dust Hazard	15,468	12,982	17,954	16%	14%	19%
HUs with Children Under 6 Years and Lead Dust Hazard	2,634	1,586	3,682	16%	11%	20%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) or HUs with resident children under age 6 (16,402) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

5.2 Dust Lead Loadings in Housing

Tables 5.2a and 5.2b present information on maximum and average dust loadings, respectively, by surface.

Table 5.2a presents the distribution of maximum dust lead loadings by surface (floor, window sill, and window trough) for all U.S. homes in the target population, for selected threshold values. As for Table 5.1, the estimates are based on the maximum dust lead loading in the home for the particular surface.

Only an estimated 6 percent of all homes have maximum floor dust lead loadings above the HUD Lead Safe Housing Rule interim standard of 40 $\mu\text{g}/\text{ft}^2$.⁴⁰ More homes have a window sill lead dust hazard than have a floor dust hazard. An estimated 14 percent of all homes have sill dust lead loadings above the HUD Lead Safe Housing Rule interim standard hazard of 250 $\mu\text{g}/\text{ft}^2$.⁴¹

⁴⁰ The average analytical detection limit for each wipe sample was 3.5 μg . While detection limits for each surface are area dependent, this corresponds to a detection limit of 3.5 $\mu\text{g}/\text{ft}^2$ for a one square foot floor sample, 7 $\mu\text{g}/\text{ft}^2$ for a typical 3 inch by 24 inch sill sample, or 8 $\mu\text{g}/\text{ft}^2$ for a typical 1 inch by 18 inch trough sample.

⁴¹ From Table 5.2a, the percent of homes with sill dust loadings above 250 $\mu\text{g}/\text{ft}^2$ equals [100% (all homes) - 82% (homes with lead in sill dust below 250 $\mu\text{g}/\text{ft}^2$) - 2% (homes with missing data) - 2% (homes with no sills)] = 14%.

Table 5.2a Distribution of Maximum Dust Lead Loadings by Surface

Maximum Dust Lead Loading in HU ($\mu\text{g}/\text{sq ft}$)	Number of HUs (000) ¹			Percent of HUs (%) ²		
	Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Floors:³						
LT LOD ⁵	38,369	34,302	42,436	40%	36%	44%
GE LOD	57,196	53,147	61,244	60%	56%	64%
GE 5	28,200	24,920	31,481	30%	26%	33%
GE 10	15,964	13,141	18,787	17%	14%	20%
GE 20	8,989	6,871	11,108	9%	7%	12%
GE 40	5,495	3,770	7,220	6%	4%	8%
GE 100	2,426	1,470	3,382	3%	2%	4%
Missing ⁶	123			0%		
Window Sills:						
LT LOD	9,602	7,326	11,879	10%	8%	13%
GE LOD	82,134	78,850	85,418	86%	83%	88%
GE 125	20,338	17,590	23,085	21%	19%	24%
GE 250	13,439	11,516	15,362	14%	12%	16%
GE 500	9,042	7,136	10,949	10%	8%	12%
No sill present in HU ⁷	2,221	848	3,594	2%	1%	4%
Missing ⁶	1,731			2%		
Window Troughs:						
LT LOD	374	0	799	0%	0%	1%
GE LOD	72,638	67,107	78,169	76%	70%	82%
GE 800	36,762	31,270	42,254	38%	33%	44%
No trough present in HU	7,318	5,176	9,459	8%	5%	10%
Missing ⁶	15,358			16%		

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ Floors include both carpeted and uncarpeted floors.

⁴ CI = 95% confidence interval for the estimated number or percent.

⁵ LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

⁶ Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

⁷ "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

An estimated 38 percent of homes have window trough dust lead above the HUD *Guidelines* for hazard of 800 $\mu\text{g}/\text{ft}^2$. This finding supports conclusions from other dust lead studies that suggest window troughs typically have the highest dust lead loadings found in a home.

Table 5.2b presents the distribution of average dust lead loadings by surface (floor, window sill, and window trough) for all U.S. homes in the target population, for selected threshold values. The average dust loading for each surface was determined by simply adding floor, window sill, or window trough dust loadings for each room sampled in each HU and dividing by the number of rooms sampled (unweighted average).⁴² This is not how either the HUD Lead Safe Housing Rule or the 1995 *Guidelines* define a lead dust hazard. Instead, it gives an estimate of whether the entire house has a hazardous level of lead-contaminated dust, as opposed to any one location in the house.

The same trends are observed in Table 5.2b for average dust lead loadings as for the distribution of maximum dust lead loadings in Table 5.2a. However, Table 5.2b shows that fewer homes have carpeted floor dust lead hazards than uncarpeted floor dust hazards (i.e. carpeted floors have lower dust lead loadings – as indicated by the results of the wipe sampling employed in the survey). In fact, the regression modeling suggested that lead loadings on carpeted surfaces were approximately 25 percent lower than smooth and cleanable surfaces and 75 percent lower than uncarpeted surfaces that were not smooth and cleanable (see Figure 7.7)⁴³

Table 5.2c summarizes Tables 5.2a and 5.2b by presenting the percent of homes with a lead dust hazard by surface under the HUD 1995 *Guidelines* and under the HUD Lead Safe Housing Rule based on the maximum and average dust lead loadings.

⁴² For averaging floor samples, only carpeted floor samples and uncarpeted floor samples were combined for the respective average (carpeted or uncarpeted).

⁴³ The regression modeling also suggested that homes with no evidence of cleaning had higher floor and window dust lead loadings (see Figure 7.7 and figure 7.9). Higher window dust lead loadings were suggested for rented homes as compared to owned homes, surfaces that were not smooth and cleanable as compared to smooth surfaces, and windows with vinyl mini-blinds as compared to those without vinyl mini-blinds (see figure 7.9).

Table 5.2b Distribution of Average Dust Lead Loadings by Surface

Average Dust Lead Loading in HU (µg/sq ft)	Number of HUs (000) ¹			Percent of HUs (%) ²		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Floors (Uncarpeted):						
LT LOD ⁴	51,252	47,180	55,323	54%	49%	58%
GE LOD	40,529	36,366	44,693	42%	38%	47%
GE 5	17,291	13,855	20,727	18%	14%	22%
GE 10	8,512	6,348	10,676	9%	7%	11%
GE 20	4,843	3,263	6,423	5%	3%	7%
GE 40	2,449	1,414	3,484	3%	2%	4%
GE 100	966	239	1,694	1%	0%	2%
No Uncarpeted	3,907			4%		
Floors (Carpeted):						
LT LOD ⁴	66,628	63,563	69,694	70%	67%	73%
GE LOD	21,356	18,700	24,012	22%	20%	25%
GE 5	5,806	4,073	7,540	6%	4%	8%
GE 10	2,374	1,488	3,261	3%	2%	3%
GE 20	1,368	674	2,061	1%	1%	2%
GE 40	298	0	634	0%	0%	1%
GE 100	59	0	190	0%	0%	0%
No Carpeted	7,704			8%		
Window Sills:						
LT LOD	12,800	10,201	15,399	13%	11%	16%
GE LOD	78,936	75,462	82,410	83%	80%	85%
GE 125	13,875	11,717	16,033	15%	12%	17%
GE 250	8,287	6,636	9,938	9%	7%	10%
GE 500	4,900	3,611	6,190	5%	4%	7%
No sill present in HU ⁵	2,221	848	3,594	2%	1%	4%
Missing ⁶	1,731			2%		
Window Troughs:						
LT LOD	663	52	1,274	1%	0%	1%
GE LOD	72,349	66,714	77,985	76%	70%	81%
GE 800	16,395	12,827	19,964	17%	13%	21%
No trough present in HU	7,318	5,176	9,459	8%	5%	10%
Missing	15,358			16%		

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.² All percentages are calculated with total housing units (95,688) as the denominator.³ CI = 95% confidence interval for the estimated number or percent.⁴ LT equals "less than." GT equals "greater than." LOD equals "limit of detection."⁵ "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.⁶ Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

Table 5.2c Comparison of Dust Lead Hazards for the HUD 1995 *Guidelines* and the HUD Lead Safe Housing Rule

Surface	Estimate of HUs (%) with a Dust Lead Hazard - based on Maximum Dust Loading		Estimate of HUs (%) with a Dust Lead Hazard - based on Average Dust Loading in HU	
	HUD 1995 <i>Guidelines</i>	HUD Lead Safe Housing Rule	HUD 1995 <i>Guidelines</i>	HUD Lead Safe Housing Rule
Floor	2%	6%	1%	3%
Window sill	9%	14%	5%	13%
Window trough	22%	NA	17%	NA

NA – Not applicable

Table 5.3 presents the distribution of dust lead loadings by room type and surface for selected threshold values. The vast majority of floors had undetectable levels of dust lead. About 1 percent of rooms had dust lead levels above the HUD Lead Safe Housing Rule standard for floors. Five percent of rooms had dust lead levels above the Lead Safe Housing Rule standard for window sills.

Tables 5.4a through 5.4c present floor, window sill, and window trough dust lead loading, respectively, by selected thresholds and by year of construction. It is evident that older homes have considerably more dust lead than newer homes. The percentage of homes over the Rule standard of 40 $\mu\text{g}/\text{sq ft}$ for floor dust (Table 5.4a) increases from less than 1 percent for post-1977 homes to 16 percent for pre-1940 homes. The percentage of homes over the sill dust guidelines (Table 5.4b) steadily increases from 4 percent for post-1977 homes to 14 percent for 1940-1959 homes to 40 percent for pre-1940 homes.

Table 5.3 Distribution of Dust Lead Loading by Room and Surfaces

Dust Lead Loading (µg/sq ft) ¹	Kitchens		Living Rooms		Bedrooms		Other Rooms	
	Number of Rooms (000) ²	Percent of Rooms (%) ³	Number of Rooms (000)	Percent of Rooms (%)	Number of Rooms (000)	Percent of Rooms (%)	Number of Rooms (000)	Percent of Rooms (%)
Floors⁴								
LT LOD ⁵	63,244	66%	98,433	78%	170,153	78%	231,924	73%
GE LOD	31,633	33%	26,732	21%	45,915	21%	84,438	27%
GE 5	14,062	15%	9,863	8%	19,340	9%	34,291	11%
GE 10	5,568	6%	4,287	3%	10,612	5%	18,933	6%
GE 20	2,571	3%	1,824	1%	4,175	2%	10,626	3%
GE 40	712	1%	880	1%	1,593	1%	7,477	2%
GE 100	335	0%	170	0%	1,354	1%	785	0%
Missing ⁶	488	1%	1,737	1%	1,002	1%	2,594	1%
<i>Total Rooms</i>	95,365	100%	126,902	100%	217,069	100%	318,956	100%
Window Sills								
LT LOD	23,001	24%	29,378	23%	38,394	18%	44,841	14%
GE LOD	50,393	53%	72,154	57%	140,748	65%	141,008	44%
GE 125	7,037	7%	10,937	9%	20,393	9%	23,472	7%
GE 250	4,329	5%	6,731	5%	11,075	5%	17,156	5%
GE 500	2,455	3%	4,386	4%	6,661	3%	10,096	3%
Missing	3,870	4%	5,462	4%	17,993	8%	16,321	5%
No Sills	18,102	19%	19,907	16%	19,934	9%	116,785	37%
<i>Total Rooms</i>	95,365	100%	126,902	100%	217,069	100%	318,956	100%
Window Troughs								
LT LOD	3,293	4%	4,125	3%	5,211	2%	6,657	2%
GE LOD	49,962	52%	64,827	51%	122,752	57%	119,236	37%
GE 800	9,249	10%	12,795	10%	23,268	11%	21,487	7%
Missing	16,542	17%	27,537	22%	57,738	27%	58,044	18%
No Trough	25,568	27%	30,413	24%	31,368	15%	135,019	42%
<i>Total Rooms</i>	95,365	100%	126,902	100%	217,069	100%	318,956	100%

¹ In this table, maximum loading is not applicable as only one dust sample was collected from each surface in each room.

² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

³ All percentages are calculated with total rooms of that type as the denominator.

⁴ Floors include both carpeted and uncarpeted floors.

⁵ LT equals "less than." GE equals "greater than or equal to." LOD equals "limit of detection."

⁶ Missing means that the floor, sill, or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

Table 5.4a Maximum Floor Dust Lead Loading by Year of Construction

Maximum Floor Dust Lead Loading($\mu\text{g}/\text{sq ft}$) ¹		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%) ²	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD ³	Number HUs ⁴	17,487	59%	13,006	47%	5,667	28%	2,208	13%
	Lower 95% CI ⁵	15,646	53%	10,272	38%	4,076	20%	782	4%
	Upper 95% CI	19,329	65%	15,740	56%	7,257	35%	3,635	21%
GE LOD	Number HUs	12,241	41%	14,868	53%	14,820	72%	15,268	87%
	Lower 95% CI	10,419	35%	12,454	44%	12,770	65%	13,008	79%
	Upper 95% CI	14,064	47%	17,281	62%	16,869	80%	17,527	96%
GE 5	Number HUs	3,233	11%	4,968	18%	8,753	43%	11,245	64%
	Lower 95% CI	2,285	8%	3,567	13%	7,060	35%	9,635	55%
	Upper 95% CI	4,181	14%	6,370	23%	10,446	50%	12,855	73%
GE 10	Number HUs	1,153	4%	2,488	9%	4,938	24%	7,386	42%
	Lower 95% CI	370	1%	1,607	6%	3,447	17%	5,802	33%
	Upper 95% CI	1,935	7%	3,369	12%	6,428	31%	8,970	52%
GE 20	Number HUs	97	0%	1,112	4%	2,784	14%	4,996	29%
	Lower 95% CI	0	0%	516	2%	1,283	6%	3,759	22%
	Upper 95% CI	267	1%	1,708	6%	4,286	21%	6,234	35%
GE 40	Number HUs	97	0%	588	2%	1,967	10%	2,843	16%
	Lower 95% CI	0	0%	216	1%	718	4%	1,989	11%
	Upper 95% CI	267	1%	961	4%	3,215	16%	3,698	21%
GE 100	Number HUs	97	0%	280	1%	935	5%	1,114	6%
	Lower 95% CI	0	0%	0	0%	121	1%	587	3%
	Upper 95% CI	267	1%	640	2%	1,750	9%	1,642	9%
Missing	Number HUs	0	0%	0	0%	77	0%	0	0%

¹ Floors include both carpeted and uncarpeted floors.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ LT equals “less than.” GE equals “greater than or equal to.” LOD equals “limit of detection.”

⁴ “Housing units” include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ CI = 95% confidence interval for the estimated number or percent.

Table 5.4b Maximum Window Sill Dust Lead Loading by Year of Construction

Maximum Floor Dust Lead Loading($\mu\text{g}/\text{sq ft}$) ¹		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%) ²	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD ³	Number HUs ⁴	6,196	21%	1,924	7%	1,074	5%	408	2%
	Lower 95% CI ⁵	4,270	14%	826	3%	277	1%	0	0%
	Upper 95% CI	8,122	27%	3,021	11%	1,871	9%	835	5%
GE LOD	Number HUs	21,823	73%	24,729	89%	18,779	91%	16,803	96%
	Lower 95% CI	19,833	68%	22,996	84%	16,956	87%	15,103	93%
	Upper 95% CI	23,814	79%	26,462	94%	20,602	96%	18,503	99%
GE 125	Number HUs	1,806	6%	4,097	15%	5,407	26%	9,028	52%
	Lower 95% CI	578	2%	2,444	9%	3,954	19%	7,196	42%
	Upper 95% CI	3,033	10%	5,749	21%	6,860	33%	10,861	61%
GE 250	Number HUs	1,029	4%	1,755	6%	3,712	18%	6,943	40%
	Lower 95% CI	139	1%	1,086	4%	2,556	12%	5,476	31%
	Upper 95% CI	1,919	7%	2,424	9%	4,867	24%	8,410	48%
GE 500	Number HUs	447	2%	747	3%	2,869	14%	4,980	29%
	Lower 95% CI	0	0%	274	1%	1,779	9%	3,712	21%
	Upper 95% CI	1,024	3%	1,219	4%	3,959	19%	6,247	36%
Missing	Number HUs	299	1%	851	3%	361	2%	220	1%
No sills	Number HUs	1,456	5%	371	1%	349	2%	45	0%
	Lower 95% CI	456	2%	0	0%	0	0%	0	0%
	Upper 95% CI	2,456	8%	762	3%	730	4%	143	1%

¹ Missing means that the sill was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill present" means that there was no sill in the HU, e.g., windows were flush with the wall, or awning windows were installed.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

⁴ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ CI = 95% confidence interval for the estimated number or percent.

Table 5.4c Maximum Window Trough Dust Lead Loading by Year of Construction

Maximum Window Trough Dust Lead Loading ($\mu\text{g}/\text{sq ft}$) ¹		Year of Construction							
		1978-1998		1960-1977		1940-1959		Before 1940	
		Number (000)	Percent (%) ²	Number (000)	Percent (%)	Number (000)	Percent (%)	Number (000)	Percent (%)
LT LOD ³	Number HUs ⁴	280	1%	94	0%	0	0%	0	0%
	Lower 95% CI ⁵	0	0%	0	0%	0	0%	0	0%
	Upper 95% CI	681	2%	235	1%	0	0%	0	0%
GE LOD	Number HUs	20,969	70%	20,319	73%	16,406	80%	14,943	86%
	Lower 95% CI	17,718	60%	17,730	64%	14,638	73%	13,192	80%
	Upper 95% CI	24,221	81%	22,909	82%	18,174	86%	16,694	91%
GE 800	Number HUs	2,252	8%	3,788	14%	6,286	31%	8,883	51%
	Lower 95% CI	1,032	4%	2,504	9%	4,500	21%	7,084	41%
	Upper 95% CI	3,473	12%	5,072	18%	8,073	40%	10,683	61%
Missing	Number HUs	4,184	14%	5,885	21%	2,966	14%	2,322	13%
No troughs	Number HUs	4,341	15%	1,576	6%	1,191	6%	210	1%
	Lower 95% CI	2,380	8%	732	3%	368	2%	0	0%
	Upper 95% CI	6,301	21%	2,419	9%	2,014	10%	451	3%

¹ Missing means that the trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No trough present" means that there was no trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

² All percentages are calculated with total housing units of that age as the denominator.

³ LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

⁴ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live

⁵ CI = 95% confidence interval for the estimated number or percent.

Tables 5.5a through 5.5c present floor, window sill, and window trough dust loading distributions by household income level. There are some significant differences shown in the table. A greater percent of homes in the higher income level have lower lead dust loadings. For example, 47 percent of higher income homes have lead dust loadings below the limit of detection, while only 29 percent of homes in the lower income level have loading below the limit of detection. Only 1 percent of homes in the higher household income level exceed 100 $\mu\text{g}/\text{ft}^2$ floor dust lead loading, while 5 percent of lower income level homes exceed this loading. Similar trends are observed for window sill and trough dust loadings.

Although the data have not been presented, there were no apparent differences between urbanization categories and dust lead loadings.

Table 5.5a Maximum Floor Dust Lead Loadings by Household Income

Maximum Floor Dust Lead Loading(mg/sq ft) ¹		Household Income			
		Less than \$30,000/year		Equal to or above \$30,000/year	
		Number (000)	Percent (%) ²	Number (000)	Percent (%)
LT LOD ³	Number HUs ⁴	9,747	29%	26,508	47%
	Lower 95% CI ⁵	6,944	23%	22,360	42%
	Upper 95% CI	12,550	35%	30,657	53%
GE LOD	Number HUs	24,038	71%	29,525	53%
	Lower 95% CI	19,932	65%	26,065	47%
	Upper 95% CI	28,143	77%	32,985	58%
GE 5	Number HUs	13,364	40%	13,215	24%
	Lower 95% CI	10,562	32%	10,859	20%
	Upper 95% CI	16,166	47%	15,571	27%
GE 10	Number HUs	8,276	25%	6,792	12%
	Lower 95% CI	6,219	19%	5,052	9%
	Upper 95% CI	10,332	30%	8,532	15%
GE 20	Number HUs	4,282	13%	4,135	7%
	Lower 95% CI	3,117	9%	2,782	5%
	Upper 95% CI	5,447	17%	5,488	10%
GE 40	Number HUs	2,819	8%	2,170	4%
	Lower 95% CI	1,710	5%	924	2%
	Upper 95% CI	3,927	12%	3,415	6%
GE 100	Number HUs	1,637	5%	435	1%
	Lower 95% CI	728	2%	57	0%
	Upper 95% CI	2,546	8%	813	1%
Missing	Number HUs	46	0%	77	0%

¹ Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value).

² All percentages are calculated with total housing units in that income class as the denominator.

³ LT equals “less than.” GT equals “greater than or equal to.” LOD equals “limit of detection.”

⁴ “Housing units” include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ CI = 95% confidence interval for the estimated number or percent.

Table 5.5b Maximum Window Sill Lead Dust Loadings by Household Income

Window Sill Dust Lead Loading(mg/sq ft) ¹		Household Income			
		Less than \$30,000/year		Equal to or Above \$30,000/year	
		Number (000)	Percent ²	Number (000)	Percent
LT LOD ³	Number HUs ⁴	1,448	4%	7,111	13%
	Lower 95% CI ⁵	376	1%	5,291	9%
	Upper 95% CI	2,520	7%	8,931	16%
GE LOD	Number HUs	29,948	89%	47,597	85%
	Lower 95% CI	24,656	84%	42,665	81%
	Upper 95% CI	35,241	93%	52,528	89%
GE 125	Number HUs	10,322	31%	8,865	16%
	Lower 95% CI	7,909	26%	6,896	13%
	Upper 95% CI	12,735	36%	10,835	19%
GE 250	Number HUs	7,671	23%	4,772	9%
	Lower 95% CI	5,776	18%	3,611	7%
	Upper 95% CI	9,565	28%	5,933	11%
GE 500	Number HUs	4,395	13%	3,893	7%
	Lower 95% CI	2,943	9%	2,773	5%
	Upper 95% CI	5,846	17%	5,014	9%
Missing	Number HUs	1,137	3%	594	1%
No sills	Number HUs	1,297	4%	809	1%
	Lower 95% CI	250	1%	151	0%
	Upper 95% CI	2,345	7%	1,466	3%

¹ Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

² All percentages are calculated with total housing units in that income class as the denominator.

³ LT equals "less than." GT equals "greater than or equal to." LOD equals "limit of detection."

⁴ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ CI = 95% confidence interval for the estimated number or percent.

Table 5.5c Maximum Window Trough Lead Dust Loadings by Household Income

Maximum Window Trough Dust Lead Loading(mg/sq ft) ¹		Household Income			
		Less than \$30,000/year		Equal to or Above \$30,000/year	
		Number (000)	Percent ²	Number (000)	Percent
LT LOD ³	Number HUs ⁴	59	0%	315	1%
	Lower 95% CI ⁵	0	0%	0	0%
	Upper 95% CI	180	1%	723	1%
LT 800	Number HUs	25,985	77%	42,253	75%
	Lower 95% CI	21,486	70%	37,300	69%
	Upper 95% CI	30,485	84%	47,205	81%
GE 800	Number HUs	9,449	28%	10,623	19%
	Lower 95% CI	6,742	20%	8,067	15%
	Upper 95% CI	12,156	36%	13,179	23%
Missing	Number HUs	5,624	17%	8,788	16%
No troughs	Number of HUs	2,162	6%	4,755	9%
	Lower 95% CI	869	3%	3,009	5%
	Upper 95% CI	3,456	10%	6,501	12%

¹ Missing means that the sill or trough was present, but that no lead value is available (either the sample was not collected, e.g., due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No sill/trough present" means that there was no sill or trough in the HU, e.g., windows were flush with the wall, or awning windows were installed.

² All percentages are calculated with total housing units in that income class as the denominator.

³ LT equals "less than." "GE equals "greater than or equal to." LOD equals "limit of detection."

⁴ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

⁵ CI = 95% confidence interval for the estimated number or percent.

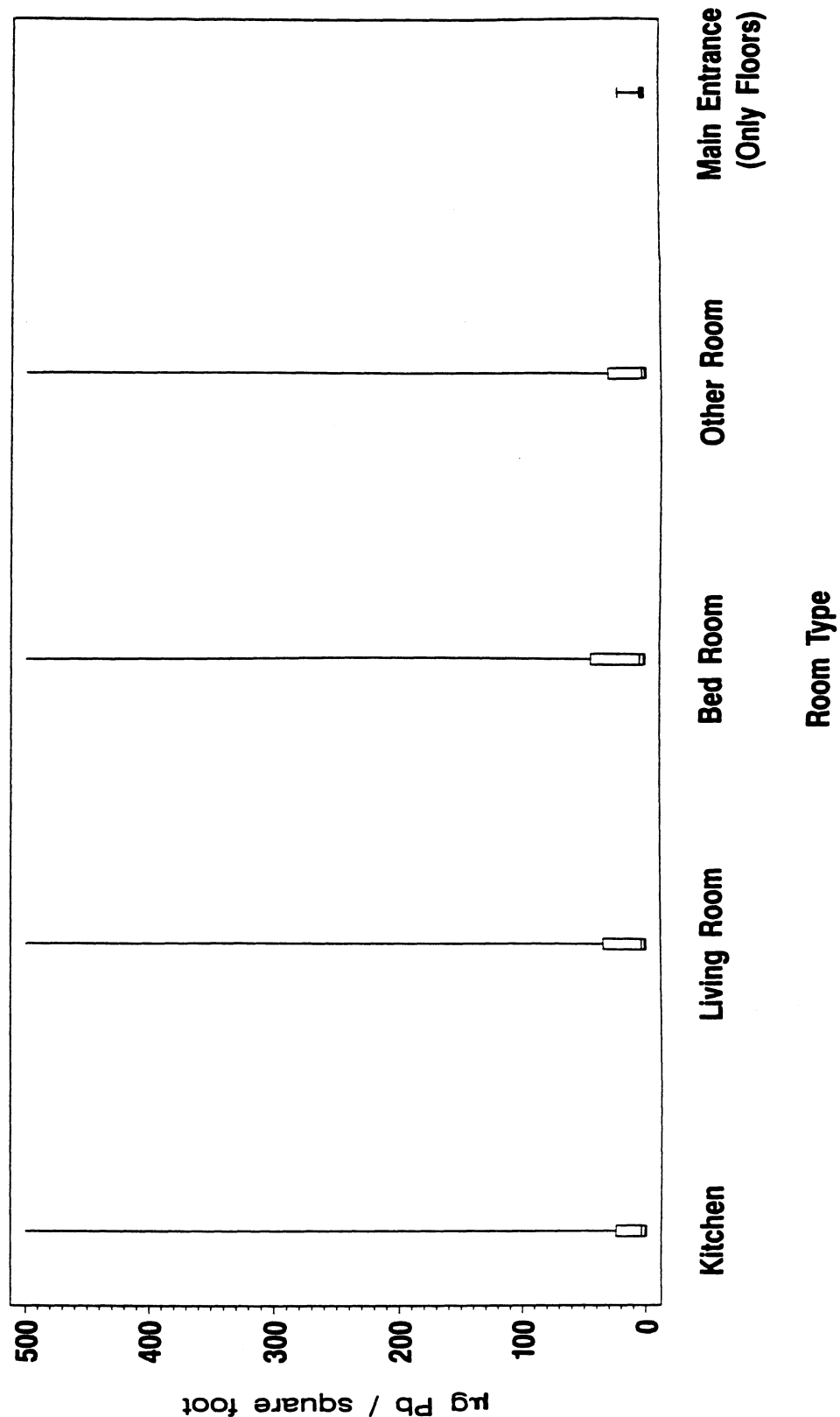
Figure 5.1 shows the distribution of the dust lead loadings by room type: kitchen, common living area, bedroom, and other room. Figure 5.2 shows the distribution of the dust lead measurements by surface and carpet. In both figures, the distributions are extremely right-skewed. None of the boxes extend above 40 $\mu\text{g}/\text{ft}^2$, which means that the 75th percentile is less than 40 $\mu\text{g}/\text{ft}^2$. However, there are dust lead loadings well above 100 $\mu\text{g}/\text{ft}^2$. On troughs, they extend above 1,000 $\mu\text{g}/\text{ft}^2$ (not shown due to truncation of the vertical axis).

Table 5.6 presents selected parameters of the distributions of dust lead loadings by surface types, corresponding to the boxplots in Figure 5.2. Table 5.6 also presents geometric means and standard deviations. The distributions in Table 5.6 are all right-skewed, so that they are not normally distributed. A better model would be the lognormal distribution. Chapter 7 includes a discussion of distributional models for these data.

Figure 5.1 Box Plots for Dust Lead Loadings by Room

Box Plots for Dust Lead Loadings by Room

Values beyond the 5th and 95th percentiles are not plotted
Data is unweighted



Whiskers of box plot may extend past range of Y - axis

Figure 5.2 Box Plots for Dust Lead Loadings by Surface

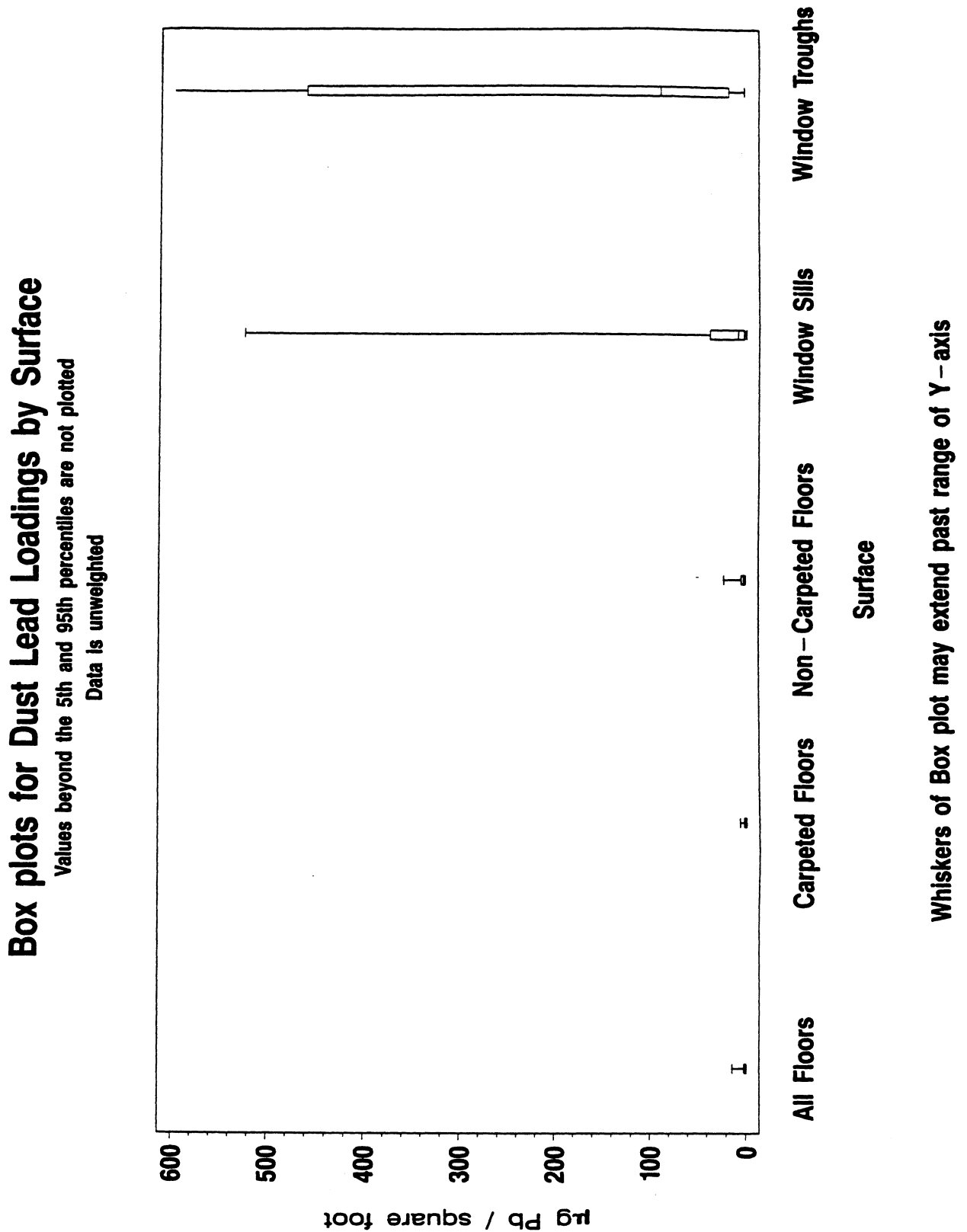


Table 5.6 Estimated Empirical Distribution Parameters of Dust Lead Loadings by Surface Types

	Floors	Window Sills	Window Troughs
	mg/ft ²	mg/ft ²	mg/ft ²
Arithmetic Mean	13.6	194.9	1,990.9
Arithmetic Standard Deviation	483.5	1682.7	12,086.5
Geometric Mean	1.1	9.4	96.4
Geometric Standard Deviation ¹	3.8	9.3	14.4
25 th Percentile	.375	2.0	18.0
Median	0.9	8.3	89.1
75 th Percentile	2.0	37.13	462.0
90 th Percentile	6.0	172.8	2,824.2
95 th Percentile	13.2	524.9	6,974.6
Number of Samples	3,894	2,302	1,607

¹ The geometric standard deviation is computed as $\exp(s)$, where s is the arithmetic standard deviation of the natural logarithms of the loadings (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company New York).

For this table, zero and negative values were set to 0.375.

5.3 Association between Interior Dust Lead Hazards and LBP Condition

Table 5.7 presents the prevalence of interior dust lead hazards in relation to the condition of the interior LBP. Dust lead hazards are more likely to exist in homes with deteriorated LBP. An estimated 61 percent of homes with significantly deteriorated LBP have lead dust hazards, while only 33 percent of homes with LBP in good condition have lead dust hazards. Only 4 percent of homes with no interior LBP have lead dust hazards. Although it appears from the data that the presence of LBP, especially significantly deteriorated LBP, contributes to higher dust lead hazard, there are additional sources of lead in the environment to account for dust lead in homes with no lead-based paint.

Table 5.7 allows one to compare the relative risks (with 95 percent confidence intervals on that risk) of interior lead dust hazards associated with different paint conditions. The presence of significantly deteriorated LBP makes a house 1.8 (± 0.5) times as likely to have an interior lead dust hazard compared to a house where the LBP is in good condition, and 10.0 (± 1.9) times as likely as a house without LBP. Even a house with LBP in good condition is 5.4 (± 0.8) times as likely to have interior lead dust hazards as one without any LBP.

Table 5.7 Association Between Dust Lead Hazards and Presence and Condition of Interior Lead-based Paint

All HU Ages							
		No Interior LBP		Interior LBP in Good Condition		Significantly Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Estimate ¹	62,752	94%	15,244	67%	2,389	39%
	Lower 95% CI ²	60,141	90%	12,633	56%	1,565	26%
	Upper 95% CI	65,363	98%	17,855	78%	3,213	53%
Interior Dust Lead Hazards	Estimate	4,068	6%	7,508	33%	3,727	61%
	Lower 95% CI	2,584	4%	6,024	26%	2,505	41%
	Upper 95% CI	5,552	8%	8,992	40%	4,949	81%
Total HUs		66,820	100%	22,752	100%	6,116	100%

¹ Estimate is either the number of permanently occupied, noninstitutional housing units (000) in which children are permitted to live, or the percentage of total housing units.

² CI = 95% confidence interval for the estimated number or percent.

6. RESIDENTIAL SOIL LEAD

Chapter 6 presents estimates of the prevalence of soil lead by lead concentration, and the association between soil lead concentration and exterior lead-based paint condition. Relevant estimates are compared with the findings of the 1990 LBP Survey. The prevalence of soil lead hazards in housing is presented in Chapter 3. Since soil lead hazards include lead in soil in children's play areas, most estimates in this Chapter are based on the subsample of 375 homes with data on the presence or absence of children's play areas in the yards and on the extent of soil lead hazards in children's play areas. A few tables in this chapter may be independent of the presence or absence of lead-contaminated soil in children's play areas; such tables are therefore based on the full sample and have a footnote indicating that the basis is the full sample

6.1 Prevalence of Residential Soil Lead, All Sampled Locations

A composite soil sample was collected at each of five sites on the property of each dwelling unit: 1) near the most commonly used entrance, 2) the dripline and 3) the mid-yard line of the wall with the main entrance, and 4) the dripline and 5) mid-yard line of a second, randomly-selected wall. The main entrance sample was a composite sample of two cores from the main entrance area. The dripline and mid-yard samples on each wall were composite samples from three locations along the length of the sample site. In addition soil samples were collected from children's play areas for a subsample of homes. At each of these homes, up to four samples were collected from children's play equipment, when present; otherwise, one sample was collected from an area of the yard identified as being where children play. *The tables in this section and in Section 6.2 are based on the lead concentration data from all of these soil samples, referenced as "all sampled locations".* Section 6.3 then presents data on soil lead concentrations in *children's play areas*, while Section 6.4 presents corresponding data for the "*rest of the yard*", i.e., areas not identified as children's play areas.

Table 6.1 presents the number and percentage of HUs by selected soil lead concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. Table 6.1 includes all soil, whether bare or covered, and all sampled locations, both play areas and all other locations. An estimated 78 percent ($\pm 6\%$) of homes have soil lead levels above the limit of detection.⁴¹ An estimated 21 percent

⁴¹ The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA SW 840 Method 3050 procedures.

($\pm 4\%$)⁴² of homes have soil lead levels above 400 ppm, and 12% ($\pm 3\%$) have soil lead levels above 1,200 ppm. Only 7 percent of homes were found to have soil lead above 2,000 ppm. The maximum soil values for each HU have been used in Table 6.1. The effect of using the average soil lead for each HU would drive the distribution towards the lower thresholds, i.e. more homes have lower average soil lead concentrations.

Table 6.1 Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations, All Sampled Locations

Soil Lead	Number of HUs (000) ¹			Percent of HUs (%) ²		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
GE ⁴ 0 ppm	93,111	91,090	95,131	97%	95%	99%
GE 20 ppm	74,621	68,764	80,478	78%	72%	84%
GE 50 ppm	56,266	49,840	62,693	59%	52%	66%
GE 200 ppm	29,234	28,240	30,228	31%	30%	32%
GE 400 ppm	20,390	17,032	23,748	21%	18%	25%
GE 1,200 ppm	11,145	7,580	14,709	12%	8%	15%
GE 1,600 ppm	7,426	5,289	9,563	8%	6%	10%
GE 2,000 ppm	6,809	4,535	9,084	7%	5%	10%
GE 5,000 ppm	2,987	1,548	4,427	3%	2%	5%
Missing ⁵	335	0	960	0%	0%	1%
No Soil	2,242	330	4,154	2%	0%	4%
Total	95,688					

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ "Missing" means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

Care is to be exercised in comparing the tables in this Chapter with Tables 3.3 and 3.6, which tabulate the prevalence of soil lead hazards. The tables in this chapter present the distribution of residential soil lead concentrations at selected locations, while soil lead hazards are defined in terms of soil lead concentrations in two types of locations. Specifically, a housing unit is defined to have a soil lead hazard if soil lead concentrations exceed 400 ppm in play areas or exceed 2,000 ppm in the rest of the yard. Thus, the tables in this section do not directly compare with Tables 3.3 and 3.6.

⁴² All confidence intervals are at the 95 percent level for the estimated number or percentage.

Table 6.2 presents the number and percentage of HUs by selected soil lead concentration thresholds for bare soil only, but still for all sampled locations. Three percent of homes were found to have bare soil lead above the HUD Lead Safe Rule soil lead hazard of 2,000 ppm, while seven percent are above the EPA Section 403 rule threshold of 1,200 ppm.

Table 6.2 Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentrations, All Sampled Locations

Bare Soil Lead	Number of HUs (000) ¹			Percent of HUs (%) ²		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
GE ⁴ 0 ppm	77,888	72,054	83,722	81%	75%	88%
GE 20 ppm	55,114	47,348	62,881	58%	50%	66%
GE 50 ppm	40,023	31,365	48,680	42%	33%	51%
GE 200 ppm	15,299	11,626	18,971	16%	12%	20%
GE 400 ppm	9,996	6,398	13,594	10%	7%	14%
GE 1,200 ppm	6,271	2,733	9,809	7%	3%	10%
GE 1,600 ppm	3,900	1,670	6,131	4%	2%	6%
GE 2,000 ppm	3,124	827	5,420	3%	1%	6%
GE 5,000 ppm	1,580	(148)	3,309	2%	0%	4%
No Bare Soil	15,413	9,789	21,037	16%	10%	22%
No Soil	2,242	330	4,154	2%	0%	4%
Missing ⁵	145	(238)	527	0%	0%	1%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ "Missing" means that soil was present, but that no lead value is available (either the sample was not collected, e.g. due to inaccessibility or respondent refusal, or the laboratory did not submit a value). "No soil" means that there was no soil on the property to sample.

Table 6.3 presents the number and percentage of housing units by construction year for selected soil lead concentration thresholds for all soil, whether bare or covered, and for all sampled locations. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, only 9 percent of home built between 1960 and 1977 have soil lead above 400 ppm, while this is the case for 67 percent of pre-1940 homes. Thus, the data suggest that older homes have higher soil lead concentrations than new homes.

Table 6.3 Distribution of Maximum Soil Sample (Bare and Covered) Lead Concentrations by Construction Year, All Sampled Locations

Soil Lead Concentration	Number of HUs (000) ¹				Percent of HUs (%) ²			
	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998
GE ³ 0 ppm	16,328	19,605	27,608	29,569	93%	95%	99%	99%
GE 20 ppm	16,328	19,279	25,238	13,776	93%	94%	91%	46%
GE 50 ppm	15,820	17,670	14,092	8,684	91%	86%	51%	29%
GE 200 ppm	13,314	9,950	4,495	1,476	76%	48%	16%	5%
GE 400 ppm	11,613	6,283	2,410	84	67%	31%	9%	0%
GE 1,200 ppm	6,536	3,922	686	-	37%	19%	3%	0%
GE 1,600 ppm	4,455	2,284	686	-	26%	11%	3%	0%
GE 2,000 ppm	3,929	2,194	686	-	23%	11%	3%	0%
GE 5,000 ppm	1,891	865	231	-	11%	4%	1%	0%
Missing ⁴	145	-	190	-	1%	0%	1%	0%
No soil	1,003	939	95	205	6%	5%	0%	1%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units of that age as the common denominator.

³ GE equals "greater than or equal to."

⁴ "Missing" means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).
"No soil" means that there was no soil on the property to sample.

Table 6.4 presents the number and percentage of housing units by construction year for selected soil lead concentration thresholds for bare soil only, again for all sampling locations. As seen above for all soil, as the soil lead threshold increases, the number of newer homes meeting the criteria for bare soil decreases faster than the older homes. In fact, practically no newer homes (1960-1998) have lead in bare soil above 1,200 ppm, and less than 4 percent have soil lead above 400 ppm.⁴³ Thus, the data suggest that older homes have higher bare soil lead levels than new homes. Since the amount of lead added to commercial residential paint declined from 1940 to 1980, these observations are not unreasonable, and have been reported by others.⁴⁴ However, no apparent trend in soil lead level was seen between different urbanization categories and soil lead concentration.

⁴³ Even fewer homes will have greater than 9 square feet of bare soil above 400 ppm or 2,000 ppm (soil lead hazard as specified in the Lead Safe Housing Rule).

⁴⁴ Francek, M. (1992.) *Soil lead levels in a small town environment: A case study from Mt. Pleasant, Michigan*. Environmental Pollution 76. pp. 251-257.

Table 6.4 Distribution of Maximum Soil Sample (Bare Soil Only) Lead Concentration by Construction Year, All Sampled Locations

Bare Soil Lead Concentration	Number of HUs (000) ¹				Percent of HUs (%) ²			
	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998
GE ³ 0 ppm	12,015	16,843	23,185	25,845	69%	82%	83%	87%
GE 20 ppm	12,015	15,404	17,345	10,350	69%	75%	62%	35%
GE 50 ppm	11,193	12,789	10,437	5,603	64%	62%	37%	19%
GE 200 ppm	7,243	6,073	1,793	190	41%	30%	6%	1%
GE 400 ppm	5,148	3,736	1,111	0	30%	18%	4%	0%
GE 1,200 ppm	3,386	2,886	0	0	8%	9%	0%	0%
GE 1,600 ppm	2,006	1,894	0	0	6%	2%	0%	0%
GE 2,000 ppm	1,320	1,804	0	0	19%	14%	0%	0%
GE 5,000 ppm	1,106	475	0	0	12%	9%	0%	0%
Missing ⁵	145	0	0	0	1%	0%	0%	0%
No Bare Soil	4,313	2,762	4,613	3,724	25%	13%	17%	13%
No Soil	1,003	939	95	205	6%	5%	0%	1%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units of that age as the common denominator.

³ GE equals "greater than or equal to."

⁴ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).
⁵ "No soil" means that there was no soil on the property to sample.

Figure 6.1 presents a series of boxplots showing the distribution of soil lead concentrations at each of the five sample sites. As with paint lead and dust lead loadings, soil lead concentrations are extremely skewed with over three-fourths of the samples under 200 ppm, but some samples are well above 1,000 ppm.

Table 6.5 presents selected parameters of the distributions of soil lead concentrations by sample sites, corresponding to the boxplots in Figure 6.1. Table 6.5 also presents geometric means and standard deviations. As with the distributions of paint lead loadings and dust lead loadings, the distribution of soil lead concentrations is right-skewed. Thus, a normal distribution would not be a suitable model for the distribution. A lognormal distribution would be a more suitable distribution. Chapter 7 includes a discussion of modeling these data.

Figure 6.1 Box Plots for Lead in Soil Samples by Sample Site

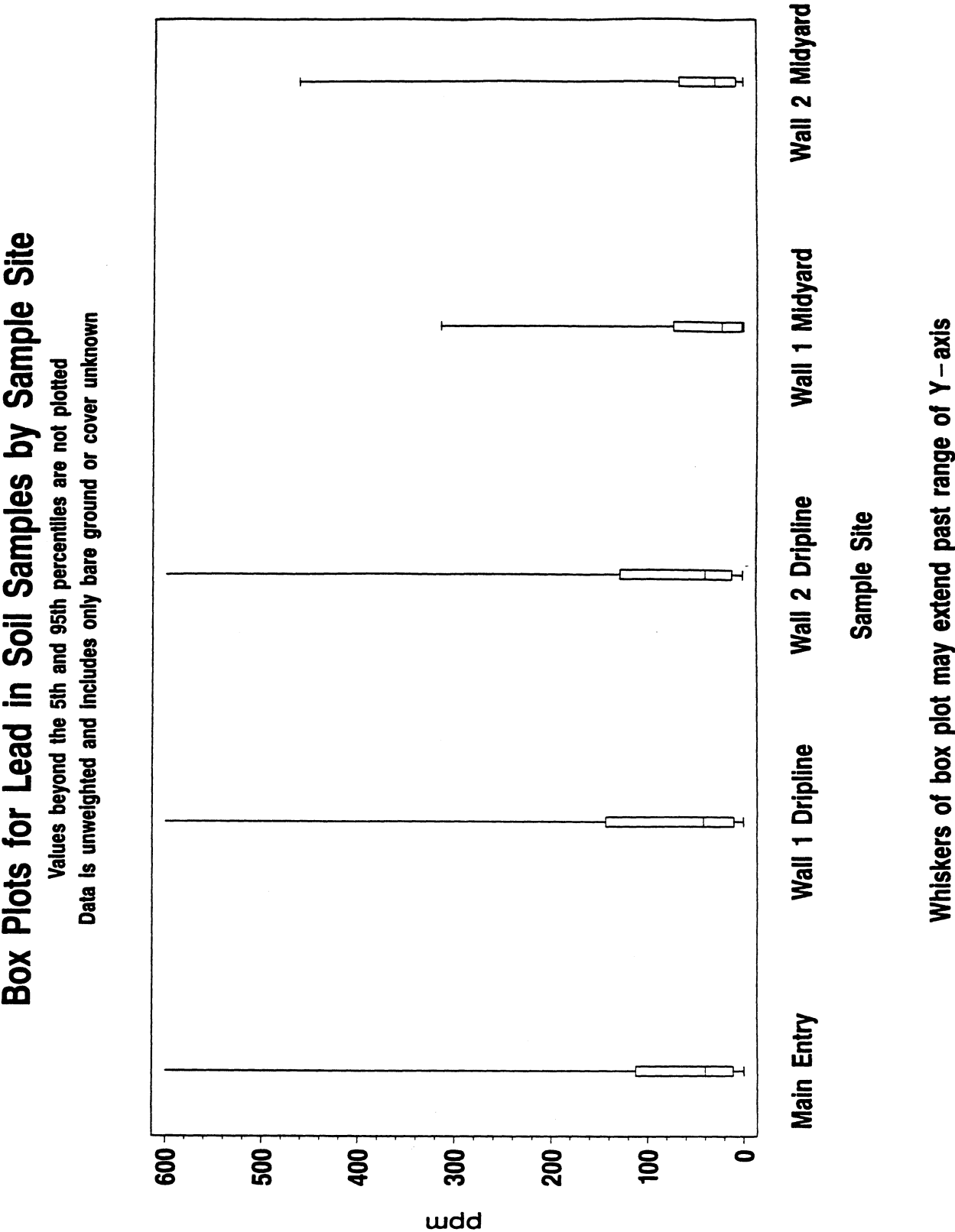


Table 6.5 **Estimated Empirical Distribution Parameters of Soil Lead Concentrations by Sample Site**

	Main Entry	Wall 1 Dripline	Wall 2 Dripline	Wall 1 Midyard	Wall 2 Midyard
	ppm	ppm	ppm	ppm	ppm
Arithmetic Mean	234.8	242.9	404.1	87.3	123.4
Arithmetic Standard Deviation	1,094.4	817.6	1,612.7	194.7	360.4
Geometric Mean	43.3	44.5	49.0	28.1	29.9
Geometric Standard Deviation ¹	5.6	5.8	6.8	4.3	4.9
25 th Percentile	12.1	11.4	10.8	7.8	8.5
Median	40.2	38.8	40.3	27.0	29.1
75 th Percentile	133.4	130.7	165.4	76.3	74.2
90 th Percentile	433.5	553.5	712.5	209.0	277.0
95 th Percentile	1,005.8	1,110.8	1,444.5	411.3	538.8
Number of Samples	707	704	704	723	728

¹ The geometric standard deviation is computed as $\exp(s)$, where s is the arithmetic standard deviation of the natural logarithms of the concentrations (see, e.g., Gilbert, R. O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company New York). For the calculations of the geometric mean and standard deviation, zero and negative values were set to 5.

6.2 Association between Bare Soil Lead and Exterior Paint Condition

Table 6.6 shows the association between bare soil lead concentration and the condition of the exterior LBP. Higher bare soil lead concentrations occur for homes with deteriorated LBP. An estimated 56 percent ($\pm 8\%$) of homes with intact or minimally-deteriorated LBP have bare soil lead above 20 ppm, while 73 percent ($\pm 19\%$) of homes with deteriorated LBP have bare soil levels above 20 ppm. Only 4 and 2 percent of homes free of significantly deteriorated LBP have bare soil lead levels above 1,200 and 2,000 ppm, respectively, while 24 and 13 percent of homes with deteriorated LBP have bare soil lead levels above 1,200 and 2,000 ppm, respectively.

Table 6.6 Association Between Bare Soil Lead Concentration and Presence of Significantly Deteriorated Exterior LBP, All Sampled Locations

Bare Soil Lead	Housing Units without Significantly Deteriorated Exterior LBP ^{1,2}			Housing Units with Significantly Deteriorated Exterior LBP ^{1,2}		
	Percent	Lower 95% CI ³	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI
GE ⁴ 0 ppm	83%	77%	88%	73%	55%	92%
GE 20 ppm	56%	48%	63%	73%	54%	92%
GE 50 ppm	38%	30%	47%	67%	51%	83%
GE 200 ppm	13%	9%	17%	39%	19%	58%
GE 400 ppm	8%	5%	11%	30%	11%	49%
GE 1,200 ppm	4%	2%	7%	24%	7%	41%
GE 1,600 ppm	2%	1%	4%	17%	4%	30%
GE 2,000 ppm	2%	0%	4%	13%	2%	24%
GE 5,000 ppm	1%	0%	2%	8%	0%	17%
Missing ⁵	0%	0%	0%	1%	0%	5%
No Bare Soil	15%	11%	20%	22%	3%	41%
No Soil	2%	0%	4%	4%	0%	9%
Total	100%			100%		

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with the number of HUs with and without deteriorated LBP, 11,473 and 84,215, respectively, as the denominators.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal). "No soil" means that there was no soil on the property to sample.

6.3 Prevalence of Bare Soil Lead in Children's Play Areas

Table 6.7 presents the number and percentage of housing units with bare soil lead in children's play areas above selected concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. An estimated 51 percent ($\pm 6\%$) of homes have bare soil lead levels in play areas above the limit of detection.⁴⁵ An estimated five percent ($\pm 3\%$) of homes with play areas have soil lead levels above 400 ppm, while an estimated two percent ($\pm 2\%$) of homes have play area soil lead levels above 2,000 ppm.

Where there were more than one soil sample collected from children's play areas at a home, the maximum soil value for housing unit has been used in Table 6.7. The effect of using the average soil

⁴⁵ The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA Method 3050 procedures.

lead for each housing unit would drive the distribution towards the lower thresholds, i.e. more homes would have lower soil lead concentrations.

Table 6.7 Distribution of Maximum Soil Lead Concentrations in Children's Play Areas

Bare Play Area Soil Lead	Number of HUs (000) ¹			Percent of HUs (%) ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
GE ⁴ 0 ppm	76,404	69,826	82,982	80%	73%	87%	294
GE 20 ppm	49,019	42,946	55,092	51%	45%	58%	209
GE 50 ppm	28,878	25,828	31,929	30%	27%	33%	127
GE 200 ppm	10,849	7,899	13,800	11%	8%	14%	101
GE 400 ppm	4,856	2,096	7,616	5%	2%	8%	84
GE 1,200 ppm	2,493	458	4,529	3%	1%	5%	82
GE 1,600 ppm	2,078	92	4,063	2%	0%	4%	80
GE 2,000 ppm	1,777	0	3,871	2%	0%	4%	77
GE 5,000 ppm	380	0	1,231	0%	0%	1%	1
No play area	12,368	6,659	18,077	13%	7%	19%	53
Missing ⁵	6,916	1,862	11,969	7%	2%	13%	23
Total	95,688			100%			375

¹ "Housing units" are permanently occupied, noninstitutional residential units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).

"No soil" means that there was no soil on the property to sample.

Table 6.8 presents the number and percentage of housing units with bare soil lead concentration in children's play areas by selected thresholds, by housing unit construction year. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, nearly all newer homes (1960-1998) have bare play area soil lead below 400 ppm. Thus, the data suggest that older homes have higher bare play area soil lead concentrations than new homes. Since the amount of lead added to commercial residential paint declined from 1940 to 1980, these observations are not unreasonable, and have been reported by others.⁴⁶

⁴⁶ Francek, M. (1992.) *Soil lead levels in a small town environment: A case study from Mt. Pleasant, Michigan*. Environmental Pollution 76. pp. 251-257.

**Table 6.8 Distribution of Maximum Soil Lead Concentrations in Children's Play Areas, by
Construction Year**

Bare Soil Lead Concentration	Number of HUs (000) ¹				Percent of HUs (%) ²			
	Before 1940	1940 - 1959	1960 – 1977	1978 – 1998	Before 1940	1940 – 1959	1960 - 1977	1978 – 1998
GE ⁴ 0 ppm	14,641	15,953	22,536	23,275	84%	78%	81%	78%
GE 20 ppm	14,552	13,074	13,238	8,155	83%	64%	48%	27%
GE 50 ppm	12,562	8,920	4,733	2,664	72%	43%	17%	9%
GE 200 ppm	6,508	2,804	320	1,217	37%	14%	1%	4%
GE 400 ppm	3,325	1,469	62	0	19%	7%	0%	0%
GE 1,200 ppm	1,498	995	0	0	9%	5%	0%	0%
GE 1,600 ppm	1,082	995	0	0	6%	5%	0%	0%
GE 2,000 ppm	872	905	0	0	5%	4%	0%	0%
GE 5,000 ppm	380	0	0	0	2%	0%	0%	0%
No Play Area	613	102	3,410	2,790	13%	22%	7%	13%
Missing ⁵	2,222	4,489	1,947	3,710	4%	1%	12%	9%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

¹ "Housing units" are permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units of that age as the common denominator.

³ GE equals "greater than or equal to."

⁴ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).

"No bare soil" means that there was no bare soil in children's play areas on the property to sample.

Table 6.9 shows the association between bare play area soil lead concentration and the condition of the exterior LBP. Higher bare soil lead concentrations occur in play areas for homes with significantly deteriorated LBP. An estimated 46 percent ($\pm 7\%$) of homes with intact or minimally-deteriorated LBP have bare play area soil lead above 20 ppm, while 89 percent ($\pm 11\%$) of homes with significantly deteriorated LBP have bare soil levels above 20 ppm. Only three percent ($\pm 3\%$) of homes with intact or minimally-deteriorated LBP have bare play area soil lead levels above 400 ppm, while 18 percent ($\pm 12\%$) of homes with significantly deteriorated LBP have bare soil lead levels above 400 ppm.

Table 6.9 Association Between Bare Soil Lead Concentration and Presence of Significantly Deteriorated Exterior LBP, in Children's Play Areas

Bare Play Area Soil Lead	Housing Units without Significantly Deteriorated Exterior LBP (%) ^{1,2}			Housing Units with Significantly Deteriorated Exterior LBP (%) ^{1,2}		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
GE ⁴ 0 ppm	79%	71%	86%	90%	79%	100%
GE 20 ppm	46%	39%	53%	89%	77%	100%
GE 50 ppm	24%	20%	29%	73%	55%	91%
GE 200 ppm	8%	4%	12%	35%	17%	53%
GE 400 ppm	3%	1%	6%	18%	6%	30%
GE 1,200 ppm	1%	0%	3%	13%	2%	24%
GE 1,600 ppm	1%	0%	3%	11%	0%	23%
GE 2,000 ppm	1%	0%	2%	10%	0%	23%
GE 5,000 ppm	0%	0%	0%	3%	0%	11%
No Play Areas	14%	7%	20%	7%	0%	17%
Missing ⁵	8%	2%	14%	3%	0%	7%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with the number of HUs with and without deteriorated LBP, 10,651 and 85,037, respectively, as the denominators.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).

"No soil" means that there was no soil on the property to sample.

6.4 Prevalence of Bare Soil Lead in the Rest of the Yard

Table 6.10 presents the number and percentage of housing units with bare soil lead in the rest of the yard -- i.e., areas *not* identified as children's play areas -- above selected concentration thresholds: LOD, 50, 200, 400, 1,200, 1,600, 2,000, and 5,000 ppm. An estimated 75 percent ($\pm 6\%$) of homes have bare soil lead levels in the rest of the yard above the limit of detection.⁴⁷ An estimated 10 percent ($\pm 4\%$) of homes have soil lead levels above 1,200 ppm in the rest of the yard, while an estimated 6 percent ($\pm 2\%$) of homes have soil lead levels above 2,000 ppm.

⁴⁷ The sample limit of detection for this study was determined to be 20 ppm by testing four distinct soil types from among the study samples in accordance with EPA Method 3050 procedures.

Table 6.10 Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard

Soil Lead Concentration	Number of HUs (000) ¹			Percent of HUs (%) ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
GE ⁴ 0 ppm	90,348	87,218	93,479	94%	91%	98%	323
GE 20 ppm	71,537	65,843	77,230	75%	69%	81%	258
GE 50 ppm	54,250	48,525	59,976	57%	51%	63%	162
GE 200 ppm	27,353	25,438	29,267	29%	27%	31%	116
GE 400 ppm	19,709	16,109	23,310	21%	17%	24%	70
GE 1,200 ppm	9,939	6,435	13,444	10%	7%	14%	53
GE 1,600 ppm	6,220	4,034	8,407	7%	4%	9%	49
GE 2,000 ppm	5,905	3,727	8,083	6%	4%	8%	38
GE 5,000 ppm	2,987	1,548	4,427	3%	2%	5%	17
No Soil/No Bare Soil ⁵	2,310	366	4,254	2%	0%	4%	9
Missing ⁵	3,029	693	5,365	3%	1%	6%	12
Total	95,688			100%			375

¹ "Housing units" are permanently occupied, noninstitutional residential units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ GE equals "greater than or equal to."

⁵ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).

"No soil" means that there was no soil in the rest of the yard to sample. "No bare soil" means there was no bare soil in the rest of the yard.

Table 6.11 presents the number and percentage of housing units with bare soil lead concentration in the rest of the yard by selected thresholds, and by housing unit construction year. In general, as the soil lead threshold increases, the number of homes meeting the criteria decreases as the housing unit age increases. In fact, nearly all (91%) homes built between 1960 and 1977 have bare soil lead concentrations below 400 ppm in the rest of the yard.

Table 6.11 Distribution of Maximum Bare Soil Lead Concentrations in the Rest of the Yard, by Construction Year

Bare Soil Lead Concentration	Number of HUs (000) ¹				Percent of HUs (%) ²			
	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998	Before 1940	1940 - 1959	1960 - 1977	1978 - 1998
GE ⁴ 0 ppm	15,858	19,372	26,950	28,168	91%	94%	97%	95%
GE 20 ppm	15,858	18,947	24,151	12,581	91%	92%	87%	42%
GE 50 ppm	15,350	17,492	13,509	7,900	88%	85%	48%	27%
GE 200 ppm	13,051	9,524	4,430	348	75%	46%	16%	1%
GE 400 ppm	11,255	5,960	2,410	84	64%	29%	9%	0%
GE 1,200 ppm	6,326	2,926	686	0	36%	14%	3%	0%
GE 1,600 ppm	4,245	1,289	686	0	24%	6%	3%	0%
GE 2,000 ppm	3,929	1,289	686	0	23%	6%	3%	0%
GE 5,000 ppm	1,891	865	231	0	11%	4%	1%	0%
No Soil/No Bare Soil ⁵	1,211	939	160	0	7%	5%	1%	0%
Missing ⁵	407	233	783	1,606	2%	1%	3%	5%
Total	17,476	20,544	27,893	29,774	100%	100%	100%	100%

¹ "Housing units" are permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units of that age as the common denominator.

³ GE equals "greater than or equal to."

⁴ Missing means that soil was present, but that no lead value is available (usually due to inaccessibility or respondent refusal).

⁵ "No soil" means that there was no soil in the rest of the yard to sample. "No bare soil" means there was no bare soil in the rest of the yard.

6.5 Comparison of Prevalence of Soil Lead to the 1990 LBP Survey

Table 6.12 compares the prevalence of soil lead found in the National Survey with the prevalence of soil lead found in the 1990 LBP Survey. The estimate of homes reported for the National Survey have been limited to those with 500 ppm soil lead or greater and to homes built before 1980 for comparability to the 1990 LBP Survey protocols and findings (see Appendix B for a comparison of the protocols for the two studies). Statistical comparison shows no significant difference in the prevalence of soil above or below 500 ppm in the two studies.

Table 6.12 Comparison of the Prevalence of Lead-Contaminated Bare Soil in the National Survey and the 1990 LBP Survey

	1990 LBP Survey (pre-1980 HUs)		Current National Survey (pre-1980 HUs)	
	Number (000)	Percent (%)	Number (000)	Percent and (CI) ¹ (%)
HUs with Bare Soil Lead Above 500 ppm	15,699	20%	15,909	23% (19-27%)
HUs with Bare Soil Lead Equal to or Below 500 ppm	61,478	80%	50,290	73% (70-77%)
No Bare Soil	--	--	2,557	4%
Total	77,177	100%	68,756	100%

¹ CI = 95% confidence interval for the estimated percent.

7. SOURCES OF ERROR IN THE NATIONAL SURVEY DATA

Chapter 7 examines the quality of the data and the resulting quality of projected national estimates. The greatest source of error in the National Survey estimates is sampling error – as discussed in Volume II, Chapter 2. This chapter addresses two additional important potential sources of error – nonresponse bias and measurement bias – and discusses their effects on the national estimates of the prevalence of lead-based paint (LBP), lead in dust, and lead in soil.⁴⁸

The chapter concludes with a summary of the data collection quality assurance activities, including results of telephone verification, field team audits, field dust and soil quality control samples, laboratory performance on dust and soil quality control samples, and paint testing quality control.

7.1 Statistical Concepts and Terminology

There are two broad types of error in survey estimates: sampling error and nonsampling error:

- **Sampling error:** Sampling error arises from surveying a random sample rather than a complete census of all housing units (HUs). It is a function of the sample size and sample design. Different samples of the same size drawn using the same sample design will yield varying estimates of the population parameters. This variation about the true population parameter is the sampling error.
- **Nonsampling error:** Nonsampling errors arise from a number of sources, including differential response rates from different demographic groups, types of HUs, and geographical areas; unknown differences between the respondents and nonrespondents; differences between the sample frame and the target population; some types of processing and data reduction techniques; and classification bias due to measurement error inherent in XRF and laboratory instrumentation and variation in a measured parameter across a surface and among rooms.

Throughout the report, the term *weight* has been used in conjunction with the sampled HUs, rooms, and surfaces. It is important that these terms be understood.

⁴⁸ Another source of error in the survey is response bias, i.e., how correct was the information provided by the respondents? Significant information obtained from respondents included year of construction (HU age) and age of children. These data were not verified by other means and are thus associated with an unknown amount of error. However, the overall distribution of HU age and age of children reported by survey respondents were consistent with study expectations (see Volume II, Chapter 2), indicating no systematic bias in these responses.

- **Housing Unit (HU) weight:** The HU weight is the number of HUs in the target population that a single HU in the survey represents. The weight is calculated by taking the inverse of the probability of selection for that unit. Thus, if the probability of selection is 0.01, the sample weight is 100. With multi-stage samples, the overall probability of selection is the product of the conditional probabilities of selection at each stage. HU weights for this survey reflect nonresponse adjustments and post-stratification to the 1997 American Housing Survey (AHS) housing unit totals by Census region, HU age category, and presence of children under age 18.
- **Room weight:** The room weight is the number of rooms in the target population that a single room in the survey represents. Room weights were determined by dividing the post-stratified HU weights by the probability of room selection based on the inventory of all rooms in each HU. A nonresponse adjustment was then made to account for noncompleted rooms. A room was only considered to be complete if some environmental samples and data were collected in the room.
- **Component weight:** The component weight is the number of components in the target population that a single component tested in the survey represents. For most lead samples, the component weight equaled the nonresponse-adjusted room weight. There were two exceptions: 1) XRF measurements on windows and doors, and 2) window dust samples. For these components, a sample of one door or window per room was selected. To complete component weights for these components, the nonresponse-adjusted room weights were divided by the component probability of selection, i.e., the inverse of the total number of doors or windows in the room.

7.2 Potential for Nonresponse Bias

The objective of the nonresponse analysis was to estimate the potential impact of survey nonresponse on the estimated prevalence of LBP in housing. To accomplish this, three analyses were conducted. First, the weighted distribution of the National Survey sample was compared and found to be comparable with the AHS and CPS (this analysis was presented in Chapter 2). Second, an analysis of completion rates was performed to look for correlates with nonresponse. Third, the survey estimates for the “hard-to-recruit” and HUs that initially refused (proxies for the nonrespondents) were compared with estimates from HUs that were relatively easy to recruit and had no history of refusal.

7.2.1 Analysis of Completion and Response Rates

An analysis of completion rates was conducted for the entire sample of 1,984 fielded HUs. The analysis looked at the relationship between completion rates and factors such as age of housing, race, ethnicity, geographic location, income, tenure, and presence of multi-family housing. Given that these data were generally not available at the individual HU level for the noncompletes, data for the block

group to which the HU belonged was used for the entire sample, with the exception of HU age. The housing unit age reported by respondents was used when available, which was the case for approximately one-half of the HUs. The source of the block group data was the 1990 Census. Completion rates were also compared for HUs receiving an advance letter addressed to "Current Resident" and HUs receiving a letter addressed to a household member.

The completion rates for the analysis were calculated as the weighted proportion of the HUs sampled that completed both screener and data collection, or else were found to be ineligible. Ineligibles were considered to be screener completes in the sense that their eligibility status was determined during the screener. For a large proportion of the sample (39%), eligibility could not be determined, usually because contact could not be made. Most nonresponse occurred at the screener stage and resulted in unknown eligibility status. Of the 1,984 HUs sampled, 831 completed both the screener and data collection and 229 were found to be ineligible. Of the remaining 924 that did not complete the data collection, 149 were eligible and another 775 were of unknown eligibility. Thus, there were 1,060 completes and 924 noncompletes overall. The overall unweighted completion rate for the survey was 53.4 percent; the overall weighted completion rate was 53.1 percent.

Formulas for unweighted screener and data collection completion rates are given below, along with the eligibility rate, refusal rate, and overall response rate. The overall completion rate is calculated as the product of the completion rate at each stage.⁴⁹

$$\text{Screener completion rate} = 100\% \times \frac{\# \text{ screener completes} + \# \text{ ineligible}}{\# \text{ fielded}} = 100\% \times \frac{943 + 229}{1,984} = 59\%$$

$$\text{Data collection completion rate} = 100\% \times \frac{\# \text{ eligible completing data collection} + \# \text{ ineligible}}{\# \text{ eligible completing screener} + \# \text{ ineligible}} = 100\% \times \frac{1,060}{1,172} = 90\%$$

The overall response rate measures the response among eligible HUs. The number of eligible nonrespondents must be estimated because eligibility cannot usually be established for households that don't complete the screener. It is assumed that the eligibility rate among HUs whose eligibility is unknown is the same as for HUs that did complete the screener. The eligibility rate among HUs that completed a screener was 81 percent. The refusal rate is the rate of refusal among HUs where

⁴⁹ In the data collection completion rate, the ineligible cases are included in both numerator and denominator. If the ineligible cases are not included, the data collection completion rate drops from 90 to 88 percent.

contact was established. (Numerous attempts were made to gain cooperation. Among respondents, two-thirds cooperated on the first or second attempt. While the average number of attempts to complete was 2.6, some housing units didn't cooperate until the eleventh attempt.) HUs that were vacant or couldn't be located, that had no one at home, that were in a locked, gated community where access couldn't be gained, or that couldn't otherwise be contacted were subtracted from the total sample size of 1,984 in the denominator. The overall response rate for the survey was 51.7 percent.

$$\text{Eligibility Rate} = 100\% \times \frac{\# \text{ Eligible}}{\# \text{ Eligible} + \# \text{ Ineligible}} = 100\% \times \frac{943}{943 + 229} = 81\%$$

$$\text{Refusal Rate} = 100\% \times \frac{\# \text{ of refusals}}{\# \text{ contacted}} = 100\% \times \frac{564}{1,634} = 34.5\%$$

$$\begin{aligned} \text{Overall Response Rate} &= 100\% \times \frac{\# \text{ eligible completing data collection}}{\# \text{ eligible completing data collection} + \# \text{ eligible nonrespondents}} \\ &= \frac{831}{831 + (149 + .81 * 775)} = 51.7\% \end{aligned}$$

Overall completion rates by Census Division and block group characteristics such as race/ethnicity, housing age, and type of housing are presented in Table 7.1. Mean percents for several characteristics by completion status are given in Table 7.2. For housing age, the predominant building age category for the block group was assigned to the HU, except when HU age was available from survey respondents. It is important to keep in mind that (with the exception of HU age) the characteristics apply only to the block group in which the HU is located, and may not apply to the HU itself. The associations between completion status and these characteristics were tested using chi-square and t-tests that take into account the HU weights and the survey design.

Significant associations were found between completion status and percents Hispanic and African American, percent below the federal poverty level, housing age, and tenure (see Table 7.2). Different completion rates for groups within a category cannot always be explained, but could be due to factors such as the use of incentives, attitudes of householders, etc. In Table 7.1, the highest response rates were found among HUs in block groups with 30 percent or more Hispanic population, 30 percent or more in poverty, and in newer housing (1978 or later). The differences in response rates are substantial for these characteristics, ranging from 9 to 14 percentage points or more (possibly a function of the \$200

incentive having greater value for these households). This means that if the lead outcome variables are correlated with any of these characteristics (such as housing age), a greater potential for nonresponse bias would exist had these characteristics not been used in adjusting for nonresponse at the screener and data collection stages. Nonresponse adjustment factors were calculated within cells defined by the block group percent of low-income population, percent of Hispanic or African American population, and percent of pre-1940 and pre-1960 housing. In addition, the nonresponse-adjusted HU weights were poststratified to 1997 AHS housing unit totals by Census region, housing unit age, and presence of a child under 18. Use of the final adjusted weights in all analyses therefore greatly reduces this potential bias in estimates for the national housing stock.

The presence or absence of a household member name on the advance letter was also significantly correlated with completion rates. For HUs located in higher income block groups (i.e. fewer than 30 percent of the households are below the federal poverty level), the response rate for HUs with a name on the advance letter was significantly **lower** ($p = .01$) than for HUs receiving a letter addressed to "Current Resident" (48% vs. 56%). For HUs located in lower income block groups (i.e. more than 30 percent of the households are below the federal poverty level), however, the completion rates were not significantly different.

Response rates for the play areas sample were also calculated using the above formula. Weighted and unweighted response rates were examined in the same manner, but given the smaller sample size the characteristics were restricted to Census Region, building age category, and soil lead. The national response rate for the play areas survey was 79.5 percent weighted and 78.0 percent unweighted (higher than the national survey since we were returning to previously willing HUs). For each subset, the response rate remained between 71 and 85 percent. None of the response rate differences observed for the play areas survey were statistically significant at the $\alpha = .10$ level.

Table 7.1 Completion Rates by 1990 Census Block Group Characteristics

1990 Census Block Group Characteristic	Number of HUs	Unweighted Completion Rate	Weighted Completion Rate	P-Value for Chi-square test¹
Census Division				
New England	102	52%	53%	0.42
Middle Atlantic	289	53%	49%	
East North Central	289	49%	46%	
West North Central	181	55%	55%	
South Atlantic	326	52%	53%	
East South Central	144	53%	54%	
West South Central	208	56%	58%	
Mountain	136	57%	58%	
Pacific	309	56%	57%	
% Hispanic Population				
Less than 30% Hispanic	1832	52%	52%	0.005
30% or more Hispanic	152	65%	65%	
% African American Population				
Less than 30% African American	1731	52%	53%	0.08
30% or more African American	253	60%	59%	
% Population in Poverty				
Less than 30% in Poverty	1796	53%	52%	0.04
30% or more in Poverty	188	60%	61%	
% Multi-family Housing Units (5+)				
Less than 30% Multi-family HUs	1522	53%	53%	0.42
30% or more Multi-family HUs	462	56%	55%	
Age of Housing Unit²				
Pre-1940	456	48%	45%	<0.001
1940 – 1959	363	59%	60%	
1960 – 1977	806	47%	45%	
1978 and later	359	70%	74%	

¹ Chi-square test between completion rate and housing characteristic - takes into account the HU weights and sample design.

² Reported HU age used when available for HUs completing screener.

Table 7.2 Mean Percents for Completed and Noncompleted Housing Units by 1990 Census Block Group Characteristics

1990 Census Block Group Characteristic	Mean of Characteristic		P-value for t-test between completes and noncompletes ¹
	Completes	Noncompletes	
Percent HUs Pre-1940 ²	18%	25%	0.001
Percent Population below Poverty Level	12%	11%	0.080
Percent Multi-Family HUs (5+)	17%	16%	0.535
Percent Multi-Family HUs (20+)	7%	7%	0.908
Percent HUs Owned	63%	66%	0.042
Percent Population: African American	11%	8%	0.006
Percent Population: Hispanic	8%	5%	0.005

¹ The test takes into account the HU weights and sample design.

² HU age reported by respondents was used when available for HUs completing screener.

7.2.2 Comparison of “Hard-to-Recruit” Versus “Easy-to-Recruit” HUs

Lead measurements were not available for the HUs whose occupants refused to participate in the survey or who could not be contacted, so it is not possible to know how their participation would have changed the estimates of lead prevalence in housing. However, if the HUs that initially refused but later cooperated (or those HUs requiring several attempts to complete the screener) are similar to the survey nonrespondents, they may be considered as a proxy group for the nonrespondents. If they are significantly different, this may indicate the likely direction of the nonresponse bias in the lead prevalence estimates.

The initial refusals were compared with HUs with a history of no refusal. HUs requiring 4 or more attempts to complete the screener were also compared with those requiring 3 or fewer attempts. The number of attempts was split at 3-4 for two reasons. Two-thirds of respondents cooperated on the first or second attempt and the average number of attempts to complete was 2.6. The comparisons were made for four key statistics and by the housing characteristics recorded by the interviewer. The statistics were 1) the presence of LBP anywhere in the home, 2) the presence of deteriorated LBP anywhere in the home, 3) presence of LBP hazard anywhere in the home, and 4) the presence of a soil lead hazard. The housing characteristics were the respondent's race/ethnicity, household income, tenure, building age, and presence of a child under 18. Comparison of whether or not the household had initially refused (or required more than three attempts to obtain a completed screener) and these characteristics is presented in Table 7.3.

Table 7.3 Comparison of Easy-to-Recruit Respondents Versus Hard-to-Recruit Respondents

National Survey Estimates	Initial Refusal (%)	p-value ¹	More than 3 Attempts to Complete Screener (%)	p-value ¹
Presence of LBP anywhere in HU				
Yes	9.2	0.60	17.3	0.67
No	10.0		15.1	
Presence of Significantly Deteriorated LBP anywhere				
Yes	6.0	0.05	12.8	0.29
No	10.4		16.7	
Presence of Significant LBP Hazard in HU				
Yes	5.6	0.0007	15.8	0.84
No	11.6		16.5	
Presence of Soil-Lead Hazard				
Yes	8.7	0.85	6.2	0.29
No	9.9		16.7	
Ethnicity				
Hispanic	10.7	0.78	9.6	0.14
Non-Hispanic	9.7		16.8	
Race				
White	10.2	0.38	16.9	0.12
African American	6.7		11.7	
Asian, Pacific Islander, Hawaiian, American Indian, Other	8.9		14.4	
Presence of Child under 18				
Yes	9.9	0.85	15.1	0.31
No	9.5		16.6	
Year of Construction				
Pre-1940	7.2	0.22	18.6	0.18
1940 – 1959	6.1		11.5	
1960 – 1977	12.1		13.3	
1978 or later	11.4		20.2	
Tenure (moved up to be w/hsg info)				
Owned	11.2	0.03	15.8	0.15
Rented	6.3		16.8	
Type of Housing				
Single-family	10.3	0.02	15.4	0.58
Multi-family	5.8		19.9	
Household Income				
Less than \$30,000	4.7	<0.0001	12.3	0.03
\$30,000 or More	11.7		17.8	
Household Income				
Less than \$20,000	4.7	0.05	11.1	0.02
\$20,000 - \$39,999	6.8		15.6	
\$40,000 - \$59,999	10.9		16.8	
\$60,000 and over	13.5		18.9	
Poverty				
Below Poverty Level	4.6	0.003	9.9	0.005
At or Above Poverty Level	9.8		17.0	

¹ Chi-square test of association between Ease of Recruitment and Reported Housing Characteristics.

Table 7.3 shows that poorer households were much less likely to have an initial refusal, and required fewer attempts to obtain a completed screener. This is consistent with earlier analysis showing higher response rates for lower income households. It could be that the monetary incentive was more effective among lower income households in improving response rates, or that higher income HUs were more difficult to contact.

Table 7.3 also shows that households with LBP, significantly deteriorated LBP, significant LBP hazard, or soil lead hazard were just as likely to require more than three attempts to complete the screener as those without these lead characteristics. While households with LBP or soil hazards were just as likely to initially refuse as other households, those with significantly deteriorated LBP or LBP hazards were significantly more likely to initially refuse than those without these characteristics. This could be due to the fact that more lower income homes participated in the survey and lower income homes are more likely to have these characteristics.

The nonresponse analysis shows that the households that responded were more likely to be located in densely Hispanic and low income areas, and to be renters as opposed to home owners. They are also more likely to live in newer housing (post-1977).

If the initial refusals who agreed to cooperate are representative of nonrespondents, there would be a potential for bias in unweighted estimated prevalence of HUs with deteriorated LBP or LBP hazards. This means that there would be a potential for bias in the estimated prevalence of HUs with an LBP hazard. However, this was partially corrected by using race/ethnicity, low-income indicators, and building age in making nonresponse adjustments to the HU weights. The weighting adjustments do not eliminate nonresponse bias completely, but they do reduce it when variables that are correlated with both the response rates and propensity to have a lead hazard are used in the nonresponse adjustments. Comparison of the nonresponse-adjusted and poststratified weighted distribution of housing from the National Survey with the AHS and CPS in Table 2.1 show that the weighted National Survey sample matches the national housing distribution closely. These results suggest that there is probably not a serious nonresponse bias in the weighted estimates of lead hazard prevalence.

7.3 Correcting for Classification Bias Due to Measurement Error

Homes were classified as having LBP and lead hazards based on the XRF readings of paint and the analysis of dust and soil samples. Random variation associated with instrument or laboratory measurement, sample collection, and random selection of sampling locations, can induce a classification bias resulting in a bias in the estimated prevalence of HUs with LBP and lead hazards. In addition, paint and dust measurements were made in a sample of rooms – not all rooms. Under this protocol, it is possible for a home to have LBP or a LBP dust hazard in the unsampled rooms and non-lead-based paint and/or no dust-lead hazard in the sampled rooms. Such HUs would be incorrectly classified as not having LBP and/or LBP hazards (false negatives). For this report, measurement error refers to the combined effect of instrument or laboratory measurement variation, sampling variation, spatial variation, and the incomplete sampling of rooms on the important survey estimates.

The specific procedures, equations, and justification for the measurement error correction are presented in Appendix C of Volume II. The findings for the measurement error analyses for paint, dust, and soil are discussed below in Sections 7.3.1 through 7.3.3 below. The measurement error adjusted values (lead loading or concentration) have, to the extent possible, the same distribution as the true lead loading or lead concentration values, without the effect of measurement error. The measurement error corrected values are a weighted average of the observed measurements and predicted values from a regression model. Calculating the weights requires modeling the magnitude of the measurement error variance and the regression error variance. Replicate measurements were used to estimate the measurement error variance.

7.3.1 Measurement Error - Paint XRF Measurements

XRF readings to measure paint lead loading were taken on painted surfaces within the sampled rooms and on accessible exterior surfaces on two sides of the building to assess the lead loading in paint. The measurement error adjustment procedures were first applied to the interior XRF readings. Because the measurement error adjusted XRF values were very close to the original interior XRF readings, it was considered unnecessary to apply a measurement error adjustment to the exterior XRF readings.

For the measurement error analysis for paint lead measurements, the objective was to determine the number and percentage of homes with LBP. A surface with LBP is a surface with an average lead loading across the surface of 1.0 mg/cm² or greater when tested with an XRF analyzer. The

instrument calculates its best internal estimate of the lead loading, which it rounds to the nearest 0.1 mg/cm² for display. Therefore, to classify surfaces in an equivalent manner, the error corrected XRF readings were rounded to the nearest tenth unit for classifying surfaces.⁵⁰ The classification of surfaces as having or not having LBP is used to classify homes as having or not having LBP.

The measurement error adjustment procedure assumes that the distribution of the true paint lead loading around the average for similar homes and the distribution of the measurement error are normal. This assumption provided a relatively poor description of the XRF readings due to the presence of many zero XRF readings and long tails in the XRF distribution (the measurement error adjustment results are expected to be sensitive values in the tails of the distribution). As a result, the measurement error adjustment for paint lead loadings should be considered approximate, at best. Additional research into the measurement error of the XRF instrument and the distribution of paint lead loading across components would be required to improve the measurement error adjusted values.

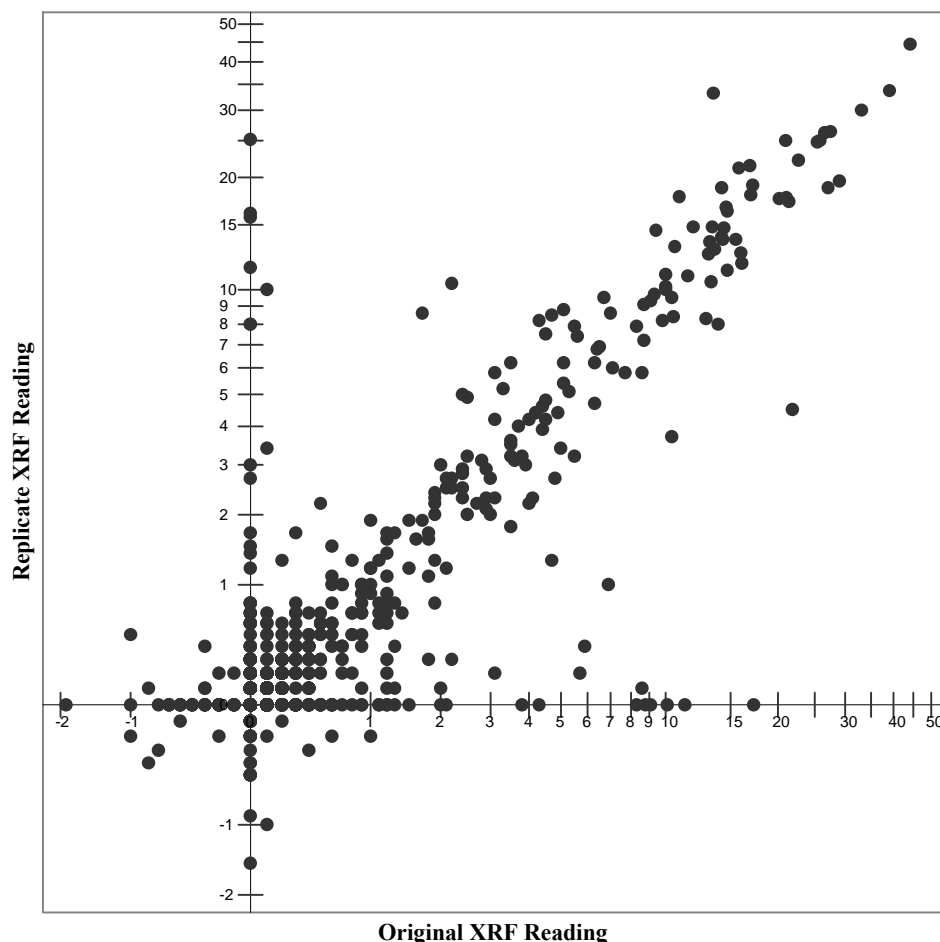
Figure 7.1, which shows a scatter plot of replicate XRF readings, helps to illustrate the distribution of the XRF readings. The original XRF reading is on the horizontal axis and the replicate reading is on the vertical axis. Three situations occur. The first is where both XRF readings are zero (72.3 percent of the replicate pairs) - these pairs provide essentially no information about measurement error. The second case is where one of the two readings is zero (12.4 percent of the replicate pairs) - these pairs fall on the axes. Lastly, there is the case where both XRF readings are non-zero (15.3 percent of the replicate pairs) - these generally fall on the diagonal in Figure 7.1. For these points, the differences between the replicate XRF readings have an approximately normal distribution as assumed by the measurement error correction procedure.

The XRF variation among all surfaces within a home increases with the average XRF reading within the home. This suggests that the measurement error will also increase with the paint lead loading on a component. Surfaces with lead loading near zero will have relatively precise measurements and we expect that large differences between replicate readings when one reading is zero will be relatively rare. However, there are many surfaces for which one reading is zero and the other paired reading is relatively large (may be due to two different parts of a component having very different paint lead loadings).⁵¹

⁵⁰ Rounding to the nearest tenth unit for classifying surfaces is equivalent to classifying a surfaces as having LBP if the average lead loading across the surface is 0.95 or greater.

⁵¹ Whatever the explanation for the pattern in the data, the patterns are not consistent with the assumptions behind the measurement error adjustment. Since no consistent pattern was found that would provide a better model, the measurement error adjustment as described in Appendix C (Volume II) was applied to the data. The results provide one estimate of the effect of measurement error on the assessment of the

Figure 7.1 Original and Replicate XRF Readings on the Same Component



Note: The axes use the transformed scale used for analysis (see Equation 9 in Appendix C, Volume II).

For the measurement error adjustment, homes in which all XRF readings were zero or negative (162 HUs) were assumed to have no paint lead. The remaining homes were used in the measurement error analysis. For those homes, the model used to predict paint lead loadings had factors for housing unit ID, room type, year of construction, and interactions of year of construction by substrate, component, and percent deteriorated paint. A preliminary analysis suggested that the relationship between paint deterioration and XRF reading was not linear. To make the relationship closer to linear, the cube of the percent deterioration was used in the model. A further analysis of the relationship would be necessary to provide a better model.

number of homes with LBP. However, other assumptions or other modeling approaches may provide very different estimates of the magnitude of the effect of measurement error.

The regression analysis predicts the approximate median of the interior paint lead loading. Figure 7.2 shows the relative median paint lead loading estimated from regression, by construction year category and component substrate. Figure 7.3 shows the relative differences in median paint lead loading associated with combinations of construction year and region of the country. Figure 7.4 and 7.5 shows the relative differences in the median paint lead loading versus component type, room type, component condition, metro status, presence of pets, overall home cleanliness, and the number of days the air conditioning was used in the last month. Because the assumptions behind the measurement error analysis provide a poor description of the XRF measurements, the patterns illustrated in Figures 7.2 to 7.5 should be considered suggestive of, rather than descriptive of, patterns in the population.

Figure 7.2 Predicted Relative Median Paint Lead Loading by Construction Year of the Home and Substrate (based on regression model)

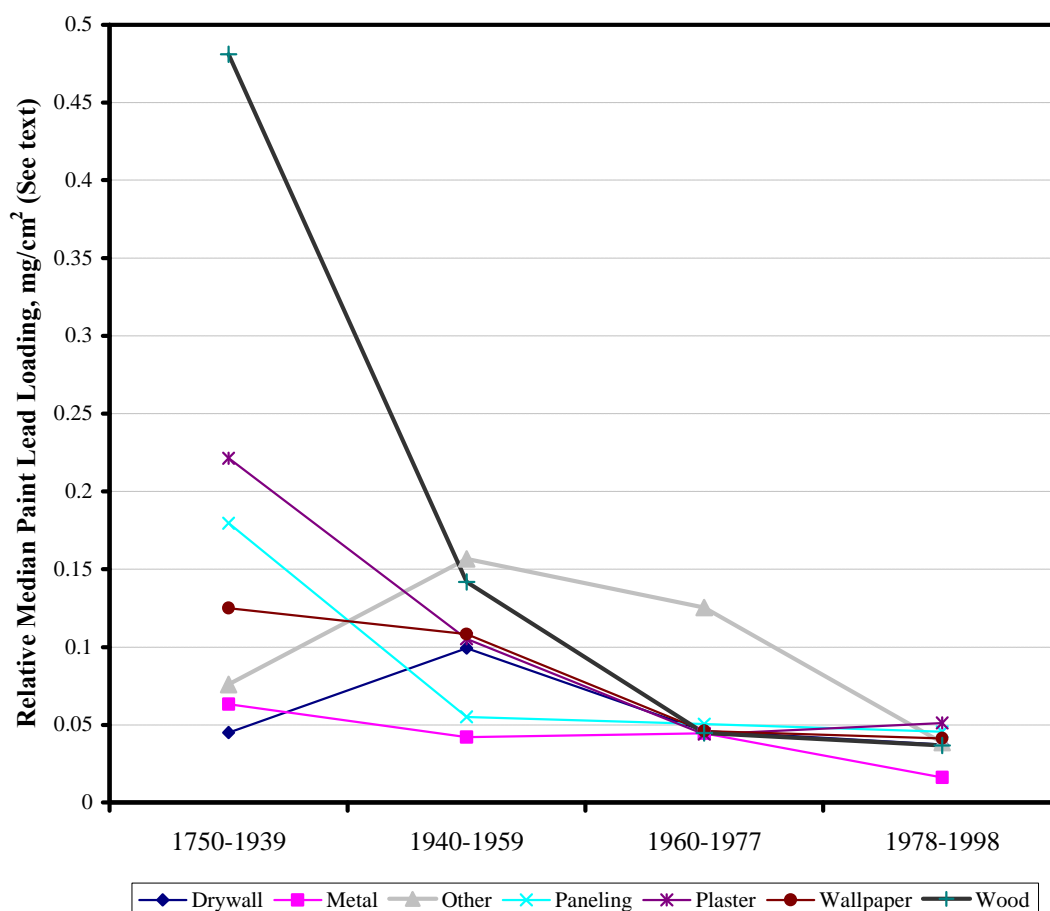
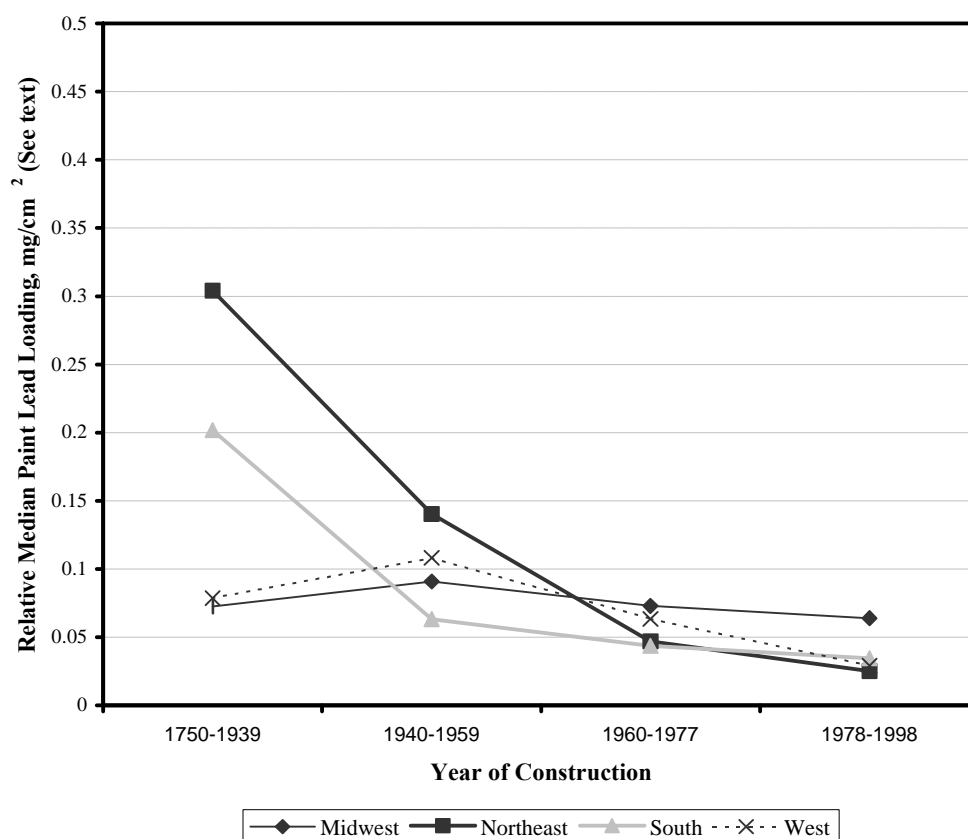


Figure 7.2 shows that interior paint lead loadings are highest in the oldest homes and lowest in the newest homes. The patterns for paint lead loading on specific substrates also generally decrease with the age of the home. The paint lead loadings are highest on wood surfaces in the oldest homes. For components with drywall, paneling, metal, plaster, wallpaper, and wood substrates, the median paint lead loading is low (less than 0.05 mg/cm²) for homes built since 1960. However, median paint lead loading on other substrates (such as brick, concrete, stone, and vinyl) are higher for homes built in the 1960 to 1977 period.

Figure 7.3 shows that the highest predicted median paint lead loading is found in homes built before 1960 in the northeast US and in homes built before 1940 in the southern US.⁵²

Figure 7.3 Predicted Relative Median Paint Lead Loading by Construction Year of the Home and Region (based on regression model)



⁵² Care should be taken when comparing these data to tables presented in Chapter 4. For example, a home was included in Table 4.1 if any one component had LBP. Values plotted in Figures 7.2 through 7.5 represent the predicted median paint loadings in the home (i.e., for all components). Thus, while Table 4.1 shows that 53% of homes in the Midwest have LBP, Table 7.3 shows that the median lead loading for all components is lowest for homes in the Midwest. This could be due to there being fewer components with LBP or the lead content of individual components could be lower in Midwest homes.

Figure 7.4 shows that higher paint lead loadings are generally found on doors, window jambs and window sashes. There are relatively small but significant differences in the paint lead loading among rooms of different types. After accounting for other factors, paint lead loadings are generally higher in children's bedrooms and in kitchens.

Figure 7.4 Predicted Relative Median Paint Lead Loading by Component Type and Room Type (based on regression model)

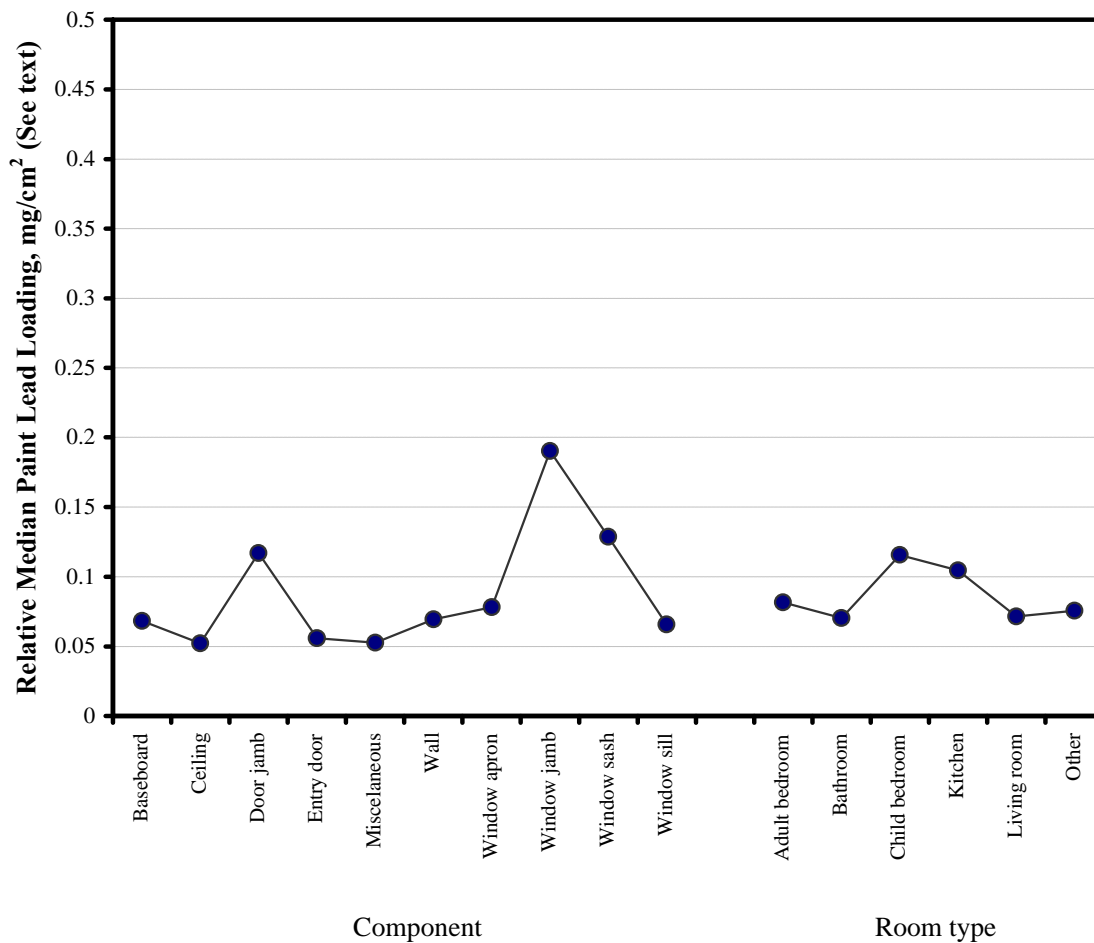
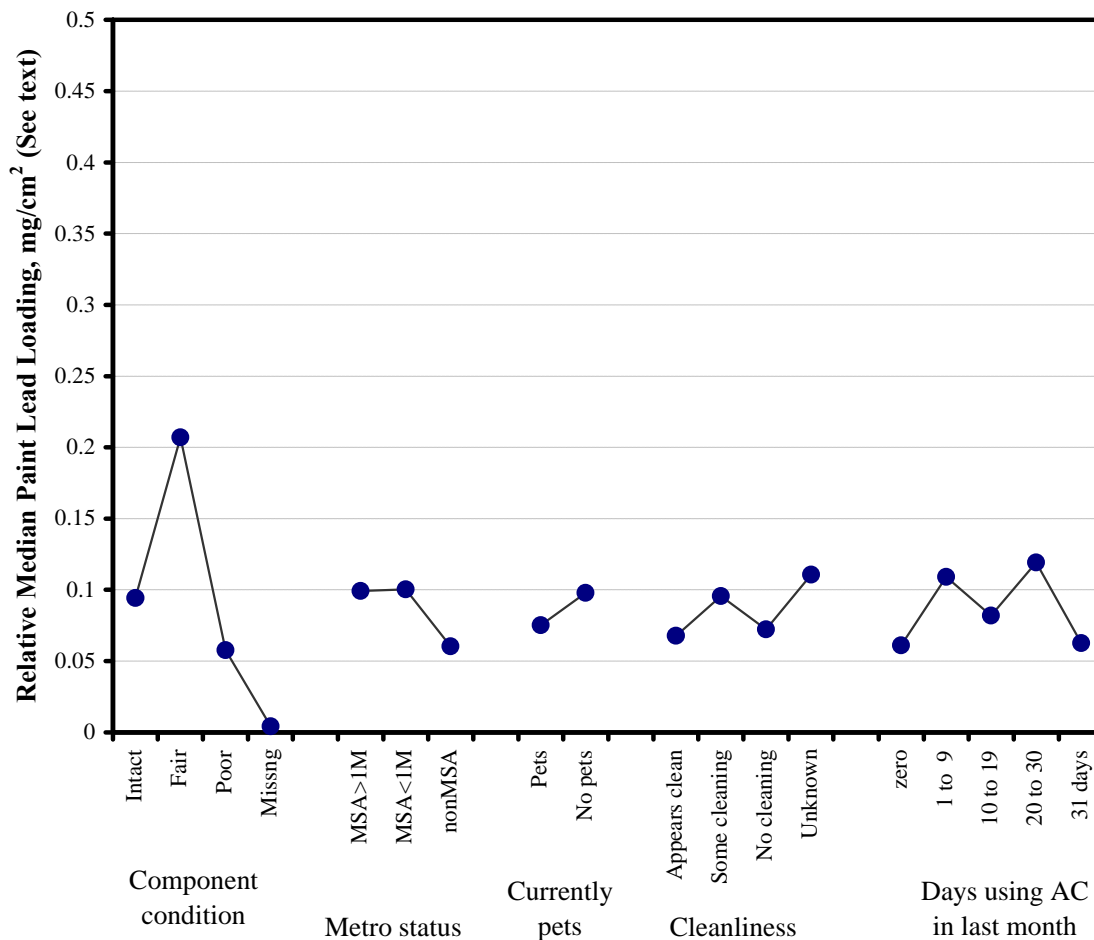


Figure 7.5 shows that higher paint lead loadings are generally found on components that were judged to be in fair condition as opposed to intact or poor condition. However, relatively few surfaces were judged to be in fair condition. Small but significant differences were associated with metro status (lower paint lead loading in non-MSAs), presence of pets (lower in homes with pets), overall cleanliness, and days using air conditioning in the last month.

Figure 7.5 Predicted Relative Median Paint Lead Loading by Component Condition, Metro Status, Presence of Pets, Overall Cleanliness, and Air Condition Use in the Last Month (based on regression model)



As part of the exploratory analysis to identify the model for the data, such additional variables as tenure and race were considered and not found to be significant predictors.

The measurement error adjustment procedure identified approximately 30 percent of the XRF readings as outliers. Outliers are those measurements that are more than 2.5 standard deviations above or below the mean of the non-outliers. In this case, the measurement error procedure makes a conservative adjustment. The non-outlier data were assumed to have a normal error distribution, however, the distribution of the residuals had a tight distribution in the center and very long tails, inconsistent with the normal distribution assumption. The resulting estimate of the error variance was very small, resulting in almost no estimated effect of measurement error. Using the measurement error procedure in Appendix C (Volume II), the measurement error adjusted paint lead loadings are essentially equal to the XRF readings. Additional work would be required to develop a better model for the XRF readings and other assumptions might provide a significantly different assessment of the effects of measurement error.

The tentative results from the measurement error analysis are that the interior XRF readings provide a reasonable measure of the paint lead loading for many surfaces. For the remaining surfaces that look like outliers when judged relative to a normal distribution, the effect of measurement error is difficult to assess. We believe that similar conclusions are likely to apply to exterior surfaces; however, no measurement error adjustment was attempted for the exterior surfaces.

7.3.2 Measurement Error – Dust Lead Measurements

Dust samples were taken at all surveyed homes from the floor at the main entrance and from the floors, window sills, and window troughs of the sampled rooms. Separate measurement error adjustments were performed for the floor and window dust samples.

Floor Dust Lead Loading

The model for predicting floor dust lead loading included factors for household ID (as a class variable), surface characteristics at the sample location, and the interaction of the type of floor cover and year of construction. The measurement error adjustment procedures excluded three percent of the floor dust measurements as outliers. The regression analysis predicts the approximate median of the floor dust lead loading.

Figure 7.6 shows the relative median floor dust lead loading estimated from regression, by construction year category and type of floor cover in the sampled room. The predicted median floor dust lead loadings were highest for the oldest homes and decrease for homes constructed more recently. The

floor lead loading was generally higher in rooms with no floor covering than in rooms with wall-to-wall carpets. Rooms with some floor covering had floor dust loadings similar to or somewhat greater than in rooms with wall-to-wall carpets, and lower than rooms with no floor covering. The floor lead loadings for the unknown floor cover category represent primarily the floor dust lead loadings for the main entrance (94% of the data in the unknown category, as this information was not recorded). The dust lead loading at the main entrance was similar to dust lead loading from other rooms that have no floor covering.

Figure 7.6 Predicted Relative Median Floor Dust Lead Loadings by Construction Year Category and Floor Cover in the Sampled Room (based on regression model)

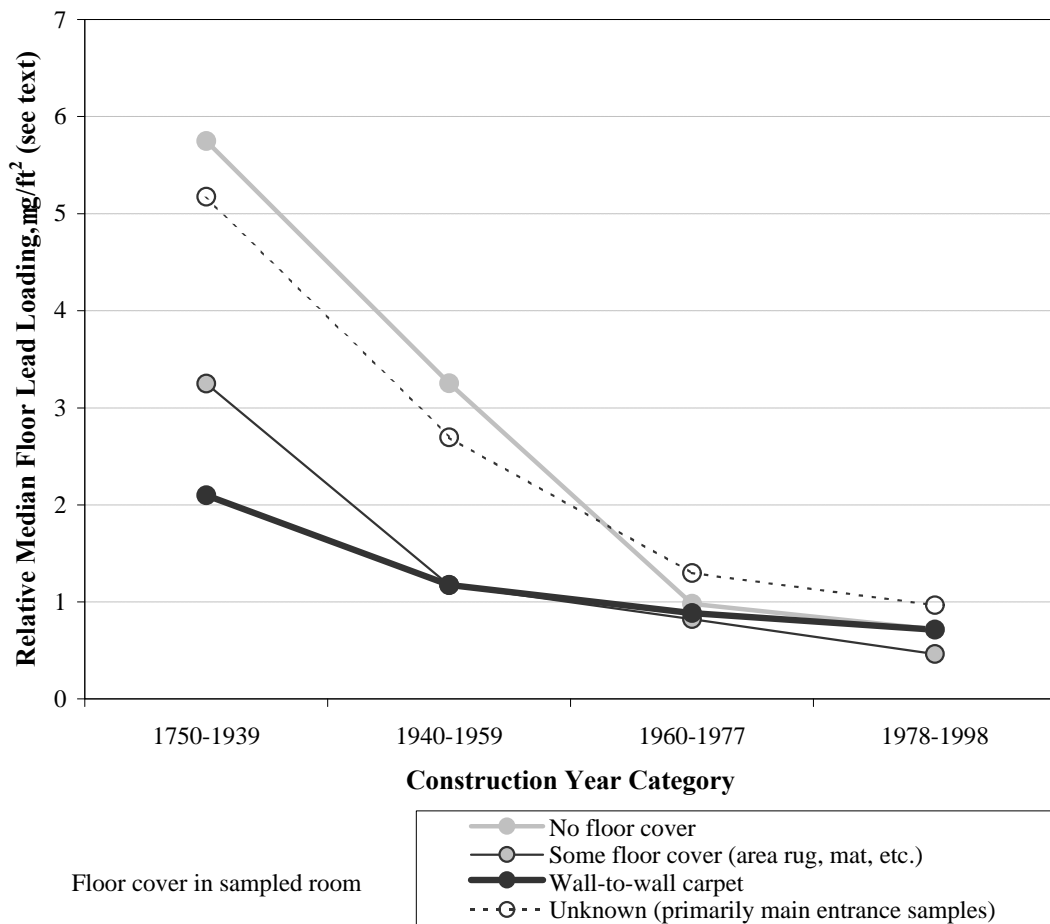
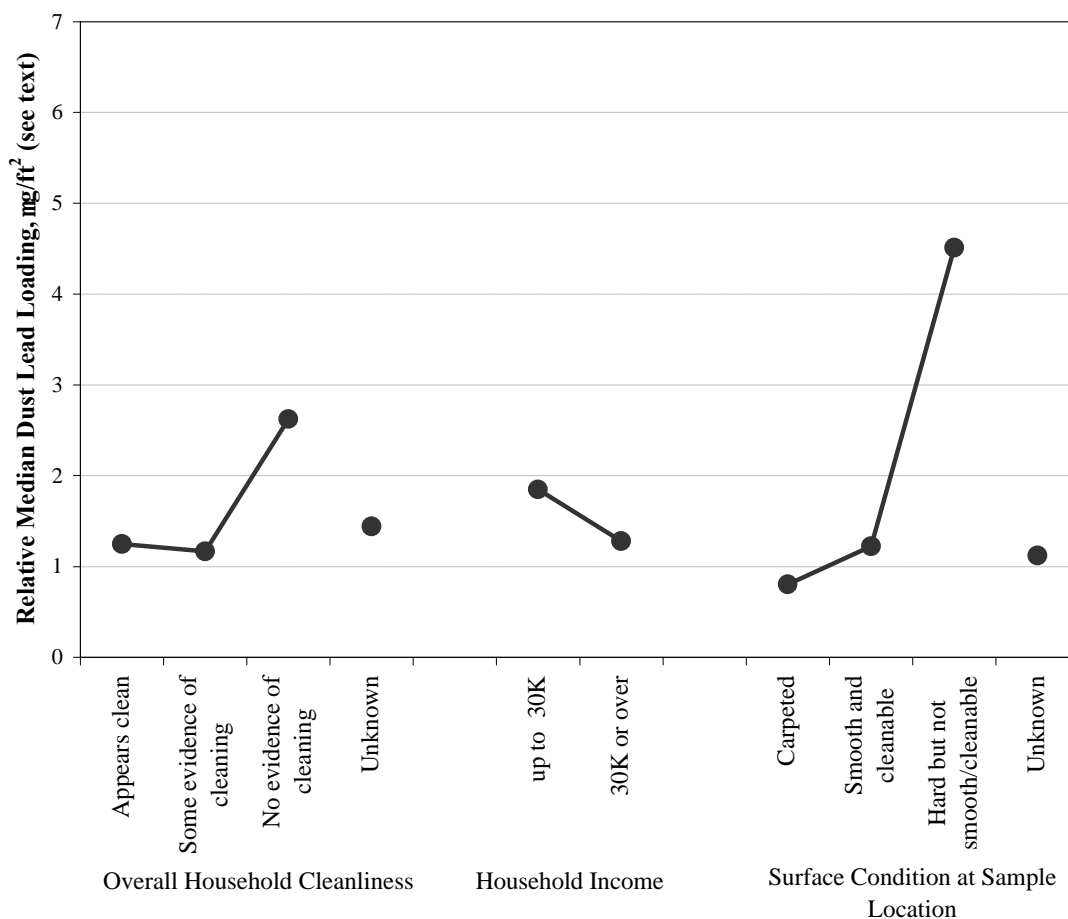


Figure 7.7 shows the relative median floor dust lead loading estimated from regression, by home cleanliness, household income, and surface sampled. Dust lead loadings were on average higher in lower income homes, and in homes that show no evidence of cleaning (a small minority of all homes).⁵³ Dust lead loadings were also higher on hard surfaces that were not smooth and cleanable (a small minority of all surfaces), perhaps because these surfaces are more difficult to clean or perhaps because they collect dust faster between cleanings. Carpets had lower lead loading than smooth and cleanable surfaces, using the wipe sampling methods employed.

Figure 7.7 Predicted Relative Median Floor Dust Lead Loadings by Cleanliness, Household Income, and Surface Condition (based on regression model)



⁵³ These results suggest that cleaning activity will generally affect dust lead loading.

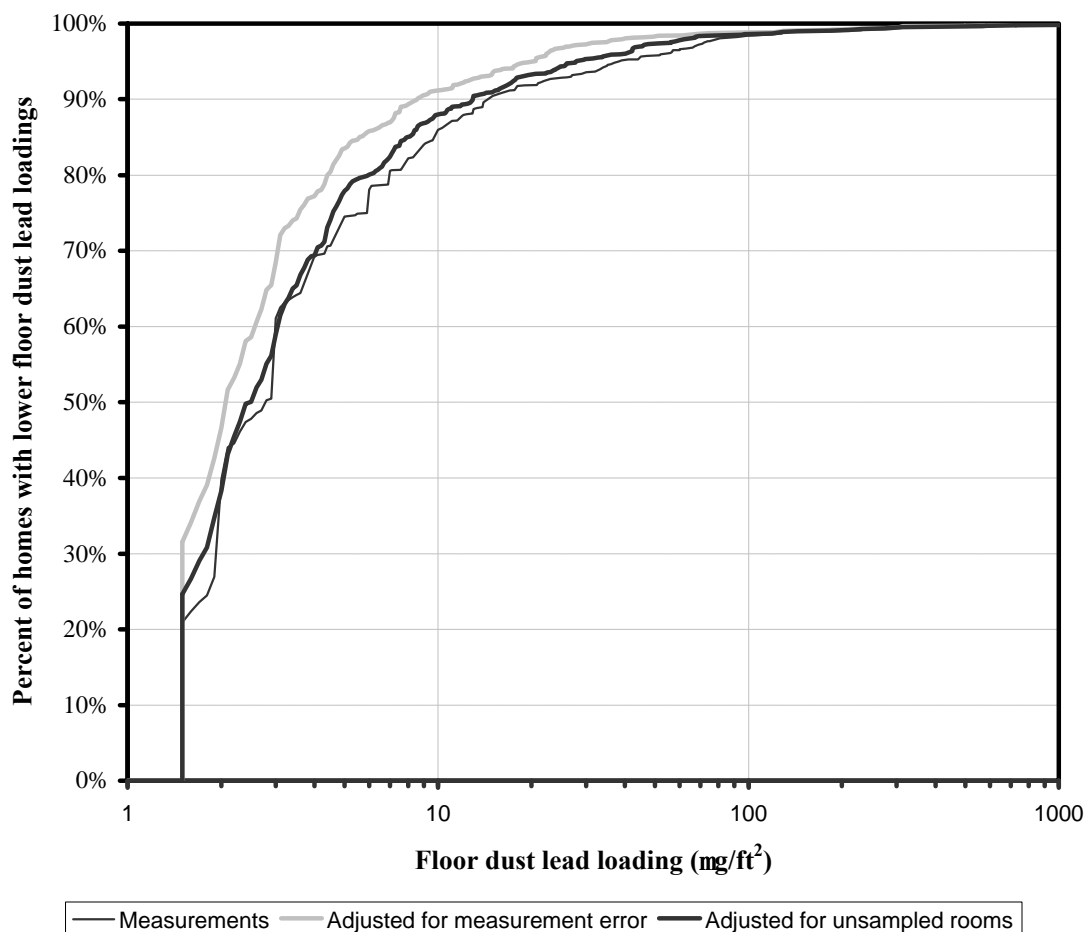
As part of the exploratory analysis to identify the model for the data, additional variables were considered and not found to be significant predictors. In particular, the type of room (bedroom, bathroom, kitchen, etc.) and presence of pets were not significant.

Figure 7.8 shows the cumulative distribution of the maximum floor dust lead loading at homes. The figure shows three cumulative distributions:

1. The maximum of the floor dust lead loading measurements at a home (bottom thin black line).
2. The maximum measurement error adjusted floor dust lead loading across the sampled rooms (top gray line).
3. The maximum measurement error adjusted floor dust lead loading across all rooms, sampled and unsampled (middle thick black line).

The difference between the first (bottom thin black) and second (top gray) curves shows the effect of the measurement error adjustment on the classification of the measured surfaces. The difference between the second (top gray) and the third (middle thick black) curves illustrates the effect of random selection of rooms on the classification of homes. Measurement error tends to increase the number of homes, and incomplete sampling of rooms tends to decrease the number of homes, classified as having maximum floor dust lead loading above a selected value. For the floor data, these effects partially cancel out so that the number of homes classified as having floor lead over a specified value using either the maximum adjusted lead loading value or the maximum observed measurements is similar. The difference between the first (bottom thin black) and the third (middle thick black) curves illustrates the combined effect of doing both the measurement-error adjustment and unsampled-room adjustment.

Using the measurement error corrected values, an estimated four percent of homes (about 4 million homes) have floor dust lead loadings of $40 \mu\text{g}/\text{ft}^2$ or more in one or more rooms. This is about one percent fewer homes than estimated using the actual floor dust measurements.

Figure 7.8 Cumulative Distribution of the Maximum Floor Dust Lead Loading for Homes

Window Dust Lead Loading

Window dust samples were taken from randomly selected windows in the sampled rooms within surveyed homes. For the measurement error correction, one objective was to estimate the number of rooms having or not having average window sill dust lead loading and average window trough dust lead loading less than a selected value. A second objective was to estimate the number of homes with average room window sill and window trough dust lead loading less than a selected value in all rooms. The first objective required estimating lead loadings for the missing values and adjusting for measurement error. The second objective also required adjusting for the unknown lead loading in the unsampled rooms.

Scatter plots of the data showed that the log transformed window sill and trough measurements are linearly related, with the ratio of the trough to sill lead loading being roughly constant at about 11. The proximity of the sill to the trough suggests that the similar factors may affect the lead loading at these two locations. Therefore, the analysis below used both the window sill and window trough dust lead loadings in the same model for calculating the measurement error adjustment. Because the log transformation was used, the model assumes that the same factors predict the relative sill and trough lead loadings and that the ratio of the sill to trough lead loading was constant across homes. Although a separate measurement error adjustment could have been performed separately for sill and trough measurements, this combined approach was expected to provide a similar adjustment. The measurement error adjustment procedures excluded three percent of the floor dust measurements as outliers.

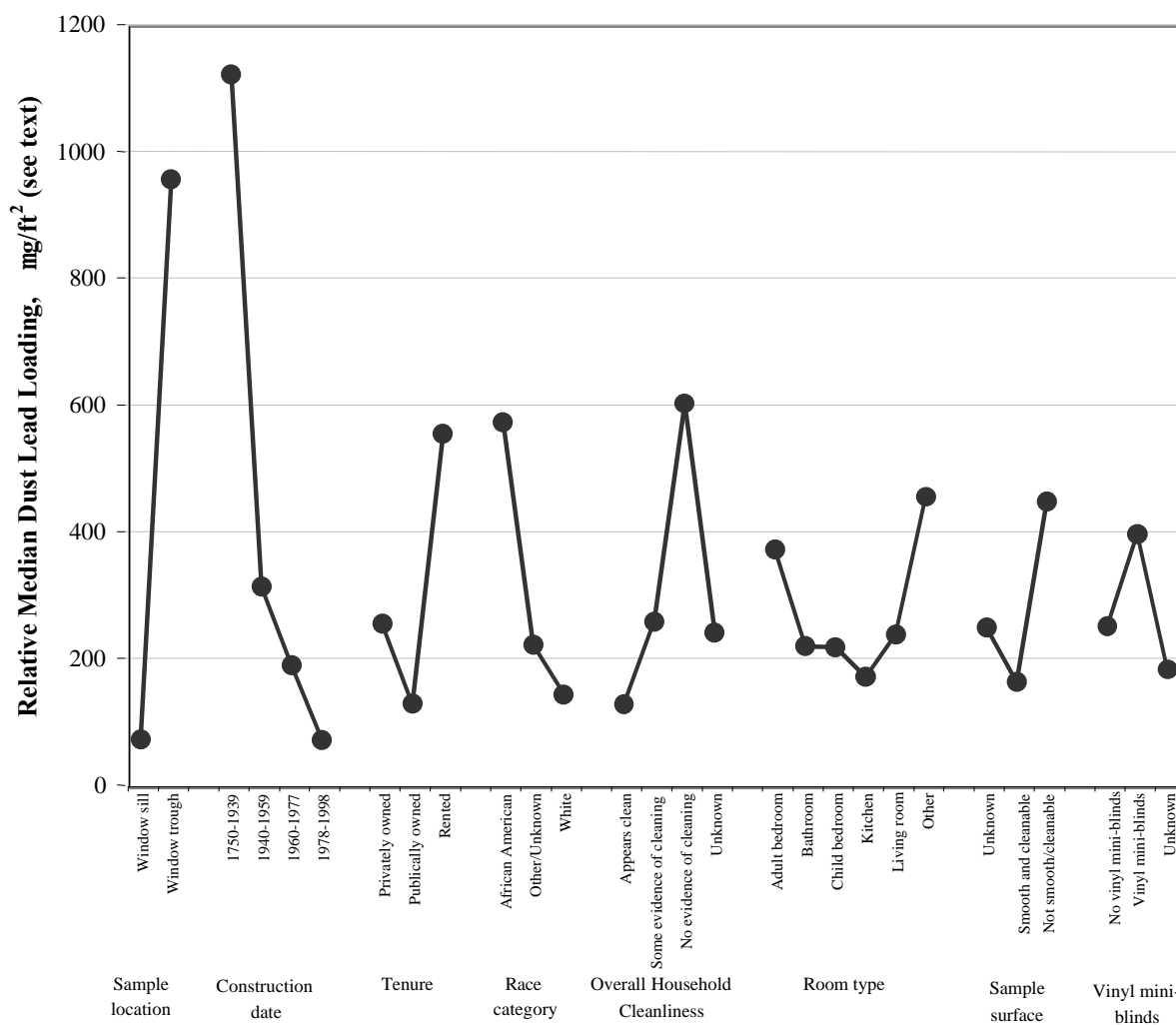
Two models were fit to the data. One was used for predicting window dust lead loading in homes with at least one window lead loading measurement. A second model was used to predict window dust lead loading for homes with no window dust lead loading measurements in the data files. The predictors in each model are presented in Table 7.4.

Table 7.4 Regression Model Used for Different Categories of Homes

Category of homes	Number of homes	Factors for predicting window dust lead loading
I. Homes with no window dust samples	17	Sample location (sill or trough), year of construction, tenure, race category of occupants, overall household cleanliness as judged by the interviewer, and room type.
II. Homes with at least one window dust sample	808	Sample location (sill or trough), household ID (as a class variable), surface characteristics at the sample location, whether the window has a vinyl mini-blind, and room type.

Figure 7.9 shows the relative differences in median window dust lead loading associated with different levels of sample location (sill or trough), year of construction, tenure, race category, overall household cleanliness, surface characteristics, room type, and presence of vinyl mini-blinds.

Figure 7.9 Predicted Median Window Dust Lead Loading by Various Factors (based on regression model)



The predicted median window dust lead loading is much higher in the window trough than on the window sill. Lead loading is highest for the oldest homes and lower for homes constructed more recently. The window lead loading is generally higher for rented homes than in private owned homes and higher in homes with African American residents and in homes with residents of other races. The small number of homes that have no apparent indication of cleaning have higher window dust lead loadings than homes that were classified as showing some evidence of cleaning or appearing clean. Although most rooms had similar window dust lead loading measurements, measurements were somewhat higher in adult bedrooms and “Other” rooms (rooms not classified as kitchen, living room, or bedroom). Samples from window surfaces that were not smooth and cleanable had higher lead loading than samples from smooth and cleanable surfaces. Finally, windows with vinyl mini-blinds had

somewhat higher dust lead loading than windows without vinyl mini-blinds. Differences for other window coverings were not statistically significant.

Figure 7.10 shows the cumulative distribution of the maximum window sill dust lead loading within homes. The figure shows four cumulative distributions:

1. The maximum of the window dust lead loading measurements within a home (thin black line).
2. The maximum of the window dust lead loading measurements or predicted values for missing data (also a thin black line).
3. The maximum measurement-error-adjusted window dust lead loading across the sampled rooms (thick gray line).
4. The maximum measurement-error-adjusted window dust lead loading across all rooms, sampled and unsampled (thick black line).

For various reasons, such surfaces being inaccessible, data were not available for some window surfaces. The first curve assumes that the lead loading on all surfaces with missing data is negligible. As a result of the measurement error adjustment, predicted values are available for all surfaces. For surfaces with no data, the predicted values were used. The second curve, to the right of the first curve, shows the cumulative distribution of the best estimate of the lead loading on all window surfaces, i.e., the measurement on surfaces with data and the predicted values on surfaces with no measurements. The predicted values are referred to as imputed values. The imputation generally affects the lower portion of the distribution.

The third curve shows the distribution of the measurement error adjusted estimates. Since measurement error will generally increase the maximum within-home measurements, the effect of the measurement error correction is to slightly reduce estimated maximum within-home window dust lead loading. The fourth curve shows the cumulative distribution of the measurement error corrected measurements after accounting for the incomplete sampling of rooms. These values will be referred to as the adjusted values. The primary difference between the maximum of the observed window sill dust lead loading measurements and the final adjusted maximum in each home is due to the incomplete sampling of rooms.

Using the adjusted values, a predicted 19 percent of homes (18 million homes) have a window sill dust lead loading of at least 250 $\mu\text{g}/\text{ft}^2$ in at least one room. This is about five percent more

homes than estimated using the actual measurements. A predicted 22 percent of homes (21 million homes) have a window trough dust lead loading of at least 800 $\mu\text{g}/\text{ft}^2$ in at least one room. This is about 20 percent more than estimated using the actual measurements.

Figure 7.10 Cumulative Distribution of the Maximum Within-Home Window Sill Dust Lead Loading

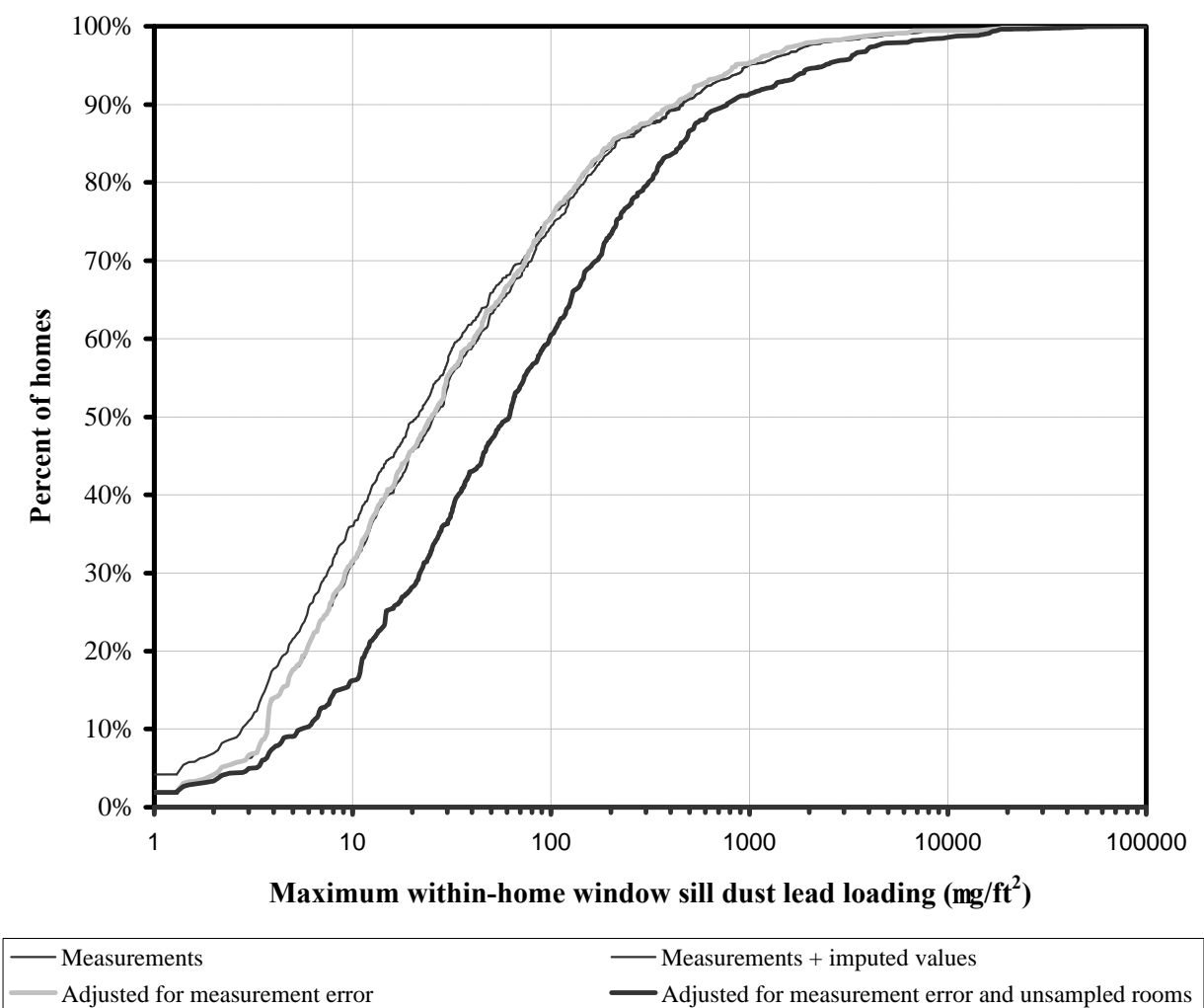
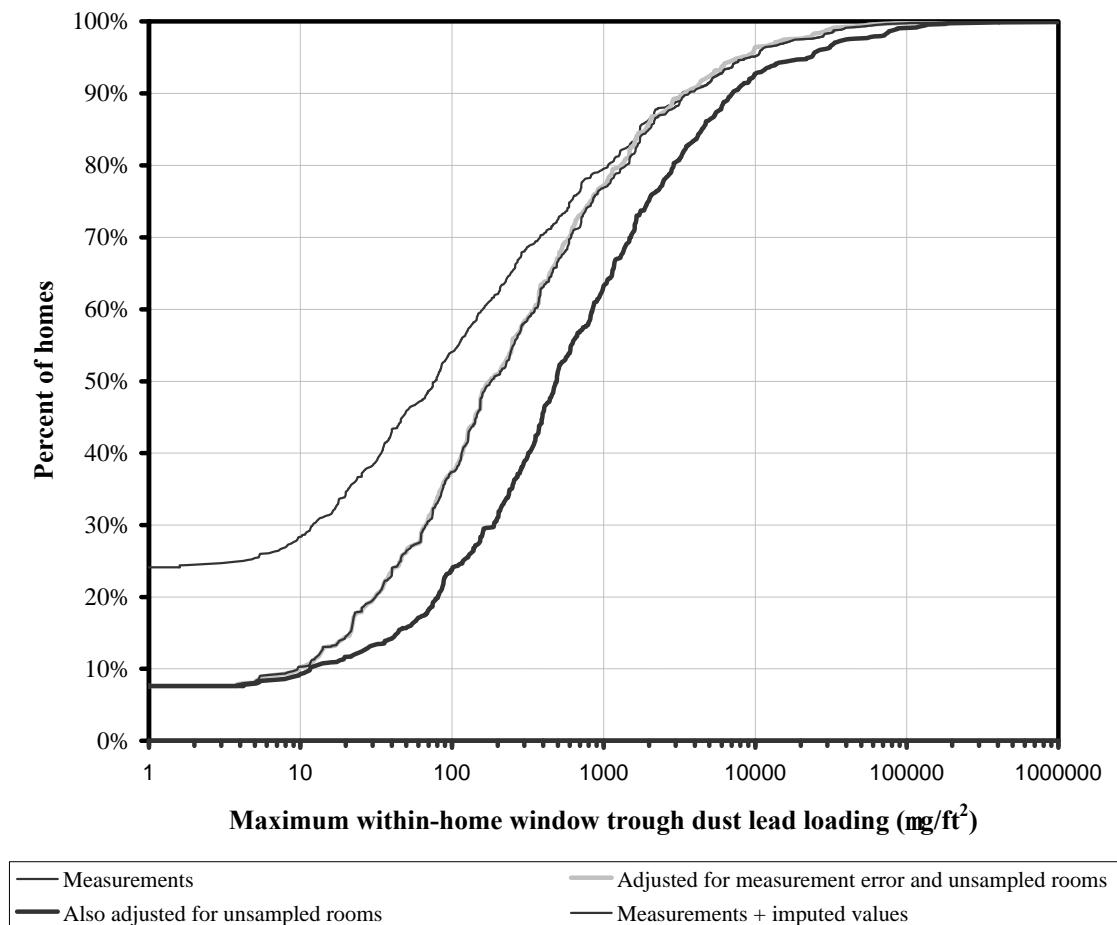


Figure 7.11 shows the cumulative distribution of the maximum window trough dust lead loading within homes. The figure shows four cumulative distributions for the measurements (thin upper thin black line), the measurements plus imputed values (lower thin black line), the measurement error corrected values for the sampled rooms (gray line) and the final adjusted values that account for the incomplete sampling of rooms

Because there were many surfaces for which window trough data could not be obtained, there are relatively large differences between the distributions for the measurements and the measurements with imputed values. As with the window sill lead loading, the measurement error adjustment for the available measurements makes only a small difference compared to the effect of missing data and the incomplete sampling of rooms.

Figure 7.11 Cumulative Distribution of the Maximum Within-Home Window Trough Dust Lead Loading



7.3.3 Measurement Error – Soil Lead Measurements

Soil samples were taken at all surveyed homes at the major entrance and along the dripline and midyard of two sides of the home, if soil was present. For the soil measurement error correction, the objective was to determine the number and percentage of homes with average soil lead concentrations above a selected value at the three sample sites - midyard, dripline, and main entrance.⁵⁴

Table 7.5 describes the regression model used for different categories of homes.

- For Category I homes, there was no soil at any of the three sample sites, and so no model was required. This situation occurred if all areas of the yard were covered with concrete, asphalt, or rock. Also, a specific sample site could have no soil if the site did not exist (for example, the dripline and the property line coincided so that there was no midyard sample site).
- For Category II homes, at least one of the sample sites had soil, but there were no soil lead measurements for the home. This situation could arise if the respondent denied permission to collect soil samples, or if adverse conditions existed, such as an ongoing storm, frozen ground, the presence of a dog, or large rocks mixed in with the soil. The measurement error corrected soil lead concentrations are the predicted values from the regression model.
- For Category III homes, all soil measurements were equal to zero. While the sample detection limit was determined to be 20 ppm, the laboratory provided an estimate of the soil lead for all samples with levels below the detection limit. However, negative laboratory estimates were reported as zero. The measurement error corrected soil lead concentrations are assumed to be less than the detection limit.
- For Category IV homes, some or all of the soil measurements were equal to a non-zero value (i.e., a value at or more than the detection limit). These values were used to predict soil lead concentrations for the category IV and category II homes.

⁵⁴ The average of the available midyard and average of available dripline samples were used for the measurement error analysis, regardless of which side of the house they were collected. That is, separate assessments were not made for midyard and dripline areas on each side of the home.

Table 7.5 Regression Model Used for Different Categories of Homes

Category of homes	Number of homes	Model for measurement error corrected soil concentrations
I. Homes with no soil at any sample site	45	Not applicable.
II. Homes with soil, but no soil measurements	8	Log transformed soil lead concentration = a mean for each combination of construction year category and soil sample location and a mean for each combination of construction year category and region.
III. Homes with all soil lead measurements equal to zero (therefore no within-home variation)	33	All measurements assumed to be less than the detection limit.
IV. Homes with soil lead measurements, some or all of which are non-zero	745	Log transformed soil lead concentration = a mean for each combination of construction year category and soil sample location, a mean for each combination of construction year category and region, and a mean for each home

The regression analysis predicts the approximate median of the soil lead concentrations. Figures 7.12 and 7.13 show the relative median soil lead concentration for homes within each construction year category by sample location and region. As expected, older homes have higher soil lead concentrations. Concentrations are also higher on average in the northeast region and lower in the western region of the country. Soil lead concentrations are higher on average at the dripline sample location and lower at the midyard sample location. The measurement error adjustment procedures excluded three percent of the floor dust measurements as outliers.

As part of the exploratory analysis to identify the model for the data, additional variables were considered. In particular, orientation of the side of the building (north, east, south, or west) and ground cover (bare soil, grass, ivy, moss, mulch, and other or unknown) were examined. Neither the side of the house on which the samples were taken nor the ground cover was a significant predictor of soil lead concentrations, after adjusting for the effects of year of construction, region, and sample location.

Figure 7.12 Predicted Relative Median Soil Lead Concentrations by Construction Year Category and Sample Location (based on regression model)

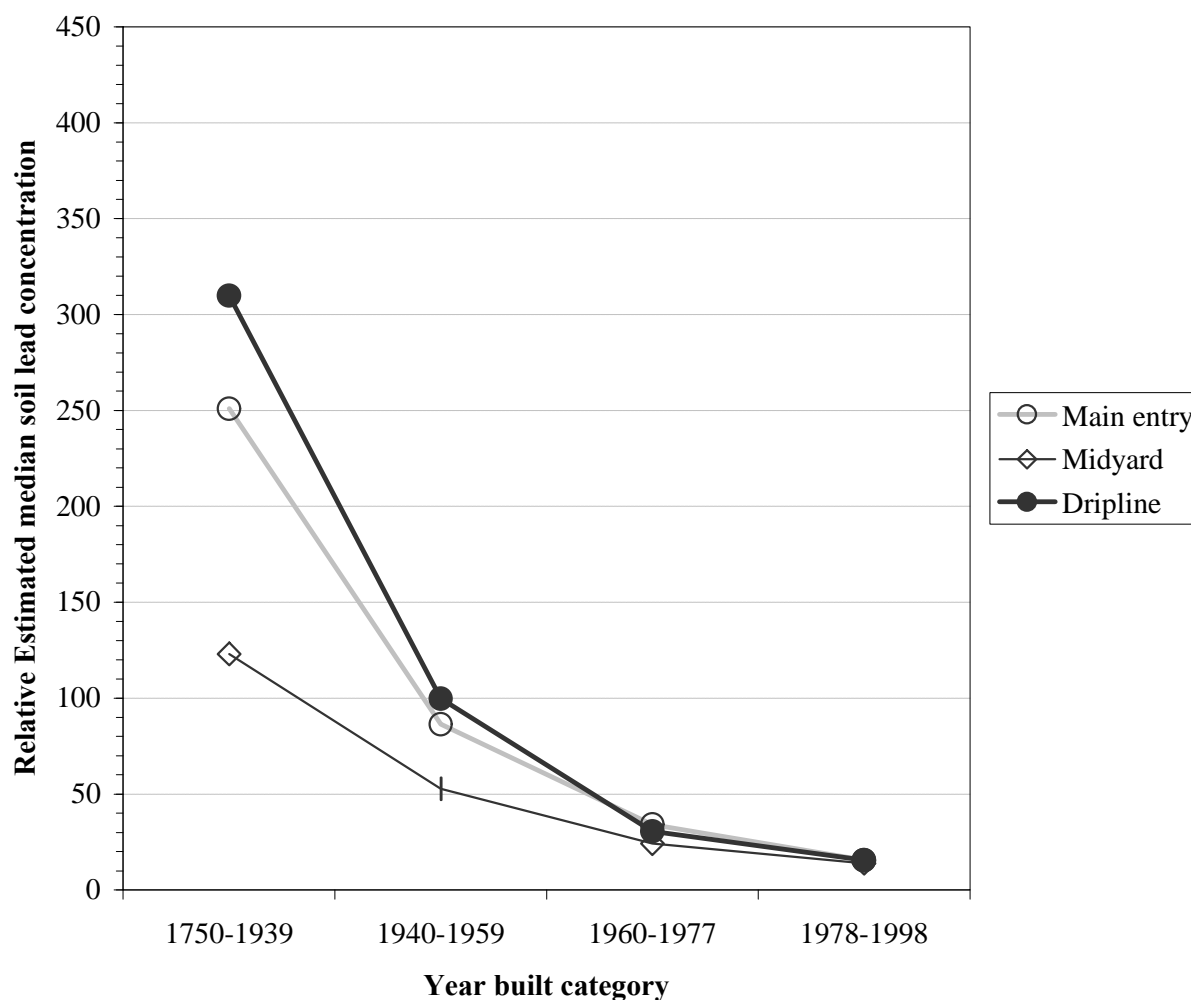


Figure 7.13 Predicted Median Soil Lead Concentrations by Construction Year Category and Region (based on regression model)

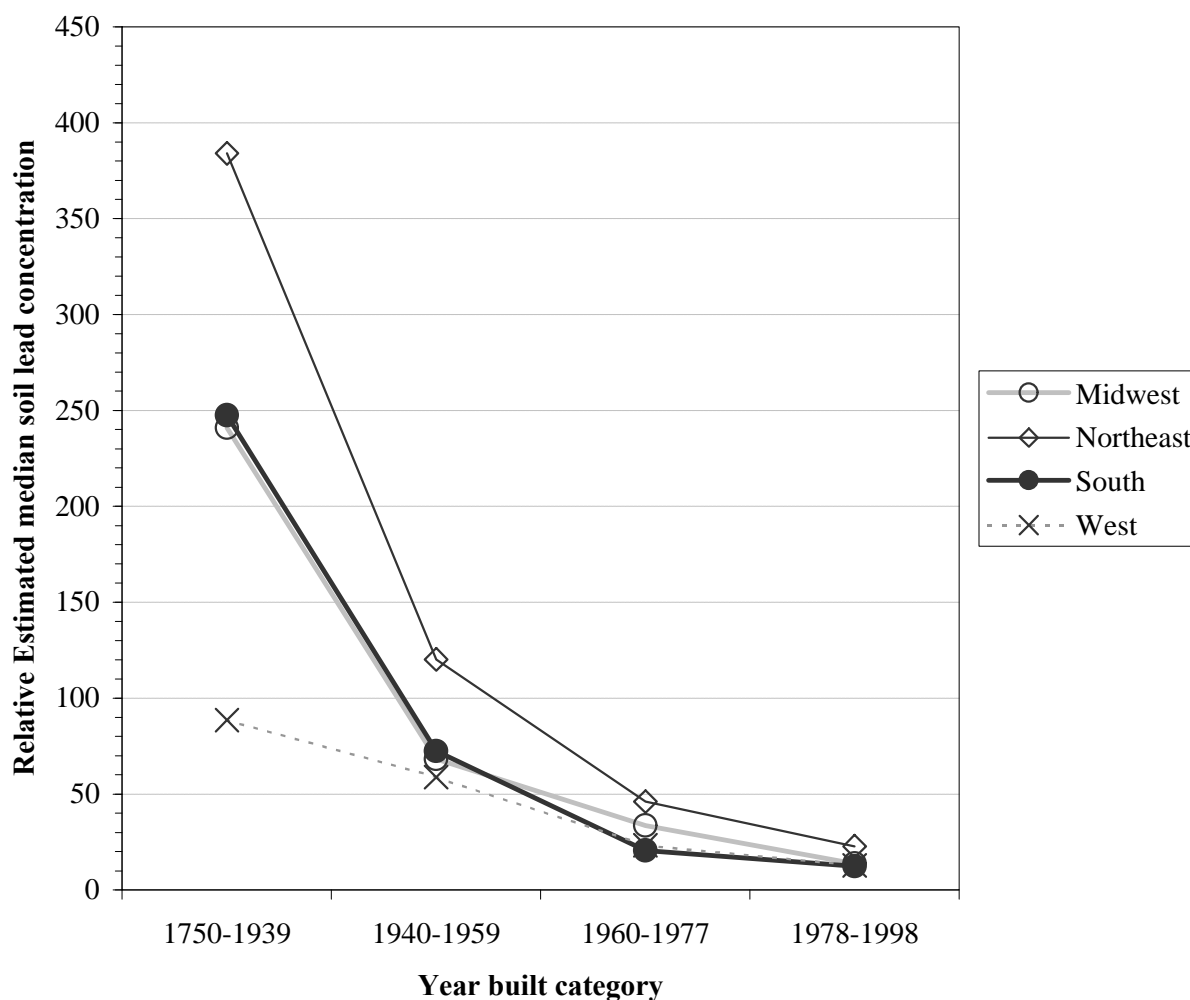
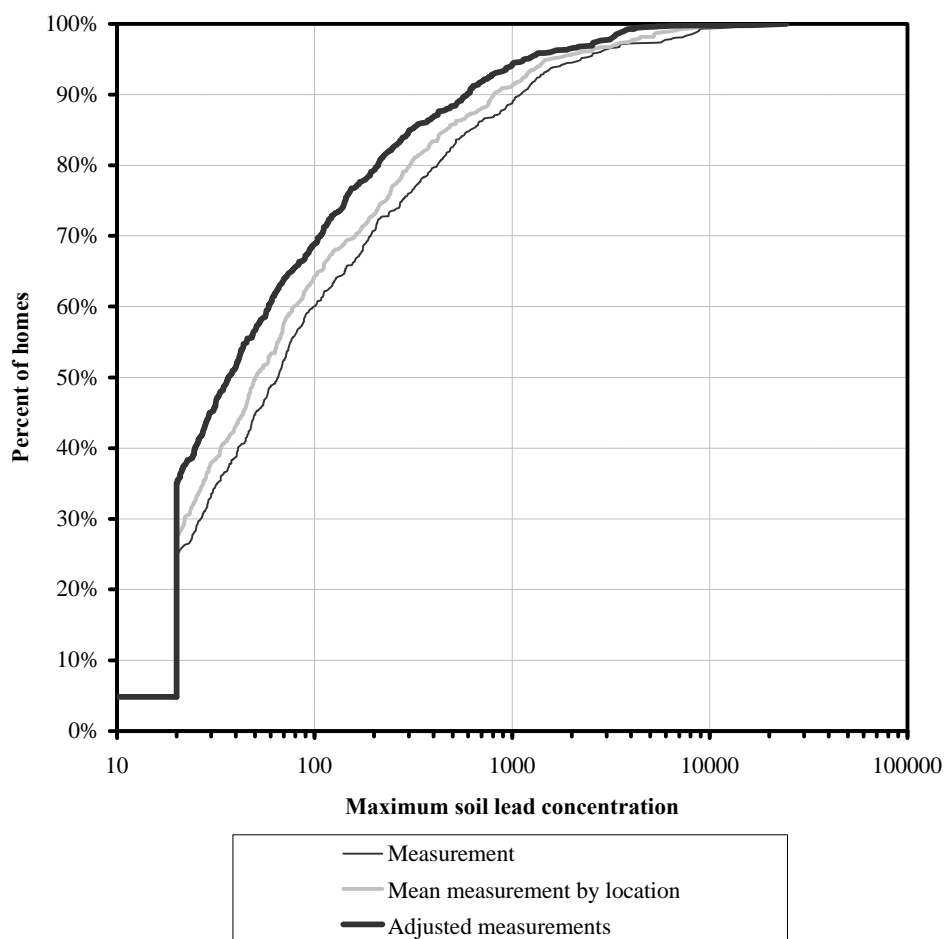


Figure 7.14 shows the cumulative distribution of the maximum soil lead concentration at homes. The figure shows three cumulative distributions:

- The maximum of the soil lead measurements at a home (bottom thin black line).
- The maximum within each home of the average soil lead measurements at the entrance, dripline, and midyard (middle gray line).
- The maximum measurement error corrected soil lead measurements (top thick black line).

Figure 7.14 Cumulative Distribution of the Maximum Soil Lead Concentration for All Homes

Note: Play area soil sample results were not included in the analysis for Figure 7.14. Thus, data may vary slightly from that presented in Chapter 6.

The difference between the first and second curves shows the effect of taking replicate soil measurements (i.e. more than one sample for a given sample location at a home). As more measurements are taken, it is more likely that a sample will be taken which has an unusually high measurement (either due to laboratory variation or due to sampling a small area with a locally high concentration). The second curve is most comparable to the third curve. The difference between the second and the third curve is due to the measurement error correction. The fact that the third (measurement error corrected) curve is to the left of the other curve is because, after correcting for measurement error, the percentage of homes judged to have soil lead concentrations above any selected value is decreased.

Using the measurement error corrected values, an estimated 3.6 percent of homes with soil (about 3.4 million homes) have soil lead concentrations above 2,000 ppm in one or more of the sampling locations (dripline, midyard, and main entrance). This is about two million fewer homes than estimated using the observed soil lead measurements. Since (see Table 3.2) approximately one-sixth of homes with a LBP hazard also had an exterior hazard, this finding is unlikely to dramatically change the national estimate of homes with a LBP hazard.

7.4 Quality of Field Data Collection and Analysis

Quality assurance was integrated into all components of the study, including a defensible study design, experienced project personnel, utilization of well-planned, detailed and tested protocols for all aspects of data collection, thorough study-specific training of experienced field staff, electronic sample and data management, and ongoing communication between individuals responsible for each stage of the study. These procedures are described in detail in Volume II, Chapter 6.

Four types of replicate sampling were conducted to estimate measurement error: replicate XRF testing of one random component per room, replicate dust sampling of one surface per home, replicate soil sampling at a different sample site at every third home, and replicate room sampling at a subset of homes. The analyses utilizing these replicate data and resultant measurement error estimates are presented above in Section 7.3.

This section summarizes the results of the various activities focussed at ensuring quality of the field data collection and laboratory analysis of the environmental samples.

7.4.1 Field Data Collection

A number of procedures were instituted to ensure quality of the field data collection, including a manual edit of all data and samples by the field team, review by the Field Supervisor upon return of the data to Westat headquarters, and reconciliation of any errors with the field team prior to submission of any samples to the laboratory. In addition, random telephone verification and field team audits were conducted; dust sample material screens were analyzed; and dust blanks and spike samples and blind soil reference samples were included in the sample stream.

Telephone Verification of Data Collection

The Field Director contacted a random subsample of 82 (10%) households by telephone to verify the team's activities and conduct and to validate selected information from the data forms. No field problems were identified by this process.

In addition to the random verification process, a number of respondents and potential respondents utilized the toll-free phone number, or the HUD phone number, to ask questions, verify the survey, and express concerns. All questions or concerns were answered or addressed by the Field Director or HUD.

Random Field Audits

The QA Officer or designee, and HUD and NIEHS representatives, conducted random field audits at 31 households to verify that the protocols were followed and data collection was accurate and complete. In addition to the field audits, the QA Officer conducted 17 telephone audits to ascertain the team members' understanding of the protocols, especially when more than two months had elapsed between assignments. Problems noted during these audits were corrected directly with the individual team members. In addition, the results of audits were immediately relayed to the Field Office. As appropriate, all field staff were notified by memo of any issues identified with the protocols.

Lead Dust Wipe Sample Collection

■ Lead Dust Wipe Materials Screens

The purpose of a materials screen was to verify that the various sampling supplies to be used in the field did not have lead contamination. Two screens were prepared and analyzed for every lot of wipe materials and sample tubes before being used in the study. The analyses showed that all material screens had below 1.5 µg lead.⁵⁵

⁵⁵ EPA's National Lead Laboratory Accreditation Program (NLLAP) requires wipes to be used in the field to have less than 5 µg lead/wipe.

■ Field Blank Wipes

One field blank wipe was prepared for each HU at a specified random sample location where another wipe sample was collected. All field blanks were below 50 µg lead/wipe, as specified in HUD *Guidelines*. Most field blanks (98+% of all field blanks) had lead levels below the detection limit for the analytical run (approximately 3.5 µg lead/wipe). Of 15 field blanks with lead values above 3.5 µg lead/wipe, only one blank had more than 20 µg lead/wipe; this wipe had 43 µg lead and was collected in a home with elevated window sill and trough lead dust levels. Data from this home were used in the survey since the blank was still below the 50 µg guideline.

■ Reference (Spike) Sample Dust Wipes

Reference wipe samples were made in advance of the fieldwork by placing a known quantity of National Institute of Standards and Technology's Standard Reference Material (NIST SRM) 1579a on the same wipe material used in the study. The reference wipes were labeled like a regular sample so that the laboratory was blinded to fact that these were quality control samples. The Field Office inserted one reference wipe sample with each group of 50 samples before sending samples to the laboratory. A total of 206 reference wipes, ranging from 21 to 516 µg lead/wipe, were submitted over the course of the study. The average reference sample recovery was 96% (range from 83% to 115%) with a standard deviation of ± 5.25 percent. With a few exceptions, all sample recoveries were within the HUD *Guidelines* acceptable range of 80 to 120 percent. The laboratory was requested to re-analyze those batches with values outside acceptable limits. Recoveries were acceptable on the second run (see Section 6.7 of Volume II) and the second set of data was used for the entire batch of samples.

Soil Quality Control Samples

■ Reference Soil Samples

Reference soil samples were purchased before the fieldwork began. The Field Office labeled and included one reference sample with each group of samples from every three households (approximately one sample in ten). A total of 83 soil reference samples were submitted to the laboratory. The average recovery was 104% (range 84% to 121%) with a standard deviation of ± 8.04 percent. Two analytical batches contained a reference sample with a recovery of 121%, exceeding the control limits of 80 to 100 percent. The laboratory was requested to re-analyze these batches. Recoveries were

acceptable on the second run (see Section 6.9, Volume II) and the second set of data was used for the entire batch of samples.

Two types of reference soil samples were used: urban soil provided by University of Cincinnati (640, 3,132, and 6,090 ppm lead), and NIST SRM 2709 (San Joaquin soil, 18.9 ppm lead) and SRM 2711 (Montana soil, 1,162 ppm lead). It is interesting, but not unexpected, that the average recovery of 89% for the NIST Montana soil was lower than the average of 105% for the urban soils. Lead in urban soils tends to be from more leachable sources (i.e. paint, past automobile emissions, industrial facilities).⁵⁶

7.4.2 Laboratory Quality Control Samples

Each laboratory provided quality assurance procedures during the selection and qualification process. These approved procedures (outlined in the National Survey's Protocol and Sample Design Report, June, 1999) were adhered to for all study samples. In general, the laboratories performed instrumental and duplicate quality control analyses, as required by ASTM E 1613-94 and the American Industrial Hygiene Association's Environmental Lead Laboratory Accreditation Program (ELLAP) Quality Manual and Policies, to ensure that the original calibration solutions were accurate, the instruments were properly zeroed, instrumental drift was not excessive, and carryover between samples did not occur. These included duplicate injections of the same sample, method blanks, and spiked samples at a minimum frequency of five percent of the samples.

7.4.3 Laboratory Selection Quality Assurance

The laboratories used for analysis of dust and soil samples, respectively, were recognized by the EPA under its National Lead Laboratory Accreditation Program (NLLAP) for those analyses throughout the laboratory qualification and performance phases of the National Survey. This recognition provided assurance of the quality of laboratory performance of lead analyses and reporting. In addition, the laboratories were accredited by the American Industrial Hygiene Association; this accreditation provided a separate assurance of the quality of laboratory management and performance of environmental analyses and reporting.

⁵⁶ Personal communication with Sandy Roda, Director, Hematology and Environmental Laboratory, University of Cincinnati.

7.5 Paint Testing Quality Assurance

Calibration of the XRF analyzer was performed before and after testing in every home. In no case was the instrument used if the calibration criteria were not met, i.e. the analyzer read 0.0 mg/m² on the 0.0 film and between 0.9 and 1.2 mg/m² on both the front and back of the 1.0 film. In addition, the average of three readings on the front of the 1.0 film was between 0.9 and 1.2 mg/m².

APPENDIX A

Comparison of Findings on LBP Hazards with Respect to *de minimis* Hazards Under the HUD Lead Safe Housing Rule and the 1995 HUD *Guidelines*

APPENDIX A

Comparison of Findings on LBP Hazards with Respect to *de minimis* Hazards Under the HUD Lead Safe Housing Rule and the 1995 HUD *Guidelines*

A.1 Introduction

When the National Survey was initiated, the 1995 HUD *Guidelines* were the main criteria for determining whether a LBP hazard was present in a home; these had been used by the EPA in issuing its interim LBP hazard guidance (60 *Federal Register* 47248, September 11, 1995). By the time the survey was completed, HUD had issued a regulation that defined LBP hazard in a different manner than the *Guidelines*. Thus, two definitions of LBP hazard were used in the draft analysis and data presentation: the 1995 HUD *Guidelines* definition and the interim standards for *any* LBP hazard in the HUD Lead Safe Housing Rule (24 CFR 35).³⁶ Under both definitions, a home is said to have a LBP hazard if one or more of the following conditions prevails: LBP with deterioration above certain thresholds; floor dust lead loadings above certain thresholds; window sill dust lead loadings above certain thresholds; or soil lead concentrations above certain thresholds. In addition, under the *Guidelines* definition, elevated window trough dust lead loadings above certain thresholds can be a LBP hazard. The *Guidelines* thresholds are higher than the Lead Safe Housing Rule thresholds for deteriorated LBP, floor dust lead loadings, and window sill dust lead loadings; but lower for soil lead concentrations. Further, at the time of the initial data analyses, the play area soil data had not been collected; thus, these data are not included in the current discussion. However, since some readers may find this information to be of interest, this appendix presents a side-by-side summary of the key survey findings with respect to these two previous definitions of a LBP hazard.

A.2 Definitions of Lead-Based Paint (LBP) Hazards

The number of housing units (HUs) classified as having a LBP hazard depends on the definition employed in such classification. A LBP hazard is defined as “any condition that causes exposure to lead from lead-contaminated dust; bare, lead contaminated soil; LBP that is deteriorated; or LBP present on accessible surfaces, friction surfaces, or impact surfaces.” Three operational definitions

³⁶ See Chapter 3 for a complete description of each of these definitions (Definitions II and III). Definition I for significant LBP hazard is used for findings presented throughout Volume I.

have been utilized in the analysis of the National Survey data. The first definition defines *significant lead-based paint (LBP) hazards* in accordance with the HUD Lead Safe Housing Rule (24 CFR 35). This definition is the focus of the results presented in the body of this report, especially Chapter 3:

Definition I: Significant LBP Hazard, HUD Lead Safe Housing Rule

If any of the following situations exist in a home, then a significant LBP hazard exists in the home under this definition:

- Deteriorated LBP – LBP with deterioration larger than the *de minimis* levels per Section 35.1350(d) of the Lead Safe Housing rule, viz., deterioration of more than 20 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or damage to more than 10% of the total surface area of interior small surface area components types (window sills, baseboards, trim).³⁷ LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm²; or
- Lead-contaminated dust – Dust on floors with greater than or equal to 40 µg/ft² lead, dust on window sills with greater than or equal to 250 µg/ft² lead³⁸; or
- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

Definition I-b: Significant LBP Hazard, EPA Identification of Dangerous Levels of Lead Rule

The EPA Identification of Dangerous Levels of Lead Rule, (40 CFR 745), issued under Section 403 of the Toxic Substances Control Act, contains a different definition of soil lead hazard than that contained in Definition I, viz., the EPA Section 403 rule uses 1,200 ppm as the threshold for soil lead concentrations outside of children's play areas. This leads to a variation on definition I for a significant LBP hazard -- if any of the following situations exist in a home, then a LBP hazard exists under this definition:

- Deteriorated LBP and Lead-contaminated dust – same as Definition I

³⁷ Intact LBP present on accessible surfaces, friction surfaces, or impact surfaces were not included in the definition of LBP hazard for the estimates presented in this report because this information was not specifically collected for each component.

³⁸ Window trough dust is not considered in the definition of a LBP hazard under the HUD Lead Safe Housing Rule.

- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 1,200 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

Data on the prevalence of LBP hazards under definition I-b are presented in Chapter 3.

The second definition of a LBP hazard is also based on the HUD Lead Safe Housing Rule (24 CFR 35). This definition differs from the first one by including deteriorated LBP below the *de minimis* thresholds that define a significant LBP hazard and excluding play area soil. The third definition was in place at the start of the study; it is presented in the 1995 HUD *Guidelines*. LBP hazard findings obtained under the second and third definitions are presented later in this appendix³⁹. The second and third definitions follow.

Definition II: Any LBP Hazard, HUD Lead Safe Housing Rule

The second definition of a LBP hazard is based on the HUD Lead Safe Housing Rule (24 CFR 35). It includes both *de minimis* and significant LBP hazards. If any of the following situations exist in a home, then a LBP hazard exists under this definition:

- Deteriorated LBP – LBP with any deterioration, where, as before, LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm²; or
- Lead-contaminated dust – Dust on floors with greater than or equal to 40 µg/ft² lead, dust on window sills with greater than or equal to 250 µg/ft² lead⁴⁰; or
- Bare, lead-contaminated soil – More than 9 square feet of bare soil with a lead concentration greater than or equal to 2,000 ppm lead, or 400 ppm for bare soil in an area frequented by a child under the age of 6 years.

Definition III: LBP Hazard, 1995 HUD *Guidelines*

The third definition of a LBP hazard is based on the 1995 HUD *Guidelines*. If any of the following situations exist in a home, then a LBP hazard exists under this definition:

³⁹ The tabulations in this appendix on LBP hazards under the Lead Safe Housing Rule do not include play area soil lead hazards.

⁴⁰ Window trough dust is not considered in the definition of a LBP hazard under the HUD Lead Safe Housing Rule.

- Deteriorated LBP – LBP in poor condition. LBP is defined as any paint or other surface coating (e.g., varnish, lacquer, or wallpaper over paint) that contains lead equal to or greater than 1.0 mg/cm². The HUD *Guidelines* define poor condition as damage to more than 10 square feet (exterior) or 2 square feet (interior) of LBP on large surface area components (walls, doors) or damage to more than 10% of the surface area of small surface area components (window sills, baseboards, trim)⁴¹; or
- Lead-contaminated dust – Dust on floors with greater than 100 µg/ft² lead, dust on window sills with greater than 500 µg/ft² lead, or dust on window troughs with greater than 800 µg/ft² lead; or
- Bare, lead-contaminated soil – Any bare soil with a lead concentration greater than 2,000 ppm lead.

A.3 Prevalence of Lead-Based Paint Hazards in Housing

An estimated 31 million (±4 million) or 32 percent (±4%) of HUs in the United States have LBP hazards as defined by the HUD 1995 *Guidelines*, while 26 million (±3 million) or 27 percent (±3%) have LBP hazards as defined by the HUD Lead Safe Housing Rule. Tables A.1a and A.1b present the number and percentage of housing units with LBP hazards by selected characteristics, according to the two definitions of LBP hazard.

Homes in Northeastern and Midwestern states are more likely to have LBP hazards than homes in Southern or Western states. An estimated 49 percent (*Guidelines*) and 44 percent (Lead Safe Housing Rule) of homes in the Northeast have LBP hazards, while the estimates are 26 percent (*Guidelines*) (18 percent under the Lead Safe Housing Rule) and 21 (16)⁴² percent for homes in the South and West, respectively. Older homes are more likely to have LBP hazards than newer homes. An estimated 17 (9) percent (±5%) of homes built between 1960 and 1977 have LBP hazards, but the percentage increases to 54 (45) percent (±10%) for homes built between 1940 and 1959, and to 73 (73) percent (±10%) for homes built before 1940. Similar results were found for homes with children under age 6 by age of construction.

An estimated 4.6 million (± 1.3 million) homes, or 28 percent (± 8 percent) of all homes with children under age 6, have LBP hazards, as defined by HUD 1995 *Guidelines*. An estimated 4.3

⁴¹ Intact LBP present on accessible surfaces, friction surfaces, or impact surfaces were not included in the definition of LBP hazard for the estimates presented in this report because this information was not specifically collected for each component.

⁴² Here, and in the sequel, the first number or percentage is the estimate under the *Guidelines* definition of lead-based paint hazard, while the second number is the estimate under the Lead Safe Housing Rule definition.

million homes (± 1.3 million), or 26 percent (± 7 percent) of all homes with children under age 6, have LBP hazards, as defined by HUD Lead Safe Housing Rule. An estimated 1.2 million (± 0.6 million) homes with household incomes under \$30,000 and resident children under age 6 have LBP hazards (1995 *Guidelines*), representing 24 percent ($\pm 12\%$) of all such homes. Under the HUD Lead Safe Housing Rule definition, this estimate is 1.2 (± 0.6) million homes ($25\% \pm 12\%$).

More homes with lower income occupants have LBP hazards than homes where occupants have higher incomes. Under the *Guidelines*, an estimated 41 (36) percent of households with less than \$30,000/year income have LBP hazards, compared with 27 (26) percent of households in the \$30,000/year or above income level. More renter-occupied housing has LBP hazards than does owner-occupied housing. An estimated 44 (32) percent of renter-occupied housing has LBP hazards, while only 27 (25) percent of owner-occupied housing has LBP hazards.

Table A.1a Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as defined by HUD 1995 Guidelines, by Selected Characteristics

HUD 1995 Guidelines: LBP Hazards ¹								
Characteristic	All HUs (000) ²	Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied HUs	95,688	31,001	27,155	34,847	32%	28%	37%	831
Region:								
Northeast	19,290	9,503	6,687	12,318	49%	35%	63%	155
Midwest	22,083	8,507	7,100	9,913	39%	31%	46%	196
South	35,474	9,090	7,549	10,632	26%	21%	30%	277
West	18,841	3,901	2,875	4,927	21%	15%	27%	203
Construction Year:								
1978-1998	29,774	2,479	1,227	3,732	8%	4%	13%	220
1960-1977	27,874	4,688	3,290	6,087	17%	11%	22%	267
1940-1959	20,564	11,113	9,304	12,923	54%	46%	62%	186
Before 1940	17,476	12,720	11,310	14,129	73%	66%	80%	158
One or More Children Under Age 6:								
All HU ages	16,402	4,634	3,397	5,871	28%	21%	36%	184
HUs built 1978-1998	5,847	242	0	527	4%	0%	9%	56
HUs built 1960-1977	5,098	487	173	802	10%	3%	16%	61
HUs built 1940-1959	3,055	1,940	1,205	2,674	64%	39%	88%	40
HUs built before 1940	2,401	1,965	1,161	2,770	82%	40%	100%	27
Housing Unit Type:								
Single family	82,651	26,836	23,616	30,055	32%	28%	37%	705
Multi-family	13,037	4,165	2,614	5,717	32%	22%	42%	126
Occupant Status:								
Owner-occupied	66,232	18,170	15,846	20,494	27%	24%	31%	539
Renter-occupied	29,074	12,765	9,260	16,270	44%	34%	54%	289
Refusal/Don't Know ⁵	381							3
Income:								
Less than \$30,000/year	33,830	13,767	10,457	17,077	41%	32%	49%	309
Equal to or more than \$30,000/year	56,111	15,226	12,829	9,260	27%	23%	31%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6								
All Income Categories	16,402	4,634	3,397	5,871	28%	21%	36%	184
Less than \$30,000/year	4,791	1,161	576	1,747	24%	12%	36%	61
Equal to or more than \$30,000/year	11,236	3,378	2,346	4,410	30%	21%	39%	117
Refusal/Don't Know	375							6
Government Support:								
Government support	4,809	1,191	293	2,088	25%	8%	42%	54
No government support	86,070	28,352	24,088	32,616	33%	28%	38%	733
Refusal/Don't Know	4,809							44

Table A.1a Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD 1995 *Guidelines*, by Selected Characteristics (continued)

HUD 1995 <i>Guidelines</i> : LBP Hazards ¹								
Characteristic	All HUs (000) ²	Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Poverty:								
In Poverty	13,221	5,472	3,520	7,423	41%	30%	53%	137
Not in Poverty	76,336	22,538	18,397	26,679	30%	24%	35%	651
Refusal/Don't Know	6,130							43
Race								
White	77,005	24,601	20,942	28,261	32%	27%	37%	622
Other ⁶	16,937	5,953	4,022	7,885	35%	26%	45%	193
Refusal/Don't Know	1,746				26%			16
Ethnicity:								
Hispanic/Latino	7,434	2,535	1,291	3,778	34%	21%	48%	86
Not Hispanic/Latino	87,008	27,854	23,830	31,877	32%	27%	37%	736
Refusal/Don't Know	1,246							9

¹ LBP hazard as defined in text and HUD 1995 *Guidelines*.

² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

³ All percentages are calculated with the "All HUs" column in each row used as the denominator.

⁴ CI = 95% confidence interval for the estimated number or percent.

⁵ Refusals and "don't know" responses by survey respondents.

⁶ "Other" race includes African American, Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

Table A.1b Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD Lead Safe Housing Rule, by Selected Characteristics

HUD Lead Safe Housing Rule: LBP Hazards ¹								
Characteristic	All HUs (000) ²	Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Total Occupied HUs	95,688	25,501	22,767	28,235	27%	24%	30%	831
Region:								
Northeast	19,290	8,455	6,475	10,435	44%	34%	54%	155
Midwest	22,083	7,540	6,675	8,405	34%	30%	38%	196
South	35,474	6,514	5,226	7,803	18%	15%	22%	277
West	18,841	2,992	2,097	3,886	16%	11%	21%	203
Construction year:								
1978-1998	29,774	1,098	215	1,981	4%	1%	7%	220
1960-1977	27,874	2,509	1,543	3,475	9%	6%	12%	267
1940-1959	20,564	9,203	7,100	11,306	45%	35%	55%	186
Before 1940	17,476	12,691	10,898	14,484	73%	62%	83%	158
One or More Children Under Age 6:								
All HU ages	16,402	4,275	3,056	5,494	26%	19%	33%	184
HUs built 1978-1998	5,847	56	0	165	1%	0%	3%	56
HUs built 1960-1977	5,098	531	47	1,016	10%	1%	20%	61
HUs built 1940-1959	3,055	1,651	1,008	2,295	54%	33%	75%	40
HUs built before 1940	2,401	2,036	1,249	2,824	85%	50%	100%	27
Housing Unit Type:								
Single family	82,651	22,646	20,114	25,178	27%	24%	30%	705
Multi-family	13,037	2,855	1,548	4,162	22%	12%	32%	126
Occupant Status:								
Owner-occupied	66,232	16,275	14,147	18,402	25%	21%	28%	539
Renter-occupied	29,074	9,226	7,030	11,422	32%	24%	39%	289
Refusal/Don't Know ⁵	381							3
Household Income:								
Less than \$30,000/year	33,830	12,082	9,067	15,096	36%	27%	45%	309
Equal to or more than \$30,000/year	56,111	11,865	9,732	13,998	21%	17%	25%	482
Refusal/Don't Know	5,747							40
One or More Children Under Age 6:								
All Income Categories	16,402	4,275	3,056	5,494	26%	19%	33%	184
Less than \$30,000/year	4,791	1,176	570	1,782	25%	12%	37%	61
Equal to or more than \$30,000/year	11,236	3,005	1,896	4,114	27%	17%	37%	117
Refusal/Don't Know	375							6
Government Support:								
Government support	4,809	1,366	289	2,442	28%	6%	51%	54
No government support	86,070	23,192	20,297	26,087	27%	24%	30%	733
Refusal/Don't Know	4,809							44

Table A.1b Prevalence of Housing Units with Lead-Based Paint (LBP) Hazards, as Defined by HUD Lead Safe Housing Rule, by Selected Characteristics (continued)

HUD Lead Safe Housing Rule: LBP Hazards ¹								
Characteristic	All HUs (000) ²	Number of HUs with LBP Hazards (000)			Percent of HUs with LBP Hazards (%) ³			HUs in Sample
		Estimate	Lower 95% CI ⁴	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Poverty:								
In Poverty	13,221	4,935	3,274	6,596	37%	25%	50%	137
Not in Poverty	76,336	18,092	15,270	20,914	24%	20%	27%	651
Refusal/Don't Know	6,130							43
Race:								
White	77,005	20,457	17,790	23,124	27%	23%	30%	622
Other ⁶	16,937	4,572	3,136	6,008	27%	19%	35%	193
Refusal/Don't Know	1,746				27%			16
Ethnicity:								
Hispanic/Latino	7,434	2,681	1,486	3,876	36%	20%	52%	86
Not Hispanic/Latino	87,008	22,433	19,873	24,993	26%	23%	29%	736
Refusal/Don't Know	1,246							9

¹ LBP hazard as defined in text and HUD Lead Safe Housing Rule.

² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

³ All percentages are calculated with the "All HUs" column in each row used as the denominator.

⁴ CI = 95% confidence interval for the estimated number or percent.

⁵ Refusals and "don't know" responses by survey respondents.

⁶ "Other" race includes African American, Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, and more than one race.

The differences among LBP prevalence by urbanization, single family versus multi-family housing, poverty, ethnicity, and race are not significant in that the confidence intervals overlap.

Table A.2 presents the number of homes with LBP by location in the building—either interior or exterior, or both. Approximately one-half of the homes with LBP hazards have the hazard on the interior only—18 (12) percent of all homes, but 55 (44) percent of homes with LBP hazards.

Table A.3 presents data for the presence of LBP hazards in homes by type of hazard, for all homes and for homes with one or more children under the age of 6 years, and for both definitions of hazard. The percentages in the upper line of each row of Table A.3 show the percent of all HUs with the type of LBP hazard, while the percentages in the lower line of each row of Table A.3 show the percent of all HUs with a child under age 6 with that type of LBP hazard.

Under the 1995 *Guidelines* definition, the number of homes with LBP hazards is dominated by homes with lead dust hazards. Of the 31 million homes with LBP hazards (under the *Guidelines*), an estimated 24 million have dust lead hazards, 16 million have deteriorated LBP, and 2 million have soil lead hazards.⁴³ The pattern is somewhat different under the HUD Lead Safe Housing Rule, reflecting the different thresholds for deteriorated LBP and dust lead hazards. Of the 26 million homes with LBP hazards (under the Lead Safe Housing Rule), an estimated 15 million have dust lead hazards, 17 million have deteriorated LBP, and 2 million have soil lead hazards.

Table A.2 Prevalence of Lead-Based Paint (LBP) Hazards by Location in the Building

HUD 1995 <i>Guidelines</i> : LBP Hazard							
LBP Hazard Location	Number of HUs ¹ (000)			Percent of HUs ²			HUs in Sample
	Estimate	Lower 95% CI ³	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI	
Interior only	16,961	13,717	20,205	18%	14%	21%	152
Both Interior and Exterior	9,459	6,845	12,073	10%	7%	13%	82
Exterior only	4,581	2,913	6,249	5%	3%	7%	43
Anywhere	31,001	26,502	35,500	32%	28%	37%	277
No LBP Hazard	64,687	60,188	69,186	68%	63%	72%	554
Total HUs	95,688			100%			831
HUD Lead Safe Housing Rule: LBP Hazard							
LBP Hazard Location	Number of HUs (000)			Percent of HUs			HUs in Sample
	Estimate	Lower 95% CI	Upper 95% CI	Percent	Lower 95% CI	Upper 95% CI	
Interior only	11,329	8,834	13,824	12%	9%	14%	101
Both Interior and Exterior	8,537	6,577	10,498	9%	7%	11%	81
Exterior only	5,635	3,828	7,442	6%	4%	8%	48
Anywhere	25,501	22,719	28,284	27%	24%	30%	230
No LBP Hazard	70,187	67,404	72,969	73%	70%	76%	601
Total HUs	95,688			100%			831

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) as the denominator. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

⁴³ The estimates for the three types of LBP hazard do not add to the total number of homes with LBP hazards because some homes have two or all three of the three types of hazards.

Table A.3 Prevalence of Lead-Based Paint (LBP) Hazards in Housing Units with a Child Under 6 Years of Age by Type of Hazard

HUD 1995 Guidelines						
Type of Hazard	Number of HUs (000)¹			Percent of HUs (%)²		
	Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Deteriorated Lead Based Paint						
All HUs	15,659	13,444	17,874	16%	14%	19%
HUs w/ Child Under 6	2,707	1,883	3,531	17%	11%	22%
Interior Lead Dust						
All HUs	23,899	19,197	28,600	25%	20%	30%
HUs w/ Child Under 6	3,467	2,217	4,717	21%	14%	29%
Lead Contaminated Soil						
All HUs	2,435	1,150	3,719	3%	1%	4%
HUs w/ Child Under 6	644	106	1,181	4%	1%	7%
Any LBP Hazard						
All HUs	31,001	27,155	34,847	32%	28%	37%
HUs w/ Child Under 6	4,634	3,397	5,871	28%	21%	36%
HUD Lead Safe Housing Rule						
Type of Hazard	Number of HUs (000)			Percent of HUs (%)		
	Estimate	Lower 95% CI	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
Deteriorated Lead Based Paint						
All HUs	17,098	14,778	19,417	18%	15%	20%
HUs w/ Child Under 6	3,045	2,106	3,985	19%	13%	24%
Interior Lead Dust						
All HUs	15,021	12,424	17,617	16%	13%	18%
HUs w/ Child Under 6	2,551	1,515	3,587	16%	9%	22%
Lead Contaminated Soil						
All HUs	1,559	209	2,910	2%	0%	3%
HUs w/ Child Under 6	476	0	996	3%	0%	6%
Any LBP Hazard						
All HUs	25,501	22,767	28,235	27%	24%	30%
HUs w/ Child Under 6	4,275	3,056	5,494	26%	19%	33%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.² Percentages are calculated with total housing units (95,688) or with housing units with a child under age 6 (16,402) as the denominator, or as applicable.³ CI = 95% confidence interval for the estimated number or percent.

A.4 Prevalence of Deteriorated Lead-Based Paint

Although there are many homes with LBP, the condition of the paint is important in determining whether a hazard exists. Except during renovations and certain other disturbances, intact paint is believed to pose little immediate risk to occupants. However, deteriorated paint may present an immediate danger to occupants, especially to young children.

Table A.4 presents the number and percentage of HUs with deteriorated LBP by location in the building - either interior or exterior, or both. Estimates are provided for two definitions of deteriorated LBP hazard, as follows:

1. HUD 1995 *Guidelines* – A LBP hazard is defined as LBP in poor condition. Poor condition is defined as damage to more than 10 square feet (exterior) or 2 square feet (interior) of lead-based paint on large surface area components (walls, doors) or damage to more than 10% of the total surface area of small surface area components (window sills, baseboards, trim).
2. The HUD Lead Safe Housing Rule – This rule defines a LBP hazard when LBP exhibits any deterioration, no matter how small the area of damage.

Table A.4 Prevalence of Deteriorated Lead-Based Paint (LBP) by Location in the Building

Deteriorated Paint per 1995 Guidelines							
All Construction Years	Number of HUs¹ with Deteriorated LBP (000)			Percent² of HUs with Deteriorated LBP(%)			HUs in Sample
	Estimate	Lower 95% CI³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	3,251	2,127	4,374	3%	2%	5%	31
Both Interior and Exterior	4,407	2,999	5,815	5%	3%	6%	44
Exterior Only	8,329	6,185	10,473	9%	6%	11%	72
No Deteriorated LBP	79,701	77,265	82,137	83%	81%	86%	684
TOTAL	95,688			100%			831
Post-1977 Construction Year							
Interior Only				0%	0%	0% ⁴	0
Both Interior and Exterior				0%	0%	0% ⁴	0
Exterior Only	83	0	240	0%	0%	1%	1
No Deteriorated LBP	29,692	28,741	30,643	100%	97%	100%	219
TOTAL	29,774			100%			220
Deteriorated Paint per HUD Lead Safe Housing Rule							
All Construction Years	Number of HUs with Deteriorated LBP (000)			Percent of HUs with Deteriorated LBP(%)			HUs in Sample
	Estimate	Lower 95% CI	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI	
Interior Only	4,180	2,851	5,509	4%	3%	6%	39
Both Interior and Exterior	6,236	4,661	7,811	7%	5%	8%	62
Exterior Only	7,009	4,922	9,097	7%	5%	10%	61
No Deteriorated LBP	78,263	75,953	80,572	82%	79%	84%	669
TOTAL	95,688			100%			831
Post-1977 Construction Year							
Interior Only				0%	0%	0% ⁴	0
Both Interior and Exterior	56	0	165	0%	0%	0% ⁴	1
Exterior Only	83	0	240	0%	0%	1%	1
No Deteriorated LBP	29,636	28,677	30,595	100%	96%	100%	218
TOTAL	29,775			100%			220

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² Percentages are calculated with total housing units (95,688) as the denominator, or total post-1977 housing units (29,775), as applicable. Percentages may not total 100% due to rounding.

³ CI = 95% confidence interval for the estimated number or percent.

⁴ When there are no observed HUs, the statistical estimate has no variability, and thus the upper end of the confidence interval is reported as 0%. It is, of course, possible that some HUs with the characteristic exist. Thus, upper confidence limits of 0% should be interpreted as "less than 0.5%."

Using the HUD 1995 *Guidelines* definition, an estimated 16 million (± 2 million) or 17 percent ($\pm 2\%$) of housing units in the United States have deteriorated LBP. Roughly one-third of these homes have deterioration on both interior and exterior surfaces. The deteriorated LBP is only on the exterior for approximately one-half of the homes with deteriorated LBP.

Using the HUD Lead Safe Housing Rule definition, an estimated 17 million (± 2 million) or 18 percent ($\pm 3\%$) of housing units in the United States have deteriorated LBP. Roughly 40 percent of these homes have deterioration on both interior and exterior surfaces. The deteriorated LBP is only on the exterior for approximately 40 percent of the homes with deteriorated LBP.

Table A.5a presents the number and percentage of housing units with deteriorated LBP (HUD 1995 *Guidelines*) by construction year. The data suggest that older homes are more likely to have deteriorated LBP than newer homes. An estimated 3% of homes built between 1960 and 1977 have deteriorated LBP, but the percentage increases to 30% for homes built between 1940 and 1959, and to 51% for homes built before 1940. No significant differences were found when this was crossed with urbanization category.

Table A.5b shows the percent of homes with deteriorated paint that have deteriorated LBP. While for most homes (80 percent) built before 1940, their deteriorated paint is LBP, this is only true for half of the homes built between 1940 and 1959, and for practically none of homes built since 1960.

Table A.5a Distribution of Housing Units (HUs) with Deteriorated Lead-Based Paint (LBP) and Deteriorated Paint by Construction Year

HUD 1995 <i>Guidelines</i> : LBP in Poor Condition							
Construction Year	Total HUs (000) ²	Number of HUs with Deteriorated LBP (000)			Percent of HUs with Deteriorated LBP (%) ¹		
		Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
1978-1998	29,774	83	0	240	0%	0%	1%
1960-1977	27,874	848	207	1,489	3%	1%	5%
1940-1959	20,564	6,216	4,329	8,102	30%	21%	39%
Before 1940	17,476	8,841	7,099	10,582	51%	42%	60%
Total HUs	95,688	15,987	13,868	18,105	17%	15%	19%

**Table A.5b Distribution of Housing Units (HUs) with Deteriorated Lead-Based Paint (LBP)
and Deteriorated Paint by Construction Year (continued)**

HUD 1995 <i>Guidelines</i> : Paint in Poor Condition							
Construction Year	Total HUs with Deteriorated Paint (000) ²	Number of HUs with Deteriorated LBP (000)			Percent of HUs with Deteriorated Paint that is Deteriorated LBP (%) ¹		
		Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
1978-1998	3,979	83	0	240	2%	0%	6%
1960-1977	7,503	848	207	1,489	11%	3%	20%
1940-1959	11,348	6,216	4,229	7,917	55%	38%	71%
Before 1940	11,070	8,841	6,796	10,247	80%	64%	96%

¹ Percentages may not total 100% due to rounding.² "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.³ CI = 95% confidence interval for the estimated number or percent.

A.5 Prevalence of Dust Lead in Housing

Table A.6 presents the prevalence of all homes and homes with one or more children under 6 years of age with a dust lead hazard somewhere in the home,⁴⁴ as defined by HUD 1995 *Guidelines* and the HUD Lead Safe Housing Rule. The HUD 1995 *Guidelines* considered lead in dust to be a hazard when dust on floors had greater than 100 µg/ft² lead, dust on window sills had greater than 500 µg/ft² lead, or dust on window troughs had greater than 800 µg/ft² lead. The new HUD Lead Safe Housing Rule, defines a dust lead hazard as greater than or equal to 40 µg/ft² lead on floors or 250 µg/ft² lead on window sills. There is no longer a hazard level defined for dust lead on window troughs.

Using the HUD 1995 *Guidelines* of dust lead hazard, an estimated 25 percent (±5%) of all homes have dust lead hazard somewhere in the home, while 4 percent (±2%) of all homes, nearly 3.5 million homes, have both a child under 6 years of age and a dust lead hazard.

Using the HUD Lead Safe Housing Rule definition, slightly fewer homes have dust lead hazards. An estimated 16 percent (±2%) of all homes have a dust hazard somewhere in the home, and 3 percent (±1%) of all homes have both a child under 6 years of age and a dust lead hazard. While it might be expected that the number of homes with dust lead hazards would be greater under the new HUD Lead

⁴⁴ The maximum lead dust loading on any surface tested (floor, window sill, and window trough) in the home was used to determine whether a dust lead hazard existed.

Safe Housing Rule because of the lower floor and sill dust lead standards, the deletion of trough dust lead from the definition may explain the lower number of homes with dust lead hazards, as will be seen.

Table A.6 Prevalence of Housing Units with a Dust Lead Hazard Somewhere in the Home

HU Category ¹	Number of HUs (000)			Percent of HUs(%) ²		
	Estimate	Lower 95% CI ³	Upper 95% CI	Estimate	Lower 95% CI	Upper 95% CI
HUD 1995 Guidelines:						
HUs with Lead Dust Hazard	23,899	19,197	28,600	25%	20%	30%
HUs with children under 6 years and Lead Dust Hazard	3,467	2,217	4,717	21%	14%	29%
HUD Lead Safe Housing Rule:						
HUs with Lead Dust Hazard	15,021	12,424	17,617	16%	13%	18%
HUs with children under 6 years and Lead Dust Hazard	2,551	1,515	3,587	16%	9%	22%

¹ "Housing units" include permanently occupied, noninstitutional housing units in which children are permitted to live.

² All percentages are calculated with total housing units (95,688) or HUs with resident children under age 6 (16,402) as the denominator.

³ CI = 95% confidence interval for the estimated number or percent.

A.6 Association between Dust Lead Hazards and LBP Paint Condition

Table A.7 presents the prevalence of dust lead hazards in relation to the condition of the interior LBP. Dust lead hazards are more likely to exist in homes with deteriorated LBP. An estimated 72 percent of homes with deteriorated LBP (1995 *Guidelines*) have lead dust hazards, while only 42 percent of homes with LBP in good or fair condition have lead dust hazards. Only 15 percent of homes with no interior LBP have lead dust hazards. Although it appears from the data that the presence of LBP, especially deteriorated LBP, contributes to higher dust lead hazard, there are additional sources of lead in the environment to account for dust lead in homes with no lead-based paint. Table A.7 allows one to compare the relative risks (with 95 percent confidence intervals on that risk) of interior lead dust hazards associated with different paint conditions. The presence of deteriorated LBP makes a house 1.7 (± 0.5) times as likely to have an interior lead dust hazard compared to a house where the LBP is in good condition, and 4.9 (± 1.9) times as likely as a house without LBP. Even a house with LBP in good condition is 2.8 (± 0.8) times as likely to have interior lead dust hazards as one without any LBP.

Table A.7 Association Between Dust Lead Hazards and Presence and Condition of Interior Lead-based Paint

All HU Ages: 1995 Guidelines							
		No Interior LBP		Interior LBP in Good Condition		Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Estimate ¹	56,980	60%	12,288	13%	2,155	2%
	Lower 95% CI ²	53,448	56%	9,215	10%	1,287	1%
	Upper 95% CI	60,512	63%	15,361	16%	3,024	3%
Interior Dust Lead Hazards	Estimate	9,840	10%	8,922	9%	5,503	6%
	Lower 95% CI	6,733	7%	6,156	6%	3,740	4%
	Upper 95% CI	12,946	14%	11,689	12%	7,265	8%
Total HUs	95,688						
Post-1977 Construction: 1995 Guidelines							
		No Interior LBP		Interior LBP in Good Condition		Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Estimate	26,363	89%	1,014	3%	0	0%
	Lower 95% CI	24,522	82%	183	1%	0	0%
	Upper 95% CI	28,205	95%	1,845	6%	0	0%
Interior Dust Lead Hazards	Estimate	2,214	7%	183	1%	0	0%
	Lower 95% CI	1,012	3%	0	0%	0	0%
	Upper 95% CI	3,417	11%	545	2%	0	0%
Total HUs	29,774						
All HU Ages: HUD Lead Safe Housing Rule							
		No Interior LBP		Interior LBP in Good Condition		Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Number HUs	62,752	66%	13,070	14%	4,563	5%
	Lower 95% CI	60,141	63%	10,461	11%	2,956	3%
	Upper 95% CI	65,363	68%	15,679	16%	6,170	6%
Interior Dust Lead Hazards	Number HUs	4,068	4%	5,382	6%	5,853	6%
	Lower 95% CI	2,584	3%	3,414	4%	4,433	5%
	Upper 95% CI	5,552	6%	7,350	8%	7,273	8%
Total HUs	95,688						
Post-1977 Construction: HUD Lead Safe Housing Rule							
		No Interior LBP		Interior LBP in Good Condition		Deteriorated Interior LBP	
No Interior Dust Lead Hazards	Number HUs	27,801	93%	958	3%	56	0%
	Lower 95% CI	26,162	88%	144	0%	0	0%
	Upper 95% CI	29,440	99%	1,771	6%	165	1%
Interior Dust Lead Hazards	Number HUs	777	3%	183	1%	0	0%
	Lower 95% CI	0	0%	0	0%	0	0%
	Upper 95% CI	1,572	5%	545	2%	0	0%
Total HUs	29,774						

¹ Estimate is either the number of permanently occupied, noninstitutional housing units (000) in which children are permitted to live, or the percentage of total housing units (95,688 or 29,774).

² CI = 95% confidence interval for the estimated number or percent.

APPENDIX B

Comparison of Protocols for the HUD 1990 Survey of Lead-Based Paint (LBP) in Housing and the HUD National Survey of Lead and Allergens in Housing

**Comparison of Protocols for the HUD 1990 Survey of Lead-Based Paint (LBP) in Housing
and the HUD National Survey of Lead and Allergens in Housing**

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lead and Allergens in Housing
Types/numbers of housing units selected for the survey and whose data were available to the TSCA Section 403 risk analysis	284 housing units selected from occupied, permanent, non-institutional housing in the 48 coterminous states built prior to 1980 and having the potential for containing children. (These units were all privately-owned. While publicly-owned units were also selected for the survey, data for these units are not considered in this summary.)	831 housing units selected in a three-stage stratified random sample from occupied, permanent, non-institutionalized housing having the potential for containing children. 75 primary sampling units (PSUs).
Breakdown of selected units by year built	Pre-1940: 27% 1940-1959: 31% 1960-1979: 42% Post-1979: 0%	Pre-1940: 18% 1940-1959: 22% 1960-1977: 29% Post-1977: 31%
Dates of environmental sampling	November 1989 to March 1990	August 1998 to February 1999, and from July to August 1999
Selecting rooms for environmental sampling	<p>Telephone household interview provided information on rooms. One room was selected for sampling in each of the following strata:</p> <ul style="list-style-type: none"> ■ <u>Wet room</u> -- rooms containing plumbing (e.g., kitchen, bathroom, laundry room, utility room) ■ <u>Dry room</u> -- all rooms not classified as wet rooms ■ <u>Main entryway</u> (floor dust samples only) 	<p>Room Inventory Form from the Screening/Recruiting Questionnaire was used to obtain information on rooms. One room was randomly selected for sampling in each of the following four strata:</p> <ul style="list-style-type: none"> ■ <u>Kitchen</u> ■ <u>Common living area</u> (e.g., living room, den, family room) ■ <u>Bedroom</u> in which one or more children aged 17 years or younger regularly slept, or any regularly-occupied bedroom if no such children lived in the unit (occasionally, two such bedrooms were selected) ■ <u>Other random room</u> among the remaining rooms in the housing unit. (Note: Two rooms were randomly selected from this stratum if the stratum contained at least six rooms.) ■ <u>Main entry (floor dust only)</u> ■ <u>Interior common area (multi-family dwellings, floor dust only)</u>
Method of assigning sampling weights	Weights reflect the various stages of sampling. Total of the sampling weights equaled the	Weights reflect the various stages of sampling. Total of the sampling weights

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lead and Allergens in Housing
	estimated number of housing units with children under age 7 years (13,912,000, as estimated by the 1987 AHS). Total of the sampling weights within a given census region equaled the estimated number of units with children under age 7 years in the census region.	within a given census region equals the estimated number of units in the census region.
Method for taking dust samples for lead analysis	Blue Nozzle vacuum (a few wipe samples were also collected). <i>Sampling house dust for lead: basic concepts and literature review.</i> (1995). EPA 747-R-95-007.	Wipes, collected in accordance with ASTM E1728-95, <i>Practice for the field determination of settled dust samples using wipe sampling methods for lead determination by atomic absorption spectrometry techniques.</i>
Number and location of floor-dust samples per room	One sample from each selected room (location not dictated in the protocol)	One sample from each selected room, generally taken from the center of the largest open area of the room.
Window sill/trough dust sampling approach	A window was selected within each selected room according to a ranking scheme. Sampling was performed from both the sill and trough of the selected window until enough dust was collected or until the entire sill or trough was vacuumed.	Entire sill and trough sampled from a random window in the selected room. Trough definition included sliders.
Number and location of sill and trough dust samples per room	One sample from the sill and one sample from the trough of the selected window in the selected wet room and dry room	One sample from the sill and one sample from the trough of the selected window in each selected room
Method of analyzing dust samples	Graphite Furnace Atomic Absorption Spectroscopy (GFAA) (with EPA SW-846 digestion method)	Flame Atomic Absorption Spectrometry (FAAS) using NIOSH method 7082 Digestion method: modification of EPA SW-846 Method 3050 or ASTM ES 36-94 (hot-plate digestions utilizing nitric acid and/or perchloric acid and/or hydrogen peroxide). Method same as used in proficiency testing within the Environmental Lead Laboratory Accreditation Program (ELLAP).
Soil sampling approach	One composite sample of up to 3 core samples (the latter two taken within 20 inches of the first), each taken at a depth of 10 cm, was collected at each of the following locations: <u>entryway, drip-line, and remote area</u> (i.e., an area halfway between the unit and its property boundary, or within 25 feet of the unit, whichever was less).	Two sides of the unit were selected for soil sampling: the side containing the major entryway (Wall 1) and a second, randomly-selected side (Wall 2). Samples were collected from the top 0.5 inches of soil at the following three sites: ■ <u>Main entry</u> - a single sample from Wall 1

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lead and Allergens in Housing
		<ul style="list-style-type: none"> ■ <u>Foundation/drip-line</u> - one sample from each of Walls 1 and 2, each sample being a composite of 3 core subsamples taken within 3 feet of the foundation ■ <u>Mid-yard area</u> - one sample from each of Walls 1 and 2, each sample being a composite of 3 core subsamples taken midway between the drip-line and boundary of the housing unit property. ■ <u>Play Area</u> – one composite sample from bare soil under each unit of fixed play equipment. <p>Soil samples were collected in accordance with core sampling procedures based on ASTM E1727-95 (described in the HUD <i>Guidelines</i> and in EPA's <i>Residential Sampling for Lead: Protocols for Leaded Dust and Soil Sampling</i>). Samples were collected from bare soil when possible. If no bare soil existed, samples were collected from covered surfaces if possible.</p>
Method of analyzing soil samples	ICP-AES (with SW-846 digestion method)	ICP-AES using NIOSH method 7082 Digestion method: modification of SW-846 Method 3050 or ASTM ES 36-94 (hot-plate digestions utilizing nitric acid and/or perchloric acid). Method same as used in proficiency testing within the Environmental Lead Laboratory Accreditation Program (ELLAP).
Handling dust-lead and soil-lead measurements below the detection limit	As log-transformed lead amounts are reported in the database, only positive measurements are represented. No indication is given as to when data may have been truncated due to being below detection limits.	The final results as reported by the instrument are recorded in the database (i.e., not-detected results are not censored), along with detection limits.
Method for taking paint-lead measurements	Spectrum analyzer XRF instrument (single 60-second spectrum reading measurement using a 40 millicurie cobalt source). Measurements were adjusted to statistically correct for measurement bias.	Spectrum analyzer XRF analyzer (full-period readings with a 20-second minimum in accordance with the applicable HUD-approved Performance Characteristic Sheet .)
Approach to selecting <u>interior</u> painted	Painted surfaces were categorized into the following four strata:	The following painted components were measured for lead in each selected room:

Area	HUD National Survey of Lead-Based Paint in Housing	HUD National Survey of Lead and Allergens in Housing
components for paint-lead measurements	<ul style="list-style-type: none"> ■ Walls/ceilings/floors ■ Metal substrate ■ Non-metal substrate ■ Other surfaces <p>Five painted components were selected randomly for testing in each of the selected wet and dry rooms, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere in the unit that may be suspected to contain lead.</p>	<ul style="list-style-type: none"> ■ All four major walls ■ Ceiling ■ Door of major entryway ■ Window selected for dust sampling ■ Baseboard ■ Floor ■ Up to two other painted surfaces: Technician choice based on surfaces containing deteriorated paint or friction areas.
Approach to selecting <u>exterior</u> painted components for paint-lead measurements	<p>Painted surfaces were categorized into the following four strata:</p> <ul style="list-style-type: none"> ■ Wall (randomly-selected) ■ Metal substrate within the selected wall ■ Non-metal substrate within the selected wall ■ Other surfaces within the selected wall <p>Five painted components were selected randomly for testing from the side of the unit containing the selected wall, one from each stratum along with a fifth selected randomly from among all strata. In addition, up to two purposive measurements were taken from paint anywhere on the exterior of the unit that may be suspected to contain lead.</p>	<p>Painted siding was measured for lead levels on each exterior wall. In addition, the following painted components were measured for lead on a random wall:</p> <ul style="list-style-type: none"> ■ Miscellaneous trim (2 measurements) ■ Window ■ Door of major entryway – wall independent. ■ Porch and railing – wall independent ■ Up to two other painted surfaces