U.S. Department of Housing and Urban Development
Office of Policy Development and Research

Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing

Report to Congress

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U.S. Department of Housing and Urban Development
Washington, DC

December 7, 1990

ACKNOWLEDGMENTS

Direction of the Study

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Research Team and Contracts

Research was carried out by the cooperative efforts of seven firms working closely with staff of HUD and the U.S. Environmental Protection Agency (EPA). Key members of the research team include:

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The national survey of lead-based paint in housing was conducted for HUD by Westat, Inc., in affiliation with Dewberry and Davis and KTA-Tator, under Contract HC-5848. Analyses were conducted by Westat, Inc., in affiliation with Speedwell, Inc., and Aspen Systems Corp., under the same contract. Policy recommendations were prepared by HUD. Laboratory services for the survey were provided by Midwest Research Institute, under an interagency agreement between HUD and EPA (HUD No. 90-03). Research Triangle Institute prepared the initial design of the national survey under contract to HUD (HC-5796).

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HUD/EPA Interagency Task Force on Lead-Based Paint

Task Force participants contributed to the report in many ways, including assistance in designing the research, formulating proposed Federal actions, and reviewing numerous drafts.

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EXECUTIVE SUMMARY

The Lead-Based Paint Poisoning Prevention Act, as amended by Section 566 of the Housing and Community Development Act of 1987, requires the Secretary of Housing and Urban Development to "prepare and transmit to the Congress a comprehensive and workable plan, including any recommendations for changes in legislation, for the prompt and cost-effective inspection and abatement of privately-owned single family and multifamily housing, including housing assisted under section 8 of the United States Housing Act of 1937." In fulfillment of this mandate, the Department of Housing and Urban Development (HUD) proposes, in this report, a balanced and comprehensive plan designed to overcome the barriers that have inhibited efforts to address the hazards of lead-based paint in the past, and to support State and local governments and the private sector in the difficult but necessary task of reducing these hazards in American homes.

The "comprehensive and workable plan" is one of a series of research, demonstration, and policy actions initiated by HUD in response to the 1987 amendments to the Lead-Based Paint Poisoning Prevention Act. Other actions include a national survey to better estimate the extent of lead hazards in our Nation's housing stock, a major multi-city demonstration to identify the most cost-efficient methods for lead hazard abatement, research on lead hazard testing technology, and the development of interim technical guidelines for the testing and abatement of lead hazards in public housing (known as "the HUD guidelines"). Further legislative amendments in 1988 require a "comprehensive and workable plan" for lead paint abatement in public housing. That report is scheduled for transmittal to the Congress in 1991.

This report focuses on lead paint abatement, as mandated by the Congress. However, evidence showing the beneficial effects of abatement upon health is not as precise as would be desirable. One published study indicates that traditional abatement methods, which are less stringent than those called for by the HUD guidelines, do not reduce blood lead levels without continual dust control; three recent unpublished studies conclude that traditional abatement has salutary health effects; and one recent doctoral dissertation concludes that the health effects are positively related to the stringency of the abatement standards and that dust lead suppression is very important. This body of research indicates that abatement has value but the findings offer conflicting evidence on the merits of alternative abatement strategies. Clearly, more research is needed to better understand the relationship between abatement and health effects, especially because lead paint testing and abatement are extremely costly.

LEAD IN THE ENVIRONMENT

There are many sources of lead in the environment--including drinking water, food, emissions from gasoline combustion, and industrial emissions, as well as paint. This multiplicity of sources makes it difficult to identify the exact contribution of lead-based paint to lead poisoning, or to quantify the extent to which abating lead-based paint will reduce the incidence of elevated blood lead levels. Indeed, the research on which this report is based provides some indirect evidence that the higher incidence of elevated blood lead levels among poor children may be related to factors other than lead-based paint. More research needs to be conducted to determine the extent to which various sources of lead in the environment contribute to the problem. This will permit development of a comprehensive cost-effective approach to reducing the overall lead hazard. The Administration is planning an interagency effort to address the problem.

However, while there are many sources of lead in the environment, it is clear that lead-based paint plays a major role in high blood lead levels. Lead poisoning certainly derives from the direct ingestion of paint chips, and such cases are often severe. Recent studies indicate that dust and soil, inside and outside of the dwelling, may be the most significant pathway for low-level lead exposure and that lead-based paint is an important source of household dust lead. Ironically, lead-based paint abatement itself is one source of dust, if inadequate cleanup procedures are followed. There is in fact a strong indication that the process of renovation or repainting, which includes scraping and sanding of old lead paint surfaces, generates dust lead that often remains in the residential environment. Thus, while abatement of lead hazards can contribute to the reduction of blood lead levels, recent research shows that great care must be taken during abatement to protect occupants, workers, and the surrounding environment from further contamination.

It has been known for many years that lead is a powerful toxicant that attacks the central nervous system and is particularly damaging to the neurological development of young children. Doctors have known that high levels of lead in the body can result in convulsions, pronounced mental retardation, and even death, if not treated. However, recent medical research has found that low levels of lead exposure have more serious health consequences than previously thought. Effects include reductions in intelligence and short-term memory, slower reaction times, and poorer hand-eye coordination. At low levels of lead exposure, these neurobehavioral deficits are usually subtle, presenting no obvious, subjective evidence of disease. This research is described in the section on Effects of Low-Level Exposure in Chapter 2.

The U.S. Public Health Service has responded to emerging knowledge about the effects of low-level exposure by periodically lowering the level of lead in blood that warrants medical attention. In 1970, this level stood at 60 micrograms of lead per deciliter of blood (ug/dl). It was lowered to 40 ug/dl in 1971, to 30 ug/dl in 1975, and to 25 ug/dl in 1985. An advisory committee to the Centers for Disease Control (CDC) is now considering a new statement advising that blood lead levels in the range of 10-15 ug/dl, and perhaps lower, are harmful to the neurological development of fetuses and young children and can result in deficits in intelligence that are probably irreversible.

This reduction in the blood lead level of concern has significantly increased the number of children considered to be at risk. The Agency for Toxic Substances and Disease Registry of the Centers for Disease Control estimates that 200,000 or 1.5 percent of the Nation's black and white children under 6 years of age and living in metropolitan areas in 1984 had blood lead levels of 25 ug/dl or greater. For levels of 15 ug/dl or greater, the estimate was 2,400,000 children or 17 percent -- more than 10 times greater. The Agency has estimated that 3 to 4 million children nationwide had levels of 15 ug/dl or greater in 1984, after inclusion of those groups not represented in the detailed estimates for nonmetropolitan areas and less numerous racial and ethnic groups.

At the same time, average blood lead levels in the United States have been declining since the 1970s because of the reduction of lead in gasoline, but the problem remains one of the Nation's most widespread childhood health problems stemming from environmental conditions.

EXTENT OF LEAD-BASED PAINT IN HOUSING

In 1989-1990, HUD undertook a major national survey in order to better estimate the extent of lead paint hazards in the Nation's housing stock. The survey finds that lead-based paint is widespread in housing. Of the 77 million privately owned and occupied homes built before 1980, 57 million, or three-fourths, contain lead-based paint. Of these 57 million units, an estimated 9.9

million are occupied by families with children under the age of 7, who are most at risk from lead poisoning. However, a much smaller number of units have conditions that pose priority hazards: 3.8 million of the units occupied by young children have peeling paint, excessive amounts of dust containing lead, or both problems. Of these, 1.8 million are occupied by children whose families have incomes above $30,000, which is approximately the median income for all households; 2.0 million are occupied by lower-income families with children, of whom 0.7 million are owner-occupants, and 1.3 million are renters. This identification and classification of priority groupings is important to devising an appropriate abatement strategy and understanding the cost implications.

The survey includes data on the characteristics of the housing unit and the household occupying it. As expected, lead-based paint is found more often in prewar housing units than in those built since 1940. Some other findings are more surprising. In particular, there is no correlation between the incidence of lead-based paint and the income of the household. Lead-based paint is found as often in the homes of the well-to-do as the poor. This is somewhat unexpected, because studies of blood lead in children find a much higher incidence of elevated blood lead levels among the poor. This apparent discrepancy may be due to worse physical conditions and more dust lead in the homes of lower-income families. It may stem also from poorer nutrition, which increases the absorption of lead into the body, and from greater exposure to lead in water from old pipes.

The survey also provides new and unexpected information on the location of lead paint within individual housing units. Most public attention has focused on lead-based paint on interior walls and surfaces, and lead dust inside the unit, but in fact more units have lead paint on the exterior than on the interior. Of the 57 million units with lead-based paint, 18 million have it only on exterior surfaces, 11 million only on interior surfaces, and 28 million on both exterior and interior surfaces.

In agreement with prior research, the survey finds an association between lead paint and the presence of excessive levels of lead in dust and soil. Approximately 14 percent of all housing units built prior to 1980, or 10.7 million homes, have lead in interior surface dust that exceeds the HUD guidelines. The chance of a home having excessive dust lead is about twice as large if the home has high levels of interior lead-based paint than if it does not. However, most of the homes with interior dust have it only on the window sills or in the window wells within which the bottom of the window fits when it is closed. Only about 1 million units have excessive lead dust exclusively on the floors.

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Soil outside the building is another direct source of childhood lead exposure, and also a potential source of lead in house dust which can be tracked into the dwelling or blown in. Approximately 16 percent of all homes built prior to 1980 have concentrations of lead in soil adjacent to the house that exceed EPA guidelines. The chance of this occurring is at least 4 to 5 times greater if the house has exterior lead-based paint, than if it does not.

THE COST OF ABATING LEAD-BASED PAINT

The cost of abating lead-based paint in American housing is potentially very large, and the long-term cost-effectiveness of any abatement strategy is uncertain. Using the removal methods described in the HUD guidelines for public housing, the cost per unit would be about $7,700 on average, excluding testing and relocation. The cost would be lower, on the order of $5,500 per unit, if abatement were done by encapsulating lead-painted surfaces with acrylic, epoxy, or similar high-performance coatings instead of removing the paint. Encapsulation is acceptable under the HUD guidelines, but the long-term durability and cost-effectiveness of this approach has not been studied to date. The average cost of abating units with priority hazards, i.e., nonintact lead-based paint or excessive levels of lead in dust, is higher still: $8,900 for encapsulation and $11,900 for removal. Costs for priority-hazard units are higher than average because such units tend to have more surfaces with lead-based paint than do other units.

Using less rigorous abatement methods that have been employed traditionally in various local abatement programs, as well as in public housing in the past, the cost of abating the average unit would be lower, about $2,100 per unit, again excluding testing and relocation. Traditional abatement would leave lead paint on surfaces that are presumably out of the reach of small children. Typically traditional abatements focus on either peeling paint or interior paint to a height of five feet, involve less worker protection, and require less rigorous cleanup than the HUD guidelines. These methods entail a risk of poisoning from lead dust remaining after abatement, or lead dust that is subsequently created by the lead-based paint that has not been abated. The expanded definition of abatement established in the Housing and Community Development Act of 1987, including all interior and exterior surfaces, and the concomitant requirements for enhanced protection and cleanup, raise the cost of abatement significantly, as reflected in the costs under the HUD guidelines.

childhood poisoning. Childhood lead poisoning is usually discovered through blood lead screening programs that, in most areas, reach only five percent of the children. With regard to the private sector, the only significant effort HUD has identified is the development of environmental standards for the secondary mortgage market by the Federal National Mortgage Association (FNMA). There is very little private abatement, even though lead paint is just as common in the houses of the well-to-do as it is in those of the poor.

Such inaction may be due in part to a lack of public awareness regarding the recent findings of medical research on neurological damage of low-level lead exposure, the hazards of dust lead, and the linkage of lead-based paint to such exposure. Even if the public was aware of this information, however, there is a dearth of industry capacity to perform the testing and abatement work competently, little direct guidance as to proper procedures, high costs that inhibit action, and no reason to expect that abatement will completely eliminate the lead hazard.

A COMPREHENSIVE PLAN

As noted, lack of public awareness of the problem coupled with the high cost of testing and abatement have combined to produce relatively little public or private action to address this public health issue.

Aware of this lack of progress, the Department proposes a comprehensive plan intended to mitigate the problems that have inhibited efforts to address the hazards of lead-based paint. Categories of activity are as follows:

- Secretary Kemp will appoint a Department-wide task force to update the lead-based paint regulations in HUD programs.
- Secretary Kemp will also initiate a consultative process with other agencies to update the regulations dealing with the reduction of lead paint hazards in all Federally owned properties prior to sale for residential use.
- The Federal Government will continue to support State and local screening programs to increase the proportion of the Nation's children who are checked for lead poisoning.
- Public education efforts aimed at individuals, the real estate industry, and State and local Government agencies will be expanded.

- Additional Federal research activities will be undertaken to reduce the cost and improve the reliability of testing for lead in paint and dust, and also to reduce the cost of safe and effective abatement.

- Additional research will also be undertaken on the cost-effectiveness of various abatement strategies. This will include analysis of the specific contribution of lead-based paint to lead in the blood, and the extent to which the various current abatement strategies result in long-term health benefits, such as a lower incidence and severity of lead poisoning. Complementing this analysis, in-place management strategies will be developed and tested to see if lead hazards can be reduced to tolerable levels in individual housing units on a more cost-effective basis.

- Research to determine what should be done about exterior soil lead and interior dust lead in carpets, upholstered furniture, forced air ducts, and similar sources will be initiated.

- Because housing regulation is primarily a responsibility of State and local governments, the Federal Government will work with State and local governments to increase their ability to regulate and support hazard reduction activities. This will include working with the private sector to provide training in lead abatement for construction workers and other participants in the abatement and remodelling industries.

- A substantial volume of Federal funds and other resources are already available for support of lead-based paint abatement and lead poisoning prevention. However, as awareness of the problem grows through public education, the demand for access to abatement resources can be expected to increase significantly. To meet this emerging need, the Administration is developing options to provide additional financial support for single family and multifamily abatements in units owned or occupied by low and moderate income households. Assistance would be targeted to families with young children living in homes with priority hazards.

The proposed Federal actions reflect continuing consultation by HUD with other agencies, including the Environmental Protection Agency, the Department of Health and Human Services, the Department of Labor, the Department of Commerce, and the Consumer Product Safety Commission. Specific actions will be implemented only after additional discussion with those agencies.

A summary description of the proposed activities follows.

Updating HUD Lead-Based Paint Regulations

In light of recent statutory changes as well as new knowledge on the nature and extent of lead poisoning, HUD will conduct a thorough and critical review of its existing program regulations childhood poisoning. Childhood lead poisoning is usually discovered through blood lead screening programs that, in most areas, reach only five percent of the children. With regard to the private sector, the only significant effort HUD has identified is the development of environmental standards for the secondary mortgage market by the Federal National Mortgage Association (FNMA). There is very little private abatement, even though lead paint is just as common in the houses of the well-to-do as it is in those of the poor.

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concerning lead-based paint. Secretary Kemp is establishing a task force to analyze current regulations in all programs and propose modifications. The task force will report to the Secretary in six months.

Addressing Hazards in Other Federally-Owned Housing

Secretary Kemp will also initiate a consultative process with other Federal agencies that offer residential properties for sale to the public, in order to update the regulations aimed at eliminating the hazards of lead-based paint in these properties.

Expanded Information and Education Effort

There is a general lack of awareness of the seriousness of lead exposure and ways to avoid it. Parents of young children as well as real estate professionals must be made aware of the dangers of lead poisoning and elevated blood lead levels, the availability of lead screening, and the protective measures that can be taken to avoid exposure. To remedy this, HUD, in cooperation with other Federal agencies, will undertake a program (1) to produce and widely disseminate brochures and other materials to the general public, and (2) to establish a national information clearinghouse and technical hotline to provide needed technical information to homeowners, the health and building industries, and others concerned with the lead-based paint problem. Both of these efforts will accelerate the transmittal of research results and other important information to the public.

Research and Demonstration Activities

There is a pressing need for expanded health, epidemiological, and environmental research and demonstration activities to support the effective elimination of lead poisoning. Research is needed in cost-effective testing and abatement of lead in paint, dust, and soil, as well in better understanding the contribution of lead paint to blood lead levels. This research will be undertaken on a multi-agency basis.

Research on the health effects of abatement. A major study is proposed to analyze the relationship among the concentrations, amounts, and condition of lead paint, dust and soil lead, and childhood blood lead levels. This study has two principal purposes: (1) to determine which housing has the highest risk of causing childhood lead poisoning and is thus of highest priority for abatement, and (2) to support the estimation of the benefits of abatement. In particular, additional research is necessary to clearly establish the relationship of lead-based paint to blood lead levels and the contribution of abatement to the reduction of blood lead levels, especially in children. It is critical to determine what types of abatement are most cost-effective in order to achieve maximum positive health impacts from available abatement resources.

Testing for lead in paint, dust, and soil. The cost of testing is high, and the testing industry at present has limited capacity. It appears that no more than 500,000 private housing units can be tested annually. Therefore, an essential prerequisite of any effective strategy for the elimination of lead paint hazards is the availability of inexpensive, reliable methods of detection for homeowners and contractors, as well as more sensitive, reliable, and nondestructive methods to be used by professional inspectors. Specific projects include the evaluation of spot testing for lead, improving X-ray fluorescence (XRF) lead analyzers, and the development of laboratory standards and standard lead reference materials.

Research on lead-based paint abatement methods, products, and procedures. The cost of abatement is also high, in the current state of technology. Although there has been substantial progress in developing procedures for lead paint abatement, much still needs to be known. A number of initiatives are proposed, including a review of worker protection standards, identification of new abatement technologies, monitoring the long-term efficacy of abatement, and the review of guidelines for handling and disposing of lead paint waste. In addition, HUD will prepare and disseminate a full report on its multi-city abatement demonstration in Federally-owned housing, and will prepare technical guidelines for testing and abatement in private housing.

Research on lead in soil and household dust. Lead in the soil appears to be a source of interior dust lead, as the soil is tracked or blown into the housing unit. There is an immediate need to better understand how to abate lead in exterior soil. It is also desirable to study abatement of dust found in carpets, air ducts, furniture, and other personal property. Several proposed research projects will significantly advance knowledge of how such lead hazards can be quickly, safely, and efficiently abated.

In-place management. There is a need to establish procedures to promote the maximum reduction of lead exposure through good maintenance practices. Property owners need to be able to apply measures that are relatively low in cost, but effective. A demonstration is proposed to test the cost-effectiveness of alternative hazard reduction measures.

Capacity Building and Local Program Development

State and local governments have primary responsibility for regulating housing conditions in the United States. At present, most have devoted few resources to the problem of lead-based paint. The Federal Government must assist State and local governments to develop the capacity to assume a leadership role in regulating and managing large-scale and effective programs of lead-based paint hazard elimination. Three Federal actions are proposed: (1) the development of training curricula and a training control system, (2) the preparation of information for State legislators, and (3) the creation of an information exchange system for State and local governments. The Administration is considering other ways to help States and localities. One possibility is demonstration grants to encourage the development and implementation of innovative local strategies for lead hazard reduction.

Financial Assistance for Lead-Based Paint Abatement

The Administration is developing options to provide additional financial support for single family and multi-family residential abatement. Low and moderate income homeowners and/or landlords would be eligible for abatement assistance to units with priority hazards, occupied by families with young children.

EXISTING FEDERAL RESOURCES

Although there is no present Federal categorical program to abate lead-based paint, there are a number of HUD programs under which lead-based paint abatement is an eligible activity. These include both grant and loan programs, and also mortgage insurance.

The Community Development Block Grant Program ($2.9 billion) makes funds available for rehabilitation of housing to be occupied by low- and moderate-income families. The new HOME program represents another important potential resource for financing lead-based paint testing and abatement. Authorized by the Cranston-Gonzalez National Affordable Housing Act of 1990, HOME is a block grant program to State and local governments which encourages the design and implementation of housing programs tailored to local needs. Considerable housing rehabilitation is expected since the bill explicitly promotes such efforts. As authorized, HOME would receive $1 billion in FY 1991 and $2.086 billion in FY 1992.

HUD provides insurance for housing rehabilitation through a number of programs. Property Improvement Loan Insurance (Title I) is available for single-family owner-occupied homes; the loan limit is $17,500 for 15-year loans. These loans finance alterations, repairs, and improvements to existing structures, and offer a means of financing lead-based paint abatement. Section 203(k) is available to owners or purchasers of existing homes that need repair; it can be used to finance renovations only or to combine the cost of buying the home with the cost of renovating it, in a single transaction. Rehabilitation of multifamily housing can be insured through Sections 221(d)(4) and 223(f). These programs insure housing primarily for moderate and middle income families.

In addition, the Department of Health and Human Services funds programs which can be used to screen children for elevated blood lead levels. This screening process, in addition to identifying children who need medical treatment, also leads to the identification of dwelling units which should be targeted for lead-based paint abatement or in-place management activities.

HHS's categorical grant program of Grants to States for Childhood Lead Poisoning Prevention, funded at $3.9 million in 1990, is used solely for these lead screening activities. Three HHS block grant programs for States--the Maternal and Child Health Block Grant ($554 million in 1990), the State Preventive Health and Health Services Block Grant ($83 million in 1990), and the Community Health Centers program ($427 million in 1990) are also sources of funding for lead poisoning prevention activities, if States choose to use them for this purpose.

THE CONTRIBUTION OF THE PUBLIC HOUSING ABATEMENT PROGRAM

It is important to keep in mind that the public housing program has played an important leadership role in the reduction of lead hazards. Lead-based paint is being abated now in public housing. This is being done in accordance with explicit provisions of the Lead-Based Paint Poisoning Prevention Act that require abatement in public housing that is assisted under the to apply measures that are relatively low in cost, but effective. A demonstration is proposed to test the cost-effectiveness of alternative hazard reduction measures.

Capacity Building and Local Program Development

State and local governments have primary responsibility for regulating housing conditions in the United States. At present, most have devoted few resources to the problem of lead-based paint. The Federal Government must assist State and local governments to develop the capacity to assume a leadership role in regulating and managing large-scale and effective programs of lead-based paint hazard elimination. Three Federal actions are proposed: (1) the development of training curricula and a training control system, (2) the preparation of information for State legislators, and (3) the creation of an information exchange system for State and local governments. The Administration is considering other ways to help States and localities. One possibility is demonstration grants to encourage the development and implementation of innovative local strategies for lead hazard reduction.

Financial Assistance for Lead-Based Paint Abatement

The Administration is developing options to provide additional financial support for single family and multi-family residential abatement. Low and moderate income homeowners and/or landlords would be eligible for abatement assistance to units with priority hazards, occupied by families with young children.

EXISTING FEDERAL RESOURCES

Although there is no present Federal categorical program to abate lead-based paint, there are a number of HUD programs under which lead-based paint abatement is an eligible activity. These include both grant and loan programs, and also mortgage insurance.

The Community Development Block Grant Program ($2.9 billion) makes funds available for rehabilitation of housing to be occupied by low- and moderate-income families. The new HOME program represents another important potential resource for financing lead-based paint testing and abatement. Authorized by the Cranston-Gonzalez National Affordable Housing Act of 1990, Comprehensive Improvement Assistance Program (CIAP). The HUD guidelines were developed for the public housing program, and it was during the development of the guidelines that the need for many of the research projects and training activities proposed in this report was identified.

HUD intends to monitor and evaluate the testing and abatement that is undertaken in public housing closely, with particular attention to costs and health effects. HUD also intends to test in-place management procedures in public housing and to monitor the results closely. All this activity will enhance practical technical knowledge about lead hazard reduction and will generate growth in the supply of experienced inspectors, testers, and contractors, all to the eventual benefit of privately owned housing.

FEDERAL EXPENDITURES AND RESOURCES

This report is being prepared at the beginning of the FY 1992 budget cycle. It is therefore not feasible to estimate the amount of Federal funding to support the plan during FY 1991 and beyond. A full-scale budget review of all activities proposed in this plan will occur in the normal course of the FY 1992 budget process.

During FY 1990, approximately $11 million was obligated in support of lead-based paint activities. Of this amount, $160,000 is being spent on public information; $8.2 million on testing and abatement research; $1.6 million for research on health effects; and $770,000 on State and local capacity building.

THE CHANGING NATURE OF THE LEAD-BASED PAINT PROBLEM

Lead-based paint has been regarded as a public policy concern since the passage of the Lead-Based Paint Poisoning Prevention Act in 1971. Over the ensuing 19 years, however, the nature and extent of both the lead-based paint problem and the problem of elevated blood levels have been frequently re-specified, as more has been learned. When the Act was passed, chewing on lead paint chips was regarded as the primary health hazard from lead paint, and the U.S. Public Health Service had set 60 micrograms of lead per deciliter of blood as the level warranting medical attention; concern has now shifted to lead dust, and the level of lead in the blood warranting attention is 25 micrograms per deciliter, and may be reduced in the near future. Similarly, the concentration of lead in paint regarded as serious was 2 milligrams per square centimeter in many local abatement efforts during the 1970s; in the HUD regulations issued in August 1986 and in the Housing and Community Development Act of 1987, it was set at 1 milligram. Abatement standards were also less rigorous, and abatement was less costly. The combined effect of the lower concentration level and the more costly abatement is substantial. HUD's national survey found that 43 percent of the housing units built before 1980 have concentrations above 2 milligrams, compared to 77 percent with concentrations above 1 milligram. The average cost of abating in accord with the HUD guidelines averages between $5,500-$7,700 per housing unit depending on the method used; the cost of abating to prior standards is about $2,100. The total cost of abatement by today's standards is thus five or six times as large as it would have been by the standards of 20 years ago.

This plan has been developed at the present time in response to the request of the Congress. It is based on the best currently available information, and the research that underlies the plan has itself contributed to what is known about lead-based paint. However, the plan is not intended as a static document. Research and abatement activity is now underway that will add to what is known about lead-based paint. The public housing abatement demonstration is an example. A new survey of blood lead levels in children is in progress as part of the third National Health and Nutrition Examination Survey. Further research should also be undertaken to fill the gaps in knowledge that have been noted in the report, and to reduce the high cost of testing and abatement. The plan will be modified in the future as more is learned about the problem and about the most cost effective ways to address it.

CHAPTER 1

INTRODUCTION

This report responds to the requirement in the Lead-Based Paint Poisoning Prevention Act (LPPPA), as amended, that the Secretary of Housing and Urban Development "prepare and transmit to the Congress a comprehensive and workable plan, including any recommendations for changes in legislation, for the prompt and cost-effective inspection and abatement of privately-owned single family and multifamily housing, including housing assisted under section 8 of the United States Housing Act of 1937."[1]

This report also provides "an estimate of the amount, characteristics, and regional distribution of housing in the United States that contains lead-based paint hazards at differing levels of contamination," as required by the same legislation. Other Congressional requirements are addressed in this report, as explained later in this chapter.

This chapter provides background on the history of lead-based paint production in the United States and the relevant legislative and regulatory history. The responses of the Department of Housing and Urban Development (HUD) to recent Congressional directives on lead-based paint are summarized. The final sections of the chapter describe the organization of the report and the interagency consultation that has occurred during its preparation.

PAINT PRODUCTION HISTORY

Lead-based paints have been produced since ancient times. The first factory to produce white-lead pigments in the United States was established in 1804 in Philadelphia.[2] Paints with lead-based

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[1]Amendment in Section 566 of the Housing and Community Development Act of 1987 (Public Law 100-242).

[2]McKnight, Mary E.; Byrd, W. Eric; Roberts, Willard E.; and Lagergren, Eric S. (December 1989), *Methods for Measuring Lead Concentrations in Paint Films* (NISTIR 89-4209), U.S. Department of Commerce, National Institute of Standards and Technology, p. 1, citing Mattiello, J.J. (1942), *Protective and Decorative Coatings*, Vol. II, (New York: John Wiley and Sons, Inc.).

pigments were highly regarded for their durability, adhesion, and hiding qualities. Based on the history of the production of white-lead pigments relative to other pigments, lead concentrations in paint manufactured in the United States were probably highest during the first two or three decades of the 20th century.[3] However, lead-based paint remained in widespread use during the 1930s and 1940s and to a declining extent into the 1970s.

LEGISLATIVE AND REGULATORY HISTORY

Although many cases of severe lead poisoning were reported in the United States during the first half of this century, it was not until the 1950s that public health officials in some of the larger cities began to trace the cause of many of the cases to old housing with deteriorating lead-based paint. In the 1950s and 1960s several older, larger cities began to regulate the use of lead-based paint, educate the public on its dangers and how to avoid them, and screen children for lead poisoning. Some cities with early regulations banning the use of lead-based paint on interior surfaces were Baltimore, MD; Chicago, IL; Cincinnati, OH; Jersey City, NJ; New Haven, CT; New York, NY; Philadelphia, PA; St. Louis, MO; Washington, DC; and Wilmington, DE.[4] In 1955, the paint industry adopted a voluntary standard limiting the use of lead in interior paints to no more than 1 percent by weight of nonvolatile solids.

In 1971, the Federal Government enacted LPPPA, which, among other things, required the Secretary of Health, Education and Welfare (now the Secretary of Health and Human Services) to prohibit the use of lead-based paint in residential structures constructed or rehabilitated by the Federal Government or with Federal assistance in any form. Lead-based paint was defined as paint containing more than 1 percent by weight. In 1972, HUD issued regulations prohibiting lead-based paint in HUD-associated housing.

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[3]Lead-based paints were not the only paints in use in the early 20th century. Paint production data from the Census of Manufacturers indicate that, by 1919, the production of water and calcimine-based paints almost equaled those with white lead. Around 1920, a zinc-based compound known as lithopone came into use as a supplement or replacement for white-lead pigments in interior paints. In the 1930s, titanium dioxide was introduced as a hiding pigment. The production of titanium dioxide pigments equaled that of leaded pigments by the late 1940s and, by the late 1950s, was five times greater. Latex paint came into use in the 1930s and, by the 1950s, was the dominant paint for interior walls. Lead was seldom used with latex paint; it was primarily an additive to oil and alkyd paints.

[4]Gilsinn, J.F. (1972), *Estimates of the Nature and Extent of Lead Paint Poisoning in the United States*, U.S. Department of Commerce, National Bureau of Standards, Table 1, p. 11.

The 1971 act also authorized a national program to encourage and assist States and cities to conduct mass screening programs to identify children with lead poisoning, refer them for medical treatment, investigate their residential environments for sources of lead, and order abatement. During most of the 1970s, this program was administered by the Centers for Disease Control (CDC). In 1981, the program was folded into the Maternal and Child Health Services Block Grant to the States. In 1988, the Lead Contamination Control Act authorized the resumption of a small categorical program to assist local screening programs.

In 1973, LPPPA was amended to lower the lead content allowed in paint to 0.5 percent until December 31, 1974, and 0.06 percent after that date unless the Consumer Product Safety Commission (CPSC) found that a higher percentage was safe. In 1974, CPSC reported to Congress that it considered 0.5 percent lead to be a safe level. The 1973 amendments also required HUD to eliminate, to the extent practicable, the hazard of lead-based paint poisoning in pre-1950 housing covered by housing subsidies and applications for mortgage insurance, and also in all pre-1950 federally owned housing prior to sale. HUD issued regulations implementing those requirements in 1976.

In 1976, additional amendments to LPPPA lowered the paint lead limit to 0.06 percent unless CPSC again determined that a higher limit not exceeding 0.5 percent was safe. In 1977, CPSC declined to make such a finding; thus, according to the law, lead-based paint became defined as paint containing more than 0.06 percent as of June 23, 1977. In 1978, CPSC, acting under the authority of the Consumer Product Safety Act, banned the sale of lead-based paint to consumers and the use of lead-based paint in residences and other areas where consumers have direct access to painted surfaces. CPSC concluded that the impact of the ban would not be severe, because 95 percent of latex paints and 70 percent of oil paints intended for consumers were already in compliance.

In 1983, HUD was ordered by the court in *Ashton* v. *Pierce* to conduct further rulemaking. In that case, public housing tenants in the District of Columbia alleged that HUD's lead-based paint regulation was deficient for failing to define intact lead-based paint surfaces as an "immediate hazard" requiring treatment. At the time of *Ashton*, HUD's requirements pertained primarily to defective paint. In 1986 and 1987, HUD issued new regulations for all HUD housing programs that redefined "immediate hazard" and changed the construction cutoff date from 1950 to 1973 in most cases.

In 1987, Congress amended LPPPA to require (1) inclusion of intact paint in the definition of immediate hazard and a construction cutoff date of 1978, (2) several detailed changes to the lead-based paint requirements of the public housing program, (3) an extensive research and demonstration program, and (4) several reports, including this "comprehensive and workable plan" for abatement in privately owned housing. Further amendments in 1988 required a comprehensive and workable plan for abatement in public housing.

In response to the 1987 amendments, HUD issued new regulations in June 1988 pertaining primarily to the public housing program but also making 1978 the construction cutoff date for all programs and defining "applicable surface" to include intact paint for all programs in accordance with the act. Major regulatory changes for the nonpublic housing programs have been delayed until the completion of an abatement demonstration program pursuant to mandates contained in the 1987 amendments.

RESPONSES TO RECENT STATUTORY DIRECTIVES

This section describes HUD's response to other reporting requirements mandated in either the Housing and Community Development Act of 1987 or the Stewart B. McKinney Homeless Assistance Amendments Act of 1988. These reporting requirements have to do with testing technology, estimates of the amount of housing nationwide that contains lead-based paint, abatement methods, in-place management of lead-based paint hazards, and a comprehensive and workable plan for abatement in public housing.

Testing Technology

The 1987 amendments to LPPPA called for an examination of:

- The most reliable technology available for detecting lead-based paint, including x-ray fluorescence (XRF) and atomic absorption spectroscopy (AAS);
- Safety considerations in testing;
- The overall accuracy and reliability of laboratory testing of physical samples, XRF machines, and other available testing procedures; and
- The availability of qualified samplers and testers.

To respond to these directives, HUD sponsored research at the National Institute of Standards and Technology (NIST). NIST examined three types of technologies: (1) chemical spot tests done on site, (2) portable XRF analyzers (also an on-site technology), and (3) laboratory analysis of paint samples. HUD also conducted a separate test of sodium sulfide spot testing as a part of the abatement demonstration that is described later in this section.

A summary of the NIST findings is provided in Chapter 4 and Appendix D of this report. A complete account of the investigation is available in two published reports.[5]

National Hazards Estimate

The 1987 amendments to the Lead-Based Paint Poisoning Prevention Act call for "an estimate of the amount, characteristics, and regional distribution of housing in the United States that contains lead-based paint hazards at differing levels of contamination."

After examining available data on the extent and rate of occurrence of lead-based paint in housing, HUD concluded that a national survey of lead-based paint in housing was necessary to respond to this statutory mandate and to supply other information needed in the development of this report. The initial design of the survey was prepared by Research Triangle Institute, and the final design and implementation was completed by Westat, Inc. Both were under contract to HUD. A description of the survey and its findings with regard to the amount of private housing with lead-based paint are provided in Chapter 3 of this report. Further methodological description is found in Appendix A. The findings for public housing will be presented in a subsequent report.

Technical Guidelines on Testing and Abatement

Congress, HUD, and the public health community concluded that HUD's 1986 regulations did not adequately address concerns about identification of lead-based paint, protection for the occupants and workers, the need for thorough post-abatement cleanup (to ensure a safe environment), and disposal of waste generated by the abatement procedures. To address this problem, the Senate

[5]McKnight et al. *Methods for Measuring Lead Concentrations in Paint Films*; McKnight, Mary E.; Byrd, W. Eric; and Roberts, Willard E. (May 1990), *Measuring Lead Concentration in Paint Using a Portable Spectrum Analyzer X-Ray Fluorescence Device* (NISTIR W90-650), U.S. Department of Commerce, National Institute of Standards and Technology.

and House Appropriations Committees in August 1988, directed HUD to contract with the National Institute of Building Sciences (NIBS) to develop interim guidelines for testing, abatement, cleanup, disposal, and worker protection until new HUD regulations and guidelines could be produced. Utilizing a consensus approach and a task force of experts from both the public and private sectors, NIBS provided its report to HUD in March 1989.

The report accompanying the NIBS guidelines included several significant minority opinions about the potentially high cost of implementing the guidelines in public housing. Therefore, HUD's Office of Public and Indian Housing convened a special working group of outside experts to review the guidelines and identify more cost-effective ways to conduct abatement without posing safety risks to workers or residents. A revision, entitled "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing" (hereafter referred to as the HUD Interim Guidelines) specifically directed itself to issues of concern to public housing agencies. The testing sections of the HUD Interim Guidelines were made to conform to the results of the NIST research. The HUD Interim Guidelines were published originally in the *Federal Register* on April 18, 1990.[6] A revised chapter on worker protection was published in the *Federal Register* on September 28, 1990; and, also in September, HUD published and distributed a complete revised version of the Interim Guidelines, including minor technical and typographical changes as well as the revised chapter on worker protection.

The NIBS guidelines have been used in the demonstration of abatement techniques in HUD-owned Federal Housing Administration (FHA) single-family housing. The HUD Interim Guidelines are being used in the demonstration of lead-based paint testing and abatement techniques in public housing.

Abatement Demonstration

The 1987 amendments required HUD to conduct a major demonstration in HUD-owned (FHA) properties to examine "the most efficient and cost-effective methods for abatement, including removal, containment, or encapsulation of the contaminated components, procedures which minimize the generation of dust (including high-efficiency vacuum removal of leaded dust) and

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[6] U.S. Department of Housing and Urban Development (1990), "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing," *Federal Register* 55 (April 18): 14557-14789.

procedures that provide for offsite disposal of the removed components in compliance with all applicable regulatory standards and procedures." Further amendments in 1988 directed that the demonstration be conducted in public housing as well as in FHA properties. The two parts of the demonstration, FHA properties and public housing, began at different times with somewhat different research designs.

FHA properties. HUD selected a support contractor to manage the demonstration in January 1989. After an extensive research-design effort, in which the Environmental Protection Agency (EPA) was closely involved, 173 HUD-owned single-family properties in seven metropolitan areas were selected for abatement on the basis of a detailed statistical design. While the statute called for the abatement research to be conducted in both single-family and multifamily properties in HUD's inventory, no multifamily properties met the conditions established for the demonstration. Therefore, this demonstration is limited to single-family properties. Data on abatement methods in multifamily properties will be collected in connection with the abatement demonstration in public housing, discussed below. Abatement work for the demonstration was completed in July 1990. Preliminary findings on costs are presented in Chapter 4 of this report; additional methodological description is provided in Appendix E. A complete report on the demonstration will be published in 1991.

Public housing. In addition to the research objectives cited above for the abatement demonstration in FHA properties, the lead-based paint abatement demonstration in public housing is designed (1) to determine the degree to which the abatement of individual units in multifamily public housing projects creates risks to residents and workers in nearby units from lead-contaminated dust, and (2) to investigate the most appropriate ways to integrate lead-based paint abatement activities with the process of comprehensively modernizing public housing projects.

Three public housing agencies--Omaha, NE; Albany, NY; and Cambridge, MA--are participating in the lead-based paint abatement demonstration in public housing. The Omaha project consists of attached town house units, while the Albany and Cambridge projects consist of multifamily projects with enclosed stairs and corridors. A total of 106 units are involved. Testing of these units has been completed; abatement will occur over the next several months.

The results of the demonstration will be reported to Congress in 1991.

In-Place Management of Lead-Based Paint Hazards

The Lead-Based Paint Poisoning Prevention Act directs HUD to examine and report on the "merits of an interim containment protocol for public housing dwellings that are determined to have lead-based paint but for which comprehensive improvement assistance under Section 14 of the United States Housing Act of 1937 is not available." With the high cost of existing abatement techniques and the impossibility of abating all units containing lead-based paint immediately, HUD believes that in-place management, or "interim containment," must be considered. In general terms, in-place management would involve repainting of defective paint surfaces, thorough cleanup of dust, avoidance of further damage to lead-based paint surfaces, monitoring of the condition of such surfaces, and periodic maintenance and cleaning. It is viewed as an interim measure to protect occupants until safe, cost-effective abatement procedures can be established and implemented. HUD is developing a protocol for in-place management of lead-based paint hazards in public housing. A draft for public comment is expected to be available in early 1991.

The concept of interim in-place management may be useful in privately owned housing as well as public housing. Research on the effectiveness of in-place management is proposed in Chapter 6.

Comprehensive and Workable Plan for Abatement in Public Housing

As required by Section 1088 of the McKinney Amendments Act of 1988, HUD will develop a comprehensive and workable plan for the abatement of lead-based paint hazards in public housing, drawing on data from the public housing abatement demonstration, the national survey of lead-based paint in housing, and the assessment of abatement methods conducted as part of the demonstration of lead-based paint abatement techniques in FHA properties. The report containing the comprehensive and workable plan is scheduled for transmittal to Congress in 1991.

INTERAGENCY CONSULTATION

Throughout all the efforts described in this report, HUD has consulted with and sought advice from Federal agencies with expertise in lead-based paint, including the Centers for Disease

Control, the Consumer Product Safety Commission, the Environmental Protection Agency, the National Institute of Environmental Health Sciences, the National Institute for Occupational Safety and Health, the National Institute of Standards and Technology, and the Occupational Safety and Health Administration.

In April 1989, at the direction of Congress, HUD and EPA executed a Memorandum of Understanding (MOU) which called for close cooperation between the two agencies on lead-based paint issues. Under the MOU, EPA has provided technical assistance in the development of testing and analysis procedures, and in the planning, design, implementation, and review of the abatement demonstrations and the national survey of lead-based paint hazards. EPA has contributed directly to the development of the recommendations of this report. A task force on lead-based paint issues, with members from the Federal agencies listed above, has been meeting regularly since April 1989 and has assisted in identifying research and data needs that must be addressed before a national program to abate lead-based paint hazards can be effective.

ORGANIZATION OF THE REPORT

The report has six chapters, including this introduction. Chapter 2 provides the reader with an overview of the problem of lead in the environment: its toxic effects (particularly with regard to children); the estimated number of children with differing levels of lead in their bodies, and how these children are distributed by race, family income, and urban location; the sources of lead in the environment and the ways humans are exposed to it (i.e., through air, water, food, dust, soil, and paint); and available information on the contribution of lead-based paint to childhood lead poisoning. Chapter 2 draws heavily from the 1988 report by the Agency for Toxic Substances and Disease Registry, entitled *The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress*.

Chapter 3 includes the required estimates of the extent of lead-based paint hazards in United States housing. These estimates are based on the national survey sponsored by HUD. Data on lead in dust and soil are also provided.

Chapter 4 describes alternative methods of reducing lead-based paint hazards, their costs and effectiveness, and factors affecting the choice of abatement strategy. This chapter is based on a combination of data from the national survey and the demonstration of abatement methods sponsored by HUD.

Chapter 5 explains the current regulatory and programmatic activity--Federal, State, and local--pertaining to lead-based paint, and also discusses private sector activity.

Finally, Chapter 6 presents a comprehensive program of Federal actions to assist in the abatement of lead-based paint in privately owned housing.

CHAPTER 2

LEAD IN THE ENVIRONMENT: AN OVERVIEW

This chapter provides a summary description of the overall problem of lead in the environment. It is based entirely on the literature, and primarily on the 1988 report by the Agency for Toxic Substances and Disease Registry (ATSDR), *The Nature and Extent of Lead Poisoning in Children in the United States: A Report to the Congress.*[1] Topics discussed include the toxic effects of lead in the human body, the number of children estimated to be at risk of toxic effects nationally and by various population groups, the sources and pathways of lead in the environment, and the contribution of lead-based paint to lead poisoning.

TOXIC EFFECTS

Lead is a powerful toxicant with no known beneficial purpose in the human body. The primary target organ is the central nervous system, but virtually all parts of the body can be injured at high levels of internal exposure. Convulsions, comas, and even death can result if treatment is not provided. At the lower levels of lead exposure that are more commonly found in the population, subtle neurological effects are of most concern. Long-lasting impacts on intelligence, motor control, hearing, and emotional development of children have been documented at levels of lead in the body that are not associated with obvious symptoms.[2]

Infants and young children are more at risk from exposure to lead than adults, because (1) their neurological systems are developing and are more vulnerable to damage; (2) their frequent hand-to-mouth activity brings them into greater contact with lead in the environment, especially in dust and soil; (3) their bodies absorb and retain a larger percentage of ingested lead per unit of body

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[1] U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (1988), *The Nature and Exent of Lead Poisoning in Children in the United States: A Report to Congress.*

[2] ATSDR, *Lead Poisoning*, Chapter IV; Needleman, H. L.; and Gatsonis, C.A. (1990), "Low Level Lead Exposure and the IQ of Children," *Journal of the American Medical Association* 263:673-678.

weight than adults, and more of the lead in the body is available in the blood and soft tissues to exert toxic effects;[3] and (4) children often experience nutritional deficiencies (especially of iron, calcium, and other metals) that enhance uptake, absorption, and retention of lead in the body.

Lead in adults is also of concern, however. Of particular importance is the fact that blood lead in pregnant women can transfer through the placenta to the fetus. Lead has also been associated with small increases in blood pressure in adult human males, and studies of animals have linked lead with cancer and reproductive system abnormalities.[4] In 1985, the Environmental Protection Agency (EPA) classified lead as a probable human carcinogen.[5]

Exposure to lead is characterized as either external or internal to the body. External exposure is measured in terms of the concentration of lead in the material (air, water, food, dust, soil, or paint) to which people are exposed in the environment. The most common measure of internal exposure is the concentration of lead in whole blood, usually expressed in micrograms of lead per deciliter of blood (ug/dl). Blood lead is generally considered a measure of recent exposure, because its half-life (the time it takes for one-half of the lead to move from the blood) is estimated to be about 25 days in adults.[6] However, the half-life of blood lead may be longer for young children; one study reported approximately 10 months for 2-year-olds.[7]

An important aspect of lead is that it accumulates in the body and is stored in the bones. The half-life of lead in the most dense mineral portion of bone is approximately 20 years.[8] However,

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[3]ATSDR, *Lead Poisoning*, Chapter III.

[4]Ibid., Chapter IV.

[5]*Federal Register* 50:46936, Nov. 13, 1985.

[6]ATSDR, *Lead Poisoning*, p. III-5, citing Rabinowitz, M.B.; Wetherill, G.W.; and Kopple, J.D. (August 1976), "Kinetic Analysis of Lead Metabolism in Healthy Humans," *Journal of Clinical Investigation* 58:260-270.

[7]ATSDR, *Lead Poisoning*, p. III-5 citing Succop, P.A.; O'Flaherty, E.J.; Bornschein, R.L.; Clark, C.S.; Krafft, K.; Hammond, P.B.; and Shukla, R. (1987), "A Kinetic Model for Estimating Changes in the Concentration of Lead in the Blood of Young Children," in *International Conference: Heavy Metals in the Environment*, Vol. 2, edited by Lindberg, S.E.; and Hutchinson, T.C. (Edinburgh: CEP Consultants, Ltd.), pp. 289-291.

[8]ATSDR, *Lead Poisoning*, p. III-9.

circulating blood lead is apparently a function of both current and past internal exposure. Bone lead contributes lead back to blood via resorption.[9]

Physiological stress can "mobilize" lead from bone to the bloodstream. Scientists have documented increases in blood lead during pregnancy.[10] Thus it is theoretically possible for pregnant women to transfer lead absorbed in childhood to their fetuses.

Very severe childhood lead poisoning--involving such symptoms as kidney failure, gastrointestinal problems, coma, convulsions, seizures, and pronounced mental retardation--can occur at blood lead levels as low as 80 ug/dl. At or above 40 ug/dl, children may experience reduced hemoglobin (the oxygen carrying substance in blood), the accumulation of a potential neurotoxicant known as ALA, and mild anemia. Near 30 ug/dl, studies have found slowed nerve conduction velocity. And between 10-15 and 25 ug/dl, researchers have documented slower reaction time, reductions in intelligence and short-term memory, other neurobehavioral deficits, and adverse effects on heme biosynthesis and vitamin D and calcium metabolism.[11]

EFFECTS OF LOW-LEVEL EXPOSURE

Four major longitudinal studies--in Boston, Cincinnati, Cleveland, and Port Pirie, South Australia--have reported significant relationships between early low-level lead exposure and later deficits in neurobehavioral performance on the same standard test of infant intelligence (the Bayley Mental Development Index).[12] As summarized by ATSDR, "these studies are remarkably consistent in identifying a link between low-level lead exposure during early development and later neurobehavioral performance. . . . Moreover, the studies generally point to the prenatal period of exposure as the most critical, although postnatal exposure may still be important and may even override the effect of prenatal exposure under some conditions. Blood lead levels of 10 to 15

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[9]Ibid., p. III-11.

[10]Ibid., p. III-9.

[11]Ibid., pp. 10, IV-21.

[12]Results of the studies are summarized in ATSDR, *Lead Poisoning*, pp. IV-8-13. and in Michael, J.; Davis and David J. Svendsgaard (September 1987), "Lead and Child Development," *Nature* 329:297-300.

ug/dl, and possibly lower, constitute a level of concern for these effects."[13] Deficits of 2 to 8 points were found on the Bayley Mental Development Index for every increment in blood lead of 10 ug/dl.[14] The Bayley Index has a mean of 100 and a standard deviation of 16. A few points may not be significant for one individual but could be very important for large populations. For instance, a downward shift of 4 points for a large population of children would increase by 50 percent the number of children scoring less than 80 on the Bayley Index.[15] (At least four other longitudinal studies similar to the four reported above are underway in Australia, Yugoslavia, Mexico, and Scotland.)

Several well-conducted studies have reported significant associations between maternal blood lead levels and preterm deliveries and reductions in weight and length of babies at birth. ATSDR concluded that such effects can occur at levels of less than 15 ug/dl.[16]

One of the important questions regarding low-level lead exposure in young children has been whether the effects are long lasting. A recent report[17] of an 11-year longitudinal study concluded "that exposure to lead in childhood is associated with deficits in central nervous system functioning that persist into young adulthood." Between 1975 and 1978 the investigators obtained baby teeth from first and second graders in two suburban Boston school districts and selected 270 children whose dentin lead levels were either low or relatively high but not so high as to cause obvious symptoms of lead poisoning. This cohort underwent neurobehavioral testing three times: in 1977-1978, 1983, and 1988. (By 1988, attrition had reduced the number of subjects to 132, who had slightly lower childhood dentin lead levels, higher IQs, and higher socioeconomic status than the 138 subjects not available for testing in 1988.)

In the 1977-1978 evaluation, the high-lead group had a median IQ 6 points lower than that of the low-lead group, after controlling for factors such as socioeconomic status. Five years later, the

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[13]ATSDR, *Lead Poisoning*, p. IV-13.

[14]Davis and Svendsgaard, "Lead and Child Development," p. 298.

[15]Ibid., p. 300.

[16]ATSDR, *Lead Poisoning*, pp. IV-17-19.

[17]Needleman, Herbert L.; Schell, A.; Bellinger, D.; Leviton, A.; and Allred, E.N. (1990), "The Long-Term Effects of Exposure to Low Doses of Lead in Childhood," *New England Journal of Medicine*, 322:83-88.

findings were similar, and the high-lead group had a higher rate of school failure. In 1988, neurobehavioral deficits were still found to be significantly related to the lead content of baby teeth, and the high-lead group were more likely to have dropped out of school, have a lower class standing, increased absenteeism, lower vocabulary and grammatical-reasoning scores, poorer hand-eye coordination, longer reaction times, and slower finger tapping.

REDUCTIONS IN THE EXPOSURE LEVEL OF CONCERN

Over the past 20 years, the U.S. Public Health Service has responded to emerging knowledge about the effects of low-level lead exposure in children by lowering, on three occasions, the blood lead level said to warrant medical intervention. In 1970, the level was 60 ug/dl. Shortly after the Lead-Based Paint Poisoning Prevention Act was enacted in 1971, the level was lowered to 40 ug/dl. In 1975, the level was lowered again to 30 ug/dl, and in 1985 it was lowered still further to 25 ug/dl.[18] It should be noted that the 1985 definition of an elevated blood lead level as 25 ug/dl or greater was intended as "a cutoff point for medical referral from screening programs" and was not meant to imply that children with levels below 25 ug/dl were without risk.[19] In 1986, the World Health Organization identified 20 ug/dl as an upper limit.[20] Also in 1986, EPA cited 10-15 ug/dl as the range associated with neurological deficits.[21] An advisory committee for the Centers for Disease Control is currently considering an updated statement on childhood lead poisoning.

ESTIMATES OF THE NUMBER OF CHILDREN EXPOSED

Lowering the blood lead level designated as the threshold of concern makes an enormous difference in the number of children considered to be at risk. ATSDR estimated that 1.5 percent

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[18]U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control (1985), *Preventing Lead Poisoning in Children*, p.1.

[19]ATSDR, *Lead Poisoning*, p. 3.

[20]World Health Organization, Regional Office for Europe (1986), *Air Quality Guidelines* (review draft), Vol. II: Lead, Chapter 19.

[21]U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office (1986), *Air Quality Criteria for Lead*, (EPA Report No. EPA-600/8-83/028aF through dF), 4 Vols.

of the white and black children between 6 months and 5 years of age living in metropolitan areas of the United States had blood lead levels greater than 25 ug/dl in 1984. At levels greater than 20 ug/dl, the estimate was 5.2 percent; and for levels greater than 15 ug/dl, the estimate was 17 percent. The numbers of children corresponding to these percentages were 200,000, 715,000, and 2,400,000.[22] Thus, based on these estimates, reducing the level of concern from 25 to 15 ug/dl increases the number of children considered to be at risk of neurological and other impairments by a factor of at least 10. Because of inadequacies in the basic data, the estimates did not include Hispanic children, nor did they include children living in nonmetropolitan areas. ATSDR estimated that, if those groups had been included, the total number of children under 6 with blood lead levels greater than 15 ug/dl would have been 3 to 4 million in 1984.

It is probable that there has been a decline in blood lead levels since 1984 because of the continued reduction in the use of leaded gasoline and of lead in food. However, updated estimates of childhood lead exposure will not be available until 1992, when the results of the first round of the third National Health and Nutrition Examination Survey are available.

An entirely different source of information on the prevalence of childhood lead poisoning is the lead screening programs conducted by State and local health departments. ATSDR surveyed all known State and local lead screening programs during 1985 and 1986. Responding entities included approximately 14 State and 26 local programs. They reported 11,739 annual cases of lead toxicity, or 1.5 percent of the 785,285 children screened during a 1-year period.[23] Interestingly, 1.5 percent is the same rate of occurrence as that estimated for the entire nation at the 25 ug/dl level. This similarity in rates may not be significant, however. Most screening programs used erythrocyte protoporphyrin, a screening technique with an estimated sensitivity of 25-70 percent. Therefore, the actual rate of occurrence of blood lead greater than 25 ug/dl was probably greater than 1.5 percent for the high-risk populations on which screening programs tend to concentrate.

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[22]ATSDR, *Lead Poisoning*, p. 4. The ATSDR estimates were based on the 1980 census and the second National Health and Nutrition Examination Survey (NHANES II), which was conducted in the late 1970s. Census counts of children were updated to 1984 with vital statistics data for the period 1980 to 1984. NHANES II data on the incidence of childhood blood lead greater than 15, 20, and 25 ug/dl were updated to 1984 by statistically modeling the association between blood lead and lead in gasoline, and then estimating the change in blood lead levels between the date of NHANES II (approximately 1978) and 1984 based on the known reduction of lead in gasoline during the same period. ATSDR acknowledged that any reduction in blood lead levels due to the reduction of lead in food between 1978 and 1984 was not accounted for.

[23]Ibid., Table V-14. Toxicity was either the 25 or 30 ug/dl blood lead level, depending on whether the year of the screening was 1986 or 1985.

DISTRIBUTION OF EXPOSED CHILDREN

ATSDR found that childhood blood lead levels were associated with race, family income, residence inside or outside of a metropolitan central city, and the size of the metropolitan area. The highest incidence of elevated blood lead was found among black children in the lowest family income group, living in central cities of metropolitan areas of 1 million or more. Sixty-eight percent of that group was estimated to have levels greater than 15 ug/dl in 1984; 10.6 percent had levels greater than 25 ug/dl (see Table 2-1). The lowest incidence was found among white children in the highest income group living outside central cities in metropolitan areas of less than 1 million (4.7 percent at 15 ug/dl, 0.2 percent at 25 ug/dl). The incidence was roughly two to four times higher among black children than among white children of similar income and place of residence. For children of both races, the incidence among those of the lowest income group was two to four times that of the highest income group, holding place of residence constant. Children living in metropolitan areas of 1 million or more had about 45 percent higher incidence than those in metropolitan areas of less than 1 million. Within metropolitan areas of the same size, the incidence among those living in central cities was roughly 30 percent higher than those living outside central cities.

Scientists do not know why black children have a higher incidence of internal lead exposure than whites after income and urban location are held constant. There may be several reasons, including greater environmental exposure (perhaps from older, more deteriorated housing), behavioral factors (such as nutrition, and mouthing behavior), and biological differences (perhaps in the rate of absorption and retention of lead). Differences in incidence by income group are assumed to be caused by environmental and, to a lesser degree, behavioral factors.

Although the percentage of children with elevated blood lead levels may be relatively low for some population groups, the number of affected children is substantial in all groups. Table 2-2 shows, for example, that there were 241,200 white children from suburban, middle-income homes in metropolitan areas of over 1 million in population estimated to have blood lead levels greater than 15 ug/dl in 1984. This compares to 234,900 central-city black children from lower income homes.

Large metropolitan areas may have higher blood lead levels than smaller areas because vehicle miles per capita (and thus leaded gasoline emissions) tend to be associated with size of urban area. Industrial emissions may also be associated with size of place. The higher blood leads in central

TABLE 2-1
PERCENTAGES OF CHILDREN 0.5-5 YEARS OLD ESTIMATED TO EXCEED SELECTED BLOOD LEAD LEVELS BY FAMILY INCOME, RACE, SIZE OF METROPOLITAN AREA, AND RESIDENCE INSIDE OR OUTSIDE CENTRAL CITY, 1984

Blood Lead Level	Metropolitan Area Population	Family Income and Race					
		< $6,000		$6,000-$14,999		> $14,999	
		White	Black	White	Black	White	Black
> 15 ug/dl	**Inside Central City**						
	< 1,000,000	25.7	55.5	15.2	41.1	7.1	26.6
	> 1,000,000	36.0	67.8	22.9	53.6	11.9	38.2
	Outside Central City						
	< 1,000,000	19.2	45.9	10.9	32.4	4.7	19.5
	> 1,000,000	27.7	57.8	16.8	43.7	8.1	28.9
> 25 ug/dl	**Inside Central City**						
	< 1,000,000	2.1	7.7	1.1	4.1	0.4	1.5
	> 1,000,000	3.0	10.6	1.5	5.9	0.5	2.2
	Outside Central City						
	< 1,000,000	1.6	6.1	0.8	3.2	0.2	1.1
	> 1,000,000	2.3	8.4	1.2	4.6	0.4	1.7

Note: The income intervals used in this table are those used for NHANES II data, which have a midpoint year of 1978. ATSDR did not adjust the intervals to 1984 dollars. The intervals can be considered generally as representing low, moderate, and above-median family income levels.

Source: ATSDR, Lead Poisoning, Tables V-1 and V-2.

TABLE 2-2
NUMBERS OF CHILDREN (000s) 0.5-5 YEARS OLD
ESTIMATED TO EXCEED SELECTED BLOOD LEAD LEVELS
BY FAMILY INCOME, RACE, SIZE OF METROPOLITAN AREA, AND
RESIDENCE INSIDE OR OUTSIDE CENTRAL CITY, 1984

Blood Lead Level	Metropolitan Area Population	Family Income and Race						Total
		< $6,000		$6,000-$14,999		> $14,999		
		Black	White	Black	White	Black	White	
> 15 ug/dl	**Inside Central City**							
	< 1,000,000	78.9	43.7	57.1	46.0	41.8	33.6	301.1
	> 1,000,000	234.9	113.0	184.9	124.6	151.0	93.4	901.8
	Outside Central City							
	< 1,000,000	71.4	106.4	74.4	158.9	50.7	124.3	586.1
	> 1,000,000	44.6	120.4	49.9	241.2	64.4	71.1	591.6
Total		**429.8**	**383.5**	**366.3**	**570.7**	**307.9**	**322.4**	**2380.6**
> 25 ug/dl	**Inside Central City**							
	< 1,000,000	10.9	3.2	5.7	2.6	2.4	2.7	27.5
	> 1,000,000	36.7	7.4	20.4	5.2	8.7	7.8	86.2
	Outside Central City							
	< 1,000,000	9.4	7.9	7.3	9.3	2.8	7.3	44.0
	> 1,000,000	6.5	8.6	5.3	11.9	3.8	5.9	42.0
Total		**63.5**	**27.1**	**38.7**	**29.0**	**17.7**	**23.7**	**199.7**

Note: The income intervals used in this table are those used for NHANES II data, which have a midpoint year of 1978. ATSDR did not adjust the intervals to 1984 dollars. The intervals can be considered generally as representing low, moderate, and above-median family income levels.

Source: ATSDR, Lead Poisoning, Tables V-4, V-5, and V-6.

cities can probably be explained by more automobile and industrial emissions per capita than in suburbs, and also by a greater proportion of old houses with lead-based paint, often at higher lead paint concentrations, all of which have combined to leave higher lead concentrations in soil and dust. In addition, central cities have a larger proportion of houses with lead pipes than the suburbs. These sources of lead in the environment are discussed in the next section.

SOURCES AND PATHWAYS OF LEAD IN THE HUMAN ENVIRONMENT

Lead is ubiquitous in the human environment and derives from many sources. No single factor accounts for childhood lead poisoning. Although lead occurs naturally in small quantities in the earth's crust, virtually all of the hazardous levels of lead derive from man made processes and products. The principal industrial use of lead is in the manufacture of storage batteries. Other current uses include the production of ammunition, various chemicals, and sinkers for fishing. The use of lead in paint additives, gasoline additives, solder, and pipes has been reduced substantially or eliminated; but the old installed products or residuals from their use remain in the environment.

The principal pathways of adult exposure to lead are air, drinking water, and food. For infants and young children, however, surface dust and soil are important pathways, because young children play on floors and in outside play spaces that may be contaminated with lead and frequently put fingers, toys, and other objects in their mouths. More importantly for this report, surface dust and soil are thought to be major pathways for childhood exposure to lead from lead-based paint. Air can also be a pathway for lead deriving from lead-based paint, because lead may be in airborne dust during refinishing or renovation activities or because of windblown surface dust. Children may also become exposed to lead from lead-based paint by directly eating chips of lead-based paint or chewing on protruding surfaces painted with lead-based paint; in such cases, lead-based paint is likely to become a direct source of severe lead poisoning. Direct eating of lead-based paint is thought to be most frequent among children who have a condition known as pica (a tendency to eat nonfood items).

Each of the pathways--air, water, food, and dust and soil--has multiple sources of potential lead contamination. Science has not been able to ascertain the precise contribution of each of these pathways to blood lead levels. These pathways and the sources of lead associated with them are discussed briefly in the following paragraphs to give the reader a context in which to consider the role of lead-based paint as a contaminant. Then the next section provides a discussion of what is known about the contribution of lead-based paint to childhood lead poisoning.

Air

Air can be contaminated by emissions from gasoline combustion, smelters and battery factories, and the combustion of oil, coal, waste oil, and municipal wastes. Windblown dust is another source of air pollution. The reduction of lead in air during the past 15 years has been a major achievement in environmental health, largely due to the reduced use of leaded gasoline. The reduction of lead in air correlates very well with declines in childhood blood lead levels between 1976 and 1980 found by the second National Health and Nutrition Examination Survey (NHANES II).[24] Lead in air is now believed to be a problem only in proximity to a few stationary sources.[25] EPA reports that total atmospheric lead emissions dropped 94 percent between 1978 and 1987. The use of leaded gasoline has declined by over 90 percent since 1978 as a result of the use of unleaded gasoline in new cars, the phasedown of leaded gasoline, and attrition in the supply of vehicles that burn it. Also, lead emissions from industrial and other stationary sources have declined because of compliance with State plans and regulations aimed at achieving national air quality standards, and because of reduced industrial activity.

Water

Drinking water can be contaminated at the point of supply (i.e., surface or ground water contaminated by fallout from the air or from solid waste), in distribution through old lead pipes, or from lead solder in plumbing. Lead in drinking water is of great concern, because even very small concentrations can cause exposure, given the large amounts of water people consume. It appears that lead in drinking water is more completely absorbed by the body than lead in food or other substances, especially when the water is not drunk with a meal. For lead in food, 10-15 percent is absorbed by adults; for water, the absorption rate is 35-50 percent.[26]

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[24] Ibid., p. VI-21.

[25] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (1989), *Review of the National Ambient Air Quality Standards for Lead: Exposure Analysis Methodology and Validation* (Staff Report), p. II-5.

[26] ATSDR *Lead Poisoning*, p. VI-36, citing EPA, *Air Quality Criteria for Lead*.

Although lead contamination of drinking water rarely occurs at the point of supply in municipal water systems, EPA's Office of Drinking Water proposed, in 1988, a revision of the existing lead standard of 50 micrograms per liter (ug/l) to 5 ug/l, measured at the entry point to the distribution system or the treatment plant.

Most lead in drinking water is thought to stem from lead pipes and lead solder in plumbing. In some parts of the country, lead pipes were used until the early 1900s for interior plumbing and for the connections from the street main to the building. Although lead plumbing is most likely in houses built before 1930, in some cities the practice of using lead pipes for the connection lines continued until only recently.[27] In 1987, there were approximately 14 million housing units (16 percent of the nation's total) that were built prior to 1930; 2.7 million of these homes lodged children under 7 years old.[28]

Most experts think that lead solder is the major cause of tap water contamination in the United States. The 1986 Safe Drinking Water Amendments banned the use of lead solder, with enforcement by the States to be effective by June 1988.

Samples of tap water taken for EPA in 580 cities in 47 States indicate that 16 percent of the water from U.S. kitchens contains 20 ug/l or more of lead, which is the proposed EPA maximum contaminant level. This study was completed in 1986. More recent studies indicate that the percentage of housing units with tap water lead concentrations of greater than 20 ug/l may be even greater.[29]

The method most commonly proposed to reduce lead concentrations in tap water is reducing the corrosiveness, or acidity, of the water. This reduces the leaching of lead from solder or pipes. Preliminary results of an EPA study indicate that, for houses older than 5 years, 51 percent of the first-flush tap water samples are likely to have a lead concentration of greater than 20 ug/l when

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[27]U.S. Environmental Protection Agency, Office of Drinking Water (April 1987), *Lead and Your Drinking Water* (OPA-87-006).

[28]Estimated from tabulation of American Housing Survey data by Paul Burke, Office of Policy Development and Research, HUD. The American Housing Survey is a biennial survey of the Nation's housing conducted by the Bureau of the Census for HUD. Results are available in published and electronic form from the Bureau of the Census.

[29]ATSDR, *Lead Poisoning*, p. VI-36, VI-37.

the water has a pH of 6.4 or less. If the pH is 8.0 or greater, only 13 percent of the samples are expected to have lead concentrations greater than 20 ug/l.[30] (Acidity is inversely related to pH.)

Food

Food can be contaminated by deposition of airborne lead onto crops or water, during transportation or processing, or from containers with lead solder, lead glaze, or other materials with lead. Food, like water, is of concern as a pathway because of the large quantities that are consumed by all segments of the population.

In food processing, the primary source of lead has been solder in the seams of cans. A phasing out of lead solder in cans began in the late 1970s, resulting in a significant reduction in lead in canned food. ATSDR reported that lead in evaporated milk declined from 0.5 micrograms per gram (ug/g) wet weight in the early 1970s to 0.07 ug/g in 1981 and that lead in some juices declined approximately 95 percent.[31]

Surface Dust and Soil

Surface dust includes house dust and street dust (dust on hard exterior surfaces such as sidewalks, streets, and playgrounds). Soil may be divided into soil dust (the very top layer of soils with which people are in contact) and soil below the very top layer, although such a distinction is not yet common in the literature. Lead in surface dust and soil of all types can come from weathering and chipping of lead-based paint, scraping and sanding of lead-based paint in preparation for refinishing, renovations that break surfaces painted with lead-based paint, atmospheric fallout from the combustion of leaded gasoline and factory emissions, industrial solid waste, and dust and dirt that is carried into the home on shoes and clothing (especially from factories or construction sites) or by pets.

Surface dust is mobile. It can be transported by wind and carried on clothing, shoes, and pets. Thus the source of interior house dust is partly external to the dwelling. Rabinowitz found that the

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[30]Ibid., Table VI-17, p. VI-43.

[31]Ibid., p. VI-45.

lead isotope composition of dust lead in Boston homes with no lead-based paint closely resembled the background soils in the city parks.[32]

A large number of studies published during the past two decades have indicated an association between dust lead and childhood blood lead. Three studies are summarized here because of the apparent importance of dust lead as a pathway for paint lead.

In 1980 Charney and colleagues reported the results of a study in Rochester, NY, of the environments and behavior of 49 young children with high blood lead levels (40-79 ug/dl) and 50 children with "low" levels (less than 30 ug/dl). The investigators hypothesized that children in the high blood lead group would have more lead on their hands and in interior surface dust in their homes than the low blood lead group. The results of the study supported acceptance of the hypothesis. The mean interior surface dust values were 265 and 123 ug/sample for, respectively, the high- and low-lead groups. The mean hand dust values were, respectively, 49 and 21 ug/sample. Also, the mean values of soil lead were, respectively, 1,563 and 1,008 parts per million (ppm); and 46 percent of the homes of the high-lead group yielded paint chips that were 1 percent or more lead, compared to 26 percent of the homes of the low-lead group. The researchers were able to achieve a relatively high level of explanation of blood lead variance when they confined their data to age groups. For example, for all children aged 18-32 months, the explanation of variance was 73 percent (r^2 x 100), with dust lead, soil lead, race, and pica as the independent variables. Other independent variables were significant for other age and racial groups. The authors concluded that although several factors accounted for childhood lead poisoning, dust lead and hand lead were strongly correlated with blood lead, and that interior dust lead should be taken into account in attempting to reduce lead hazards in residential environments.[33]

In 1983, Charney and colleagues reported on a HUD-funded study in Baltimore of whether dust control measures, in addition to treatment of potential lead-based paint hazards, would lower blood lead levels. The subjects were children between 15 and 72 months of age at the time of enrollment, with blood lead levels of between 30 and 49 ug/dl. Lead-based paint that was not

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[32]Rabinowitz, Michael B. (1987), "Stable Isotope Mass Spectrometry in Childhood Lead Poisoning," *Biological Trace Element Research* 12:223-229.

[33]Charney, E.; Sayre, J.; and Coulter, M. (February 1980), "Increased Lead Absorption in Inner City Children: Where Does the Lead Come From?", *Pediatrics*, 65(2).

intact or was chewable and within 4 feet of the floor was removed or covered in the homes of all subjects. After the paint treatment, dust control was practiced in the homes of a study group of 14 children; a control group of 35 of the subject children had no dust control. Dust control consisted of twice monthly wet mopping by the research team of each room that contained greater than 100 ug lead per sample. Families were encouraged to clean these same areas in the intervals between research team visits, and to wash the children's hands frequently. Blood lead levels in the study group fell an average of 6.9 ug/dl after 1 year, compared to 0.7 ug/dl in the control group. Study group children with the highest initial blood lead levels had the greatest reductions. The investigators concluded that their results showed "that a focused dust-control program can reduce blood lead levels more than standard lead removal in the home."[34] It should be noted, however, that the lead-based paint abatement protocols recommended now (i.e., in 1990) are more extensive than those in common practice in the early 1980s (and used in the Charney study). Among other things, a thorough dust cleanup, using high-efficiency vacuum cleaners and a phosphate wash, are standard.

Bellinger and colleagues (1986) enrolled 249 metropolitan Boston children with low-to-moderate blood lead levels at 1 month of age and collected data semiannually on blood lead levels, environmental lead (water, air, dust, paint, and breast milk/formula), sociodemographic factors, home environment and care-giving style, behavior (especially mouthing), and development. The children came largely from white, middle-to-upper-middle-class, well-educated, intact families, and were at low risk of developmental handicap. Twenty-three variables were analyzed in terms of their ability to predict blood lead levels at 24 months. (Although paint data were collected, no paint variable was used in the analysis.) In bivariate analysis, only five variables were significantly correlated with blood lead: blood sample collected between May and August, refinishing activities in the home within 6 months of blood sample collection, lead content of house dust, greater amounts of thumb/finger sucking, and a greater number of significant life events (e.g., pregnancy, job change, marital separation). All five of these variables were positively correlated to blood lead. The 23 independent variables were grouped in 5 sets, and multiple regression was run individually with the variables in each set. The environmental lead set and the mouthing set were significantly associated with blood lead, but home environment/care giving, child development, and sociodemographic characteristics were not. The percentage of variance explained by

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[34]Charney, E.; Kessler, B; Farfel, M.; and Jackson, D. (1983), "Childhood Lead Poisoning: A Controlled Trial of the Effect of Dust-Control Measures on Blood Lead Levels," *New England Journal of Medicine* 309(18):1089-1093.

environmental lead was 22.9, four times that explained by mouthing (5.5). Dust lead was the most important environmental variable, although refinishing and month of sample selection were significant. The investigators concluded that "the most promising approach for achieving community-wide reductions in children's blood lead levels is reduction of the amount of lead in the proximate environment."[35]

THE CONTRIBUTION OF LEAD-BASED PAINT TO LEAD POISONING

The widespread occurrence of lead in the environment from auto emissions, lead pipes, solder, and other sources has confounded efforts to estimate the relative contribution of paint lead to body burden. Nevertheless, the efforts of a number of researchers over the years allow some crucial findings to be derived. These findings are briefly stated here; they are then discussed in more detail and documented.

- Eating chips of lead-based paint can result in severe poisoning; however, such episodes are relatively infrequent.
- Ingestion of dust and soil containing lead through hand-to-mouth activity is a more common pathway among children than eating paint chips.
- Researchers have found significant associations between lead in children's blood and lead on their hands, and in the dust and soil in and around their homes.
- There is evidence that homes in poor condition elevate the hazards of exposure to lead-based paint.
- Home refinishing (scraping and repainting), if not properly performed, can significantly increase the hazard level.
- Studies of health effects of traditional abatement practices (i.e., treatment of defective and accessible paint surfaces with little or no worker protection, etc.) have reported conflicting findings.

The association between paint lead and dust lead is discussed further in Chapter 3, based on an analysis of data from HUD's national survey of lead-based paint in housing.

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[35]Bellinger, D.; Leviton, A.; Rabinowitz, M.; Needleman, H.; and Waternaux, C. (1986), "Correlates of Low-Level Lead Exposure in Urban Children at 2 Years of Age." *Pediatrics* 77(6):826-833.

Ingestion of Lead-Based Paint

The literature on clinical cases of lead poisoning clearly documents the severe poisoning that can result from eating chips of lead-based paint or chewing on protruding surfaces painted with lead-based paint.[36] These cases tend to occur among children with pica (the tendency to eat nonfood substances), who are estimated to make up about 20-30 percent of the childhood population of inner cities.[37] While such cases are infrequent, they are very serious.[38] Past and current Federal policy has focused on eliminating such poisoning by treating defective paint and chewable surfaces.

The Cincinnati Study of Pathways Between Paint Lead and Blood Lead

There have been a number of studies in recent years of the relationship between blood lead levels in children and the amount of lead contained in dust and soil in and around their homes. However, the published literature includes very little on the relationship between children's blood lead and measures of the extent of lead-based paint in a dwelling unit. An exception to this is the work of members of the Institute of Environmental Health at the University of Cincinnati Medical Center.

The Cincinnati lead study, a prospective study of the mechanisms of childhood lead exposure, began in 1980 and is ongoing.[39] The study design called for tracking children's blood lead quarterly from birth and collecting environmental samples of interior surface dust, exterior surface dust

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[36]ATSDR, *Lead Poisoning*, p. VI-10.

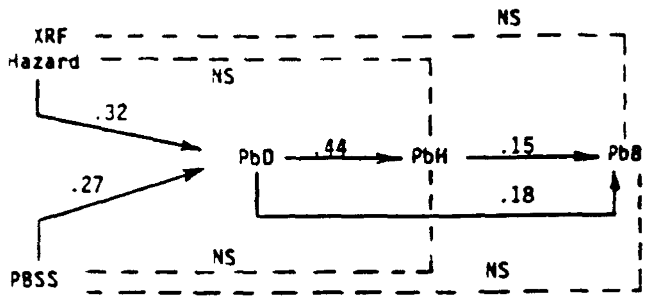
[37]Barltrop, D. (1966), "The Prevalence of Pica," *American Journal of Disabled Children*, 112:116.

[38]Although relatively infrequent, the number of children with higher blood lead levels is not trivial. NHANES II indicated that only 0.5 percent of children less than 6 years old had blood lead levels of 40 ug/dl or greater; this amounted to 82,290 children in 1980 nationwide. It is not known precisely what proportion of this poisoning was derived from lead-based paint, but experts are strongly of the opinion that "clinical lead poisoning is most frequently associated with ingestion of lead-bearing paint." NHANES III will answer whether this occurrence has declined. (Data from National Center for Health Statistics, Amnest, J. L. and Mahaffey, K. (1984), *Blood-Lead Levels for Persons Ages 6 Months - 74 Years: United States, 1976-1980*. Vital and Health Statistics. Series 11, No. 233. DHHS Pub. No. (PHS) 84-1683, Public Health Service, Washington. Quotation from Piomelli, Sergio; Rosen, John F.; Chisolm, J. Julian, Jr.; and Graef, John W. (1984). "Management of Childhood Lead Poisoning," *Journal of Pediatrics, 105:523-532.* Reprinted in *Prevention of Lead Poisoning in Young Children, A Statement by the Centers for Disease Control*, January 1985.)

[39]Bornschein, R.L.; Hammond, P.D.; Dietrich, K.N.; Succop, P.A.; Krafft, K.M.; Clark, C.S.; Pearson, D.; and Que Hee, S.S. (1985), "The Cincinnati Prospective Study of Low-Level Lead Exposure and Its Effect on Child Development Protocol and Status Report," *Environmental Research* 38: 4-18.

scrapings, and dust on children's hands, and developing an index of paint hazard. Classification of housing by type was also undertaken. Children in the Cincinnati lead study were drawn from a predominantly low socioeconomic, black inner-city neighborhood.

Analyzing the Cincinnati lead study data, Bornschein and colleagues developed a three-equation simultaneous structural model of the relationships between blood lead at 18 months (PbB), hand dust lead (PbH), interior surface dust lead (PbD), exterior surface scraping dust lead (PbSS), and an index of the lead content and condition of the paint (XRF Hazard).[40,41] A graphic depiction of the model illustrates the relationships among these study variables. The numbers adjacent to the lines are estimated regression coefficients. All coefficients are significant at $p<.05$; NS=Not Significant.[42]



[40]Bornschein, R.L.; Succop, P.A.; Krafft, K.M.; Clark, C.S.; Peace, B.; and Hammond, P.B. (1986), "Exterior Surface Dust Lead, Interior House Dust Lead and Childhood Lead Exposure in an Urban Environment," in *Trace Substances in Environmental Health, II, 1986. A Symposium*, edited by D.D. Hemphill (University of Missouri, Columbia).

[41]Bornschein et al. (1986) described the index as follows: "Paint lead was evaluated using X-ray fluorescence (XRF) on a maximum of 15 painted surfaces within the dwelling. For each XRF reading, the environmental technician also rated the primary (predominant fault) and (if appropriate) the secondary condition of the painted surface. These values vary from 0 to 10, where high values indicate poorer surface quality. A paint hazard score (XRFHAZ) for each residence was derived from a linear combination of the product of the XRF measurements and the condition code values for the painted surface. This produces a weighted average score which takes into account not only the Pb content of the painted surface, but also the (potential) availability of Pb which migrates from the painted surface in the form of dust and paint chips to children."

[42]The estimated structural equations in the model follow (the distribution of the measurements of lead are skewed to the right. The logarithmic transformation helps normalize the distribution and reduces the influence that a few large observations might have on our analysis):

$$Ln(PbB) = 1.276 + .152\,Ln(PbH) + .182\,Ln(PbD), \qquad R^2 = .38$$

$$Ln(PbH) = -0.966 + .444\,Ln(PbD), \qquad R^2 = .22$$

$$Ln(PbD) = 4.691 + .325\,Ln(XRFHAZ) + .268\,Ln(PbSS), \qquad R^2 = .38$$

This graphic indicates that lead in paint does not directly impact blood lead levels, but it does impact them through the pathways:

- Lead-based paint hazard index ---> dust lead ---> blood lead, and
- Lead-based paint hazard index ---> dust lead ---> hand lead ---> blood lead.

In addition, it should be noted that exterior surface scraping dust lead derives, in part, from paint lead. Bornschein, et al (1986) report a correlation of .30, with a significance at $p<.001$, between these two variables.

The conclusion is that, except for children with pica, dust is the immediate source of lead for children and that lead-based paint is primarily a contributor to dust lead. The Cincinnati investigators point out that the lack of a path from paint lead to hand lead or blood lead "is not surprising since this would imply that paint chips were adhering to the hand or being deliberately ingested, both of which are low probability events in the study population. Rather, the results support the hypothesis that peeling paint is eventually ground into dust which then contaminates hands, toys and food."[43]

Effects of Housing Condition

There is evidence that the condition of the paint affects the level of the hazard, because defective paint provides chips that are more accessible for direct ingestion and can readily contaminate the house dust. In an early paper from the Cincinnati study, Clark and colleagues compared environmental variables and blood lead levels (for children who had not moved) across housing types.[44] Four housing types were identified:

1. Public housing and private housing built after World War II (WWII), with relatively low levels of paint and dust lead.
2. Rehabilitated housing, originally built before WWII, also with low levels of paint lead, but moderate levels of exterior dust lead.

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43 Bornschein et al. (1986), p. 537.

44 Clark, C.S.; Bornschein, R.L.; Succop, P.; Que Hee, S.S.; Hammond, P. D.; and Peace B. (1985), "Condition and Type of Housing as an Indicator of Potential Environmental Lead Exposure and Pediatric Blood Lead Levels," *Environmental Research* 38:46-53.

3. Pre-WWII housing, satisfactory appearance, with relatively high paint lead and moderate dust lead.

4. Pre-WWII housing, deteriorating or dilapidated, with relatively high paint and dust lead.

No significant differences were found among these housing types in the (geometric) mean blood lead levels up to 3 months of age. Thereafter, mean blood lead levels for the housing in the poorest condition (Group 4) increased dramatically, approaching 35 ug/dl for children reaching 18 months of age. By comparison, mean blood lead levels were between 15 and 20 ug/dl for Groups 2 and 3 housing and between 10 and 15 ug/dl for Group 1 housing.

Comparing the pre-WWII satisfactory and deteriorating/dilapidated groups, Clark and colleagues reported very similar scores on maximum lead content of paint measured by x-ray fluorescence (XRF), but the deteriorating/dilapidated housing had much higher interior surface dust levels and much higher hand dust levels. This study may indicate the importance of "unsoundness" as a marker for lead poisoning hazard.

Isotope Ratio Analysis

Two studies have conducted isotopic analyses of lead in children's blood and environmental lead to make inferences about the sources of the blood lead.[45] Rabinowitz examined three severely lead poisoned boys (blood lead levels of 120, 83, and 66 ug/dl) and found that lead in their blood and feces resembled accessible paint lead, and that the house dust lead appeared to be a mixture of paint lead (20-70 percent) and exterior soil lead.[46] Yaffe and colleagues examined 12 children with blood lead levels above 30 ug/dl.[47] The lead in their blood resembled the lead in paint from exterior walls and the soils in adjacent areas where they played. Yaffe's data suggest that the soil lead came from the paint lead and that the soil lead was the proximate cause of the blood lead.

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[45]These analyses exploited the fact that lead obtained from different sources differs in isotopic composition.

[46]Rabinowitz. (1987) "Stable Isotope Mass Spectrometry in Childhood Lead Poisoning."

[47]Yaffe, Yechiam; Flessel, Peter C.; Wesolowski, Jerome J.; Del Rosario, Aurora; Guirguis, Guirguis N.; Matias, Violeta; Degarmo, Thomas E.; Coleman, Gordon C.; Gramlich, John W.; and Kelly, William R. (July/August 1983), "Identification of Lead Sources in California Children Using the Stable Isotope Ratio Technique," *Archives of Environmental Health* 38(4):237-245.

Effects of Refinishing

Home refinishing--sanding, scraping, and repainting--can result in increased dust lead and elevated blood lead levels. As mentioned in the prior section of this chapter on surface dust and soil, Bellinger and colleagues. (1986) reported a significant association between blood lead levels at age 24 months and recent home refinishing activities. Rabinowitz and colleagues, analyzing the same data, found a mean blood lead increase of 1.4 ug/dl (standard error = 0.7) in homes with recent refinishing.[48] Homes without recent refinishing had no significant change in the children's blood lead. The association between refinishing and change in blood lead varied with the concentration of lead in the paint in the home.

Effects of Lead-Based Paint Abatement

The studies cited above on the associations among paint lead, dust lead, soil lead, and childhood blood lead indicate that removal or covering of lead-based paint in the childhood environment should reduce the risk of lead poisoning, especially if dust lead is reduced in the process. The few reported studies of the health effects of lead-based paint abatement generally support this conclusion, although with some caveats.

In the previously cited study of dust control in Baltimore, Charney and colleagues found that traditional deleading did not reduce mean blood lead levels, but when such abatement was followed by thorough cleaning and wet mopping twice a month, mean blood lead levels fell by 6.9 ug/dl within a year, from 38.6 ug/dl to 31.7 ug/dl.[49] Traditional deleading removed or covered interior nonintact and chewable surfaces within four feet from the floor. Open flame heating of paint was often used on wood trim, along with scraping and sanding. Stripped surfaces were often left unpainted. Exterior surfaces were not abated. Cleanup after abatement was minimal.

In a later study, also in Baltimore, Farfel compared the results of traditional deleading with a modified abatement protocol. In the latter procedure, all interior nonintact and easily accessible intact lead-based paint was removed using a heat gun, or was covered with a fiberglass mat.

[48]Rabinowitz, Michael; Leviton, Alan; and Bellinger, David (April 1985), "Home Refinishing, Lead Paint, and Infant Blood Lead Levels," *American Journal of Public Health*, 75(4):404.

[49]Charney, et al. (1983), "Childhood Lead Poisoning."

Household belongings were covered, kitchen cabinets were sealed, and open doors were covered with plastic sheeting to contain dust. All abated surfaces were repainted. Cleanup included vacuuming with a standard vacuum cleaner and wet mopping with a high-phosphate solution. A nurse provided in-home education to parents on the importance of housekeeping and personal hygiene to reduce the risk of exposure to dust lead.

Farfel found 1) that neither the modified nor the traditional method of abatement was successful in reducing blood lead levels of children, and 2) that traditional abatement apparently made conditions worse, at least in the short term. He concluded that both findings were due primarily to exposure to high dust lead levels. Dust lead levels remained high after abatement in both types of housing. They were higher than the levels that are now used as clearance standards in Maryland and Massachusetts and are recommended by HUD for clearance of abated units in public and Indian housing.[50] Furthermore, some of the children from both groups had contact with their homes during abatement, and these children had significantly higher post-abatement blood lead levels than children with no reported contact. Also of note is the fact that homes in the most deteriorated condition tended to have the highest dust lead levels, which is similar to the finding of the Cincinnati study cited earlier in this chapter.

Farfel identified several abatement procedures that would reduce dust lead levels. These procedures were much more extensive and stringent than those followed in the modified abatement in his study. They included: 1) abatement of more than just accessible and defective surfaces, with particular attention to windows, which may generate substantial amounts of dust lead due to abrasion of paint during opening and closing; 2) more effective cleanup, including the use of vacuums with special filters that trap very small particles (these are known as HEPA, for high efficiency particle accumulator, vacuums); 3) the use of engineering and work practices that minimize and contain dust generated during abatement; 4) greater care in protecting occupants and their belongings during abatement; 5) greater care in protecting workers during abatement; 6) proper disposal of hazardous waste; and 7) post-abatement clearance testing of dust lead levels

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[50] Office of Public and Indian Housing, U.S. Department of Housing and Urban Development, "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing," September 1990, p. 125.

prior to reoccupancy.[51] These suggested procedures formed the basis for the HUD interim Guidelines on testing and abatement that were published in 1990.

Three additional studies (all as yet unpublished) report blood lead reductions following traditional abatement. In New York City, Rosen and colleagues reported a reduction in mean blood lead levels of children not receiving chelation treatment from 29 ug/dl to 21 ug/dl (or 28 percent) approximately 24 weeks after abatement.[52] Abatement consisted of scraping, spackling, and repainting. Copley, in an unpublished study, found that mean blood lead levels of untreated children in St. Louis dropped from 43.9 ug/dl to 34.2 ug/dl (or 22 percent) 6 to 12 months after abatement that involved some encapsulation as well as repainting.[53] In Massachusetts, Amitai and colleagues found a decrease in mean blood lead levels from 35.7 ug/dl to 25.5 ug/dl (or 29 percent) 8 months after abatement, which sometimes included encapsulation or replacement of painted surfaces.[54] Importantly, the Massachusetts study also found that blood lead levels increased during abatement (children were not relocated) if the method relied on dry scraping and sanding, but declined later.

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[51]Farfel, Mark (1987). "Evaluation of Health and Environmental Effects of Two Methods for Residential Lead Removal," Doctoral Dissertation, School of Hygiene and Public Health of the Johns Hopkins University, Baltimore, MD. Also, Farfel, M.; and Chisolm, J.J., Jr. (1990). "Health and Environmental Outcomes of Traditional and Modified Practices for Abatement of Residential Lead-Based Paint," *American Journal of Public Health*, v. 80, no. 10, pp. 1240-1245.

[52]Rosen, John F.; Markowitz, Morri E.; Bijur, Polly E.; Jenks, Sarah T.; Wielopolski, Lucian; Kalef-Ezra, John A.; and Slatkin, Daniel N. (in press), "Sequential Measurements of Bone Lead Content by L-X-Ray Fluorescence in $CaNa_2EDTA$-Treated Lead-Toxic Children," *Environmental Health Perspectives*.

[53]Copley, Charles G. (unpublished paper), "The Effect of Lead Hazard Source Abatement and Clinic Appointment Compliance on the Mean Decrease of Blood Lead and Zinc Protoporphrin Levels."

[54]Amitai, Yona; Brown, Mary Jean; Graef, John W.; and Cosgrove, Edward (unpublished paper), "Effects of Residential Deleading on the Blood Lead Levels of Lead Poisoned Children."

SUMMARY AND CONCLUSIONS

Medical research during the past decade has found that childhood lead poisoning is more widespread and has more serious consequences than had previously been thought. It now appears that the threshold level of lead in blood that is associated with deficits in neurological development, 10-15 ug/dl, is roughly one-half the level of 25 ug/dl set in 1985 by the Centers for Disease Control as a cutoff point for medical referral. This has major implications for the number of children considered to be at risk, since the number of children with blood lead levels greater than 15 ug/dl is roughly 10 times the number with levels above 25 ug/dl. It is estimated that the number of children under 6 years of age in the United States that were above the lower threshold (15 ug/dl) was 3 to 4 million, or 17 percent of that age group, in 1984. (Updated estimates will be available in 1992, from the National Health and Nutrition Examination Survey.)

Furthermore, published studies have found strong associations between prenatal lead exposure and deficits in infant development. It appears that prenatal exposure is a more powerful determinant of developmental problems in infancy than postnatal exposure. Therefore, lead exposure among women of childbearing age is now an important public health concern. Finally, recent research has found that impairment in neurobehavioral functioning--including lower intelligence, longer reaction times, poorer hand-eye coordination, and short-term memory loss--is long lasting and probably irreversible.

The rate of occurrence of elevated blood lead levels is greater among black children than white children, and among children from low-income families than those from upper-income families. Inner-city children have higher rates than suburban children, and large metropolitan areas are worse than small urban areas. Nevertheless, children from all socioeconomic groups and geographic areas are affected. The number of middle-income, white, suburban children that are at risk of lead poisoning is about the same as the number of lower-income, black, inner-city children.

The rate of occurrence of lead poisoning has declined since the 1970s because of the reduction of lead in gasoline, but a large amount of lead remains in the residential environment. The primary sources are lead-based paint, lead in pipes and solder (which affect drinking water), and dust and soil lead. Dust and soil has been contaminated over the years by fallout from vehicular and industrial emissions and from lead-based paint that has been scraped and repainted or has simply deteriorated or weathered.

The multiplicity of sources of lead in the environment makes it difficult to measure the exact contribution of lead-based paint to lead poisoning. Much depends on the situation. In some locations, industrial or vehicular emissions may be dominant. In others, contaminated drinking water may be the culprit. It seems clear, however, that paint often plays a major role. Recent studies indicate that dust and soil, both inside and outside the dwelling, may be the most widespread source of low-level childhood lead exposure. However, paint lead has been found to be a common source of dust lead, especially in deteriorated housing that contains lead-based paint. Repainting has also been associated with elevated blood lead levels, presumably because the scraping and sanding that is often associated with preparation of the surface generates dust lead. Severe lead poisoning often derives from direct ingestion of lead-based paint; that is, a child may chew or swallow a paint chip, or he/she may chew on a protruding surface painted with lead-based paint.

Studies of the health effects of lead-based paint abatement indicate that there is a high risk that traditional abatement practices may result in increased lead exposure, at least in the short term. Findings are mixed regarding the long term health effects of traditional abatement on childhood blood lead levels. However, the studies of traditional abatement have provided the basis for major improvements in abatement procedure that are now reflected in the HUD Interim Guidelines. Abatement conducted according to the Guidelines is much more extensive than traditional abatement in terms of the surfaces that are abated; it is much more careful in protecting occupants, workers, and the environment from exposure to contaminated dust and waste; and it requires that dwellings pass a stringent post-abatement clearance test to assure that interior dust lead loadings are below specified levels.

The following conclusions regarding lead hazards can be drawn from the information presented in this chapter:

1. There are many sources of lead that contribute to elevated blood lead levels in proportions that are not fully known or understood.

2. Contaminated dust or soil, regardless of the source of the lead, is hazardous; it appears to be the most common pathway of low-level childhood lead exposure.

3. Lead-based paint is a source of lead in housedust. Other sources include industrial and automotive emissions tracked in or blown in, or carried in on clothing.

4. Children living in housing that is both deteriorated and has lead-based paint have a high risk of experiencing elevated blood lead levels.

5. Scraping and repainting of lead-based paint is likely to create dust lead that is hazardous to children, unless measures are taken to reduce exposure to dust.

6. Based on published and unpublished studies, it appears that abatement of defective or accessible lead-based paint in the homes of poisoned children contributes to the reduction of the blood lead levels of such children, but care should be taken during abatement to avoid generating dust lead to which the child is exposed and to assure that dust lead is thoroughly cleaned up. Continual suppression of dust lead in the months following abatement is also very important.

CHAPTER 3

THE EXTENT OF LEAD-BASED PAINT IN HOUSING

The 1987 amendments to the Lead-Based Paint Poisoning Prevention Act call for an estimate of the extent of lead-based paint hazards in housing in the United States. Because of limitations in available data, the Department of Housing and Urban Development (HUD) sponsored the first national survey of lead-based paint in housing in order to provide the estimates required by the legislation. The survey was conducted by Westat, Inc., in the winter of 1989-1990. This chapter describes the prior studies of lead-based paint, explains the purpose and design of the new national survey, and presents the findings of the national survey regarding the amount of housing with lead in paint, dust, and soil.

PRIOR STUDIES

There have been four previous surveys of lead-based paint in housing. Three local surveys were conducted in the mid-1970s, and one national survey of public housing was carried out in the 1980s.

The Pittsburgh survey, conducted in 1974 and 1975 by the Allegheny County (PA) Health Department for the National Bureau of Standards (now the National Institute of Standards and Technology [NIST]) under HUD sponsorship, is by far the largest study of its type ever conducted. Approximately 3,300 housing units were inspected out of a sample of 4,000 units that represented the entire Pittsburgh urban area.[1]

[1] Shier, Douglas R.; and Hall, William G. (1977), *Analysis of Housing Data Collected in a Lead-Based Paint Survey in Pittsburgh, Pennsylvania*, Parts I and II (NBSIR 77-1250 and 77-1293), U.S. Department of Commerce, National Bureau of Standards.

The Washington, DC, survey, conducted in 1973 by the National Bureau of Standards under HUD sponsorship as a field test for the Pittsburgh survey, had a sample of 233 units (of which 115 were inspected) representing the city of Washington.[2]

The Phoenix survey, conducted in 1976 by the Arizona Department of Health Services, had a sample of 268 units representing the census tract in Phoenix considered to be of highest priority because of the high number of both pre-1940 units and children under 5 years old. One hundred and forty-six housing units were inspected.[3]

The Modernization Needs Study of Public Housing included a survey of lead-based paint abatement needs in public housing that was conducted in 1984-1985. Two hundred and sixty-two public housing units plus associated common areas were inspected in 131 public housing projects in 34 cities. The 34 cities were selected because they had community lead-poisoning prevention programs that were willing to conduct the inspections according to a survey design prepared by Abt Associates, Inc., under HUD sponsorship. The results of the study were projected to the national stock of public housing.[4]

As a basis for national estimates of the number of housing units with lead-based paint, these prior surveys are limited. The portable x-ray fluorescence (XRF) analyzers used in all of the surveys have subsequently been found by NIST to be highly imprecise at the 1.0 mg/cm^2 (milligram per square centimeter) level.[5] Furthermore, there is no way of knowing the extent to which the findings are representative of housing in the nation, because of the limited geographic coverage of most of the surveys.

The prior surveys also lack some of the information needed to analyze lead hazards in housing and estimate the cost of abatement. They provide no information on the incidence of lead in house dust and in exterior soil--two sources identified in the research literature as important pathways of

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[2]Hall, William; and Ayers, Tyrone (1974), *Survey Plans and Data Collection and Analysis Methodologies: Results of a Pre-Survey for the Magnitude and Extent of the Lead-Based Paint Hazard in Housing* (NBSIR 74-426), U.S. Department of Commerce, National Bureau of Standards.

[3]Arizona Department of Health Services, Division of Environmental Health, Bureau of Sanitation (1976), "Lead-Based Paint: Report of Findings to the State Legislature" (mimeo).

[4]Wallace, James E. (1986), *The Cost of Lead-Based Paint Abatement in Public Housing*, U.S. Department of Housing and Urban Development.

[5]McKnight, Mary E.; Byrd, Eric W.; Roberts, Willard E.; and Lagergren, Eric S. (December 1989), *Methods for Measuring Lead Concentrations in Paint Films* (NISTIR 89-4209), U.S. Department of Commerce, National Institute of Standards and Technology.

lead, deriving in part from lead-based paint. Therefore, they cannot be used to analyze the incidence of dust lead and soil lead, or the association between lead-based paint and lead in dust and soil. The prior surveys provide limited information on the number and dimensions of the surfaces containing lead-based paint within housing units. Such information can be estimated, but that procedure increases the error in calculating the costs of abatement. Such cost estimates are legislatively required for public housing and are desirable in developing policies for private housing.

Table 3-1 shows the findings of the prior surveys in terms of the percentage of housing with some paint with a concentration of lead at or above 1.0 mg/cm^2 inside or outside the unit. For housing built prior to 1940, the range was 71 to 100 percent; for homes built between 1940 and 1959, the range was 64 to 92 percent; and for units built between 1960 and 1977, the range was 48 to 76 percent. The wide ranges of these percentages underscored the need for a systematic national survey to generate estimates sufficiently reliable for analysis and policy development.

The prior surveys have been used to construct an estimate of the incidence of lead-based paint in housing. The Agency for Toxic Substances and Disease Registry (ATSDR) in 1988 estimated the total number of housing units in the United States with lead-based paint at a concentration $\geq$ 0.7 mg/cm^2 as 41,964,000.[6] This estimate assumed that lead-based paint was in 99 percent of housing units built before 1940, 70 percent of units built between 1940 and 1959, and 20 percent of units built between 1960 and 1974. The percentages were based on the Pittsburgh and Phoenix surveys, plus expert opinion. At the recommendation of the Centers for Disease Control, the lead concentration level of 0.7 mg/cm^2 was used instead of 1.0 mg/cm^2.

The difference between the percentages used by ATSDR and those in Table 3-1 are primarily in the 1960-1977 period. ATSDR used 20 percent as its best estimate for that period; Table 3-1 shows a range between 48 and 76 percent. This discrepancy apparently derives from an unexplained difference in the interpretation of the Pittsburgh survey findings.

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[6]U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (1988). *The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress*, VI-13. Estimates adapted from Anne Pope (1986), "Exposure of Children to Lead-Based Paints" (mimeo), PEI Associates, Inc., for EPA.

TABLE 3-1
INCIDENCE OF LEAD-BASED PAINT IN HOUSING
BY YEAR OF CONSTRUCTION BASED UPON PRIOR SURVEYS

	Year of Construction					
	pre-1940		1940-1959		1960-1977	
Survey	Percent	Units in Sample	Percent	Units in Sample	Percent	Units in Sample
Pittsburgh						
All Housing	88%	2,525	74%	178	61%	27
Public Housing	71	76	79	117	60	63
Washington, DC	100	63	92	24	76	17
Phoenix	100	124	85	22	NA	NA
Public Housing (1)	81	99	64	96	48	52

(1) This survey, part of the Modernization Needs Study, used different year-of-construction intervals than the other surveys. The incidence of 81 percent is for public housing built prior to 1950, and the incidence of 64 percent is for the period 1950-1959.

The ATSDR report also estimated that there were 1,972,000 housing units with lead-based paint in an "unsound" condition. This figure was provided as an indicator of the number of units in which the risk of exposure to lead from paint was greatest. It was based on data from the 1983 American Housing Survey, which reported on peeling paint, cracked plaster, and holes in walls. Peeling paint was the indicator selected to represent unsound condition. To calculate the estimate, ATSDR multiplied the estimated number of units with lead-based paint in each of the three periods of construction by a single average percentage of units with peeling paint for all housing in the nation, regardless of year of construction. This method appears to have resulted in an underestimate. In fact, the incidence of peeling paint, according to the 1983 American Housing Survey, was 8.7 percent in pre-1940 housing, 4.3 percent in housing built between 1940 and 1959, and 1.8 percent in housing built between 1960 and 1979. If these percentages had been used in the ATSDR model, the estimated number of housing units with lead-based paint and peeling paint would have been 2,574,000 instead of 1,972,000.

PURPOSE, DESIGN, AND METHODOLOGY OF THE NATIONAL SURVEY

This section presents a summary of the objectives, sample design, and survey methodology of the national survey of lead-based paint in housing conducted by Westat, Inc., under HUD sponsorship. Appendix A presents a more detailed description. Both public and private housing were surveyed, using somewhat different methodologies. The presentation in this report concentrates on private housing. Brief mention is made of public housing where deemed appropriate. A more detailed description of the methodology employed for public housing will appear at a later date in the report to Congress on a comprehensive and workable plan for lead-based paint abatement in public housing.

The objective of the national survey of lead-based paint in housing was to obtain data for estimating:

- The number of housing units (private single family, private multifamily, and public housing) with lead-based paint, by year of construction;
- The extent or surface area of lead-based paint in housing, to develop an estimate of national abatement costs;
- The condition of the paint;

- The incidence of lead in dust in dwelling units and in soil around the perimeter of residential structures;
- The characteristics of housing with varying levels of potential hazard, to examine possible priorities for abatement.

The study population consisted of nearly all occupied housing in the United States constructed before 1980. Newer houses were presumed to be lead-free because, in 1978, the Consumer Product Safety Commission banned the sale of lead-based paint to consumers and the use of such paint in residences. Vacant housing was excluded because of the practical difficulties of contacting owners. Group quarters (e.g., dormitories and jails) and projects that are occupied exclusively by the elderly were excluded from the survey, because the primary public health concern is lead poisoning in children.

INCIDENCE OF LEAD-BASED PAINT IN PRIVATELY OWNED HOMES

An estimated 57.4 million homes, 74 percent of all occupied housing units built before 1980, have lead-based paint somewhere in the building. As shown in Table 3-2, an estimated 9.9 million of these homes are occupied by families with children under the age of 7. This is 71 percent of all pre-1980 housing units occupied by families with young children.

Older homes are more likely to have lead-based paint than newer homes. An estimated 90 percent of dwelling units built before 1940 have lead-based paint in the interior or on the exterior, while 62 percent of homes built between 1960 and 1979 have lead-based paint. The age of the unit is the only attribute for which the differences between categories are significant.

In particular, there are no significant differences in the incidence of lead-based paint by the income of the household, the value of the home, or the rent. Although elevated blood lead levels are more commonly found among poor children, as reported in Chapter 2, well-to-do households are as likely to occupy homes with lead-based paint as the poor. Similarly, there is no significant difference between single-family and multifamily housing units.

Lead-based paint is found less often in the South than in other regions, but this is because the South was significantly less urban than other regions of the country until the 1970s, and its housing stock was built more recently, on the average.

TABLE 3-2
ESTIMATED NUMBER OF PRIVATELY OWNED OCCUPIED HOUSING UNITS BUILT BEFORE 1980 WITH LEAD-BASED PAINT, BY SELECTED CHARACTERISTICS
(Paint Lead Concentration >= 1.0 mg/sq cm)

Characteristic	Total Occupied Housing Units (000) (1)	Housing Units With Lead-Based Paint Anywhere in Building		Number of Housing Units in Sample
		Percent	Number (000)	
Total Occupied Housing Units Built Before 1980	77,177	74% (6%)	57,370 (4,705)	284
Construction Year:				
1960-1979	35,681	62% (10%)	22,149 (3,407)	120
1940-1959	20,476	80% (9%)	16,381 (1,824)	87
Before 1940	21,018	90% (10%)	18,916 (2,056)	77
Housing Type				
Single Family	66,418	74% (7%)	49,476 (4,520)	227
Multifamily	10,759	73% (13%)	7,894 (1,358)	57
One or More Children Under Age 7	13,912	71% (9%)	9,900 (1,302)	90
Census Region				
Northeast	16,963	93% (8%)	15,811 (1,379)	53
Midwest	19,848	76% (12%)	14,994 (2,416)	69
South	24,967	58% (11%)	14,558 (2,688)	116
West	15,399	80% (14%)	12,382 (2,120)	46
Owner-Occupied	52,894	72% (8%)	38,251 (4,160)	179
Market Value of Home				
Less than $40,000	11,885	79% (15%)	9,399 (1,820)	39
$40,000 to $79,999	10,228	53% (17%)	5,442 (1,770)	46
$80,000 to $149,999	5,582	65% (17%)	3,641 (932)	45
$150,000 and up	7,405	87% (12%)	6,474 (891)	42
Renter-Occupied	24,285	79% (9%)	19,120 (2,281)	105
Monthly Rent Payment				
Less than $400	16,339	69% (14%)	11,334 (2,314)	59
$400 and up	8,395	87% (12%)	7,324 (1,042)	40
Household Income				
Less than $30,000	46,126	76% (7%)	35,124 (3,091)	156
$30,000 and up	31,048	72% (9%)	22,345 (2,642)	107

(1) Total units data are from the 1987 American Housing Survey.

Note: Numbers in parentheses are approximate half-widths of 95% confidence intervals for the estimated percents and numbers. For example, the approximate 95% confidence interval for the percent of housing units with some lead-based paint is 74% +/- 6% or 68% to 80%.

Effect of Different Lead Concentration Thresholds

In Table 3-2, a dwelling unit is considered to have lead-based paint if any of the paint has a lead content of 1.0 mg/cm^2 or greater, as measured by XRF. This threshold follows the Federal standard for lead-based paint, established in Section 566 of the Housing and Community Development Act of 1987. However, two States have different standards: Maryland uses 0.7 mg/cm^2 as the threshold, while Massachusetts uses 1.2 mg/cm^2. All of these levels are lower than the threshold of 2.0 mg/cm^2 used in many local codes during the 1970s, and in some prior studies, such as the Pittsburgh study.[7]

Table 3-3 shows the incidence of lead-based paint in occupied housing under each of these four different lead concentration thresholds. Modifying the threshold concentration substantially modifies the number of dwelling units characterized as having lead-based paint. There are 24 million more homes with lead-based paint by the current Federal standard of 1.0 mg/cm^2 than the common standard of the mid-1970s, for example, and 18 million more by the Maryland standard than by the Massachusetts standard.

Table 3-3 also shows that the incidence of lead-based paint is much lower for newer homes on the basis of the more stringent standards. Only 18 percent of the homes built during the 1960s and 1970s have concentrations above 2.0 mg/cm^2, while 80 percent have concentrations above 0.7 mg/cm^2. Homes built before 1940, by contrast, have a consistently high incidence according to all four standards, although of course the incidence declines as the concentration increases. These differences reflect the changes in lead-based paint formulations and applications over the years. Thus newer homes are less likely to have lead-based paint than older homes, and much less likely to have an acute problem.

On the other hand, Table 3-3 shows that the number of homes with lead-based paint at lower concentrations actually increases as one moves from older to newer homes. This phenomenon is a result of the larger base of newer homes. Thus, while the incidence rate has declined over the years, the number of homes with lead-based paint potentially needing abatement has increased.

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[7] Billick, Irwin H. and V. Eugene Gray (July 1978), *Lead Based Paint Poisoning Research: Review and Evaluation, 1971-1977,* U.S. Department of Housing and Urban Development.

TABLE 3-3
NUMBER AND PERCENTAGE OF OCCUPIED HOMES WITH LEAD-BASED PAINT BY LEAD CONCENTRATION, YEAR OF CONSTRUCTION, AND LOCATION OF LEAD-BASED PAINT

Location and Construction Year	Percentage of Homes Paint Lead Concentration (mg/sq cm)			
	>=0.7	>=1.0	>=1.2	>=2.0
Interior	66%	51%	40%	22%
1960-1979	60%	41%	28%	7%
1940-1959	70%	59%	44%	20%
Built before 1940	73%	60%	57%	50%
Exterior	70%	60%	51%	36%
1960-1979	55%	42%	31%	12%
1940-1959	82%	76%	69%	46%
Built before 1940	83%	79%	69%	66%
Anywhere in Building	86%	74%	63%	43%
1960-1979	80%	62%	47%	18%
1940-1959	87%	80%	74%	52%
Built before 1940	94%	90%	79%	75%

Location and Construction Year	Number of Homes (000) Paint Lead Concentration (mg/sq cm)			
	>=0.7	>=1.0	>=1.2	>=2.0
Interior	51,008	39,401	31,024	17,239
1960-1979	21,409	14,768	9,991	2,498
1940-1959	14,333	12,058	9,009	4,095
Built before 1940	15,343	12,575	11,980	10,509
Exterior	53,674	46,686	39,641	27,562
1960-1979	19,625	15,058	11,061	4,282
1940-1959	16,790	15,474	14,128	9,419
Built before 1940	17,445	16,604	14,502	13,780
Anywhere in Building	66,321	57,370	48,443	32,888
1960-1979	28,545	22,149	16,770	6,423
1940-1959	17,814	16,381	15,152	10,648
Built before 1940	19,661	18,916	16,604	15,693

Tables B-5, B-6 and B-7 in Appendix B provide further detail on the effects of varying the lead concentration threshold. Tables B-5 and B-6 report the occurrence rates of lead-based paint at the Maryland and Massachusetts standards, respectively, while Table B-7 reports on the occurrence rate of dwelling units with 2.0 mg/cm^2 or higher.

Lead-Based Paint by Location

The survey also provides information on the location of lead-based paint within or outside the housing unit. Table 3-4 displays the number and percentage of occupied housing units with lead-based paint only on interior surfaces, only on exterior surfaces, and on both.

While most popular and public policy discussions have been concerned with lead-based paint on interior walls and lead dust within the housing unit, the survey shows that lead-based paint is more common on the outside of the housing unit. An estimated 18.0 million occupied homes (23 percent of pre-1980 homes) have lead-based paint only on the exterior of the building, compared to an estimated 10.7 million homes (14 percent) with lead-based paint only in the interior. An estimated 28.7 million homes (37 percent) have lead-based paint both inside and outside the building. Table 3-3 shows that this pattern holds for virtually all standards, in all time periods.

Nonintact Paint

Peeling or flaking paint constitutes a direct hazard to small children with pica. This was the first hazard identified by research. Table 3-5 shows the incidence of nonintact paint, both in the aggregate and by the location of the paint. A dwelling unit has nonintact lead-based paint if at least 5 square feet of the lead-based paint in the dwelling unit is defective.

Some 13.8 million occupied units are estimated to have nonintact lead-based paint. This is 18 percent of the pre-1980 housing stock, and 24 percent of the pre-1980 stock with lead-based paint. The incidence of nonintact lead-based paint, just as the overall incidence of lead-based paint, is higher on the outside of housing units than inside. Moreover, there is a higher incidence of nonintact paint among units with exterior lead-based paint than among units with interior lead-based paint. The paint is damaged in 21 percent of the units with exterior lead-based paint, compared to 13 percent for units with interior lead-based paint.

TABLE 3-4
INCIDENCE OF LEAD-BASED PAINT (LBP) BY LOCATION IN THE BUILDING

Location of LBP	Occupied Housing Units With Lead-Based Paint	
	Number (000)	Percent (1)
Interior Only	10,681	14%
Exterior Only	17,967	23%
Both Interior and Exterior	28,718	37%
Anywhere in Building	57,370	74%

(1) Base equals all 77,177,000 housing units built before 1980.

TABLE 3-5
INCIDENCE OF NONINTACT LEAD-BASED PAINT (LBP) BY LOCATION IN THE BUILDING

Location of Nonintact LBP (2)	Occupied Housing Units With Nonintact Lead-Based Paint	
	Number (000)	Percent (1)
Interior Only	3,919	5%
Exterior Only	8,577	11%
Both Interior and Exterior	1,324	2%
Anywhere in Building (3)	13,820	18%

(1) Base equals all 77,177,000 housing units built before 1980.

(2) "Interior" only means the only nonintact LBP is in the interior; there may be intact LBP on the exterior. "Exterior only" has a similar meaning.

(3) A housing unit has nonintact interior LBP if there are more than 5 sq. feet of damaged interior LBP. Similar definitions apply verbatim for exterior and any LBP. It is therefore possible for a housing unit to have nonintact "any" LBP without having either nonintact exterior LBP or nonintact interior LBP (for example, a house with 3 sq. ft. of damaged interior LBP and 3 sq. ft. of damaged exterior LBP).

ASSOCIATIONS BETWEEN LEAD IN PAINT AND DUST

As indicated in Chapter 2, the public health literature over the last few years has repeatedly implicated lead in house dust as the most common source of low-level childhood lead poisoning within a dwelling unit. The national survey includes information on the presence and location of dust within the housing units that were sampled. Table 3-6 shows the number of units with dust lead loadings in excess of Federal guidelines for homes with or without lead-based paint, and also shows the incidence of dust according to the location of the lead-based paint. The HUD Interim Guidelines for the abatement of lead-based paint in housing contain recommended clearance levels for dust lead after lead-based paint abatement. The levels are 200 micrograms per square foot (ug/ft^2) for floors, 500 ug/ft^2 for window sills, and 800 ug/ft^2 for window wells. These are the same clearance standards as are used in Maryland and Massachusetts.

Some 17 percent of the occupied homes with lead-based paint had dust lead exceeding these guidelines, while only 4 percent of the dwelling units without any lead-based paint had excessive dust lead. Thus, over 80 percent of homes with lead-based paint are not contaminated with high dust lead levels. On the other hand, the chance of a unit having excessive dust lead is about four times greater if it has some lead-based paint than if it does not have any. Table 3-6 also suggests that interior dust is more likely to be generated by exterior lead-based paint than by interior paint. While the incidence of dust is about the same for units with interior or exterior lead-based paint, in the range of 20 percent, it is almost as low for units with interior lead-based paint only as it is for units with no lead-based paint at all. There is also evidence that excessive dust lead is generated by interior and exterior lead-based paint in combination with each other; the incidence of units with excessive dust lead is highest for units with lead-based paint both inside and outside the house.

Table 3-7 offers an explanation for these findings. It shows the incidence of dust lead in different locations within the housing unit. Most of the dust is located around the windows, either in the window wells or on the window sills. Window wells and sills can easily receive dust from either the inside or the outside of the house. Fewer than 1 million units have dust on the floor with lead concentrations above the guidelines. There is likely to be more dust lead in the wells than on the sills or floor because there is typically more dust there (the wells are cleaned less often) and probably because there is abrasion of paint caused by the opening and closing of the windows.

TABLE 3-6
DUST LEAD LOADINGS IN OCCUPIED HOUSING UNITS WITH OR WITHOUT INTERIOR OR EXTERIOR LEAD-BASED PAINT (LBP)

Presence of LBP	Dust Within Guidelines (1)		Dust Exceeding Guidelines (1)	
	Number (000)	Percent	Number (000)	Percent
No LBP at All	19,084	96%	723	4%
Interior LBP Only	10,013	94%	671	6%
Exterior LBP Only	15,423	86%	2,546	14%
Both Interior and Exterior LBP	21,984	77%	6,733	23%
Any Interior LBP	31,997	81%	7,404	19%
Any Exterior LBP	37,407	80%	9,279	20%
Any LBP	47,420	83%	9,950	17%

(1) HUD Interim Guidelines.

TABLE 3-7
RATE OF OCCURRENCE OF OCCUPIED HOUSING UNITS WITH DUST LEAD IN EXCESS OF THE FEDERAL GUIDELINES

Interior Surface Dust Lead			
Location	Federal Guideline (1) (ug/sq ft)	Number (000) of Housing Units Above Guideline (1)	Percent of Housing Units Above Guideline (1)
Anywhere	varies	10,674	14%
Window well	800	8,632	11%
Window sill	500	2,572	3%
Floor	200	986	1%
Window Only (2)	varies	9,688	13%
Floor Only	200	986	1%
Both Floor and Window (2)	varies	0 (3)	0%

(1) HUD Interim Guidelines.

(2) Window includes window sill, window well or both.

(3) There were no sampled housing units in this cell. Nationally, there is some small number of housing units in this cell.

Alternative Lead Hazard Criteria: Nonintact Paint and Lead Dust

Federal and State standards (where they exist) for lead-based paint abatement are currently all based upon the measured lead content of paint. Exclusive reliance on a standard based on the measured lead content of paint raises a number of important issues for public policy. In a broad sense, the problem with a simple paint standard is that it is insufficiently discriminating. As reported in Table 3-2, approximately 57 million privately owned dwelling units constructed before 1980 would require abatement under the paint lead standard of 1.0 mg/cm^2. However, not all of these units pose the same health hazards to their occupants. There is considerable evidence in the public health literature that the condition of the paint and the existence of lead in the dust inside the house strongly influence the likelihood of lead poisoning or high blood lead levels.

Table 3-8 shows the incidence of excessive interior dust lead in relation to the location and condition of lead-based paint. Excessive dust lead levels occur more often in housing with lead-based paint, whether intact or not, than in housing without lead-based paint. Also, excessive dust lead levels occur more often in housing with nonintact lead-based paint on the exterior than in housing with intact exterior lead-based paint.[8] These conclusions are confirmed by multiple regression and pathways analyses reported later in this chapter.

Nonintact paint and excessive dust lead pose a particular problem for young children, at the same time that young children are more at risk of being damaged by lead than adults, as discussed in Chapter 2. Young children are more likely to chew nonintact paint than adults. House dust is frequently ingested by young children in the course of normal hand-to-mouth activity, and the scientific evidence regarding the existence of a positive relationship between lead in house dust and child blood lead is quite powerful.

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[8]A test of significant differences between percentages in Table 3-8 yields the following:

Location/Condition	z Statistic
Interior, intact vs. interior, nonintact	1.46
Exterior, intact vs. exterior, nonintact	2.00
LBP anyplace, intact vs. LBP anyplace, nonintact	1.49
No LBP, all intact vs. No LBP, any nonintact	0.16
LBP anyplace, intact vs. No LBP, all intact	2.47
LBP anyplace, nonintact vs. No LBP, any nonintact	2.35

Values greater than 1.65 indicate significance.

TABLE 3-8
ASSOCIATION BETWEEN LEAD IN INTERIOR DUST AND
LEAD-BASED PAINT (LBP) CONDITION FOR PRIVATELY OWNED HOUSING UNITS

Occupied Housing Units							
Location of LBP	Condition of LBP	Dust Lead Within Guidelines (1)		Dust Lead Exceeds Guidelines (1)		Total Housing Units	
		Number (000)	Percent	Number (000)	Percent	Number (000)	Percent
Interior	Intact	27,180	80%	6,979	20%	34,159	100%
	Not intact	4,817	92%	426	8%	5,243	100%
Exterior	Intact	30,987	85%	5,547	15%	36,534	100%
	Not intact	6,420	63%	3,733	37%	10,153	100%
Any	Intact	37,336	86%	6,214	14%	43,550	100%
	Not intact	10,084	73%	3,736	27%	13,820	100%
No LBP	All Intact	14,449	97%	510	3%	14,959	100%
	Any not intact	4,635	96%	213	4%	4,848	100%

(1) "Within guidelines" means that the surface lead dust does not exceed 200 ug/sq ft on floors, 500 ug/sq ft on window sills, or 800 ug/sf on window wells. See HUD Interim Guidelines.

It therefore appears that those most at risk of suffering from elevated blood lead levels, from lead-based paint as opposed to other sources of lead, are young children whose homes have nonintact paint or excessive lead dust. Table 3-9 shows the incidence of these hazards. While 57 million occupied homes have lead-based paint, less than 10 million of them are occupied by families with children under age 7, and only about 3.8 million of these also have high dust lead levels or nonintact paint. Nonintact paint is more common than excessive dust lead.
Table 3-10 provides further information about the families occupying these 3.8 million units. More than half own their home. In addition, about half have annual incomes above $30,000, which is approximately the median income among all households.

ASSOCIATION BETWEEN LEAD PAINT AND SOIL LEAD

The national survey also provides information on lead in the soil surrounding the housing unit. Lead in soil is a possible source of lead in house dust, as the soil is tracked or blown into the house. Soil lead can result from exterior lead-based paint, among a variety of environmental sources. Table 3-11 presents the estimated numbers of occupied dwelling units nationwide with soil lead, associated with the presence and condition of exterior lead-based paint. There is a strong statistical association. The table indicates that the probability of excessive soil lead somewhere on the property (i.e., near the entrance, at the drip line, or at a remote location) is four to five times larger when exterior lead-based paint is present than when it is not. Soil lead is especially likely if the paint is defective. However, it is still true that 79 percent of the time that lead-based paint is present, the soil lead is within the guidelines.

The guidelines used in the survey are the interim guidance on soil lead cleanup levels at Superfund sites recently issued by EPA.[9] Following a recommendation by the Centers for Disease Control,[10]

[9]U.S. Environmental Protection Agency (September 7, 1989), *Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites* (OSWER Directive #9355.4-02).
[10]U.S. Department of Health and Human Services, Centers for Disease Control (January 1985), *Preventing Lead Poisoning in Children* (99-2230).

TABLE 3-9
ESTIMATED NUMBER OF HOUSING UNITS REQUIRING ABATEMENT UNDER FOUR CRITERIA FOR ABATEMENT, BY PRESENCE OF CHILDREN UNDER AGE SEVEN
(Numbers Represent Thousands of Housing Units)

Criteria for Abatement	All Occupied Housing Units	Housing Units With Children
Lead in Paint (1)	57,371	9,903
Lead in Paint and Paint Not Intact (2)	13,820	3,137
Lead in Paint and Lead Dust Present (3)	9,950	1,556
Lead in Paint, Paint Not Intact, OR Lead Dust Present	20,034	3,840

(1) Lead-based paint concentration of at least 1.0 mg/sq cm

(2) At least 5 square feet of defective lead-based paint.

(3) Lead in dust exceeds 200 ug/ sq ft for floors, or 500 ug/sq ft for window sills, or 800 ug/sq ft for window wells.

TABLE 3-10
ESTIMATED NUMBER OF HOUSING UNITS WITH LEAD-BASED PAINT, ONE OR MORE RESIDENT CHILDREN UNDER AGE SEVEN, AND WITH NONINTACT LEAD-BASED PAINT OR LEAD DUST, BY HOUSEHOLD INCOME AND TENURE
(Numbers Represent Thousands of Housing Units)

	Tenure		
Income	**Rent**	**Own**	**Total**
Less than $30,000	1,305	691	1,996
More than $30,000	422	1,422	1,844
Total	1,727	2,113	3,840

Note: Because the national survey contains small samples for the detailed categories in this table, the entries for the cells are constructed from the American Housing Survey, using the AHS incidence for each category multiplied by the national survey estimated total of 3,840 units with priority hazards occupied by families with young children.

TABLE 3-11
ASSOCIATION BETWEEN LEAD IN SOIL AND EXTERIOR LEAD-BASED PAINT CONDITION FOR PRIVATELY OWNED HOUSING UNITS
(Numbers Represent Thousands of Occupied Housing Units)

Presence and Condition of Exterior Lead-Based Paint	**Lead in Soil Anywhere**			
	Within Guideline (1)		**Exceeding Guideline (1)**	
	Number	**Percent**	**Number**	**Percent**
No LBP	29,563	94%	1,941	6%
LBP Present, Intact	28,415	79%	7,358	21%
LBP Present, Not Intact	5,145	52%	4,756	48%
Any Exterior LBP	33,560	73%	12,114	27%
Total	63,123	82%	14,055	18%

(1) The guideline is 500 ppm. See EPA, Interim Guidance.

the cleanup level is set at 500 to 1,000 ppm total lead, "to be followed when the current or predicted land use is residential." When the soil lead is between 500 and 1,000 ppm, site-specific conditions should be considered in determining the necessity of cleanup. In order to be conservative with respect to soil lead on residential property, this report uses the lower limit of the EPA range, 500 ppm, in all references to the Federal guidelines for soil lead.

INCIDENCE OF LEAD-BASED PAINT BY ARCHITECTURAL COMPONENT

The national survey also includes data on the incidence of lead-based paint by each architectural component, both interior and exterior. This information is shown in Tables 3-12 and 3-13. It should be noted that the number of housing units shown in the right-hand columns of these tables report the incidence of lead-based paint on the particular component, without reference to whether lead-based paint is found on other components within the same housing unit. Lead-based paint is found more often on windows than on any other component, either inside or outside the housing unit. Overall, 27.7 million occupied homes have lead-based paint on windows, inside or outside. However, only about 600,000 have lead-based paint only on the windows.

By contrast, in many housing units lead-based paint is found on the trim, and only on the trim. Some 12.3 million homes fall in this category. "Trim" includes the separate categories of windows, doors, stairs, and baseboards in Tables 3-12 and 3-13.

AREA OF SURFACES COVERED BY LEAD-BASED PAINT

Tables 3-12 and 3-13 also report the extent of the surface areas covered with lead-based paint, for interior and exterior surfaces, respectively. Painted surfaces were quantified in the national survey in a number of different ways, depending on the component. These different methods were developed to minimize respondent burden by holding down the amount of time spent in respondents' homes. The methodology is described in detail in Appendix A.

TABLE 3-12
LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES
BY PAINTED COMPONENT FOR PRIVATELY OWNED OCCUPIED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Component	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint on component)	Amount LBP Per Housing Unit With LBP (square feet)	Number of Housing Units with LBP on Component (000s)
Walls & Ceiling	10,927	6%	280	10,481
Other (1)	3,274	51%	84	4,502
Closet	338	9%	9	3,073
Cabinets	161	9%	4	3,410
Shelves	28	3%	1	485
Fireplace	21	3%	1	260
Metal				
Radiators	861	60%	22	9,249
Air/heat vents	104	33%	3	11,774
Window systems	93	31%	2	1,775
Door trim	19	22%	0	1,217
Window trim/sill	19	34%	0	3,864
Nonmetal				
Door systems	2,494	16%	64	9,897
Window systems/trim/sills	1,879	35%	48	13,806
Crown molding	751	36%	19	3,953
Door trim	736	23%	19	11,468
Baseboard trim	553	19%	14	8,798
Stair trim	351	63%	9	1,795
Total	22,609	9%	580	NA

(1) Other components include roof beams, pipes, window grates, partitions, hampers, fuel tanks, etc.

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE 3-13
LEAD-BASED PAINT (LBP) ON EXTERIOR SURFACES BY PAINTED COMPONENT FOR PRIVATELY OWNED OCCUPIED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Component	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint on component)	Amount LBP Per Housing Unit With LBP (square feet)	Number of Housing Units with LBP on Component (000s)
Wall	31,939	41%	680	12,733
Porch	666	21%	14	2,893
Other (1)	152	13%	3	3,904
Balcony	27	5%	1	284
Stairs	22	2%	0	1.093
Metal				
Columns	286	58%	6	1,248
Soffit and fascia	276	16%	6	1,834
Door systems	224	15%	5	1,305
Railings	192	35%	4	2,844
Window trim/sill	57	29%	1	1,314
Door trim	23	19%	0	492
Non-Metal				
Soffit and fascia	3,861	31%	82	14,121
Door systems	2,138	49%	45	9,496
Columns	1,100	55%	23	3,601
Window trim/sill	1,161	61%	25	17,495
Door trim	421	39%	9	11,373
Railings	169	51%	4	2,981
Total	42,715	39%	909	NA

(1) Other components include gutters and downspouts, fire escapes, vent covers, awnings, shutters, carports, etc.

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

Interior Surface Areas

As shown in Table 3-12, there is an estimated 22.6 billion square feet of interior painted surfaces covered with lead-based paint, representing an estimated 9 percent of all interior painted surfaces in occupied dwelling units built before 1980. On average, each home with lead-based paint has an estimated 580 square feet of interior lead-based paint. Table B-8, in Appendix B, presents amounts and percentages of interior lead-based paint by the substrate material.

A small number of components and substrates account for most of the square footage of lead-based paint. Almost half of the interior lead-based paint is on walls and ceilings; however, only 6 percent of the paint on walls and ceilings is lead-based. Paint on most other components is much more likely to be lead-based than paint on walls, even though the surface areas are far less. Nonmetal crown molding is a typical example; it has only 751 million square feet of lead-based paint, but 36 percent of the paint is lead-based.

Table 3-14 presents amounts and percentages of interior lead-based paint by dwelling unit age. By almost any measure, lead-based paint appears much more often in older homes than in newer homes. About two-thirds of the lead-based paint is in pre-1940 homes. The near-equality in the number of dwelling units with lead-based paint in each age category is due to the larger number of homes built after World War II; Table 3-2 shows that the rate of occurrence has declined over the years.

Tables B-1 and B-2 in Appendix B present data on the amounts of interior lead-based paint--nationally and per home averages--by condition of the paint and other selected characteristics. Sixty-six percent of the lead-based paint is in dwelling units built before 1940; but only 11 percent is in dwelling units built in 1960-1979. Most of the paint (88 percent, overall) is intact, regardless of the age of the dwelling units. Finally, about 3 percent of the lead-based paint is under wallpaper.[11]

[11]XRF measurements were made on wallpaper for two reasons. Wallpaper is often applied over paint which may contain lead; and wallpaper is relatively easy to damage so as to expose the substrate.

TABLE 3-14
LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES
BY YEAR CONSTRUCTED FOR PRIVATELY OWNED OCCUPIED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Construction Year	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint on component)	Amount LBP Per Housing Unit With LBP (square feet)	Number of Housing Units With LBP (000s)
1960-1979	2,509	2%	157	14,768
1940-1959	5,097	8%	463	12,058
Before 1940	15,003	21%	1,250	12,575
Total pre-1980 housing	22,609	9%	580	39,401

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE 3-15
LEAD-BASED PAINT (LBP) ON EXTERIOR SURFACES
BY YEAR CONSTRUCTED FOR PRIVATELY OWNED OCCUPIED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Construction Year	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint on component)	Amount LBP Per Housing Unit With LBP (square feet)	Number of Housing Units With LBP (000s)
1960-1979	7,811	18%	521	15,058
1940-1959	12,762	43%	851	15,474
Before 1940	22,143	61%	1,384	16,096
Total pre-1980 housing	42,715	39%	909	46,628

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

Exterior Surface Areas

Tables 3-13 and 3-15 present amounts and percentages of exterior lead-based paint by the component painted and by the dwelling unit age, respectively. Tables B-3, B-4, and B-9, in Appendix B, present data on the amounts of exterior lead-based paint--nationally and per home averages--by condition of the paint, substrate, and other selected characteristics.

There are nearly 43 billion square feet of lead-based paint on exterior surfaces; about 900 square feet per dwelling unit. This represents 39 percent of all exterior paint on dwelling units built before 1980. As with interior paint, lead-based paint is more common in older homes. However, a comparison of Tables 3-14 and 3-15 show that there is more lead-based paint on the exteriors of newer homes than the interiors.

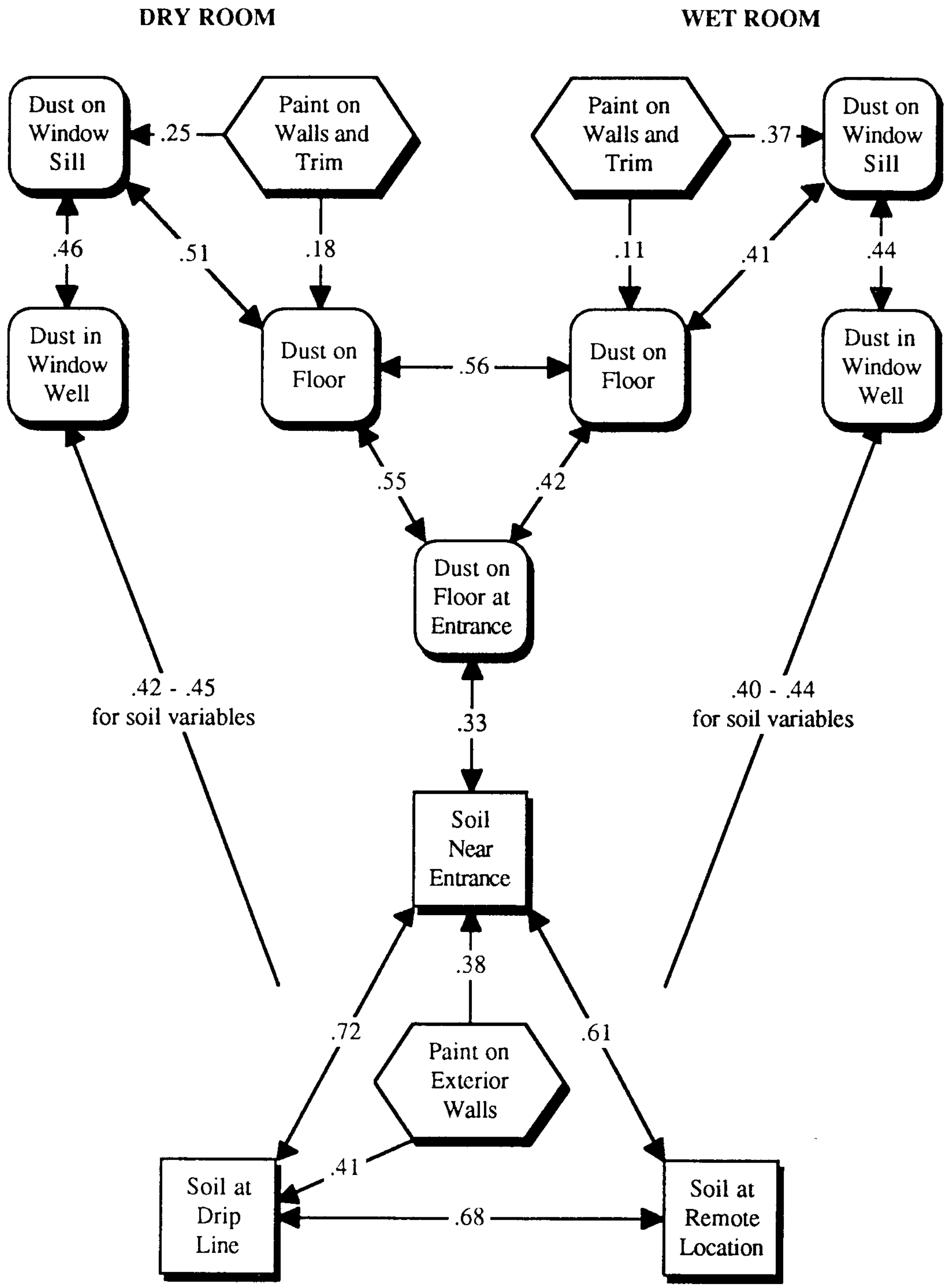
PATHWAYS

Of great concern to researchers are the pathways by which lead may be transported from lead-based paint to dust which may eventually be inadvertently ingested, particularly by young children. It may be hypothesized that exterior lead-based paint deteriorates, contaminates the soil, and finds its way into the dwelling in the form of dust. Further, it is hypothesized that interior lead-based paint contributes in various ways to surface dust. The analyses of the survey data support these hypotheses.

Figure 3-1 shows hypothesized major pathways of lead from paint to dust. Some pathways are depicted as being possibly two-way. For example, dust is shown to move back and forth between the floor at the entrance to the dwelling and the soil near the entrance. Other pathways are depicted as being one-way. For example, a pathway is shown from paint on the walls to dust on the floor, but not in the reverse direction. While it is possible that dust on the floor can be disturbed and subsequently adhere to the wall, the amount of such dust is expected to be negligible. Thus this particular pathway is depicted as being one-way.

FIGURE 3-1

MAJOR HYPOTHESIZED PATHWAYS OF LEAD FROM PAINT TO DUST, AND CORRELATION COEFFICIENTS BETWEEN THE NATURAL LOGARITHMS OF SURVEY MEASUREMENTS OF LEAD FOR EACH PATHWAY



The statistics shown in Figure 3-1 are the correlation coefficients between the natural logarithms[12] of the pairs of survey measurements of lead associated with the pathways. Paint measurements were based on XRF readings. When multiple readings were taken in a given location, a weighted (by area) average was first computed. Dust measurements were calculated by dividing the total weight of lead in the dust sample by the surface area vacuumed. Soil lead was measured in parts per million by weight.

Interpretation of Correlation Results

All of the correlations shown in Figure 3-1 are positive. All are statistically significant at the .05 level, and most are significant at the .001 level. This means that we must rule out chance in attempting to explain these associations. A full correlation matrix for all 13 variables depicted in Figure 3-1 is given in Table B-12 in Appendix B. The 78 correlation coefficients in this matrix are all positive, all but one are statistically significant at the .05 level, and most are significant at the .001 level. This implies that if high levels of lead are found at one location, they tend to be high everywhere.

Significant correlations do not in themselves imply cause and effect. However, in this case paint lead can be safely ruled out as being an effect of dust lead. And it is difficult to imagine a third factor that causes lead in both paint and dust. Thus, the most reasonable conclusion is that paint is one of the sources of lead in dust. This conclusion is supported by the regression results that follow.

Regressions of Dust Variables on Paint Variables

Regression analyses were run using the 13 variables depicted in Figure 3-1. The objective was to see how well dust could be explained as a function of lead in paint. The seven dust variables and three soil variables were each treated as dependent variables, while the three paint variables were treated as independent variables. Three additional independent variables were used which represented the percentage of paint that was damaged in the dry room, in the wet room, and on the exterior walls.

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[12] The distribution of the measurements of lead are skewed to the right. The logarithmic transformation helps normalize the distribution and reduces the influence that a few large observations might have on our analysis.

Table 3-16 shows the results of 10 regressions. The data in each column represent the results of a single regression. Table entries in each cell of the table are (1) the estimated regression coefficient and (2) the probability of obtaining such a large coefficient under the null hypotheses that the true coefficient is zero. When this probability is sufficiently small, chance is ruled out as an explanation and the true regression coefficient is regarded as being greater than zero. For example, in the regression of the lead in the dust from the floor of the dry room shown in the first column of Table 3-17, the estimated regression coefficient for paint lead on the walls and trim of the dry room is .14 with an associated probability of .030. Thus, under the null hypothesis, the chance probability of obtaining a coefficient as large as .14 is about one in 33. Boxes have been drawn around results that are statistically significant at the conventional .05 level.

The numbers of observations that were used in the regressions are shown in the first line below the matrix of regression coefficients in Table 3-16. Only observations with nonmissing data for all variables in the model are used. Thus the number of observations used in a given regression is typically less than the number of observations that can be used to compute a pairwise correlation between the dependent and a given independent variable. The second line below the table gives the values of R-squared. This value represents the fraction of the variance in the dependent variable that was explained by the independent variables.

Paint variables are significant predictors of lead in dust and soil in all 10 regressions. This further supports the earlier evidence in Tables 3-8 and 3-11 that lead-based paint is an important contributor to lead in dust and soil. Like simple correlations, significant regression coefficients do not in themselves imply cause and effect. But as discussed for correlations, it is safe to rule out causation of lead from dust to paint. And there is no apparent third factor that causes lead in both dust and paint simultaneously. Thus, it is safe to conclude that lead-based paint is one of the causes of lead in dust.

Exterior paint variables help explain interior dust lead levels in regressions 1-5 and 7 after having adjusted for the linear effects of the interior paint variables. Conversely, interior paint variables help explain lead in the soil in regressions 8-10 after having adjusted for the linear effects of exterior paint variables. This is strong evidence that lead from exterior paint travels inside the house and that lead from interior paint finds its way to the soil outside the house.

TABLE 3-16
RESULTS OF REGRESSIONS OF DUST AND SOIL LEAD AS A FUNCTION OF PAINT VARIABLES

DEPENDENT VARIABLES

	Dust Lead							Soil Lead		
	Dry Room			Wet Room			Entrance	Exterior		
INDEPENDENT VAR	floor (1)	window sill (2)	window well (3)	floor (4)	window sill (5)	window well (6)	floor (7)	drip line (8)	near entrance (9)	remote location (10)
Paint lead on walls and trim of dry room	.14	.33	-.01	.17	.00	.17	.03	.01	.01	.04
	.030	.004	.525	.016	.487	.258	.339	.410	.411	.233
Paint damage (%) in dry room	.03	.03	.24	.02	-.09	.41	.08	-.01	-.02	-.01
	.220	.340	.330	.314	.918	.084	.026	.623	.732	.636
Paint lead on walls and trim of wet room	.05	-.01	.51	-.01	.47	.52	.08	.25	.14	.14
	.253	.527	.016	.535	.000	.026	.121	.000	.006	.006
Paint damage (%) in wet room	.05	.04	-.01	.09	.10	-.14	.01	.01	.03	.02
	.014	.123	.556	.000	.001	.959	.376	.227	.044	.165
Paint lead on exterior walls	.09	.18	.38	.11	.04	-.05	.16	.27	.23	.22
	.057	.015	.010	.028	.356	.613	.002	.000	.000	.000
Paint damage (%) on exterior walls	.04	.03	.06	.02	.05	.04	.03	.02	.02	.03
	.008	.106	.237	.079	.026	.260	.021	.033	.039	.005
No. of Observations	243	192	66	250	127	55	249	229	239	235
R-squared	.11	.11	.25	.14	.26	.24	.11	.30	.23	.22

Note: In each set of table entries, the top number is the regression coefficient and the bottom number is the probability of obtaining a coefficient as large as the one observed if the true regression coefficient is zero. Boxes indicate results that are statistically significant at the .05 level.

TABLE 3-17
RESULTS OF REGRESSIONS OF DUST AND SOIL LEAD AS A FUNCTION OF PAINT VARIABLES AND AGE VARIABLES

INDEPENDENT VARIABLES	DEPENDENT VARIABLES: Dust Lead							Soil Lead		
	Dry Room			Wet Room			Entrance	Exterior		
	floor (1)	window sill (2)	window well (3)	floor (4)	window sill (5)	window well (6)	floor (7)	drip line (8)	near entrance (9)	remote location (10)
Paint lead on walls and trim of dry room	.13 .043	.32 .005	.06 .390	.16 .022	.01 .475	.13 .291	.02 .418	-.02 .637	-.01 .575	.02 .360
Paint damage (%) in dry room	.03 .279	.01 .430	.20 .345	.01 .365	-.09 .900	.39 .080	.07 .042	-.03 .859	-.04 .897	-.03 .822
Paint lead on walls and trim of wet room	.02 .390	-.04 .617	.26 .128	-.03 .651	.47 .001	.20 .213	.04 .288	.17 .001	.07 .078	.08 .054
Paint damage (%) in wet room	.05 .025	.03 .171	-.02 .627	.08 .000	.11 .001	-.20 .994	.00 .519	.00 .535	.02 .163	.00 .420
Paint lead on exterior walls	.06 .160	.14 .060	.22 .085	.08 .090	.05 .314	-.14 .789	.12 .016	.16 .000	.14 .000	.15 .000
Paint damage (%) on exterior walls	.04 .020	.03 .125	.05 .234	.02 .131	.05 .024	.06 .130	.03 .055	.01 .247	.01 .219	.02 .043
Age of dwelling is 31 to 50 years	.20 .240	.29 .245	.14 .427	.21 .227	-.31 .720	.47 .294	.18 .248	.79 .000	.57 .002	.44 .009
Age of dwelling is more than 50 years	.58 .032	.66 .096	2.63 .002	.51 .054	-.14 .585	3.23 .001	.88 .002	1.80 .000	1.51 .000	1.34 .000
No. of Observations	243	192	66	250	127	55	249	229	239	235
R-squared	.13	.12	.38	.14	.26	.40	.14	.43	.35	.35

Note: In each set of table entries, the top number is the regression coefficient and the bottom number is the probability of obtaining a coefficient as large as the one observed if the true regression coefficient is zero. Boxes indicate results that are statistically significant at the .05 level.

In none of the regressions presented are dust/soil variables included as independent (predictor) variables. Since dust lead and soil lead both have paint lead as a source, their inclusion as independent variables in a regression analysis would only serve to obscure the relationship between the paint variables and the dependent (dust/soil) variable.

Table 3-17 is similar to Table 3-16 except that two age variables have been added which are indicators of the age of the dwelling. The age variables help explain lead levels in most of the regressions. The older the dwelling, the higher the estimated lead levels. This can be seen by examining the magnitudes of the estimated regression coefficients for the age variables. In every regression, the estimated coefficient of the age > 50 indicator is greater than the estimated coefficient for the age 31-50 indicator.

One explanation for the statistical significance of the age variables is that they are merely proxies for lead-based paint. The older the home, the more likely that it contains lead-based paint, and the heavier the concentration of lead. Thus age is a predictor of paint lead. Since the measurements of lead in paint are imperfect, the age variables may, in part, represent paint lead that our paint measurements fail to capture. If this is the case, then the results of the regressions with the age variables are conservative with regard to the impact of lead-based paint, and the regressions shown in Table 3-17 are more meaningful.

Another explanation for the significance of the age variables is that they measure other sources of lead, such as auto emissions. Deposits of lead from such emissions could accumulate over time and be correlated with the age of the dwelling. The age variables are particularly useful for predicting the levels of lead in soil and the levels of lead in the dust from window wells. This may be because these areas are more often exposed to the outside air and hence auto emissions. Or it may be because lead accumulates over time in soil and window wells to a greater extent than it accumulates over time in dust on the interior floors and window sills, where it may be periodically removed by cleaning. In any event, the paint variables are more often significant in the regressions in which age is excluded.

These results establish lead-based paint as an important source of lead in the dust and soil of residential dwellings. However, it is difficult to estimate the percentage of lead in dust and soil that can be attributed to lead-based paint. Referring to the values of R-squared in the regression equations, about 20 percent to 25 percent of the variation in dust and soil lead is explained by paint variables. However, these estimates may be deceptively low because of the limitations inherent in field measurements and the fact that the statistical models do not perfectly reflect reality.

CONCLUSIONS

The national survey findings tend to confirm prior research with respect to the occurrence rate of dwelling units with lead-based paint.

- About three-fourths of the occupied housing units built before 1980 have lead-based paint, and about 70 percent of the housing units occupied by families with children under the age of 7.
- Housing built before World War II is more likely to have lead-based paint, and likely to have a higher concentration of lead within the paint, than postwar housing units.
- There is strong statistical evidence that lead-based paint is an important contributor to lead in dust. Homes with lead-based paint inside or outside are about five times as likely as homes without any lead-based paint to have high dust lead levels. Only 4 percent of dwelling units without any lead-based paint have high dust lead levels.

But the national survey goes beyond the prior research to provide much more detailed information on the lead-based paint, information which suggests that the problem of lead-based paint may have somewhat different dimensions than commonly believed.

- Lead-based paint is found as often in the homes of the well-to-do as the poor, although lead poisoning and elevated blood lead levels are more common among the poor.
- Lead-based paint is more commonly found on the exterior of a unit than on the interior.
- Lead dust is found much more frequently around the windows than the floors, and it appears that the window dust comes from both the exterior and interior paint, as well as perhaps other environmental sources besides paint.
- There is also strong statistical evidence that exterior lead-based paint, especially defective paint, is an important source of lead in soil; and lead in the soil, as well as interior lead-based paint, is a source of interior dust lead on the floors.

Nonintact paint and excessive dust lead are the primary lead-based paint hazards, according to the public health literature, particularly for young children. The survey finds that about 3.8 million housing units have either of these hazards and are occupied by families with children under the age of 7.

On average, there are 580 square feet of interior lead-based paint and 909 square feet of exterior lead-based paint in the 57 million homes with lead-based paint. The lead-based paint appears most often on windows (both interior and exterior), soffit and fascia, and exterior walls. Some 12 million housing units have lead-based paint only on the trim around windows, doors, stairs, or baseboards. In the aggregate, an estimated 22.6 billion square feet of interior surfaces, and 42.7 billion square feet of exterior surfaces, is covered with lead-based paint. This represents 9 percent of all the total area of painted interior surfaces, and 39 percent of the total areas of painted exterior surfaces, on pre-1980 dwelling units.

CHAPTER 4

THE COST OF LEAD-BASED PAINT TESTING AND ABATEMENT

This chapter reports the results of research projects on the cost and technology of both testing and abatement, in response to the 1987 amendments to the Lead-Based Paint Poisoning Prevention Act. The Department sponsored research on testing at the National Institute of Standards and Technology (NIST), in order to determine the accuracy of the available technologies. The Department has also been conducting a demonstration of abatement methods in HUD-owned (FHA) housing, to identify efficient and cost-effective methods for abatement. From this research, estimates of the cost of testing and abatement have been developed for individual housing units. It is possible to combine the cost estimates for individual units with the findings on the incidence of lead-based paint from the national survey, in order to develop estimates of the overall cost of abating lead hazards in privately owned housing.

TESTING FOR LEAD IN PAINT AND DUST

Testing is a critical first step in identifying lead hazards and deciding what action to take. The cost of testing is dependent on the desired accuracy, precision, and reliability.

Paint Testing Technology

The Housing and Community Development Act of 1987 requires HUD to report on "the most reliable technology available for detecting lead-based paint." HUD has therefore sponsored research at the National Institute of Standards and Technology (NIST) to evaluate three types of technology: chemical spot tests, portable x-ray fluorescence (XRF) analyzers, and various techniques of laboratory analysis of paint samples. The advice on testing contained in the HUD Interim Guidelines is based on the NIST findings. The NIST investigation is summarized here; additional information is provided in Appendix D.

Spot testing was considered as a potentially inexpensive technique of screening, which would simply determine whether lead is or is not present at a concentration greater than a given limit. NIST found that experienced analytical technicians could identify lead in concentrations in excess of 1.0 mg/cm^2 (the HUD regulatory limit) with a false negative rate of 10 percent. However, in the investigation of spot testing that was conducted as a part of the abatement demonstration, HUD concluded that spot testing is not yet sufficiently reliable for general use. In view of the importance of having inexpensive, reliable screening methods, HUD has asked NIST to conduct additional research on this matter.

Since its development in the 1970s, the portable XRF machine has been the preferred means of testing for lead on painted surfaces. However, since its introduction, important questions have persisted about its accuracy. After conducting laboratory and field evaluations of both the direct-reading type of XRF and the newer spectrum analyzer type, NIST concluded that neither type of XRF was accurate and precise enough to serve as a screening or measurement technique at the concentration level of 1.0 mg/cm^2 without confirmatory testing of paint samples using laboratory analysis. However, NIST did find that the spectrum analyzer XRF was significantly more precise than the direct-reading XRF. NIST found that laboratory analysis was the only reliable method of measuring lead in paints at the level of 1.0 mg/cm^2. As a result, the HUD Interim Guidelines recommend the use of laboratory testing to confirm portable XRF measurements which fall into a range of uncertainty.

Accurate testing therefore requires three factors: portable testing equipment, typically an XRF analyzer; trained inspectors to operate the XRF and interpret the results; and qualified laboratories to do supplemental testing when needed.

HUD also asked NIST to consider the safety implications of testing. NIST found no exceptional safety hazards in testing activities.

Capacity of the Testing Industry

Manufacturers of portable XRF analyzers estimate that approximately 1,000 of these devices are currently in use, and that an estimated 2,000 persons have receive training in their use for at least one full day. The Directory of Testing Laboratories published by the American Society for Testing and Materials (ASTM) lists about 350 laboratories equipped to perform standard laboratory analyses for lead concentration in paint. At the present time, there are no certification or accreditation programs or formal training courses specifically designed for personnel who measure lead in paint. Based on these data, HUD estimates that the current testing capacity is between 350,000 and 500,000 housing units annually.[1]

Lead Paint Testing Costs

To provide some information on the cost of testing for lead-based paint, four inspection firms in different metropolitan areas were surveyed. Each was asked to estimate the costs of testing two types of housing units, utilizing the HUD Interim Guidelines:

- A single-family detached home of wood construction containing three bedrooms and 2000 square feet of living space.
- An apartment in a multifamily structure containing two bedrooms and 900 square feet of living space.

It was assumed that the unit in the multifamily structure required little or no exterior testing since the building was of unpainted masonry construction, and that both units required 10 supplemental laboratory tests of paint samples to assure testing accuracy. Table 4-1 shows the results of this brief survey.

TABLE 4-1
COST ESTIMATES FOR LEAD PAINT TESTING BY FOUR INSPECTION FIRMS

Type of Unit	Inspection Firm			
	A	B	C	D
Single-Family	$385	$450	$1,000-1,500	$377
Multifamily	$285	$400	$300-800	$277

[1]If it is assumed that the 1,000 portable XRF analyzers could be used to test two units per day and would be operated 250 days per year, the maximum number of units that could be tested with XRFs would 500,000 per year. Downtime might reduce this number considerably, but testing efficiencies in multifamily structures might increase it. If the 350 laboratories could analyze an average of 40 paint samples per day and operate 250 days per year, and if an average of 10 samples was required per housing unit, laboratories could test for a maximum of 350,000 units per year. This is not necessarily a limiting factor, because not all housing units tested with XRFs would require backup laboratory analysis of paint samples.

Firms A, B, and D were reasonably close in their estimates. Firm C, a governmental agency, projected a much higher cost based upon its belief that many more supplemental laboratory tests (38 rather than 10) would have to be conducted to check a home thoroughly. The additional 28 tests would be done on substrates where the XRF cannot be used (rounded moldings, etc.). Assuming that the three private firms represent a reasonably accurate consensus of private sector estimates of the cost of conducting lead-based paint testing, estimates of average testing costs, based on the three firms, are shown in Table 4-2.

TABLE 4-2
ESTIMATED NATIONAL LEAD PAINT TESTING COSTS

Type of Unit	Percent of All pre-1980 Units	Cost/Unit
Single-Family	63.8	$404
Multifamily	36.1	$320
All Units	100.0	$374

These estimates of testing costs are based upon limited information in a relatively noncompetitive marketplace. If a firm were to test a number of units in a multifamily structure at one time, costs could come down by at least 10-20 percent per unit, but the cost of testing would still be substantial. However, given the potential market as well as substantial interest in improving the accuracy and reducing the cost of testing, there is reason to believe that more cost-effective equipment or methods will be developed in the coming years.

ALTERNATIVE METHODS OF ABATEMENT

Two basic approaches to abating lead-based paint hazards at the housing unit level are available: removal of lead-based paint from the dwelling unit, and making lead-based paint inaccessible (enclosure or encapsulation).

The two basic approaches differ in terms of what is believed to be their efficacy, both short run and long run, and their cost. These tradeoffs can best be understood by describing each approach in more detail.

Removal

The removal of all lead-based paint from a dwelling unit can be accomplished either by stripping all lead-based painted surfaces on-site or by removing lead-based painted building components and replacing them, either with new components or with the same components after the paint has been removed offsite.

There are several methods of on-site paint stripping. These methods can be grouped according to the physical method of paint removal: abrasive removal (i.e., sanding or sand blasting), chemical removal, or removal by handscraping using a heat gun.

Abrasive removal methods require the concurrent use of high-efficiency particle accumulator (HEPA) filtered vacuums to capture the dust generated during the process. Other removal methods only use HEPAs during cleanup. Regardless of the method, after all the lead-based paint has been removed, the unit should be thoroughly cleaned using HEPA vacuums and a high phosphate wash until clearance standards based on dust lead concentrations are met. The hazardous components of the waste generated by abatement are then disposed of in accordance with applicable Federal, State, and local regulations. On-site removal of lead-based paint generally requires worker safeguards, including protective clothing, respirators, personal hygiene protocols, and periodic blood lead testing.

Enclosure/Encapsulation

Lead-based paint can be made inaccessible either by encapsulating it with a material that bonds to the surface, such as acrylic or epoxy coatings or flexible wall coverings, or by enclosing it using systems such as gypsum wallboard, plywood paneling, and aluminum, vinyl, or wood exterior siding.

These methods of addressing lead-based paint hazards generate less lead dust because they generally do not require breaking painted surfaces. For this reason, the worker protection requirements may, in future revisions to the HUD Interim Guidelines, become less stringent for enclosure and encapsulation, particularly with respect to the need for protective clothing, respirators, and area containment. These methods also avoid the need for, and costs of, hazardous waste disposal. In addition, the costs of encapsulation, although not of enclosure, appear to be significantly lower than the costs of all methods of lead-based paint removal. This is true even if any cost savings from less stringent worker protection are not considered. Post-abatement cleanup of dwelling units is also likely to be less costly when low-dust-generating methods, such as encapsulation and enclosure, are employed.

The limitation of methods such as enclosure and encapsulation pertains to their long-term effectiveness. When lead-based paint is made inaccessible by encapsulation or enclosure, the hazard is deferred, not eliminated. The length of time for which the hazard is deferred will depend upon the durability of the encapsulants and enclosure materials and by the subsequent maintenance practices of the property owner. There is little or no empirical evidence currently available on how long encapsulation/enclosure methods will be effective in containing hazards from lead-based paint.

THE LEAD-BASED PAINT ABATEMENT DEMONSTRATION

The principal source of data on the cost of lead-based paint abatement is the FHA component of the lead-based paint abatement demonstration undertaken by HUD in 1989-1990.

Methodology

The demonstration was conducted in seven metropolitan areas: Baltimore, Birmingham, Denver, Indianapolis, Seattle, Tacoma, and Washington, D.C. The properties used in the demonstration were vacant, single-family dwelling units which were owned by FHA as a result of foreclosure action. Initially over 300 units were tested for the presence of lead hazards using portable XRF analyzers. Based on the results of these tests, 173 properties were selected for inclusion in the demonstration. After further testing, including laboratory analysis of paint samples, bid documents were prepared and bids were solicited from local contractors.

The demonstration was designed, among other things, to provide reliable information on the comparative costs of lead hazard abatement using different methods of abatement. Accordingly, each of the units was assigned to one of six possible abatement strategies: encapsulation, enclosure, chemical removal, abrasive removal, removal by handscraping using a heat gun, and component replacement. Each of the six unit abatement strategies prescribed the preferred method to be used on each building component, together with rules for substitution of methods if the preferred method proved infeasible. The specifications of abatement methods to be used were then incorporated in the bid documents. If the first choice of abatement method was not feasible, the rules indicated the second choice of method. If the second choice was not feasible, the rules indicated the third choice of method. These rules, or preference orderings, were as in Table 4-3:

TABLE 4-3
PREFERENCE ORDERING OF THE SIX ABATEMENT STRATEGIES

Preference Ordering	Encapsulate	Enclosure	Chemical	Abrasive	Hand-scraping	Replacement
1st choice	Encapsulate	Enclose	Chemical	Abrasive	Hand-scraping	Replacement
2nd choice	Enclose	Encapsulate	Abrasive	Chemical	Replace	Handscraping
3rd choice	Chemical	Chemical	Enclose	Enclose	Chemical	Chemical

During the course of abatement activity, multiple daily observations were made on the activities of each worker on site (e.g., Worker A: chemical stripping baseboard in Bedroom 1). In addition, information was obtained from each contractor on labor rates and on the quantities of materials by type which had been expended on abating each unit. The resulting database supports estimates of the cost of lead-based paint abatement on each component type by each method of abatement tested in the demonstration.

Abatement activities in the demonstration were undertaken in accordance with the preliminary guidelines proposed by the National Institute of Building Sciences under contract to HUD. These guidelines are quite similar to the "HUD Interim Guidelines" published in the Federal Register.[2] The guidelines incorporated stringent worker protection and environmental protection standards for all methods of abatement. These included installation of polyethylene sheeting to contain dust within the unit during abatement, the use of disposable protective clothing and respirators during abatement and testing, and disposal of hazardous waste in accordance with applicable Federal,

[2]U.S. Department of Housing and Urban Development (1990), "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing," *Federal Register 55* (April 18): 14557-14789.

State, and local laws and ordinances. Additional information on the demonstration can be found in Appendixes C and E. It should be noted that these measures to protect workers, occupants, and the environment are much more elaborate than have been used in traditional abatement programs. Furthermore, lead-based paint abatement, as the term is used in this report, involves the removal or covering of all surfaces, interior and exterior, that are painted with lead-based paint, as required by Section 566 of the Housing and Community Development Act of 1987, not just accessible, chewable, or defective paint surfaces, as has often been common practice. Therefore, abatement cost estimates reported in this chapter may not be comparable with the costs experienced in many local programs, or in public housing prior to 1990.

THE COST OF ABATEMENT FOR INDIVIDUAL HOUSING UNITS

The costs of abating lead hazards in a housing unit will vary according to the quantities and types of building components to be abated and the method of abatement employed. The average square footage of surface area requiring abatement (having lead levels greater than 1.0 mg/cm^2) for all units with lead-based paint is shown in Table 4-4. Separate estimates are provided for units with only interior lead-based paint, only exterior lead-based paint, and both interior and exterior lead-based paint. These estimates can be combined with per square foot cost estimates to arrive at estimates of the cost of lead-based abatement at the dwelling unit level.

The FHA component of the demonstration was designed to support estimates of the per square foot cost of lead-based paint abatement on different building components using different methods of abatement. As noted earlier, six different methods of abatement were tested, of which two (encapsulation and enclosure) make the lead hazards inaccessible and four (chemical stripping, abrasive removal, hand-scraping and component replacement) permanently remove the lead hazards from the dwelling unit. In the design of the demonstration, rules for the application of these methods were prescribed by the previously discussed abatement strategies, and in the course of the demonstration, information on the cost of abatement by each strategy was obtained. As a result of the demonstration, cost-effective strategies for both types of abatement were determined and the cost of abatement were estimated.

Comparing the two strategies designed to make lead hazards inaccessible, encapsulation is preferable. For every type of building component which was abated using either encapsulation or

TABLE 4-4

AVERAGE SURFACE AREA WITH LEAD LEVELS $\geq$ 1.0 mg/cm^2 BY SELECTED BUILDING COMPONENT AND LOCATION OF LEAD-BASED PAINT (LBP)

Building Component	Units with Exterior LBP only (sq. feet)	Units with Interior LBP only (sq. feet)	Units with both Exterior and Interior LBP (sq. feet)
Interior			
Walls		194.9	218.3
Ceilings		145.5	160.0
Door systems		25.9	79.3
Door trim		4.9	25.2
Window systems		6.4	32.6
Window trim		3.3	27.7
Baseboards		4.2	18.8
Exterior			
Walls	507.0		818.7
Soffit/Fascia	85.4		137.5
Door systems	35.6		62.0
Porch	9.8		20.0
Percentage of All Units with Lead-based Paint	31.4%	18.6%	50.0%

enclosure methods, encapsulation proved to be less expensive. Because there is no existing evidence to suggest that enclosure methods are more durable than encapsulation methods, the cost estimates for the encapsulation/enclosure approach are all based on the assumption that encapsulation is used for all building component types.

Among the removal strategies, different strategies proved to be cost-effective for different building components. Per square foot estimates of the cost of removing lead hazards were developed for each of the four removal methods and they have been compared to determine which methods are most cost-effective for each type of building component. The results of this analysis are presented in Table 4-5 where the assumptions on the abatement methods used for both the encapsulation and removal approaches are presented.

TABLE 4-5
ABATEMENT METHOD ASSUMPTIONS USED IN DEVELOPING ABATEMENT COST ESTIMATES AT THE DWELLING UNIT LEVEL BY SELECTED BUILDING COMPONENTS

Abatement and Approach		
Building Components	**Encapsulation**	**Removal**
Interior		
Walls	Encapsulate	Hand-scrape
Ceilings	Encapsulate	Hand-scrape
Door systems	Encapsulate	Hand-scrape
Door trim	Encapsulate	Replace
Window systems	Encapsulate	Hand-scrape
Window trim	Encapsulate	Replace
Baseboards	Encapsulate	Replace
Exterior		
Walls	Encapsulate	Chemical
Soffit/Fascia	Encapsulate	Hand-scrape
Door systems	Encapsulate	Hand-scrape
Porch	Encapsulate	Chemical

Removal of lead hazards by handscraping, using a heat gun, appears to be the most cost-effective method for interior walls, ceilings, doors and windows. Chemical stripping is the least expensive method for exterior walls which have the largest surface areas. Replacement of building components was the least expensive for door and window trim and for baseboards. Abrasive methods of paint removal were generally not very successful in the demonstration and have not been used in the development of cost estimates.

The estimated average costs of lead-based paint abatement per dwelling unit are presented in Table 4-6 for both the enclosure and removal strategies. Encapsulation is generally less expensive than paint removal, though the average difference for units with interior paint only is quite small. For all units with any lead-based paint, encapsulation is approximately 30% less expensive than removal.

The mean abatement cost estimated from the demonstration, for either encapsulation or removal, is substantially above the costs reported in various local abatement programs and activities. The average cost in these programs is often reported at around $2,100.[3]

However, there is considerable variation in estimated costs around the mean values reported in Table 4-6, and the median cost is much lower than the mean. In Table 4-7, the frequency distributions of abatement costs for both the encapsulation and removal strategies are presented. Over half of all units with lead-based paint present would cost less than $2500 to abate with either the encapsulation or removal strategies. Approximately two-thirds of all units with lead-based paint present would cost less than $5000 to abate. Thus the typical household would incur costs of less than $2,500 to abate the lead-based paint in its house or apartment. A minority, however, would incur very substantial costs. Less than 20 percent would incur costs of $10,000 or more under the encapsulation strategy, and less than 30 percent under the removal strategy; but these high costs are sufficient to raise the mean cost to double or triple the median. Units with priority hazards are found disproportionately among the units with high abatement costs, because they have a greater than average number of surfaces with lead-based paint. The mean abatement cost for units with priority hazards is $8,870 for encapsulation, and $11,870 for removal. As shown in Table 4-8, among the units with priority hazards, almost 30 percent would incur costs in excess of $10,000 for encapsulation while almost 50 percent would cost more than $10,000 under a removal strategy (15 percent would cost $25,000 or more).

TABLE 4-6
ESTIMATED AVERAGE COSTS OF ABATEMENT PER DWELLING UNIT BY LOCATION OF PAINT AND ABATEMENT STRATEGY
(Standard Errors in Parentheses)

Abatement Strategy	Units with Exterior LBP Only	Units with Interior LBP Only	Units with both Exterior and Interior LBP	All Units with LBP
Encapsulation	$2,841	$1,798	$8,447	$5,453
Removal	$4,791	$1.808	$11.720	$7,704

[3]The average of $2,100 was provided by the Centers for Disease Control, based on abatement costs reported by New York City, St. Louis, and Boston, and is in 1989 dollars.

TABLE 4-7
PERCENTAGE DISTRIBUTION OF ALL HOUSING UNITS WITH LEAD-BASED PAINT BY ESTIMATED ABATEMENT COST AND BY ABATEMENT STRATEGY

Cost Range	Encapsulation	Removal
$0 - $2,499	54.4%	54.7%
$2,500 - $4,999	13.3%	11.8%
$5,000 - $9,999	13.9%	5.6%
$10,000 - $14,999	8.2%	8.9%
$15,000 - $19,999	3.5%	8.4%
$20,000 - $24,999	1.9%	1.4%
$25,000 and over	4.7%	9.2%

TABLE 4-8
PERCENTAGE DISTRIBUTION OF HOUSING UNITS WITH LEAD-BASED PAINT AND PEELING PAINT OR LEAD DUST BY ABATEMENT COST AND ABATEMENT STRATEGY

Abatement Cost	Encapsulation	Removal
< $2,500	24.0%	26.3%
$2,500 - $4,999	23.1%	20.3%
$5,000 - $9,999	23.7%	6.1%
$10,000 - $14,999	12.9%	17.6%
$15,000 - $19,999	5.2%	14.3%
$20,000 - $24,999	1.8%	0.5%
$25,000 or more	9.2%	15.0%
Total	100.0%	100.0%

Encapsulation methods, which are designed to make lead-based paint hazards inaccessible, will not last forever. A more realistic comparison of the cost of these alternatives can be made by comparing the one-time cost of removal methods with the present value of the cost of encapsulation, that is to say, with the discounted stream of encapsulation costs incurred each time encapsulants reach the end of their useful life. The effective life of encapsulation is unknown at present, so it is not possible to determine which method is less costly when the need to reencapsulate is taken into account. It is, however, possible to calculate the break-even useful life of encapsulation, given the one-time cost estimates presented in Table 4-6.

The estimated mean one-time cost of encapsulation for units with lead present is $5,453 and the estimated cost of removal $7,704. The break-even useful life for encapsulants, using a 4 percent discount rate, is 31.4 years. If an 8 percent discount rate is employed, the break-even useful life would be 16.0 years. If the actual useful life of encapsulants exceeds the break-even, encapsulation would be the less expensive method of abatement.

Limitations of the Cost Estimates

One important limitation of the demonstration in representing real-world costs is that the abatements were conducted in vacant houses and therefore did not require the relocation of occupants or the protection of upholstered furniture and other personal property from lead dust contamination. Unless abatement is minor and the work can be effectively sealed off from the rest of the unit, persons occupying the unit to be abated must seek temporary quarters elsewhere. In some cases, this may not be more than an inconvenience; friends or family may be able to put them up. If such assistance is not available, people have to find accommodations in hotels or rental units that provide short-term leases. While a few cities such as Baltimore have a limited number of publicly owned and operated lead-free housing units for temporary occupancy, this is not often the case; and where such units do exist, they are likely to be reserved for families of very limited means. Although it is difficult to estimate such relocation costs, even a hotel stay of one week is likely to cost a minimum of $300-$400. Relocation costs would be further increased by restaurant, transportation, and furniture moving and storage costs. If furniture and other belongings are not moved, there would be a cost of sealing them off and working around them.

Two other factors might cause the cost estimates to be somewhat low. One is the fact that the metropolitan areas in which the demonstration was conducted are not necessarily representative of construction costs nationwide. The Means 1990 Commercial and Residential Repair and Remodeling Cost Data indicate that costs in five of the seven areas average 93 percent of the national average, while two areas have costs that are about 102 percent of the national average. Overall, the seven areas average about 96 percent of the national costs. The second factor is that the abatement demonstration did not include the refinishing of surfaces that were not abated. In an occupied home, aesthetic considerations might call for repainting whole rooms, even if only part of the rooms are abated.

It should also be noted that the abatement cost estimates presented above do not include estimates of the cost of disposing of the hazardous component of waste materials generated during abatement. The cost data on hazardous waste disposal in the FHA component of the demonstration were not available in time for this report and it appears that they may be difficult to interpret when they do become available. On two of the demonstration sites, waste was disposed of in regular landfills in accordance with the household exemption provisions of the Resource Conservation and Recovery Act (RCRA). In the remaining sites, waste testing over 5 ppm on the EP toxicity test was disposed of at hazardous waste sites. There was considerable variation between sites in packaging requirements, transportation costs and requirements for a separate waste stream analysis. For these reasons, the demonstration experience may not lend itself to generalization and hazardous waste disposal cost estimates have not been included in the abatement cost estimates presented here.

At the same time, other important considerations indicate that the demonstration costs may be higher than potential real-world costs. One such consideration is that a significant proportion of any future abatement will probably be conducted as a part of other rehabilitation work. The costs estimates reported in this chapter are based on the assumption that lead-based paint abatement is undertaken as a "stand-alone" activity, independent of any other rehabilitation activities. If lead-based paint abatement was carried out in conjunction with other planned rehabilitation work, the costs properly attributable to abatement per se would, in almost all instances, be lower than if only lead-based paint abatement was undertaken. Most major renovation work involves the removal and replacement of building components, some of which may be coated with lead-based paint. In this way, renovation directly reduces the cost of abatement by removing the need for it. Furthermore, when lead-based paint abatement and other rehabilitation activities are carried out in tandem, lead-based paint abatement absorbs a smaller percentage of the fixed costs of the job, and opportunities to further reduce costs through integration of abatement and rehabilitation tasks may also present themselves.

It is not possible with currently available data to estimate the extent to which the cost of lead-based paint abatement for privately owned housing could be reduced by performing abatement concurrently with planned rehabilitation activities. Integration of the two activities, in addition to reducing costs of abatement, would also increase the likelihood that rehabilitation of units with lead hazards would be carried out with appropriate standards of worker protection and that rehabilitated units would meet clearance standards for housedust.

Another feature of the demonstration that may have produced somewhat inflated cost estimates is the rules, or preference ordering of abatement methods, followed for each unit abatement strategy. While useful for experimental purposes, the abatement strategy rules would probably not represent the way in which abatement would be planned in a real-world setting, where it is likely that different combinations of abatement methods would be used on building components in the same unit. It is possible that mixed strategies might permit further economies to be achieved.

Still another consideration is that the worker protection measures used in the demonstration may have been overly conservative (and thus more costly than necessary) for some of the abatement methods that generate relatively low amounts of dust, such as encapsulation and chemical removal. The guidelines prepared by NIBS, which were relied on by the demonstration for worker protection protocols, were based on a consensus of expert opinion. Very little data was available to the group of experts on the amounts of dust lead generated by the various abatement methods. Therefore, the group had little choice but to adopt conservative standards to assure worker safety. Among other things, the guidelines called for the use of disposable suits and respirators by all workers for all abatement methods. Such equipment tends to reduce worker productivity, especially during hot weather. When the analysis of air monitoring measurements and other relevant data collected during the demonstration is complete, it may be possible to justify relaxation of some procedures in certain situations and thus provide the possibility of cost reduction.

Finally, there is the question as to whether the prices charged by the abatement contractors in the demonstration represent the prices that would be experienced if lead-based paint was undertaken on a large scale over a period of years. Few of the demonstration contractors had any significant experience with lead-based paint abatement and the associated uncertainty about the costs they would incur may have influenced them to bid high. In addition, the demonstration was a Federally sponsored research project with on-site observers present; this also may have induced high bids. Conversely, an interest in gaining experience and qualifications in what might become a growth sector of the construction business might have encouraged contractors to bid lower than they otherwise would have done. On balance, these factors probably mean that the demonstration prices were in the upper bounds of the prices that would be experienced in an expanded private sector abatement effort.

Balancing these considerations, it seems likely that the cost findings of the demonstration are, on average, reasonably representative of the costs that would be expected for stand-alone, lead-based paint abatement in vacant units if private abatement is conducted on an expanded scale in the future. If a substantial proportion of future abatement is conducted in conjunction with other rehabilitation activities, the average per unit cost attributable to abatement could be lower. On the other hand, such reductions in average costs might be overcome by the added costs of relocating occupants and protecting personal property from lead dust, if a large amount of the abatement is conducted in occupied units. In addition, costs could rise if the growth in demand for abatement services significantly exceeds the growth in the capacity of qualified inspectors and contractors.

IN-PLACE MANAGEMENT AND ABATEMENT OF DUST LEAD

The estimates of testing and abatement costs in the previous section are all based on the assumption that, a hazardous situation will be rectified by abatement of the lead hazards, either through encapsulation or removal. But the cost estimates for abatement by either method are substantial. Moreover, the capacity of the abatement industry is limited.[4]

This situation has led to consideration of ways to manage lead hazards in place until safe and cost-effective abatement can be accomplished. In-place management is oriented largely toward

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[4]"Limited" refers to the existence of abatement contractors whose procedures meet the protocols set forth in the HUD Interim Guidelines. This statement is based upon the experience of the HUD lead-based paint abatement demonstration of FHA units, utilizing the NIBS Guidelines. HUD's technical support contractor found a dearth of qualified bidders in the seven cities in which it operated. If one chooses to define abatement as it has been traditionally carried out, i.e. with little or no worker protection or dust containment, no observance of hazardous waste requirements, minimal cleanup, and no clearance requirements, then the use of the term "limited" to describe industry capacity is not appropriate.

maintenance of painted surfaces, cleanup of lead dust, and controlling further accumulation of lead dust. The emphasis on controlling lead dust derives from the conclusion, noted throughout this report, that lead dust appears to be the primary pathway of childhood exposure to lead, especially of low-level exposure. Because of the importance of dust, and because abatement of lead-based paint is so expensive, some experts in lead hazard reduction have begun to consider the possibility of a lower cost strategy that begins with a test for lead dust rather than lead paint and, if the lead dust is found to be excessive, follows with a series of actions designed to eliminate the hazard of dust lead, while the lead paint is allowed to remain in place.

Lead Dust Testing Costs

In considering a strategy focusing on dust, the question arises as to what such a strategy might cost. This section provides preliminary estimates of the costs, based on the experience gained during the course of the Federal Housing Administration (FHA) component of the abatement demonstration. The estimates assume that sampling is being conducted in an occupied six-room dwelling (six is the median number of rooms that have more than two occupants and therefore are most likely to be occupied by children).

The corresponding high and low estimates for taking the samples were $100 and $188 per unit. These divergent estimates yield a wide range for the cost of testing, from $340 to $1,028.

Based on the experience of the FHA component of the demonstration, one-time cleanup costs are estimated to range from $505 to $730. Cleanup costs will vary with the amount of furniture to be moved from room to room during the process.

Table 4-9 shows estimated costs of an assumed dust abatement protocol, beginning with initial sampling and testing and continuing on through periodic testing and cleanup. The cost of initial sampling and laboratory analysis, initial dust cleanup, and clearance sampling and analysis is estimated to range from $1,185 to $2,786. If a second cleanup is needed, the cost would grow to between $1,690 and $3,516.

At present the effective life of interim containment strategies such as in-place management is not known. Table 4-9 assumes that testing and cleanup are conducted at 6-month intervals; in that case, the cost would range from $3,380 to $7,032 at the end of 12 months. The cost of each subsequent testing and abating cycle, at whatever time interval is appropriate, would be between $845 and $1,758.

Clearly, a dust abatement strategy is potentially very expensive, especially if the cost of testing cannot be reduced, and if testing and abatement need to be repeated at frequent intervals. At the same time, such a strategy could prove to be inexpensive, if the costs are at the lower end of the range, or can be reduced as a result of further research, and if the dust does not reappear quickly. The wide range of cost estimates and the uncertainty about effectiveness indicate the need for further investigation of in-place management.

TABLE 4-9
ESTIMATED COST PER HOUSING UNIT OF A DUST LEAD ABATEMENT PROTOCOL

Activity	Low	High
1. Initial sampling and testing	$340	$1,028
2. Initial cleanup	505	730
3. Clearance sampling and testing	340	1,028
Subtotal w/o iterative cleanup	$1,185	$2,786
4. Iterative cleanup, if needed	505	730
Subtotal with iterative cleanup	$1,690	$3,516
5. 6-month sampling and testing	340	1,028
Subtotal w/o 6-month cleanup	$2,030	$4,544
6. 6-month cleanup	505	730
Subtotal with 6-month cleanup	$2,535	$5,274
7. 12-month sampling and testing	340	1,028
8. 12-month cleanup	505	730
Potential 1-year cost	$3,380	$7,032

THE NATIONAL COSTS OF LEAD-BASED PAINT TESTING AND ABATEMENT

It is possible to construct estimates of the overall cost of abating lead-based paint for the nation as a whole, using the average cost estimates for individual housing units developed in the demonstration and the incidence of lead-based paint in pre-1980 housing as reported by the national survey. This is a complicated process and the estimates are necessarily imprecise.

To be at all meaningful, estimates must be developed on the assumption that testing and abatement will occur over a period of time, rather than all at once. However, when abatement is conducted over time, the dimensions of the problem change. Each year, some older units drop out of the housing stock, reducing the number with lead-based paint. At the same time, other units which were originally vacant are occupied. Household composition changes as well. The number of units occupied by families with young children will change, as some families have children for the first time, and some children reach the age of seven. The specific units occupied by families with young children will also change, as families move. With regard to hazards, some units without peeling paint will develop that condition, while others will undergo repainting and nonintact paint will be repaired. A thorough cleaning may reduce dust lead loadings to below hazardous levels in some dwellings, while dust lead levels may become hazardous in others.

Estimated Annual Costs for Testing and Abatement

The estimated annual costs for testing and abatement costs have been calculated, using a model which takes into account most of these changes in the housing stock and the population on a probabilistic basis. (No adjustment was made for changes in paint condition, because the additional size of the statistical model needed was not justified by the increased accuracy of the result. Also, no data were available to permit adjustments for changes in dust lead condition.) For illustrative purposes, a 10-year period is assumed, during which all relevant units are tested and abated. The results of this exercise are presented in Table 4-10. Annual overall costs are shown for all units with lead-based paint, and for all units with the priority hazards of non-intact paint or excessive lead in the dust. In addition, costs are shown for the same categories of units occupied by families with young children, because of the greater risk of harm faced by these children. It should be noted that the analysis ignores the current limited capacity of the testing industry, discussed earlier in this chapter. A more "realistic" approach would be to assume that the volume of activity grows from year to year during the decade, starting from a small base.

TABLE 4-10
ESTIMATED ANNUAL NUMBER OF UNITS TO BE TESTED AND ABATED AND ESTIMATED ANNUAL COSTS OF TESTING AND ABATEMENT
(For a 10-year period)

Lead Hazard Criterion for Abatement	No. of Units to be Tested (millions)	No. of Units to be Abated (millions)	Annual Testing Cost ($ billions)	Annual Abatement Cost ($ billions)		Total Annual Cost ($ billions)	
				Encapsulation	Removal	Encapsulation	Removal
Lead in paint	82.3	60.8	$3.1	$33.2	$46.8	$36.3	$49.9
Lead in paint and either lead dust or paint nonintact	82.3	21.2	$3.1	$18.8	$25.2	$21.9	$28.3
Lead in paint and child present	30.5	21.7	$1.1	$11.8	$16.7	$12.9	$17.8
Lead in paint and either lead dust or paint nonintact and child present	27.2	7.5	$1.0	$6.6	$8.9	$7.6	$9.9

The annual costs show a wide range. The cost of testing all older housing units and abating all of the units with lead-based paint is $36 billion for encapsulation, and $50 billion for removal. The cost is much less for units with priority hazards ($22 to $28 billion), even though the cost of testing is slightly larger, because of the need to test separately for lead dust. (The analysis uses the low end of the range of cost estimates for sampling and testing dust.) The cost of testing and abating all units occupied by families with young children is in the same range. Finally, the annual cost for units with priority hazards occupied by families with young children is $8 to $10 billion.

Table 4-11 further disaggregates the annual cost for units in this last category, by income and tenure. The costs fall mainly upon upper-income homeowners and lower-income renters; each would incur expenditures of about $3 billion per year over the period. The model also calculates the number of units still having lead-based paint at the end of the 10 years. Even if all units occupied by families with children during the decade are abated, some 35 million units, approximately 60 percent of the original number of units with lead-based paint, will remain in the housing stock at the end of 10 years, and could be occupied by families with children subsequently. Similarly, abating all units with priority hazards occupied by families with children will still leave about 13 million units with priority hazards, or 65 percent of the original number of 20 million.

TABLE 4-11
ESTIMATED ANNUAL TESTING AND ABATEMENT COSTS BY INCOME GROUP, TENURE AND ABATEMENT STRATEGY FOR ALL UNITS WITH LEAD IN PAINT AND EITHER LEAD DUST OR NONINTACT PAINT AND WITH CHILD PRESENT
($ billions, 10-year period)

	Abatement Strategy					
	Encapsulation			Removal		
Annual Household Income	Owner-Occupied	Rental	All	Owner-Occupied	Rental	All
<$30,000	$1.4	$2.6	$4.0	$1.8	$3.4	$5.2
≥$30,000	$2.8	$0.8	$3.6	$3.6	$1.1	$4.7
All	$4.2	$3.4	$7.6	$5.4	$4.5	$9.9

Note: Because of small sample sizes in the cells of this table in the national survey of lead-based paint in housing, percentage estimates from the 1987 American Housing Survey were used to distribute the abatement costs across the tenure and income categories.

Annual Cost Estimates in Relation to Outlays for Maintenance and Repair of Residential Properties

These annual estimates should be put in the context of current remodelling and repainting activities. The annual Survey of Residential Alterations and Repairs, conducted by the Census Bureau, provides data on expenditures for rehabilitation and remodelling for the private housing stock. In 1989, total expenditures for upkeep and improvement of residential properties amounted to $100.9 billion. Annual expenditures for maintenance and repairs for residential properties were $42.7 billion, of which $11.3 billion was for painting, and annual expenditures for improvement, including major replacements, were $58.2 billion.

From these figures, it is clear that any substantial volume of abatement activity would involve a large increase in housing maintenance expenditures. The estimated annual cost for abating lead-based paint in all affected housing units is between one-third and one-half of total current private expenditures, and more than three times the total expenditures on repainting. The smallest annual abatement cost estimates, those for families with young children in units with priority hazards, are at least two-thirds of the current total expenditures on repainting.

CONCLUSIONS

The FHA component of the abatement demonstration shows that the cost of abating lead-based paint in accordance with the HUD guidelines is substantial. The average cost of abating is $7,700 for removal, and $5,500 for encapsulation. These are both much higher figures than the cost of $2,100 commonly found in local abatement programs, using less stringent guidelines. However, the average costs are influenced by a relatively small minority of units with exceptionally high costs. More than half of all units with lead-based paint can be abated for less than $2,500, by either method.

The cost of testing for lead-based paint is itself not negligible, about $375 per unit. The cost of testing for dust lead is estimated to range between $340 and $1,028, a wide range.

These large numbers may be lower if abatement is conducted as part of broader remodelling or rehabilitation activity in the housing unit, an issue which will be addressed in the public housing component of the abatement demonstration.

In-place management of existing lead hazards may be an appropriate strategy for a period until safe and cost-effective abatement procedures are established and implemented. In-place management focuses on removing dust and repairing nonintact paint while leaving the lead paint in place, at least temporarily. The cost and efficacy of such an interim containment strategy are not presently known and merit further investigation.

CHAPTER 5

CURRENT GOVERNMENTAL PROGRAMS AND PRIVATE SECTOR ACTIVITIES

This chapter summarizes of current Federal, State, and local activities aimed at reducing the hazard of lead-based paint in private housing. It also provides information on Federal National Mortgage Association's (FNMA) evolving environmental hazards disclosure process for multifamily and single-family properties, and private owner liability issues.

A profile of typical State and local activities based on a reconnaissance of health and housing officials is followed by a discussion of the more comprehensive approaches taken by Maryland and Massachusetts to reduce the lead-based paint hazards in their respective States. The section on Federal programs provides an overview of current regulations on lead-based paint in the primary private housing programs of the Department of Housing and Urban Development (HUD). The section on the Federal National Mortgage Association (FNMA) describes its development of an environmental hazard disclosure process (including lead-based paint) for privately owned multifamily and single-family properties. The final section summarizes the liability and insurance issues that private owners face when dealing with lead-based paint.

STATE AND LOCAL PROGRAMS

HUD undertook a telephone reconnaissance of State health and housing officials in all 50 States and found that 22 States have legislation relating to lead-based paint and have established programs to address the problem. An additional 8 States have established programs without the benefit of supporting legislation. It appears that 20 States are doing nothing, either because lead poisoning has never been perceived as a public health problem or because screening programs conducted in the early 1970s and 1980s did not determine lead poisoning to be a significant problem requiring a Statewide response.

HUD also conducted a reconnaissance of programs in Baltimore, MD; Chicago, IL; Detroit, MI; Los Angeles, CA; Louisville, KY; Minneapolis/St. Paul, MN; New York, NY; Philadelphia, PA;

and Savannah, GA. These cities have relatively active programs that in most cases operate independently of State legislation or financial support.

Typical State Programs

Most State legislation on lead-based paint is found in the health codes and was enacted in response to the passage of the Federal Lead-Based Paint Poisoning Prevention Act (LPPPA) in 1971. More specifically, it was enacted to enable State receipt of grant funds authorized by LPPPA for childhood lead-poisoning screening and treatment programs. For most of these States, identifying and responding to poisoned children still constitute the extent of their programs. Maryland and Massachusetts are the only two States that have developed more comprehensive responses to the lead-based paint hazard in which prevention of lead exposure is the ultimate goal. Five other States (California, Connecticut, New Hampshire, New Jersey, and South Carolina) have enacted expanded legislation, but the development of further regulations and programs has yet to occur in these States. From information gathered during the reconnaissance, a profile of a typical State lead-poisoning program in the 22 States with active programs is provided below.

Program organization. Regulatory and programmatic responsibilities are usually found in the State health department, with child health or similar divisions taking the primary implementation role. Implementation usually occurs through a network of public health officials working at the county or municipal level. Based on discussion with State housing officials, it is clear that lead-based paint is viewed primarily as a health problem. Interagency cooperation between housing and health officials is generally nonexistent unless called for by legislation.

Blood screening. Blood screening is the primary program activity of the States. The extent of program coverage differs greatly because of budget constraints. Most State health officials contacted during the telephone reconnaissance indicated that their screening programs reach less than 5 percent of the population under 7 years of age. Voluntary participation in, or support of, blood screening programs by private physicians is not extensive. Blood screening programs are usually provided through walk-in clinics or special screening campaigns as part of a special event (e.g., public health week).

Public information. Informing parents, physicians, landlords, and public health and housing agencies of the danger of lead poisoning and available treatment is another primary program activity. Most State officials indicated that their information programs are out of date in certain respects (e.g., testing and abatement methodologies) and inconsistent in terms of coverage. Public information activities are also very sensitive to budget cutbacks.

Medical intervention. Intervention typically occurs when poisoned children are identified as a result of blood screening. Generally, it will consist of consultation with a pediatrician who establishes appropriate medical treatment for reducing the affected child's lead burden. The establishment of an effective case management system for medical followup is the area where most State programs fall short. Effective tracking of lead-poisoning cases is generally not happening. The primary reason given for inadequate case management is lack of funds.

Environmental intervention. Generally, environmental intervention is reactive in that it does not occur unless a poisoned child has been identified. It usually involves a visit to the affected child's house by a public health nurse and a health inspector to determine the most likely sources of the lead hazard, to educate the family about the potential hazard, and to outline possible hazard abatement techniques. Most States indicate that environmental intervention is limited to the child's primary residence.

Environmental intervention may involve the testing of painted surfaces, but testing is not required in all cases. In those cases where testing is done, it is conducted by a public health official and the most frequently used testing methodology is the portable x-ray fluorescence analyzer. If lead is found in the house, abatement is typically not mandated even though the State may have legal authority to do so. Most States indicated that lead-based paint abatement is more likely to be achieved through negotiation. A public health official will work with the owner to establish a workable plan to abate the property without undue financial hardship. Use of public health citations is generally avoided because of the cost of enforcement and potential negative reactions by property owners, such as evictions or property abandonment. Effective environmental intervention is also hampered by the lack of consistent case management after initial inspection.

Abatement funding and methods. State funding for abatement activities recommended as a result of medical and environmental intervention is generally not available. Where housing rehabilitation funds are available from States, they are not specifically targeted to abatement activities. Abatement activities are generally considered eligible rehabilitation work, but abatement is not required as a condition for receiving financial assistance.

The only consistent element is the requirement for abatement "up to five feet" from the floor which reflects an overriding concern for the accessibility of potential hazards to children. Certification and training programs for abatement contractors are generally nonexistent. Requirements and procedures for post-abatement testing are not provided by most States, and the issues of worker protection and hazardous waste disposal are rarely addressed.

Selected City Programs

In the 10 cities contacted during the reconnaissance, the lead-poisoning programs have organizational and programmatic features very similar to the typical State programs. For instance, the programs are usually located in the health department, screening of high-risk children is usually a high-priority activity, and intervention involves pediatric consultation and home visits. Like the State programs, the city programs suffer from problems related to insufficient resources.

The differences between the typical State program and the programs in the selected cities are more a matter of degree than substance. Activities in the cities, although similar in nature to those in the States, are more focused and appear to receive higher priority. These differences may reflect the relative urgency of the problem in larger cities. Some of the distinguishing features are as follows:

- In most of the selected cities, local ordinances provide the statutory authority for the programs. Where State laws or regulations exist, local ordinances are typically more stringent and may supersede State requirements.

- In most of the selected cities, the health officials have expanded authority to inspect and abate. Besides intervention resulting from cases of lead poisoning, intervention may be initiated by a targeted housing inspection program or tenant complaints. Baltimore, Chicago, Louisville, New York, and Philadelphia are among the cities that have authority to engage in a more preventive approach and have had limited success in targeting neighborhoods considered at risk. Unfortunately, implementation of local ordinances is hampered by lack of funds and ineffective court enforcement.

- Interagency cooperation and coordination is much more apparent in the selected cities than in the typical State program. In New York, for instance, the Office of Housing Preservation and Development includes lead-based paint in its routine inspections and has the authority to enter units suspected of having lead-based paint problems. In the City of Baltimore, the Department of Housing and Community Development places a hazard warning on all permits for rehabilitation of properties built before 1978. The warning describes the hazards of lead-based paint and the requirements for treatment of the hazard.

- Screening of high-risk children is more systematic and usually focused on high-risk areas. Door-to-door contact and mobile blood-screening units are examples of approaches taken in target neighborhoods.

- Enforcement of abatement orders is a more critical issue because of the implications for abandonment, affordable housing, and the rights of tenants, particularly low-income tenants. Those problems are compounded in cities like Baltimore, Detroit, and Philadelphia, where the cost of abatement typically exceeds the value of the property.

Massachusetts and Maryland

Both Massachusetts and Maryland have implemented comprehensive lead-poisoning programs that are clear exceptions to the typical State program profile. The major distinguishing features of the programs are outlined below.

Interagency involvement. An important feature of both programs is the high level of interagency involvement. Even before formal legislation was passed, each State had formed a policy task force which represented a cross-section of those groups involved in the lead-poisoning issue. Those task forces helped to shape a more comprehensive legislative package based on their expanded view of the problem. That same multidisciplinary approach was written into the legislation and continues to provide an effective mechanism for policy development and implementation. The legislation in each State calls for the establishment of a lead advisory council whose membership consists of a variety of private and public individuals with an interest in the issues involved in preventing lead poisoning. Health, housing, and environmental officials are the primary public participants. In Massachusetts, the Attorney General's office and the Department of Labor and Industry also are closely involved.

Notification. Massachusetts requires that buyers be notified of the potential lead hazards in houses built before 1978. That notification is part of the sales agreement and gives the buyer the opportunity to have a lead-based paint inspection done and to rescind the purchase offer based on the results of that inspection. Maryland does not have such a requirement.

Enforcement. Massachusetts imposes civil liability on property owners who fail to comply with abatement orders. Such owners are liable for actual damages and punitive damages three times the amount of actual damages. Massachusetts' landlord/tenant law protects families with children against discrimination because of lead-based paint and preserves their right to repossession when relocated during abatement. Maryland's real property code allows tenants to deposit their rents in an escrow account held by the district court when landlords fail to remove lead-based paint that is accessible to children within 20 days of notification. Funds are held in escrow until the local health department certifies that the hazard has been corrected. Tenants may not be evicted nor may rents be raised in retaliation for placing rent in escrow.

Licensing, certification, and training. Both States provide some level of quality control over lead testers, abatement contractors, and abatement inspectors. Massachusetts requires training and licensing of abatement contractors and inspectors, and testing laboratories must be certified. Maryland does not require licensing, but has established a training program employing private and public training organizations that are certified by the State. These organizations provide participants with certificates that show they have completed the prescribed course of training. As of July 1, 1990, Massachusetts had trained and licensed over 200 contractors. It also has about 250 trained and registered inspectors. Maryland has trained and certified over 500 persons since its program began in 1989.

Funding for abatement. Both States have loan or grant programs to provide abatement funds for property owners with limited means. In addition, Massachusetts has established a $1,000 tax credit for private property owners doing lead-based paint abatement. Both States attempt to provide relocation resources for families during abatement; however, the availability of suitable interim accommodations is a serious logistical problem. In Maryland, the State has given the City of Baltimore a grant to establish "lead-safe" houses which would be used for transitional housing during abatement.

Involvement of private physicians and laboratories. Both States require reporting of all cases of lead poisoning to the State health department. Private physicians are required to screen all pre-school children for lead poisoning and report cases of children with elevated blood lead levels to appropriate authorities for followup. Private laboratories are also required to report elevated blood lead levels.

Research. Both States have legislation calling for the investigation, testing, and approval of new abatement or containment technologies. Massachusetts has yet to fund its research program, but

- Screening of high-risk children is more systematic and usually focused on high-risk areas. Door-to-door contact and mobile blood-screening units are examples of approaches taken in target neighborhoods.

- Enforcement of abatement orders is a more critical issue because of the implications for abandonment, affordable housing, and the rights of tenants, particularly low-income tenants. Those problems are compounded in cities like Baltimore, Detroit, and Philadelphia, where the cost of abatement typically exceeds the value of the property.

Massachusetts and Maryland

Both Massachusetts and Maryland have implemented comprehensive lead-poisoning programs that are clear exceptions to the typical State program profile. The major distinguishing features of the programs are outlined below.

Interagency involvement. An important feature of both programs is the high level of interagency involvement. Even before formal legislation was passed, each State had formed a policy task force which represented a cross-section of those groups involved in the lead-poisoning issue. Those task forces helped to shape a more comprehensive legislative package based on their expanded view of the problem. That same multidisciplinary approach was written into the legislation and continues to provide an effective mechanism for policy development and implementation. The legislation in each State calls for the establishment of a lead advisory council whose membership consists of a variety of private and public individuals with an interest in the issues involved in preventing lead poisoning. Health, housing, and environmental officials are the primary public participants. In Massachusetts, the Attorney General's office and the Department of Labor and Industry also are closely involved.

Notification. Massachusetts requires that buyers be notified of the potential lead hazards in houses built before 1978. That notification is part of the sales agreement and gives the buyer the opportunity to have a lead-based paint inspection done and to rescind the purchase offer based on the results of that inspection. Maryland does not have such a requirement.

Enforcement. Massachusetts imposes civil liability on property owners who fail to comply with abatement orders. Such owners are liable for actual damages and punitive damages three times the amount of actual damages. Massachusetts' landlord/tenant law protects families with children against discrimination because of lead-based paint and preserves their right to repossession when relocated during abatement. Maryland's real property code allows tenants to deposit their rents in an escrow account held by the district court when landlords fail to remove lead-based paint that is accessible to children within 20 days of notification. Funds are held in escrow until the local health department certifies that the hazard has been corrected. Tenants may not be evicted nor may rents be raised in retaliation for placing rent in escrow.

Licensing, certification, and training. Both States provide some level of quality control over lead testers, abatement contractors, and abatement inspectors. Massachusetts requires training and licensing of abatement contractors and inspectors, and testing laboratories must be certified. Maryland does not require licensing, but has established a training program employing private and public training organizations that are certified by the State. These organizations provide participants with certificates that show they have completed the prescribed course of training. As of July 1, 1990, Massachusetts had trained and licensed over 200 contractors. It also has about 250 trained and registered inspectors. Maryland has trained and certified over 500 persons since its program began in 1989.

Funding for abatement. Both States have loan or grant programs to provide abatement funds for property owners with limited means. In addition, Massachusetts has established a $1,000 tax credit for private property owners doing lead-based paint abatement. Both States attempt to provide relocation resources for families during abatement; however, the availability of suitable interim accommodations is a serious logistical problem. In Maryland, the State has given the City of Baltimore a grant to establish "lead-safe" houses which would be used for transitional housing during abatement.

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Research. Both States have legislation calling for the investigation, testing, and approval of new abatement or containment technologies. Massachusetts has yet to fund its research program, but

Maryland has been involved in an ongoing research program on the effects of lead dust on blood lead in abatement workers and the development of testing protocols for encapsulation products.

Abatement standards and procedures. Maryland has pioneered in the development of standards and procedures for worker protection during abatement, dust containment, and post-abatement cleanup, inspections, and clearances. Maryland's work on abatement methods provided much of the basis for the National Institute of Building Science's guidelines for testing and abatement of lead-based paint in housing. Those guidelines became the basis for the HUD Interim Guidelines,[1] which public housing agencies are expected to use in conducting any testing and/or abatement.

VOLUME OF PRIVATE ABATEMENT ACTIVITY

In Massachusetts, it is estimated that approximately 1,500 private property owners filed for the State tax credit for lead-based paint abatement for the first year of the program (taxable year 1989). Some of these filings may have been for multifamily projects, so the total number of housing units abated could have been larger than 1,500. In Maryland, State officials estimate that the annual number of private units abated is about 200. Outside of Massachusetts and Maryland, there are some 50 active State or local lead-poisoning prevention programs. Most of these programs have no funds for abatement but must negotiate with property owners to reduce lead paint hazards that are believed to have caused childhood lead poisoning. There are few data available on private abatements, but the numbers nationally are probably small.

A much larger volume of unintended abatement is occurring as a result of renovations, albeit with likely contamination of dust and soil. In 1987, for example, almost 3 million housing units had kitchens remodeled or added at a unit cost of more than $500, and 2.7 million units had similar activity for bathrooms.[2] In the same year, $4.5 billion was spent on work classified as remodeling. This is exclusive of work categorized as roofing, painting, siding, and other types of improvement,

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[1]U.S. Department of Housing and Urban Development (1990), "Lead-Based Paint: Interm Guidelines for Hazard Identification and Abatement in Public Housing," *Federal Register* 55(April 18):14557-14789.

[2]U.S. Bureau of the Census (1990), *Statistical Abstract of the United States*, 1990, Table No. 1282. (Data based on the American Housing Survey.)

maintenance, or repair.[3] Expenditures totaled $11.5 billion for residential maintenance work classified as painting, and $2.1 billion was spent for improvements to siding, although the number of units involved is unknown.

SUGGESTIONS FROM STATE AND LOCAL OFFICIALS

During roundtable discussions of State and local programs with Massachusetts and Maryland officials, several recommendations and suggestions for other States and localities trying to establish or improve their programs were discussed. The recommendations are as follows:

1. The process for developing programs should include as broad a base of participants as possible in order to ensure their comprehensiveness. Housing, health, environment, labor and industry, mortgage banking, realty, insurance, and tenant groups are some of the critical interests that should be represented in the program development process. Voluntary agency cooperation and coordination is ideal, but legislation calling for the establishment of a study commission or a task force may be necessary to achieve an effective level of cooperation.

2. Abatement should be treated as an integral part of the rehabilitation process when pre-1978 properties are involved. Doing abatement routinely as part of property renovation ensures that the hazard is addressed proactively and for the least cost.

3. Protection of tenant rights and the prevention of discriminatory acts resulting from the enforcement of lead-based paint requirements need to be considered. State and local policy decisions made to facilitate the elimination of the lead hazard could have the unintended effect of creating discriminatory practices by landlords who may try to avoid compliance by refusing to rent to families with small children. Existing tenants with small children are also subject to dispossession by those landlords trying to avoid potential future liability. The development of lead-poisoning policies and programs cannot be done in a vacuum. Careful consideration needs to be given to possible adverse market reactions. Policies and programs need to be consistently coordinated and monitored to ensure that the elimination of one problem does not create another.

4. Education of the public, especially private physicians, on the health hazards of lead-based paint should be undertaken. The long-term effectiveness of screening and case management is dependent upon broad-based public understanding and support. Participation by physicians in routine blood screening is particularly critical to expanded coverage of at-risk populations in all income levels.

5. The development of an effective case management system linked to blood screening is a critical precondition to expanding intervention efforts. It is not enough to know how

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[3] U.S. Bureau of the Census (1988). *Current Construction Reports-Expenditures for Residential Upkeep and Improvement: Annual 1987*, (Washington, DC: U.S. Government Printing Office), Table 1.

many children have elevated blood lead levels; what happens to them after they are identified is even more critical.

6. States and localities should carefully assess the extent of the lead-based paint problem before they embark on the development of more comprehensive programs which include preventive, as well as, reactive measures. The extent of the problem should determine the level of response. An accurate assessment will also provide an idea of the impact of the program on housing in terms of affordability and availability, particularly for low-income residents.

CURRENT HUD REGULATIONS

This section describes current HUD regulations pertaining to the hazard of lead-based paint in private housing. These regulations have evolved considerably since passage of LPPPA. Unfortunately, there has been no systematic attempt to monitor or assess the impact of the regulations on the identification or mitigation of potential lead-based paint hazards in private housing. They are outlined here for general information purposes. As indicated in Chapter 6, it is expected that changes to these regulations will be proposed in response to improved understanding of lead hazards and proper abatement procedures. A discussion of the issues associated with updating the regulations is provided in Appendix F.

All HUD programs that insure mortgages, subsidize housing, or sell HUD-owned housing, and most programs that assist rehabilitation, have regulations designed to reduce the hazards of lead-based paint in such housing. Elderly housing is specifically exempt from the requirements of LPPPA.

Requirements vary somewhat among the programs because of practicability, but all programs now apply their lead-based paint regulations to housing built prior to 1978, and all programs except public housing use approximately the same rules regarding procedures and precautions to be followed in treating or abating lead-based paint. All programs also use similar statements to notify tenants, owners, or buyers of the potential hazards of lead-based paint. A revised standard notification is under preparation, pursuant to a legislative requirement contained in the 1987 amendments to LPPPA.

The primary differences among the lead-based paint regulations of the nonpublic housing programs appear in the areas of inspection, testing, triggering of treatment, and extent of treatment. There are three types of concerns in the regulations: defective paint, chewable paint, and response to the existence of a child with an elevated blood lead level. The regulations are discussed below in terms of those three concerns.

Defective Paint

All programs require inspection for and treatment of defective paint surfaces in dwellings built before 1978. Actual testing of the paint for the existence of lead is not required in all instances because of the time and expense involved. For instance, the Federal Housing Administration (FHA) receives over 1,000,000 applications annually for single-family mortgage insurance for dwellings built before 1978, and it processes over 30,000 pre-1978 FHA-owned single-family properties for sale each year. Testing of this volume of units is not considered practicable; so the emphasis has been on identifying and treating defective paint, which is presumed to be highly hazardous if it does contain lead. According to the American Housing Survey, approximately 5 percent of all occupied single-family units have defective paint at any given time.

In the single-family mortgage insurance programs, the appraiser must inspect the dwelling for defective paint as a part of the appraisal process. If defective paint is found, treatment must be completed before endorsement. (See section on treatment procedures, below.)

In the single-family property disposition program, HUD must inspect for defective paint before closing. If found, the defective surfaces must be treated before closing, except when the sale is not to an owner-occupant, in which case treatment may be made a condition of sale.

In the multifamily mortgage insurance programs, HUD and the sponsor (owner) must inspect for defective paint before issuance of commitment. Treatment of defective paint surfaces must be accomplished prior to endorsement. For the Section 8 Loan Management Set-Aside, the requirements are basically the same as for multifamily insurance, except for responsibility and enforcement.

In the multifamily property disposition program, HUD must inspect for defective paint prior to offering for sale. Treatment is required before delivery or as a part of repairs to be made by the buyer.

For units to be occupied by families assisted by Section 8 Existing Housing Certificates or Existing Housing Vouchers, if there is a child under 7 years old, initial and periodic inspections by the local public housing agency must include inspection for defective paint. If found, treatment must be accomplished within 30 days.

For the rehabilitation programs administered by the Office of Community Planning and Development--the Rental Rehabilitation Program, the Community Development Block Grant Program, and the Section 312 Rehabilitation Loan Program--the grantee must inspect for defective paint surfaces in all units occupied by families with children under 7 years old and proposed for rehabilitation assistance. Defective paint conditions must be included in the work writeup for the remainder of the rehabilitation work.

Chewable Surfaces

No inspection or testing of chewable surfaces is required under the regulations of the single-family mortgage insurance programs. Under the single-family property disposition program, however, if a child of a purchaser who intends to occupy the property is under 7 years old, the blood lead level of the child will be tested if HUD determines that a blood lead-screening program is reasonably available. If it is found that the child has an elevated blood lead level, HUD must test chewable surfaces for lead content. If the test is positive, HUD will then treat the surfaces before closing.

In the multifamily mortgage insurance programs, chewable surfaces in buildings built prior to 1978 must be tested on a random basis. If lead-based paint is found, chewable surfaces in all units must be tested. Abatement of all chewable surfaces with lead-based paint must be a condition in the commitment. Requirements for the multifamily property disposition program and the Section 8 Loan Management Set-Aside program are basically the same as for multifamily mortgage insurance.

For Section 8 Existing Certificates and Housing Vouchers, initial and periodic inspections must include a test of chewable surfaces if the unit is to be occupied by a child with an elevated blood lead level. Requirements for the Rental Rehabilitation, Section 312, and Community Development Block Grant Programs are the same as for Certificates and Vouchers. Treatment is required within 30 days under the certificate and voucher programs; for the rehabilitation programs, abatement must be included in the rehabilitation work.

Other Requirements Triggered by Elevated Blood Lead Level in a Child

In the multifamily insurance programs, if the developer is presented with test results showing that a child under 7 years of age has an elevated blood lead level and lives in a unit in a building covered by an insurance application, the developer must test the entire unit for lead-based paint and, if the test is positive, abate all contaminated surfaces. Abatement may proceed without testing, at the developer's option. Requirements for multifamily property disposition and Section 8 Loan Management Set-Aside are similar. No other special requirements for elevated blood lead children exist for the certificate, voucher, or rehabilitation programs except those pertaining to chewable surfaces.

Treatment Procedures

The following provisions are referenced in all program-specific regulations, except those of Public and Indian Housing.

> Treatment necessary to eliminate immediate hazards shall, at a minimum, consist of the covering or removal of defective paint surfaces found in HUD-associated housing . . . .
>
> Covering may be accomplished by such means as adding a layer of wallboard to the wall surface. Depending on the wall condition, wall coverings which are permanently attached may be used. Covering or replacing trim surfaces is also permitted. Paint removal may be accomplished by such methods as scraping, heat treatment (infra-red or coil type heat guns) or chemicals. Machine sanding and use of propane or gasoline torches (open-flame methods) are not permitted. Washing and repainting without thorough removal or covering does not constitute adequate treatment. In the case of defective paint spots, scraping and repainting the defective area is considered adequate treatment.

ENVIRONMENTAL POLICIES OF THE FEDERAL NATIONAL MORTGAGE ASSOCIATION

With the exception of the FNMA there is no organized activity in private housing by lenders or owners of which HUD is aware. FNMA has taken steps to include environmental hazard identification and treatment in the private mortgage underwriting process. For multifamily rental properties, since September 1987, FNMA has required participating lenders to comply with its Environmental Hazards Management Procedures. For single-family properties, procedures are in preparation.

Multifamily Properties

Multifamily procedures require participating lenders to certify to the environmental condition of the property and the borrower's ability to maintain the property and protect it from "environmental liability and value loss." The certification is required prior to commitment of financing.

The procedures require a two-step environmental assessment process for multifamily properties. Phase I provides a quick determination of the property's condition relative to six hazard categories: asbestos, PCBs, radon, underground storage tanks, waste sites, and additional hazards. Lead-based paint is contained in the "additional hazards" category.

Hazard assessment checklists are provided for each category. The first question on the "additional hazards" checklist is whether or not the property has "any visible or documented evidence of peeling lead-based paint on the floors, walls or ceiling of tenant or common areas?" A "yes" or "don't know" answer fails the property. Processing of the application can continue only if remedial actions are determined acceptable as a result of the Phase II assessment and are implemented prior to mortgage commitment.

Phase II assessments are required in those cases where the property fails the Phase I assessment. The Phase II assessment involves a more detailed investigation into the nature and extent of identified hazards. Any testing or sampling methodologies and/or laboratory results are fully described. The Phase II assessment results in either failure or acceptance conditioned on immediate remediation or long-term maintenance. All conditions become part of the financing requirements which the lender is responsible for enforcing.

From May 1989 to June 1990 FNMA processed loans for approximately 450 multifamily rental complexes involving over 67,000 units using the procedures. Although there was some initial resistance from lenders and sellers, the market has accepted the requirements without any adverse reaction and compliance has not presented a problem, according to FNMA.

Single-Family Properties

For its single-family portfolio, FNMA is taking steps to better inform buyers of the importance of environmental issues in the "home buying thought process." It has prepared "A Home Buyer's Guide to Environmental Hazards," which is available upon request to all single-family home buyers utilizing mortgage financing that FNMA would have an interest in through its secondary market operations. The guide is intended to provide "introductory information to help home buyers understand the possible risk of exposure to environmental hazards in and around the home." Those hazards include radon, asbestos, lead, hazardous wastes, groundwater contamination, and formaldehyde. A separate section of the guide is dedicated to a discussion of each hazard. The guide also provides the buyer with options on how best to take the presence of environmental hazards into consideration in the home-buying decision process. FNMA processed over 800,000 single-family loans in fiscal year 1989, so the use of the guide in conjunction with future loan activity would result in a significant increase in public awareness of potential hazards in private housing.

PRIVATE OWNER LIABILITY

Most lead-poisoning cases involving private landlords are brought to court on the basis of the common law theory of negligence and are usually initiated as a result of a child being poisoned. For instance, in most States private landlords have a general responsibility to maintain their premises in proper repair. In those States, a lead-poisoning case might be based on the fact that a child was poisoned as a foreseeable result of the landlord's failure to maintain or repair defective paint surfaces.

Some States have passed strict liability laws which in effect create an automatic cause of action and thereby lower or eliminate the threshold for proving liability. In instances of strict liability, there is effectively no need to demonstrate negligence on the part of the landlord. In Massachusetts, for instance, plaintiffs need only prove that the poisoned child was under the age of 6 and that there is lead-based paint in the property for the owner to be liable.

The responsibilities of a private owner for lead poisoning of tenants on their property, whether due to negligence or strict liability, raises the issue of insurance coverage. Insurance for private landlords typically excludes lead poisoning because it is currently considered a noninsurable risk by the insurance industry. The risk of lead-based paint poisoning is noninsurable because a clear standard of care does not currently exist that could be used to consistently determine liability in negligence cases. As a result, both the property owner and the poisoned child lose out. Without insurance the property owner stands to lose his property in the settlement of the case and the poisoned child loses because the value of the house is much less than the potential lifetime of damages that are caused by lead poisoning.

What this suggests is a need for consistent, comprehensive, state-of-the-art procedures for the detection, testing, and abatement of lead-based paint that would define the standard of care for private owners. Federal, State, and local governments, through their regulatory powers, have the opportunity to determine the standard of care and thereby establish the basis upon which future lead-based paint cases would be judged. Courts would be less likely to find property owners negligent and insurance companies would be more likely to provide coverage for lead-poisoning liability if they knew that owners were adhering to a defined standard of care. On the Federal level, the recent issuance of the HUD Interim Guidelines is an example of providing a comprehensive definition of standards for lead-based paint in a particular class of housing. Those guidelines may also provide a potential baseline for the establishment of Federal standards for privately owned housing.

The potential liability for lead-poisoned children, as well as the cost of testing and abatement, could also create a strong incentive for discrimination by rental property owners against families with children. States and localities need to be aware of the unintended effects of their actions in this regard. To counteract potential negative effects such as discrimination, governmental efforts must carefully consider the economics of the testing and abatement equation and its effect on investment/disinvestment and management decisions by rental property owners.

A consistent, well-defined standard for testing and abatement could help prevent the potential liability of rental property owners by clearly specifying the steps that need to be taken to address the hazard. If by taking those steps property owners can minimize their future liability, they may be more likely to engage in testing and abatement activities without adverse action against families with children.

CONCLUSIONS

Based on the limited information available, it seems clear that nationally very little intentional abatement of lead-based paint is being accomplished in privately owned housing relative to the number of dwellings containing such paint. In spite of the passage of the Lead-Based Paint Poisoning Prevention Act in 1971 and the ban on residential uses of lead-based paint in 1978, the American public generally has remained unconcerned about the potential hazard.

Such inaction may be due to ignorance. The relevant information is new, and the popular media have only begun recently to publicize it. The importance of contaminated dust as the most widespread source of low-level exposure did not become clear until the 1980s. Reports of the neurological effects of low-level childhood lead exposure began to appear in 1985. The ubiquity of low-level lead exposure throughout all segments of the population has been documented in professional reports, but only a few concerned health professionals are aware of it.

Even if such information were well known, there is still a question as to whether people would consider "stand-alone" abatement of lead-based paint (independent of other rehabilitation activities) to be worth the cost. They are more likely, however, to consider abatement as a complement to renovation, or at least to carry out renovation with care, to protect occupants (especially children and women of childbearing age), workers, and the environment.

CHAPTER 6

PROPOSED COMPREHENSIVE PLAN

Although precise information is lacking, it seems clear that lead-based paint abatement has not been a major concern for private citizens, or for the State and local governments that have primary responsibility for regulating housing conditions in the United States.

Relatively few homeowners have removed lead paint from their homes. Even those who live in expensive homes and could easily afford it have not done so, judging from the results of HUD's national survey. Nor have many State and local governments addressed the problem of lead paint. Most do not yet have the regulatory and programmatic mechanisms to ensure that lead hazards in private housing will be abated efficiently and safely, and that housing with the greatest hazards for children will be abated. The lead-based paint abatement industry is small in most communities, and most private remodelling and painting contractors have little experience with abatement, particularly abatement conducted in accordance with the standards established by the HUD Interim Guidelines.

While there are no Federal categorical programs for lead paint abatement, a substantial volume of Federal resources is available through other programs. However, the recipients of this Federal assistance--local governments and private citizens--have given lead paint abatement a lower priority than other uses of available funds.

The small volume of lead-based paint abatement activity appears to be due partly to a general lack of awareness of the seriousness of lead exposure, and partly to the high cost of testing and abating lead-based paint hazards. The comprehensive program described in this chapter is intended to address these and other problems and mitigate the hazards of lead-based paint.

OVERVIEW OF THE PROGRAM

Under the Lead-Based Paint Poisoning Prevention Act, the Secretary of Housing and Urban Development (HUD) is required to establish procedures to eliminate lead paint in a number of

Federal housing programs, including both HUD programs and those of other agencies. Regulations to address these hazards have been promulgated, and have been in force since 1976, as noted in Chapter 1. However, these regulations do not incorporate the results of recent research, or the findings of the current demonstration. The Secretary is therefore appointing a Department-wide task force to update the lead-based paint regulations in HUD programs. He will also initiate a consultative process with other agencies.

The Federal Government will also continue its support for State and local screening programs to increase the proportion of the Nation's children who are checked for lead poisoning.

The Federal Government now makes available a substantial amount of assistance for lead-based paint abatement, through a number of grant, loan, and insurance programs to facilitate housing rehabilitation, under which abatement can be undertaken. In addition, HUD is proposing to establish a new program specifically to assist testing, abatement, and related activities. Details of the program will be formulated during the preparation of the FY 1992 Federal budget.

Public information efforts will be expanded, aimed at individuals, the real estate industry, and State and local government agencies. Among these will be information on available Federal resources for lead-based paint abatement and other lead poisoning prevention activities.

Federal research activities will be undertaken to reduce the cost and improve the reliability of testing for lead in paint and dust, and also to reduce the cost of safe and effective abatement.

Because little is now known about the cost-effectiveness of abatement strategies, further analysis will be undertaken on a variety of issues, such as the contribution of lead-based paint to lead in the blood, and also concerning the extent to which the various current abatement strategies result in both long-term abatement and health benefits. Complementing this analysis, in-place management strategies will be developed and tested, to see if lead hazards can be reduced to tolerable levels for a period of time until full abatement is undertaken.

Research will also be conducted to determine what should be done about exterior soil lead and interior dust lead in carpets, upholstered furniture, forced-air ducts, and similar sources.

Because housing regulation is primarily a responsibility of State and local governments, the Federal Government will work with State and local governments to increase their ability to regulate and support hazard reduction activities. This will include working with the private sector to provide training in lead abatement for construction workers and other participants in the abatement and remodelling industries.

The Federal actions outlined in this chapter constitute a coordinated, interagency program. The activities are to be sponsored or conducted by HUD, the Environmental Protection Agency (EPA), the Department of Health and Human Services (HHS), the Department of Labor, the Department of Commerce, and the Consumer Product Safety Commission (CPSC). All agencies will coordinate the implementation of the program through participation in the Interagency Task Force on Lead-Based Paint.

Some of the projects described here are already underway and are funded with monies appropriated in fiscal year 1990, but most of the activities are still in the planning stage. The exact timing, the level of effort, and the specific responsibilities of individual agencies for new elements of the program will necessarily be determined in the normal process of preparing the President's Budget for Fiscal Year 1992.

UPDATING HUD LEAD-BASED PAINT REGULATIONS

The Lead-Based Paint Poisoning Prevention Act (LPPPA) requires the Secretary of HUD to "establish procedures to eliminate as far as practicable the hazards of lead-based paint poisoning with respect to any existing housing which may present such hazards and which is covered by an application for mortgage insurance or housing assistance payments under a program administered by the Secretary." HUD has issued regulations in response to this general requirement; these regulations are described in Chapter 5. However, the recent statutory amendments and new knowledge being acquired from the HUD abatement demonstration and other research and from research by other agencies indicate that revision of the regulations should be considered.

To effectively respond to the mandate to eliminate as far as practicable the lead-based paint hazard, Secretary Kemp is appointing a Department-wide task force to recommend specific actions within each HUD program which will support the achievement of this goal. A discussion of some of the issues associated with updating the regulations is provided in Appendix F.

The current regulations do not adequately deal with dust. Therefore, HUD intends to take specific steps as soon as possible to ensure that the repair of defective paint surfaces in HUD-associated housing is accompanied by a careful cleaning. This is designed to preclude the possibility that dust generated by the repair will contribute to lead dust problems in the dwelling unit.

LPPPA also requires the Secretary to "establish and implement procedures to eliminate the hazards of lead-based paint poisoning in all federally owned properties prior to the sale of such properties when their use is intended for residential habitation." HUD has previously issued such regulations, but the regulations similarly require review and updating. HUD will therefore initiate a consultative process with other agencies, as well as updating the regulations governing its own programs.

PUBLIC INFORMATION

The seriousness of lead exposure, and information about ways to avoid it, should be made widely available to the general public. Parents of young children, and parents-to-be, have a special need to understand the importance of maintaining old homes properly, engaging in good housekeeping to reduce the risk of exposure to dust lead and paint lead, taking protective measures during repainting and remodeling, providing good nutrition for children to reduce the absorption of lead in the body, and, as a precaution, having their children screened for blood lead. The Federal Government should assist in making information on lead hazards widely available.

Participants in the residential real estate industry also should be informed about lead hazards. These include apartment owners and managers, construction contractors and workers, real estate brokers, mortgage lenders, and insurers.

Basic general information should be broadly provided to the public; in addition, information about specific problems should be offered to targeted individuals. This plan envisions information dissemination projects of both kinds.

Brochures, Notices, and Audiovisual Materials for the General Public

People learn about environmental hazards in many ways: through news media, public service announcements, specialized magazines, consumer affairs pamphlets in grocery stores, information provided by State and local agencies, etc. The primary Federal role is to get information into the hands of the people who generate the materials that are read, seen, or heard directly by the public. To achieve this objective, HUD, EPA, HHS, and CPSC will develop a coordinated effort to prepare and disseminate educational materials targeted to various groups, based on the latest knowledge on this subject.

Information Clearinghouse and Hotline

As the lead-based paint issue becomes better known and State and local agencies and property owners begin to grapple with the problem, requests for technical information will increase. Federal agencies are already receiving several calls daily. Questions include:

- My child's blood tested 14 ug/dl. Should I be concerned?
- I have an old house. How do I find out whether it has lead-based paint?
- If my house has intact lead-based paint, should I be concerned about abating it now?
- Are there inexpensive tests? I've heard there are spot test kits on the market. Are they any good? Who sells them?
- How can I find a reputable contractor?
- Do you have any recommended standards and procedures for testing and abatement that you can send me?

In a few years, State and local agencies should be able to answer these questions as well or better than the Federal Government, because much of the information necessarily concerns local matters such as local laws, contractors, and laboratories. In the meantime, Federal agencies will continue to receive a high volume of calls and the advice given the public will be incomplete and inconsistent, at best, unless a coordinated response function is established.

HUD, EPA, HHS, and CPSC will cooperatively develop a system to provide a national source of consistent, accurate information on the issues of lead-based paint and lead in dust and soil.

RESEARCH ON TESTING AND ABATEMENT

Several projects have been begun and others are proposed to reduce the cost and increase the reliability and safety of both testing and abatement of lead-based paint.

Testing

The results of the national survey of lead hazards and the abatement demonstration show that testing is generally cost-effective, but still expensive; moreover the capacity of the private lead-based paint testing industry is small. A prerequisite of any strategy to reduce the risk of childhood lead poisoning in privately owned housing is, therefore, the availability of relatively inexpensive, reliable methods that can be used by homeowners, tenants, maintenance personnel, painters, contractors, and local code enforcement officials to determine roughly whether lead is present in paint, dust, or soil at a concentration that is likely to be worth worrying about.

When more exact measurements of lead concentrations are required, there is a need for reliable devices to be used by professional inspectors to measure concentrations on site without destroying painted surfaces. When onsite measurements are unavailable or must be confirmed, laboratory analysis of paint, dust, or soil samples must be conducted; and users of laboratory services should be assured that the results are accurate and precise.

Five projects will be undertaken in order to achieve these goals: evaluation of spot tests and test kits; improvement and evaluation of portable x-ray fluorescence (XRF) analyzers; development of laboratory standards and an accreditation process; development of standard reference materials for laboratory analysis and for use with portable XRF analyzers; and standardization of sampling methods and protocols for inspection and clearance in privately owned housing.

Evaluation of spot tests and test kits. If there is to be widespread reduction of residential lead hazards, it is essential that inexpensive, reliable methods be available for lead detection. Such methods are not expected to measure the concentration of lead but merely to determine whether lead is present at an unacceptable level in paint, dust, or soil. HUD and EPA, with the cooperation of the National Institute of Standards and Technology (NIST), have initiated projects to identify and evaluate promising technologies, develop an evaluation protocol for such devices, and establish a process for assuring that marketed products are evaluated and that the results of these evaluations are readily available to State and local agencies and the general public.

Improvement and evaluation of portable XRF analyzers. Spot tests and laboratory analysis of paint samples require cutting into or discoloring the surface. The portable XRF analyzer measures lead concentrations in installed paint without destroying the painted surface. At this time, unfortunately, portable XRFs do not provide the desired accuracy and precision of measurement, but there is a possibility for improvement, using the technologies of spectrum analysis, cryogenics, and solid-state crystal detection. The market for such devices is with organizations doing a large volume of testing, such as State and local agencies, companies with large real estate interests, and private testing firms.

It is planned that HUD, EPA, and NIST will study the potential of enhancing the precision of portable XRFs, and that a standard evaluation protocol for the XRF will be developed and published.

Development of laboratory standards and an accreditation process. The HUD Interim Guidelines call for confirmatory testing with laboratory analysis of paint samples when portable XRF readings are in a certain range. Laboratory testing is also needed for dust and soil samples, although soil sampling is not called for in the HUD Interim Guidelines. Currently, there is no program for the accreditation of laboratories doing analysis of lead concentrations in paint, dust, or soil. It is proposed that EPA and NIST develop specifications for laboratory certification and quality assurance/quality control protocols for lead analyses. It is planned that these agencies will also assist in establishing a laboratory accreditation program for environmental lead analyses. The HUD Interim Guidelines advise that, in the meantime, property owners and inspectors should rely on laboratories that have accreditation for the analysis of other metals.

Development of standard reference materials for laboratory analysis and for use with portable XRF analyzers. After a thorough study of methods for measuring lead concentrations in paint films, NIST recommended that "lead-containing standard reference films should be developed for use in calibration and characterization of XRF devices. Such films are also needed in preparing paint films to use as quality control samples in sample analysis."[1] It is proposed that Federal agencies sponsor the development of these reference materials.

Standardization of sampling methods and protocols for inspection and clearance in privately owned housing. It is proposed that the participating Federal agencies review the sampling protocols contained in the HUD Interim Guidelines for both initial inspection and clearance after abatement, and make recommendations for changes appropriate to privately owned housing.

Abatement

Although there has been substantial progress recently in the development of safe, effective procedures for lead-based paint abatement, many issues remain, including standards and procedures for worker protection, proper handling and disposal of waste and debris from abatement, questions about the long-term efficacy of abatement and the durability of encapsulants, and the need to encourage the development of less expensive abatement methods and products. The following projects pertain to these concerns.

Development of standards and procedures for testing encapsulation products. There are several products on the market, some of which are new, whose manufacturers claim that they are suitable for encapsulation of lead-based paint. Currently there is no generally recognized standard for evaluating these materials. States, localities, private property owners, and contractors badly need such a standard as a basis for judging product suitability. Also, the existence of an established system for testing new products will enhance market incentives for the development of new, more cost-effective products. Therefore Federal agencies will sponsor the development of an American Society for Testing and Materials (ASTM) standard for encapsulants.

Identification and evaluation of new abatement technology. In addition to developing an evaluation standard for encapsulants, it is proposed that research be initiated to identify and evaluate potential new technologies that have the promise of reducing costs of lead-based paint abatement. An urgent need exists for finding cheaper, more cost-effective, but safe abatement

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[1] McKnight, Mary E.; Byrd, W. Eric; Roberts, Willard E.; and Lagergren, Eric S. (1989), *Methods for Measuring Lead Concentrations in Paint Films* (NISTIR 89-4209), U.S. Department of Commerce, National Institute of Standards and Technology. p. 47

methods, materials, and procedures. The Federal Government will undertake research intended to meet this need.

Review of worker protection standards and procedures. The worker protection standards and procedures contained in the HUD Interim Guidelines were developed prior to the completion of the HUD demonstration of lead-based paint abatement methods. The National Institute for Occupational Safety and Health (NIOSH), with the cooperation of the Occupational Safety and Health Administration (OSHA) and other agencies and experts, will review the findings of the demonstration and recommend modifications to the standards and procedures pertaining to worker protection.

Review of guidelines for waste handling and disposal, and evaluation of new technology. Under present regulations, contractors bidding on abatement work are uncertain whether the waste and debris that will be generated can be treated as ordinary solid waste or whether it will be classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA), which would require more expensive handling and disposal. Contractors are having difficulty finding laboratories to do the toxicity testing of the waste, perhaps because a new standard toxicity test method is being instituted by EPA. Insurance companies are unhappy with the requirements that put the burden of proof on the owner and contractor in cases involving pollution resulting from waste.

EPA is now conducting a study to determine the types of paint abatement debris likely to be hazardous under the new requirements of the Toxicity Characteristics Leaching Procedure (TCLP). Further studies will investigate alternative disposal possibilities, including the use of secondary smelters for recycling such debris. In addition, clear, practical guidance on abatement waste will be provided to property owners, contractors, insurers, and lenders. Such guidance will facilitate the planning, costing, insuring, financing, and carrying out of abatement work.

Preparation and dissemination of a full report on the HUD abatement demonstrations. HUD will prepare and make available to Congress and the public a complete technical report on the results of the abatement demonstrations in both FHA and public housing. The report, which is scheduled for completion in June 1991, is expected to include final conclusions on the relative costs of the alternative abatement strategies tested in the demonstrations, and the necessity of various worker protection and dust containment measures. It is also expected to include many practical comments and suggestions for abatement planners, property owners and managers, inspectors, monitors, contractors, and field supervisors. The report will reflect the advice, assistance, contributions, and comments of the members of the Interagency Task Force on Lead-Based Paint.

Preparation and dissemination of model technical guidelines on testing and abatement in privately owned housing. The HUD Interim Guidelines, which were prepared to apply specifically to public housing, are detailed, technical, and comprehensive. They cover testing, deciding whether to abate, abatement methods, worker protection, occupant protection, cleanup, clearance, and waste disposal. Except for those parts pertaining exclusively to public housing, the Guidelines can be used by State and local governments and the private sector as a source of standards and procedures for testing and abating lead-based paint in privately owned housing. To facilitate their use, HUD will take several actions:

1. Updating the Guidelines, based on information obtained from the abatement demonstration, other research, and public comments.
2. Removing text that pertains exclusively to the public housing program and make other changes necessary to produce a document that applies to privately owned housing, both single-family and multifamily.
3. Publishing the updated and revised Guidelines (with a target date of 1992).
4. Upon completion of the revised Guidelines, arranging for their continual amendment, through a consensus process, and their dissemination, perhaps by a private, nonprofit organization.

In managing the revision and dissemination process, HUD will continue to consult with the members of the Interagency Task Force on Lead-Based Paint and various private individuals and organizations and State and local governments.

RESEARCH ON THE HEALTH EFFECTS OF ABATEMENT

Information presented in Chapter 2 and 3 of this report clearly indicates that abatement of lead-based paint that is in poor condition in housing occupied by children will help to reduce childhood lead poisoning. However, available data are not yet adequate to permit a confident estimate of the amount of reduction in childhood blood lead levels that occurs as a result of abatement by any current method. Therefore, it is not possible to assess the relative cost-effectiveness of alternative abatement strategies.

Abatement strategies may vary in many ways: in terms of the surfaces to be abated (e.g., intact as well as nonintact, exterior as well as interior, all locations as well as those accessible to children); the method of abatement (e.g., removal/replacement or encapsulation/enclosure); the stringency of the standards and protocols (e.g., the concentration of lead in paint at which abatement is recommended, the amount of dust lead permitted after a home is abated, or the procedures to be followed for containment of dust and worker protection during abatement); which dwellings receive priority for abatement (e.g., those occupied by children with high blood lead levels, those with children who are most at risk, those with women of childbearing age, or those that are being rehabilitated); and the role of in-place management in the overall plan.

Each of these variables has cost implications as well as potential implications for the impact on childhood lead poisoning. Expensive abatement methods might offer great assurance of a cleaner environment but offer that environment to a relatively small number of children; cheaper abatement methods may offer less assurance to a larger number of children. It is also possible that more expensive methods may not turn out to be more effective at reducing lead exposure. At present, the information needed to assess methods on this basis is not available.

The participating Federal agencies will develop a practical research program to respond to these information needs, taking full account of the expected products of ongoing studies. It should be noted that while the questions to be addressed by this research are important, reliable answers may be difficult and expensive to obtain. Properly designed experiments--with control groups, a full range of biological, environmental and behavioral observations, and subjects that are followed over an adequate period of time, as well as a full range of abatement strategy variables--may be costly.

Therefore, while additional research is needed that will strengthen the ability of State and local governments and private owners to identify the housing of highest priority and the most cost-effective abatement strategies, such research must be designed for maximum efficiency.

Monitoring the Long-Term Efficacy of Abatement

The Federal Housing Administration (FHA) component of the HUD abatement demonstration removed or encapsulated lead-based paint in approximately 170 single-family houses in seven metropolitan areas. It also abated interior surface dust lead in these units, but it did not abate exterior soil and exterior surface dust lead, nor did it abate dust lead in forced-air ducts. Since the houses were unoccupied, it also did not abate dust in rugs, furniture, and other personal property that residents may have brought into the units after abatement. Monitoring the dust lead and the durability of enclosures and encapsulations in these demonstration units will provide valuable information about the long-term efficacy of the various abatement strategies used in the demonstration. Sources of possible recontamination will be identified and measured. A 3-year monitoring program is planned. EPA is already sponsoring this project.

Demonstration and Evaluation of In-Place Management Techniques

Full abatement of lead-based paint through removal or encapsulation is expensive, especially if it is not conducted in conjunction with renovation activities that occur during the life of most buildings. Realistically, only a small percentage of the Nation's housing will be fully abated during the next few years.

To achieve the maximum reduction of childhood lead exposure in the least amount of time, property owners and managers need to be able to apply measures that are relatively low in cost but known to be effective in hazard reduction, at least temporarily. This approach is known as "in-place management." Based on current knowledge, such measures should be oriented toward reducing lead in house dust by vacuuming with a high-efficiency particle accumulator (HEPA), washing surfaces with special solutions, and (with proper precautions) repairing or otherwise intervening in the most obvious sources and pathways of lead dust, whether they be lead-based paint that is in poor condition, exterior dust or soil, carpets or personal property, or forced-air ducts. These measures should include continual monitoring of dust levels and paint condition, and regular housekeeping, to guard against recontamination.

EPA is sponsoring a demonstration project to test the cost, effectiveness, and feasibility of alternative low-cost hazard reduction measures in various residential environments. This project includes the observation of childhood blood lead levels.

DEVELOPMENT OF ABATEMENT TECHNIQUES FOR LEAD IN SOIL AND FURNISHINGS

Neither the HUD lead-based paint abatement demonstration nor the HUD Interim Guidelines have addressed the question of how to abate lead in exterior soil or in dust found in forced-air ducts, carpets, rugs, upholstered furniture, and other personal property. As indicated in Chapters 2 and 3, high amounts of lead have been found in these locations, in some housing units. Two projects are proposed: one dealing with exterior sources, the other with interior sources.

Demonstration and Evaluation of Techniques for Abating Lead-Contaminated Exterior Surface Dust and Soil

Research indicates that exterior soil and dust lead is not only a direct hazard for children but that it may be transferred to interior environments via wind or by tracking in (see Chapters 2 and 3). An ongoing EPA demonstration of soil abatement methods should yield important information on the effectiveness of the excavation and removal of contaminated soil in reducing childhood lead exposure. The schedule calls for an interim report in late 1990 and a final report in 1992. EPA is planning additional studies of other soil abatement methods.

Development of Methods for Abatement of Interior Dust Lead in Forced-Air Ducts, Carpets, Furniture, and Other Personal Property

Very little has been done to determine how to abate interior dust hazards in locations other than easily accessible, fixed architectural surfaces. Investigators in Cincinnati concluded that, for the purposes of a soil and dust abatement demonstration being conducted there under EPA sponsorship, abatement of dust lead from rugs and furniture by vacuuming and cleaning was not feasible and that replacement was the practical solution.[2] This is not only expensive, but it may be unacceptable to many households. With regard to dust in forced-air ducts, the mobility of the dust must be determined before assessing the need for and techniques of abatement.

The Federal Government will sponsor research on the costs and effectiveness of alternative methods of abating dust lead in these locations. Initial exploratory work has begun.

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[2] Clark, S. (March 17, 1989), "Progress Report" (oral), Superfund Soil Lead Abatement Demonstration Projects Workshop, Columbia, Maryland.

CAPACITY BUILDING AND LOCAL PROGRAM DEVELOPMENT

In addition to enhancing public awareness of the risks of lead exposure and improving the knowledge, equipment, and materials needed to reduce lead hazards cost-effectively, a major objective of the program is to help develop the capacity in State and local governments and the private sector to translate technical information into effective action in the field.

States and localities have the primary responsibility for regulating housing in this country. They are responsible for housing codes, building codes, landlord tenant laws, real estate transfer requirements, environmental codes, health codes, and the licensing of professionals and contractors--all of which can be utilized in reducing lead hazards in housing. States and localities also provide programs of public information and technical assistance, and they administer programs of financial assistance for housing occupancy, improvement, and development. Therefore, the real work of detecting and abating residential lead hazards is done at the local level by State and local governments and the private sector. States and localities must be directly and forcefully involved if this environmental problem is to be eliminated.

Federal actions are proposed in three areas: training, information for State legislators, and an information exchange for State and local Governments. Other forms of assistance are under consideration.

Training

Many of the procedures to be followed in the abatement of lead-based paint are new, and some are still being developed. Incorrect abatement can have serious negative consequences for workers, occupants, and the general public. Therefore, training should be required for all those who will be directly involved in testing and abatement--architects, engineers, planners, abatement contractors, supervisors, workers, inspectors, and monitors. Government administrators and property owners and managers should also receive basic, general information. It is expected that the training will be provided by private training organizations.

Development of model curricula. To assure that high-quality training courses are available as soon as possible, the Federal Government should develop model curricula. EPA has already sponsored the development of a basic curriculum for HUD and public housing agency staffs, based on the

HUD Interim Guidelines published in April 1990. Plans are being made to sponsor the development of specialized curricula for courses in inspection (testing and clearance), abatement supervision, abatement project design, and a course for abatement workers. A course may also be developed on in-place management.

Training delivery and accreditation. As the demand for qualified abatement contractors and inspectors increases, private vendors can be expected to come forth to meet the demand for training. The quality of this training will directly affect the quality of abatement work, especially in the next few years, until firms have the opportunity to establish a record of competency. While the model curricula will contribute to the quality of training, they will not be sufficient to guarantee it. Other considerations will include the adequacy of course presentations, and the comprehensiveness and integrity of examinations.

There will be a need for some degree of quality control on the training industry. This function could be performed by the Federal Government, State governments, a professional organization, or a combination of the three. The mechanism for quality control might be approval of course materials, auditing of presentations, the establishment of a national examination, or a performance-based approach. EPA and HUD are examining these and other options and, working with OSHA, intend to encourage the establishment of one or more programs for assuring that the quality of the training is satisfactory.

Institutionalizing abatement training. HUD, EPA, and OSHA plan to work with construction trade unions, contractor organizations, and organizations of building code officials to incorporate lead abatement procedures in the training normally received by carpenters, painters, plasterers, and other tradespeople, and by code enforcement officials.

Development of Information for State Legislators

A few States, notably Maryland and Massachusetts, have enacted laws and promulgated regulations specifically pertaining to lead-based paint abatement, but most States have done very little in this regard (see Chapter 5). To speed up the transfer of information from pioneer States to those that may want to consider legislative action, it is proposed that the Federal Government sponsor the preparation of materials that would assist the legislative process. Such materials should include an evaluation of the relative effectiveness of various laws and regulations.

Information Exchange for State and Local Governments

As more State and local governments attempt to establish laws, regulations, and programs pertaining to lead-based paint and other lead hazards, there will be a demand for advice on program design and technical matters as well as a need to exchange ideas and experience. In time, this demand will be met by consultants, public interest groups, and professional and trade associations, as they develop expertise in this new field. In the meantime, Federal agencies will sponsor technical assistance to State and local governments and hold one national conference and several regional workshops. It is expected that these activities will commence after the HUD Interim Guidelines have been revised for use in privately owned housing, and after the activities conducted under the demonstration grants have been underway for at least one year.

Other Assistance for States and Localities

The Administration is considering other ways to help States and/or localities address the hazards of lead-based paint. For example, a limited number of Federal demonstration grants could stimulate the development and implementation of innovative local programs aimed at reducing lead hazards in the highest risk housing. Such grants could generate experience that could be evaluated and reported for the benefit of other localities. One primary goal of these grants would be to facilitate local interagency cooperation and communication in addressing the hazards of lead-based paint. Another example of potential Federal assistance would be the development of a 'model' State or local program to address lead paint hazards.

Recipient governments would have to demonstrate political commitment to eliminate lead poisoning; potential for increased cooperation between environmental, health, and housing agencies; active private sector involvement; and a significant financial contribution to the project by the local government.

Monitoring, Evaluation, and Reporting

It is proposed that the participating agencies sponsor a coordinated effort to monitor, evaluate, and report on the amount of abatement activity being undertaken nationwide, its cost, its effectiveness, the supply of qualified testers and abatement contractors, and progress by State and local governments in developing regulatory and programmatic capabilities. It is intended that particular emphasis will be given to the evaluation of the health effects of abatement conducted according to the HUD Interim Guidelines to assure that the shortcomings of traditional abatement practices have been corrected and that desired health benefits are being achieved.

It is expected that the public housing program will be an important source of data on the costs, effectiveness, and health effects of alternative abatement methods, the costs that are attributable to abatement when it is conducted in the context of housing rehabilitation, and the effectiveness of in-place management. Other sources of data may include abatements of privately owned housing being conducted in Maryland, Massachusetts, and other jurisdictions.

FINANCIAL SUPPORT FOR ABATEMENT IN PRIVATE HOUSING

Federal Resources That Can Be Used to Reduce Lead Hazards

There are no HUD categorical grants which are directed specifically to the testing for or abatement of lead-based paint hazards. However, there are substantial Federal resources in more broadly directed HUD programs which can be used for these purposes if individual homeowners and States and local governments make eliminating lead hazards a high priority. HHS funds several block grant programs to States which may be used for screening children for lead poisoning, and the categorical grant program to States for childhood lead poisoning prevention.

HUD Programs

HUD programs which may be used to address lead-based paint hazards include insurance programs, grant programs, and loans.

Insurance programs. For individual homeowners, HUD's Title I Home Improvement Loans offer a means to secure financing for lead-based paint abatement. Under Title I of the National Housing Act, HUD insures loans made by private lenders to finance alterations, repairs and improvements to existing structures, which can include work necessary to eliminate lead-based paint in a dwelling. Loans are available for single family home improvements under this program for up to $17,500 over a 15 year term. In FY 1989, HUD insured almost 81,000 Title I Home Improvement Loans, and expects to insure approximately 85,000 of these loans in FY 1990.

Also available to individual homeowners is the Section 203(k) insurance program, under which HUD insures loans for the rehabilitation of single family properties. These loans may be used for 1) financing the rehabilitation of an existing single family home; 2) financing rehabilitation and refinancing the existing debt on a home; and 3) financing the purchase and rehabilitation of a single family home. A loan insured under this program may not have a principal balance exceeding that permitted under the basic single family mortgage program. For 1990, the maximum mortgage amount on single family units in high cost areas is set at the lesser of $124,875, or 95 percent of the median one-family house price in the area.

For multifamily rental properties, HUD offers insurance both for development, primarily under Section 221(d)(4) of the National Housing Act, and for the purchase or refinancing of mortgages on existing rental units under Section 223(f). Under Section 221(d)(4), development can include substantial rehabilitation as well as new construction, so that insurance under this section of the Act can be used to fund lead-based paint abatement activities as a part of the overall renovation work on the property. Under Section 223(f), the loan for the purchase or refinancing of existing rental units may include funds to be used for rehabilitation work, which again may include lead-based paint abatement work. In 1989, HUD insured multifamily mortgages covering 64,731 rental units, and expects to insure mortgages covering 85,000 units in 1990.

Grant programs. In addition to these insurance programs, HUD funds several grant programs which are used to rehabilitate housing occupied by low and moderate income households. These grant programs include requirements that the grantee must inspect all units occupied by families with children under 7 for defective paint conditions, and that these defective paint conditions must be included in the work write-up for the remainder of the rehabilitation work. If a child with an elevated blood lead level lives in the unit, chewable surfaces must be tested for the presence of lead-based paint and, if the test is positive, all contaminated surfaces must be abated.

The largest of these grant programs is HUD's Community Development Block Grant Program (CDBG), funded at $2.9 billion in 1990. This program could be a major source of funding for lead-based paint abatement for lower-income homeowners and rental apartments serving low-income households if States and cities chose to use it for this purpose. CDBG entitlement cities and counties have historically spent a high proportion of their funds for housing-related activities, with 35 percent of their funds spent for this purpose in FY 1987, the latest year for which we have actual expenditure data. Almost all of these expenditures were devoted to improving the communities' existing housing stock for low-and-moderate income households. Actual expenditures in 1987 for housing included $441 million for rehabilitation loans and grants for single family dwelling units, and $280 million for the rehabilitation of multifamily and public housing. These entitlement communities also used $33 million of their FY 1987 grants to fund code enforcement activities. Code enforcement can include lead-based paint testing and abatement requirements if communities believe that these activities are important for the public health.

States also use a substantial portion of their Community Development Block Grant funds for housing purposes, approximately 26 percent. Planned expenditures for the rehabilitation of housing inhabited by low and moderate income households were expected to use about 19 percent of CDBG funds available to States, with about $135 million budgeted for this purpose in FY 1988. States planned to rehabilitate almost 14,500 units with these funds.

Thus, the Community Development Block Grant program is an important source of funding for the rehabilitation of housing serving low and moderate income households. This rehabilitation activity now includes abatement of defective paint conditions and chewable surfaces under the requirements cited above. It is not possible to identify actual amounts spent on lead paint abatement in CDBG rehabilitation activities because this level of detail is not required in the Grantee Performance Reports which CDBG grantees submit to HUD. States and cities could include additional lead-based paint testing and abatement activities, if they believe there are significant lead-based paint hazards within their jurisdictions which are not addressed by the current hazard identification and abatement procedures. Additionally, States and cities could target rehabilitation funds to residential properties which are considered likely to have lead-based paint hazards.

The new HOME program represents another important potential resource for financing lead-based paint testing and abatement. Authorized by the Cranston-Gonzalez National Affordable Housing Act of 1990, HOME is a block grant program to State and local governments which encourages the design and implementation of housing programs tailored to local needs. Considerable housing rehabilitation is expected since the bill explicitly promotes such efforts. In addition, matching requirements clearly favor rehabilitation over new construction. It should be noted that HOME replaces several rehabilitation programs, including Section 312 and the Rental Rehabilitation Program. The fact that abatement is probably most efficiently and economically accomplished in conjunction with general rehabilitation activities makes the likelihood of lead-based paint abatement activities under this act quite high. As authorized, HOME would receive $1 billion in FY 1991 and $2.086 billion in FY 1992.

HHS Programs

In addition to HUD programs which can be used for testing for and/or abatement of lead-based paint, there are several HHS programs that can be used to screen children for elevated blood lead levels. This screening process, in addition to identifying children who need medical treatment, also leads to the identification of dwelling units which should be targeted for lead-based paint abatement activities.

Childhood Lead Poisoning Screening. HHS now provides assistance for State and local screening programs to increase the proportion of the Nation's children who are checked for lead poisoning. This activity is undertaken primarily to identify children with undue lead exposure, but it also provides information on the extent of lead poisoning within specific communities. Screening may also enhance the effectiveness of liability laws by increasing the likelihood that landlords who allow contaminated conditions to persist will be identified.

HHS's categorical grant program of Grants to States for Childhood Lead Poisoning Prevention, funded at $3.9 million in 1990, is used solely for these lead screening activities. The Center for Disease Control's budget for FY 1991 again requests $3.9 million for grants to States for childhood lead poisoning prevention activities, including screenings and medical referrals.

Other Resources. Three HHS block grants are also sources of funding for lead poisoning prevention activities, if these activities are among the priorities set by the individual States. Because reporting for these programs is in broad categories, it is not possible to identify specific funds spent for lead screening and other prevention activities.

The Health Resources and Services Administration administers the Maternal and Child Health Block grant program funded at $554 million in FY 1990, and requested to be funded at the same level for FY 1991 in the Administration's budget for that Fiscal Year. This block grant program provides funds to each State and insular areas to provide a broad range of health services, including preventive and primary care for children. In 1982 funds from an earlier CDC categorical grant program for lead poisoning were folded into this program. States and cities may use funds available to them in this block grant for screening for lead poisoning, and other lead poisoning prevention activities if they believe this is an important public health problem in their communities.

Another HHS program which is being used by some States for lead screening activities is the State Preventive Health and Health Services Block Grant program, funded at $83 million in FY 1990, with the same amount requested by the Administration for FY 1991.

HHS Grants for Community Health Centers, with a FY 1990 funding level of $427 million, and a requested level of $438 million for FY 1991, can also be a source of funds for lead poisoning prevention activities. The Community Health Centers program provides essential health care services to underserved populations, including low-income inner city households whose children are most at risk of lead poisoning. Funds from this grant program can be used for lead screening of children.

Additional Financial Assistance for Lead-Based Paint Abatement

These programs already make available a substantial volume of resources that can be used for lead-based paint abatement, as well as other lead poisoning prevention activities. However, as awareness of the lead-based paint problem grows, through public education and various prevention programs, the demand for access to abatement resources can be expected to increase. Recognizing this emerging need, the Administration is developing options for providing additional financial support for single-family and multifamily residential abatement. Eligibility for such assistance would be restricted to low- and moderate-income homeowners and/or landlords whose properties primarily service low-and moderate-income households. Support would be provided to high-risk units where young children and priority hazards are present. The cost of testing would be covered as part of this assistance. To the extent practicable, analysis of blood lead levels would be required of program participants prior to abatement, in addition to several post-abatement screenings. Childhood blood lead analysis would generally be required for owner-occupied housing and strongly recommended for rental housing. These measures would be intended to provide a knowledge base with which to evaluate the long term health benefits associated with abatement.

Administration of the program would be the responsibility of the local government. Participating local governments would have to demonstrate a capacity to manage such an effort, especially the ability to implement a program with both housing and public health dimensions. Initially, HUD may opt to conduct pilot programs using alternative local delivery mechanisms to determine the most cost-effective local administrative approaches. Greater detail on this program will be presented in the President's FY 92 Budget.

FEDERAL BUDGET EXPENDITURES AND RESOURCES

Proposed expenditures for the program described in this chapter can not be provided here, because they will be affected by the current budget discussions between the Administration and the Congress, and because the President's Budget for Fiscal Year 1992 is in preparation for presentation in January 1991. However, expenditures in support of lead-based paint abatement and lead poisoning prevention and treatment are now being made for a number of the activities described in this report. In addition, funds and other resources are available for these purposes through a number of programs described in this chapter. The following table summarizes the expenditures and program resources during fiscal year 1990 for HUD and EPA.

TABLE 6-1
HUD-EPA EXPENDITURES AND RESOURCES
FOR LEAD-BASED PAINT ABATEMENT, FISCAL YEAR 1990

Area of Activity	Expenditures ($000)		
	HUD	EPA	Total
Public Information	---	$160	$160
Research & Demonstrations on Testing and Abatement	$6,147	2,090	8,237
Research on Health Effects of Abatement	---	1,550	1,550
Research on Abating Soil and Dust	---		
Capacity Building	---	770	770
Total	$6,147	$4,570	$10,717

APPENDIX A

METHODOLOGY OF THE NATIONAL SURVEY OF LEAD-BASED PAINT IN HOUSING

This appendix presents a description of the sample design and survey methodology of the national survey of lead-based paint in housing. Both public and private housing was surveyed, using somewhat different methodologies. The presentation in this report concentrates on private housing. Brief mention is made of public housing where deemed appropriate. A fuller description of the methodology employed for public housing will appear at a later date in the report on the comprehensive and workable plan for public housing.

SURVEY DESIGN

The objective of the national survey of lead-based paint in housing was to obtain data for estimating:

- The number of dwelling units in the United States with interior and exterior lead-based paint, by year built, type of housing, threshold level of lead concentration, and census region.
- The number of multifamily residences with lead-based paint in common areas, by year built, threshold level of lead concentration, and census region.
- The costs of abating lead-based paint in public and privately owned housing.

The study population consists of nearly all housing in the United States constructed before 1980. Newer houses were presumed to be lead-free because, in 1978, the Consumer Product Safety Commission banned the sale of lead-based paint to consumers and the use of such paint in residences. Certain other categories of housing were also excluded from the study:

- Housing used exclusively by the elderly or handicapped, i.e., housing in which the minimum age of residents is 50 and no children are allowed.[1]
- Housing for the elderly insured under Section 231 of the National Housing Act.[1]
- Group quarters such as nursing homes or dormitories.
- Vacation homes.
- Homes in Alaska and Hawaii.
- Military housing.

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[1]Housing for the elderly is exempt from the provisions of Section 302 of the Lead-Based Paint Poisoning Prevention Act.

In order to optimize the Congressionally required estimates, a design stratified on dwelling unit age and type was constructed. Privately owned dwelling units were grouped into:

- Two types of housing:
    - Privately owned single-family houses, defined as having one to four dwelling units.
    - Privately owned multifamily houses, defined as having five or more dwelling units.
- Three categories of construction date:
    - Built between 1960 and 1979.
    - Built between 1940 and 1959.
    - Built before 1940.

Table A-1 displays the national distribution of occupied privately owned housing across the six strata.

The total sample size was determined by resource limitations to be 400 dwelling units, 300 privately owned units, and 100 public housing units. The private dwelling units were allocated across the strata using statistical optimality criteria. The basic design is laid out in Table A-2.[2]

The objectives of the study required in-person visits to the sampled dwelling units. Also, a survey sample requires a sampling frame, i.e., a list of all dwelling units eligible for the survey. No such list exists nationally or even in many localities. These factors necessitated geographic clustering of the sampled homes. A multistage design was developed and employed to satisfy these requirements. Figure A-1 displays the multistage design as a flow chart; it includes data on the results of completing each stage of the design. A detailed description of the design and its implementation follows.

- A sample of 30 counties was selected from the approximately 3,000 counties in the United States. The counties were stratified by census region and selected with probability proportional to size. The size measure was the 1980 population.

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[2]It was estimated that this design would result in estimates of percentages having confidence intervals no wider than ± 7 percent for private single-family housing and no wider than ± 12 percent for private multifamily housing.

TABLE A-1
NATIONAL DISTRIBUTION OF OCCUPIED, PRIVATELY OWNED DWELLING UNITS BUILT BEFORE 1980

Number of Pre-1980 Dwelling Units (000)				
	Construction Year			
Type	1960-1979	1940-1959	pre-1940	Total
Single Family	29,137	18,782	18,499	66,418
Multifamily	6,548	1,690	2,521	10,759
Total	35,685	20,472	21,020	77,177

Source: 1987 American Housing Survey.

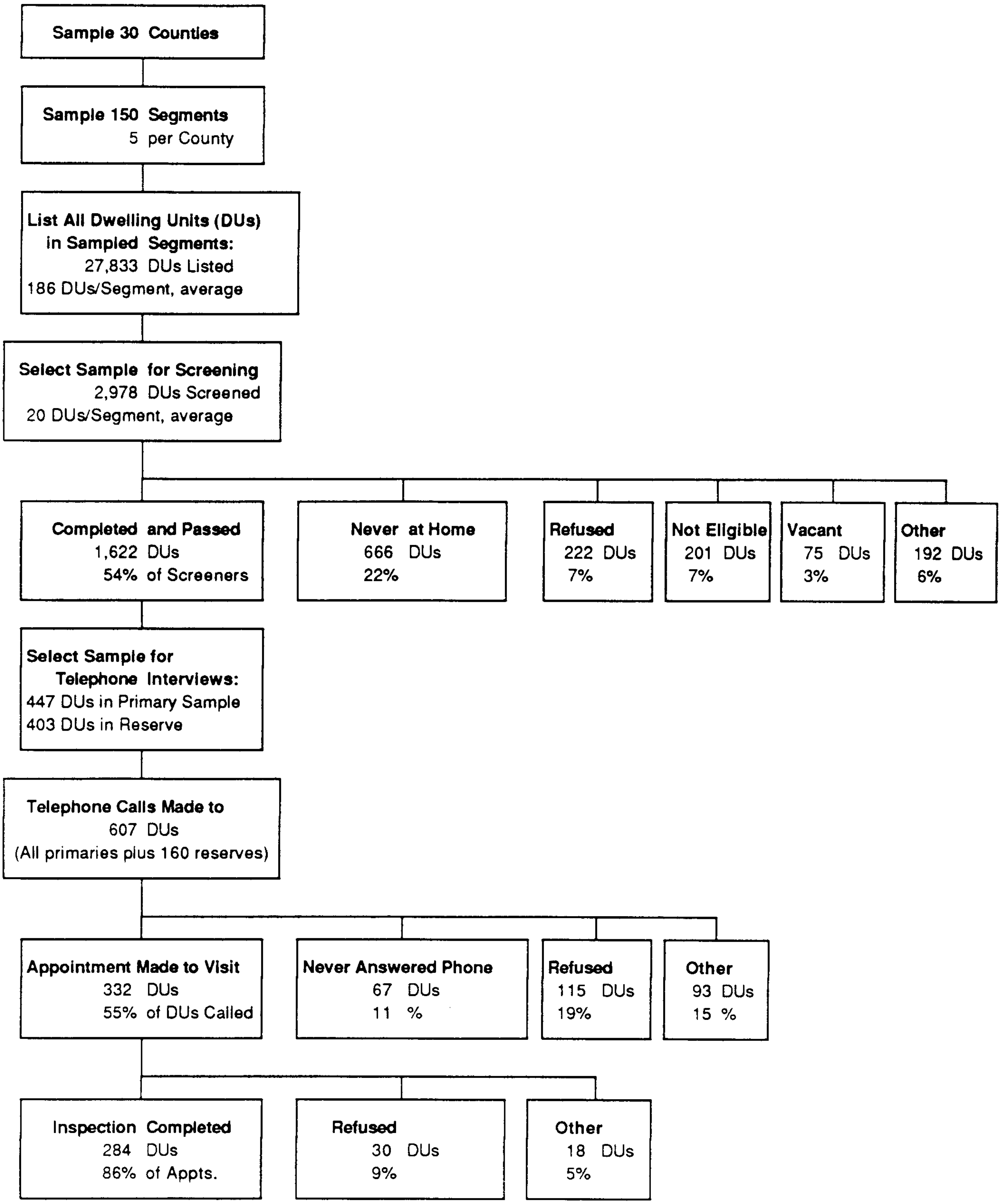
TABLE A-2
SAMPLE DESIGN PLANNED FOR NATIONAL SURVEY OF LEAD-BASED PAINT IN HOUSING

Survey Design				
	Construction Year			
Type	1960-1979	1940-1959	pre-1940	Total
Single Family	104	63	59	226
Multifamily	34	21	19	74
Total	138	84	78	300

TABLE A-3
DISTRIBUTION OF COMPLETED INSPECTIONS BY CONSTRUCTION YEAR AND DWELLING UNIT TYPE

Completed Inspection Visits				
	Construction Year			
Type	1960-1979	1940-1959	pre-1940	Total
Single Family	94	72	61	227
Multifamily	26	15	16	57
Total	120	87	77	284

FIGURE A-1
DEVELOPMENT OF THE PRIVATE HOUSING SAMPLE:
YIELD BY SAMPLE STAGES



- Within each of the 30 counties, 5 small geographic areas called segments were selected using random systematic selection. A segment is a block or group of adjacent blocks in an urban area, and a census enumeration district or group of adjacent enumeration districts in a rural area. To ensure that the full spectrum of income levels would be represented in the sample, a measure of wealth was computed for each segment. The blocks were sorted by this wealth measure and every *n*th block was selected, where *n* was chosen to be one-fifth of the number of blocks in the county. Thus, one segment was selected from the poorest fifth of the segments in the county, one segment was selected from the second poorest fifth, and so on, up to the richest fifth.

- Field interviewers were sent to each of the 150 segments to list every dwelling unit in the segment. This process created a frame for the sampling of dwelling units. The interviewers listed 27,833 dwelling units, an average of 186 per segment.

- Samples of dwelling units were selected from the lists using systematic random sampling. These dwelling units were visited by a field interviewer who conducted a brief screening interview with an adult occupant. The objective of the screening interview was to determine if the dwelling unit was eligible for the survey and, if so, which of the six age/type strata it belonged to. Screening was attempted on 2,978 dwelling units, an average of 20 per segment. Fifty-four percent of these dwelling units were determined to be eligible for the survey. Figure A-1 displays the distribution of the results of the screening efforts.

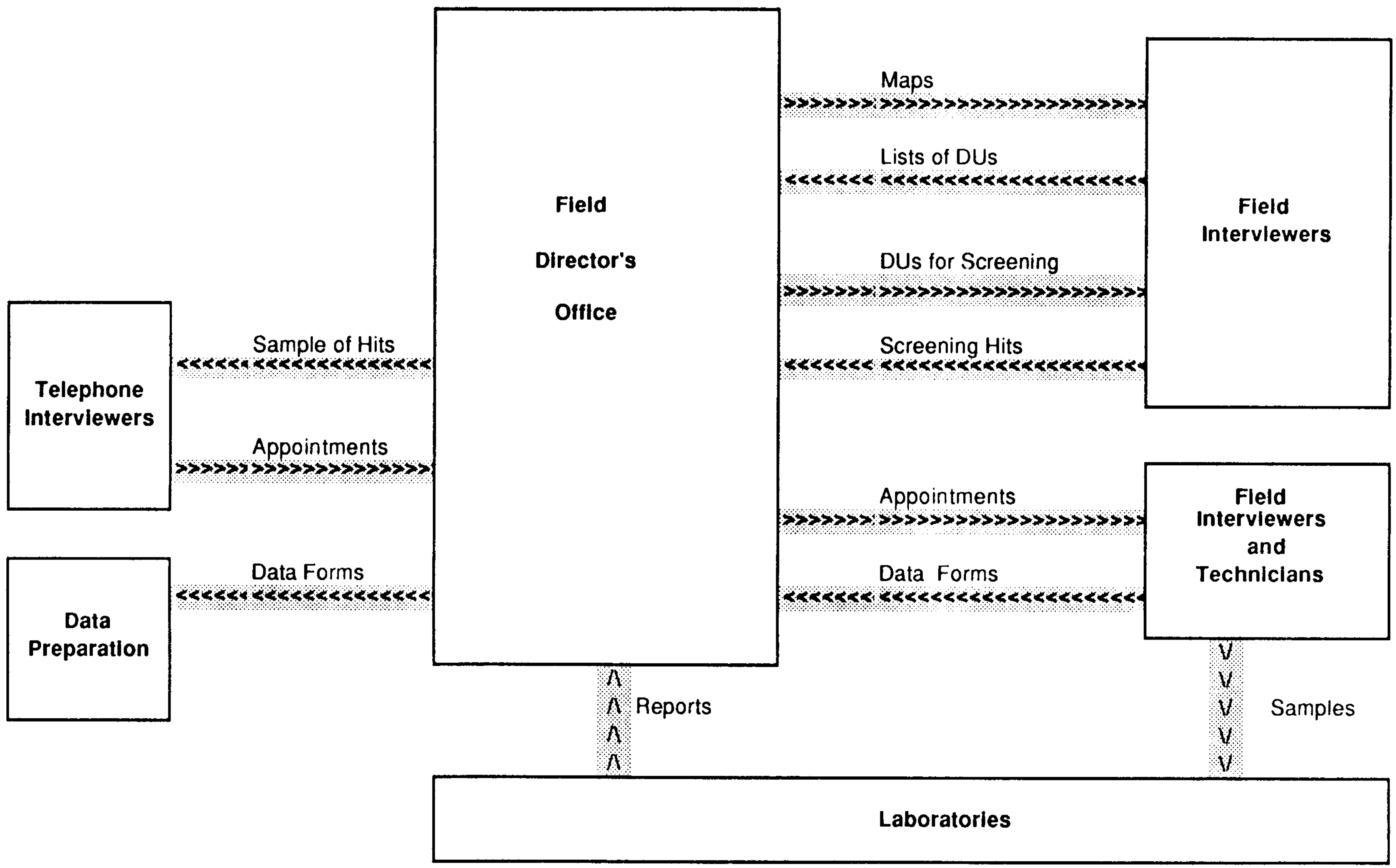
- A sample of dwelling units was randomly selected from the eligible homes according to the survey design in a manner that ensured that all eligible segments were represented in the sample. To allow for attrition (refusals, unable to contact, etc.), the initial sample size was inflated by about 60 percent, to 447 units. For 403 of these units, a reserve or backup unit was selected from the same county and design stratum. The backup was telephoned only if the primary unit failed to yield an appointment for an inspection visit.

- Telephone calls were made to the sampled homes to collect basic information about the dwelling unit and the occupants and to schedule an appointment to visit the dwelling unit. Ultimately, 607 units were telephoned, resulting in 332 appointments (55 percent).

- Inspection visits were completed with respondents who were willing to schedule an appointment and kept the appointment. An incentive of $50 was paid to each respondent who permitted a completed inspection. Inspection visits were completed in 284 private dwelling units, 86 percent of the appointments. Table A-3 displays the distribution of the completed inspections across the six design strata.

Management and control of this multistage design required the design and execution of a plan for the flow of information back and forth between the survey field director's office and the field. Figure A-2 displays the management plan.

FIGURE A-2
NATIONAL SURVEY OF LEAD-BASED PAINT: FLOW OF INFORMATION AND SAMPLES



In summary, the survey was conducted between December 1989 and March 1990 in 30 counties across the 48 contiguous states, selected to represent the entire U.S. housing stock, both public and privately owned. In addition to the 284 privately owned dwelling units in the final sample, 97 public housing units were inspected, for a total sample size of 381 dwelling units.

INSPECTION PROTOCOL

Resource limitations did not permit the complete identification, inspection, quantification, and testing of every painted surface in every inspected dwelling unit. Fortunately, the objectives of the study did not require such thorough inspections. It is possible in survey statistics to develop a good, clear picture of the aggregate population with only limited information on each sampled individual. Consequently, the limited inspection protocol described below was followed in each dwelling unit.

The inspection visits were performed by a two-person team: a field interviewer who interviewed the occupant and collected and recorded the information; and a technician who performed the x-ray fluorescence (XRF) testing and collected the dust and soil samples.

Interior Rooms

The rooms were inventoried and classified into wet and dry rooms according to the presence or absence of plumbing in the room. One wet room and one dry room were randomly selected. All painted surfaces in each of these two rooms were identified and quantified; the substrate materials were identified; the condition of the paint and substrate materials were noted. Quantification of painted surfaces was accomplished in different ways on different architectural components. For example, painted ceilings were quantified by recording their length and width in the field and using the computer to compute the area by multiplication. Trim was quantified by recording the length, assuming a typical width, and multiplying. Doors and windows were quantified by recording the number of each in the field and assuming an average painted surface area each. Table A-4 details the methodology for each component.

TABLE A-4
METHODOLOGY FOR ESTIMATING AREAS OF PAINTED COMPONENTS

Component	Data Recorded In Survey	Methodology for Estimating Painted Area
Interior		
Wall	Length, height; #doorways #windows, #fireplaces/other "holes"	Multiply; subtract 19 sq ft/doorway, 13 sq ft/window, and 16 sq ft per fireplace/other "hole".
Ceiling, floor	Length, width	Multiply.
Baseboard trim	Length	Assume width = 4 inches. Multiply.
Stair trim	Length	Assume width = 10 inches. Multiply.
Door trim	Length	Assume width = 4 inches. Multiply.
Window sills	Length	Assume width = 4 inches. Multiply.
Window trim	Length	Assume width = 4 inches. Multiply.
Crown molding	Length	Assume width = 7 inches. Multiply.
Doors	Number of doors	Assume 17 sq ft per door.
Window casing	Number of windows	Assume 5 sq ft per window.
Air/heat vents	Number of vents	Assume 1 sq ft per vent.
Radiators	Number of radiators	Assume 8 sq ft per radiator.
Shelves	Length	Assume width = 12 inches. Multiply.
Cabinets	Number of cabinets	Assume 6.25 sq ft per cabinet.
Fireplace	Number of fireplaces	Assume 16 sq ft per fireplace.
Closets	Number of closets	Assume 19 sq ft per closet.
Exterior		
Wall	Length, height	Multiply.
Window sills	Length	Assume width = 4 inches. Multiply.
Window trim	Length	Assume width = 4 inches. Multiply.
Soffit and Fascia	Length	Assume width = 20 inches. Multiply.
Door trim	Length	Assume width = 6 inches. Multiply.
Doors	Number of doors	Assume 21 sq ft per door.
Columns	Number of columns	Assume 20 sq ft per column.
Railings	Length	Assume width = 10 inches. Multiply.
Porch	Length	Assume width = 5 feet. Multiply.
Balcony	Number of balconies	Assume 24 sq ft per balcony.
Stairs	Number of steps	Assume 4 sq ft per step. Multiply.

Painted surfaces were stratified into four strata:

- Walls, ceiling, and floors;
- Trim on metal substrates (molding, window frames, door frames, etc.);
- Trim on nonmetal substrates; and
- Other (built-in shelves, cabinets, etc.)

Five components in each room were randomly selected to be tested for lead content. One component was selected from each of the four strata, with a fifth randomly selected from all four strata. The testing was accomplished by a portable XRF spectrum analyzer device that estimated the lead content of the paint.[3]

The spectrum analyzer XRFs were used because the National Institute of Standards and Technology (NIST) had determined them to be more accurate and more precise than the direct-reading XRFs used in earlier surveys,[4,5] but the spectrum analyzer XRF devices still have limitations. In particular, spectrum analyzer XRF measurements made over brick or concrete are less precise than those made over wood or plaster and, as used in the national survey, the XRF did not distinguish between paint lead on the surface and lead beneath the surface, e.g., old paint under new siding, or lead pipes. (See Appendix D for a summary of the two NIST reports.) These limitations notwithstanding, portable XRF technology was used because the survey was conducted in occupied dwellings--where it was not feasible to take paint scrapings for laboratory analysis.

Samples of dust were collected by vacuuming in three locations in each sampled room: the floor, a window sill, and a window well. In addition, a seventh dust sample was collected from the floor near the most-used entrance to the dwelling unit. The dust samples were sent to a laboratory to be

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[3]Consideration was given to scraping samples of paint for laboratory analysis. Laboratory analysis is more precise and accurate than in situ XRF. However, it requires damaging painted surfaces in peoples' homes. It was felt that the gain in measurement precision and accuracy would be more than offset by effects of a very large refusal rate.

[4]McKnight, Mary E.; Byrd, W. Eric; Roberts, Willard E.; and Lagergren, Eric S. (December 1989), *Methods for Measuring Lead Concentrations in Paint Films* (NISTIR 89-4209), U.S. Department of Commerce, National Institute of Standards and Technology.

[5]McKnight, Mary E.; Byrd, W. Eric; and Roberts, Willard E. (May 1990), *Measuring Lead Concentrations in Paint Using a Portable Spectrum Analyzer X-Ray Fluorescence Device* (NISTIR W90-650), U.S. Department of Commerce, National Institute of Standards and Technology.

analyzed for their lead content. Following the Federal Interim Guidelines, lead in dust was reported as a "loading", i.e., micrograms of dust per square foot of surface vacuumed (ug/ft^2).[6]

The interior portion of the inspection was completed by XRF testing of one or two purposively selected surfaces. The objective was to minimize the probability of missing lead-based paint in a home by testing the interior painted surface anywhere in the dwelling unit (not necessarily in the sampled wet and dry rooms) deemed most likely to contain lead. If the test failed to find lead, a second purposively selected surface was tested. If the second test also failed to find lead, purposive testing was terminated.

Exterior Wall

An exterior wall was randomly selected for inspection. All painted surfaces on the sampled wall were cataloged in the same manner as the interior rooms and subjected to XRF testing (four tests, one for each stratum of architectural components). Exterior purposive XRF tests were made using the same protocols as the interior purposive tests. Three exterior soil samples were collected: at the drip line along the sampled wall, at a remote location away from the building, and at the most-used entrance to the dwelling unit. The soil samples were sent to a laboratory for lead content analysis. Soil lead was reported as a concentration, i.e., micrograms of lead per gram of soil (ug/g), which is equivalent to parts per million (ppm). As discussed in the Federal guidelines, dust lead loadings and soil lead concentrations are not comparable units of measurement. It is not possible to convert from ug/ft^2 to ug/g in any consistently reliable way.

Common Areas

Common areas were inspected in multifamily residences. Two dust samples were taken from an interior common hall (if it existed); one just outside the sampled dwelling unit and one just inside the main entrance to the building. If the building had common rooms such as a mail room, laundry room, community room, etc., one was randomly selected and was inspected according to the protocol used for the wet and dry rooms. Finally, playgrounds were inspected. Each piece of

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[6]U.S. Department of Housing and Urban Development, "Lead-based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing," *Federal Register*, 55 (April 18):14557-14789.

playground equipment was quantified, described, and tested via XRF. Three soil samples were taken from the playgrounds.

PRECISION AND ACCURACY OF THE SURVEY DATA

This section presents a description of the response rates achieved in the national survey of lead-based paint in housing, the calculation of the sampling weights, and the precision and accuracy achieved for the survey data.

Response Rates

Tables A-5, A-6, and A-7 display the development of the sample by design stratum, from listing through screening, telephone interviewing, and inspection visits. Table A-5 gives counts of dwelling units by stratum at each stage; Table A-6 gives these counts as percentages of the design specifications in Table A-2; and Table A-7 gives the counts as percentages of the previous stage.

Table A-6a shows that about six single-family units passed the screener for each one needed in the final sample; but less than four multifamily units passed for each one needed. This differential continued through the later stages, despite efforts to overcome it by sampling multifamily homes at a higher rate, 39 percent v. 25 percent in the primary telephone sample (Table A-7b) and 51 percent v. 35 percent in the total telephone sample (Table A-7c). As a result of the differential in passing the screener, the design objectives were achieved for single-family units but there was a shortfall of 17 multifamily units.

Response rates are generally calculated and reported as the ratio of the number of completed cases to the number of eligible cases sampled and worked (attempts made to contact a respondent and solicit his/her participation in the study). Cases whose eligibility status are unknown are often apportioned between eligible and ineligible cases.

This approach was applied to the response data in Figure A-1 to obtain the overall response rates at each stage of the survey: screening stage--62 percent; telephone interviews--65 percent; and

TABLE A-5
DEVELOPMENT OF SAMPLE FROM SCREENING
THROUGH COMPLETED INSPECTION

a. Completed and Passed Screener

Type	Construction Year			Total
	1960-1979	1940-1959	pre-1940	
Single Family	432	483	436	1,351
Multifamily	134	55	82	271
Total	566	538	518	1,622

b. Primary Sample for Telephone Interview

Type	Construction Year			Total
	1960-1979	1940-1959	pre-1940	
Single Family	155	95	91	341
Multifamily	47	31	28	106
Total	202	126	119	447

c. Total Sample Worked for Telephone Interview

Type	Construction Year			Total
	1960-1979	1940-1959	pre-1940	
Single Family	199	149	121	469
Multifamily	59	39	40	138
Total	258	188	161	607

d. Appointments - Telephone Interview

Type	Construction Year			Total
	1960-1979	1940-1959	pre-1940	
Single Family	112	80	71	263
Multifamily	35	16	18	69
Total	147	96	89	332

e. Completed Inspection Visits

Type	Construction Year			Total
	1960-1979	1940-1959	pre-1940	
Single Family	94	72	61	227
Multifamily	26	15	16	57
Total	120	87	77	284

TABLE A-6
DEVELOPMENT OF SAMPLE FROM SCREENING THROUGH
COMPLETED INSPECTION AS A PERCENT
OF THE DESIGN SPECIFICATIONS

a. Passed Screener - Pct of Design

Type	Construction Year			All
	1960-1979	1940-1959	pre-1940	
Single Family	415%	767%	739%	598%
Multifamily	394%	262%	432%	366%
All	410%	640%	664%	541%

b. Primary Phone Sample - Pct of Design

Type	Construction Year			All
	1960-1979	1940-1959	pre-1940	
Single Family	149%	151%	154%	151%
Multifamily	138%	148%	147%	143%
All	146%	150%	153%	149%

c. Total Phone Sample - Pct of Design

Type	Construction Year			All
	1960-1979	1940-1959	pre-1940	
Single Family	191%	237%	205%	208%
Multifamily	174%	186%	211%	186%
All	187%	224%	206%	202%

d. Appointments - Pct of Design

Type	Construction Year			All
	1960-1979	1940-1959	pre-1940	
Single Family	108%	127%	120%	116%
Multifamily	103%	76%	95%	93%
All	107%	114%	114%	111%

e. Completed Inspections - Pct of Design

Type	Construction Year			All
	1960-1979	1940-1959	pre-1940	
Single Family	90%	114%	103%	100%
Multifamily	76%	71%	84%	77%
Total	87%	104%	99%	95%

TABLE A-7
DEVELOPMENT OF SAMPLE FROM SCREENING THROUGH COMPLETED INSPECTION AS A PERCENT OF THE PRIOR STAGE

a. Passed Screener - Pct of Population

Type	Construction Year 1960-1979	1940-1959	pre-1940	All
Single Family	1.5%	2.6%	2.4%	2.0%
Multifamily	2.0%	3.3%	3.3%	2.5%
All	1.6%	2.6%	2.5%	2.1%

b. Primary Phone Sample - Pct of Passed Screener

Type	Construction Year 1960-1979	1940-1959	pre-1940	All
Single Family	36%	20%	21%	25%
Multifamily	35%	56%	34%	39%
All	36%	23%	23%	28%

c. Total Phone Sample - Pct of Passed Screener

Type	Construction Year 1960-1979	1940-1959	pre-1940	All
Single Family	46%	31%	28%	35%
Multifamily	44%	71%	49%	51%
All	46%	35%	31%	37%

d. Appointments - Pct of Total Phone Sample

Type	Construction Year 1960-1979	1940-1959	pre-1940	All
Single Family	56%	54%	59%	56%
Multifamily	59%	41%	45%	50%
All	57%	51%	55%	55%

e. Completed Inspections - Pct of Appointments

Type	Construction Year 1960-1979	1940-1959	pre-1940	All
Single Family	84%	90%	86%	86%
Multifamily	74%	94%	89%	83%
Total	82%	91%	87%	86%

inspections--90 percent. Tables A-7d and A-7e show that there was little variation in the telephone and inspection stage response rates across the six design strata.

The major component of nonresponse at the screening stage was the difficulty of finding people at home to conduct the screening interview. These cases accounted for 22 percent of all dwelling units attempted. On the other hand, screening interviews were successfully completed with 80 percent of the eligible cases found at home.

A significant number of the refusals at the telephone interview stage were due to respondents' inability or unwillingness to schedule a visit by the field team during the 1-to-2-week period the field team would be in town. On the other hand, most respondents who made appointments kept them.

Weighting

In a complex survey it is necessary to apply sampling weights to each completed case.[7] A dwelling unit's sampling weight is, roughly, the number of pre-1980 dwelling units nationwide "represented" by the inspected unit. Sampling weights were calculated in this survey for two major reasons.

First, there was disproportionate sampling in the six design strata; multifamily dwelling units were sampled at about twice the rate as single family units (see Tables A-1 and A-2). Weights are therefore necessary to produce unbiased estimates. These initial weights are the ratios of the numbers in corresponding cells in Tables A-1 and A-2.

Second, the initial weights are often adjusted to balance differences in nonresponse and noncoverage. There were significant differences in the response rates in identifiable components of this sample. Specifically, homes with children under age 7 are overrepresented in the sample: while these homes represent 18 percent of the nation, they represent 32 percent of the sample. In addition, the regional distribution of the sample is disproportionate; the South is overrepresented while the West and Northeast are underrepresented. The weights were therefore adjusted so that the estimated numbers of dwelling units with children under age 7 would agree with the estimate in

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[7]Kish, L. (1965), *Survey Sampling*, (New York: John Wiley and Sons), Chapter 11.

the 1987 American Housing Survey (13,912,000 units), and so that the estimated numbers of dwelling units in each of the four census regions would also agree with that survey.[8]

Confidence Intervals

A complex survey with geographically clustered sampling and differential weights typically has less precision than an unclustered sample with equal selection probabilities (and equal weights) for all sampled units. The effect of the design on the precision of the data is called the *design effect*. The design effect is the ratio of the actual size sample to the size of a self-weighted sample with the same precision.[9] For example, if the sample size is 750 and the design effect is 1.5, then the precision is the same as a self-weighted sample of size 500. The advantages gained by utilizing a complex design (which may be considerable) were obtained at the cost of 250 units in the "effective" sample size.

Approximate design effects were calculated for the national survey of lead-based paint in housing, and for selected subsets of the sample. Table A-8 presents the approximate design effects (1.45 for the overall sample) and the impact of the design effect on the widths of confidence intervals.[10] Overall, confidence interval widths increase by approximately 20 percent (the square root of the design effect). Thus, an estimated percentage, e.g., percentage of dwelling units with interior lead-based paint, based on the entire private housing sample of 284 would have a 95 percent confidence interval half-width of $\pm$ 6 percent if the sample were self-weighting. In actuality, the confidence interval is 20 percent wider, $\pm$ 7 percent.

Table A-8 also shows that estimates based upon subsets of the sample often have rather wide confidence intervals. For example, any estimate of a percentage based on pre-1940 homes will have a confidence interval of up to $\pm$ 16 percent. Estimates based upon subsets of the sample, especially smaller subsets, should be interpreted cautiously.

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[8]The sampling weights include Alaska and Hawaii, even though these two States were excluded from the sample. This difference has a negligible impact on the weights.

[9]Kish, L. *Survey Sampling*, Chapter 3.

[10]Table A-8 presents the half-width of the confidence intervals; the amount to be added and subtracted from the point estimate to give the upper and lower confidence limits.

TABLE A-8
APPROXIMATE DESIGN EFFECTS AND CONFIDENCE INTERVALS
BY SELECTED CHARACTERISTICS

Characteristic	Total Dwelling Units (1) (000s)	Number of Dwelling Units in Sample	Approximate Design Effect	Confidence Intervals (2) Increase In Width Due to Design	Half-Width For A Self-Weighted Sample	Half-Width For This Sample
Total Dwelling Units Built Before 1980	77,179	284	1.45	20%	6%	7%
Construction Year						
1960-1979	35,686	120	1.21	10%	9%	10%
1940-1959	20,473	87	1.13	6%	11%	11%
Before 1940	21,020	77	2.12	46%	11%	16%
Single Family	66,418	227	1.44	20%	7%	8%
Built 1960-1979	29,137	94	1.23	11%	10%	11%
Built 1940-1959	18,782	72	1.08	4%	12%	12%
Built before 1940	18,499	61	2.08	44%	13%	18%
Multifamily	10,761	57	1.21	10%	13%	14%
One or More Children Under Age 7	13,914	90	1.22	10%	10%	11%
Single family	12,391	75	1.20	10%	11%	12%
Multifamily	1,523	15	1.09	4%	25%	26%
Built 1960-1979	6,638	40	1.20	10%	15%	17%
Built 1940-1959	3,386	15	1.12	6%	25%	27%
Built before 1940	3,890	35	1.04	2%	17%	17%
No Child Under Age 7	63,265	194	1.35	16%	7%	8%
Single family	54,027	152	1.33	15%	8%	9%
Multifamily	9,238	42	1.13	6%	15%	16%

(1) Total dwelling units are from the 1987 American Housing Survey.

(2) The confidence interval half-width is the maximum half-width of a 95% confidence interval for a percentage. For example, a 95% confidence interval for the percentage of all dwelling units with lead-based paint in the interior would be 51% +/_6%, or 45% to 57%, for a self-weighted sample; and is 51% +/-7%, or 44% to 58%, for this sample.

APPENDIX B

SELECTED DATA TABLES FROM THE NATIONAL SURVEY OF LEAD-BASED PAINT IN HOUSING

TABLE B-1
ESTIMATED NATIONAL TOTAL AMOUNTS
OF LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES
BY SELECTED CHARACTERISTICS FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)
(National Total Amounts Represent Millions of Sq. Ft.)

Characteristic	Condition of Interior Paint			Total Amount LBP
	Paint Intact	Paint Not Intact	Under Wallpaper	
Total Housing Units Built Before 1980	20,018	2,006	582	22,606
One or More Children Under Age 7	2,228	904	251	3,383
Construction Year				
1960-1979	2,053	455	0	2,508
1940-1959	4,611	301	185	5,097
Before 1940	13,354	1,250	397	15,001
Housing Type				
Single Family	18,642	1,955	542	21,139
Built 1960-1979	1,850	455	0	2,305
Built 1940-1959	4,233	290	145	4,668
Built before 1940	12,559	1,210	397	14,166
Multifamily	1,378	52	40	1,469
Built 1960-1979	203	1	0	204
Built 1940-1959	378	11	40	429
Built before 1940	795	40	0	835

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-2
ESTIMATED AVERAGE AMOUNTS
OF LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES
BY SELECTED CHARACTERISTICS FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)
(Amounts Represent Sq. Ft.)

Characteristic	Condition of Interior Paint: Paint Intact	Paint Not Intact	Under Wallpaper	Total Amount LBP
Total Housing Units Built Before 1980	508	51	15	574
One or More Children Under Age 7	317	129	36	482
Construction Year				
1960-1979	139	31	0	170
1940-1959	382	25	15	422
Before 1940	1,062	99	32	1,193
Housing Type				
Single Family	540	57	16	613
Built 1960-1979	151	37	0	188
Built 1940-1959	387	27	13	427
Built before 1940	1,108	107	35	1,250
Multifamily	283	11	1	295
Built 1960-1979	81	0	0	81
Built 1940-1959	335	10	35	380
Built before 1940	640	32	0	672

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-3
ESTIMATED NATIONAL TOTAL AMOUNTS
OF LEAD-BASED PAINT (LBP) ON EXTERIOR SURFACES
BY SELECTED CHARACTERISTICS FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)
(National Total Amounts Represent Millions of Sq. Ft.)

Characteristic	Condition of Exterior Paint		Total Amount LBP
	Paint Intact	Paint Not Intact	
Total Housing Units Built Before 1980	34,602	8,112	42,714
One or More Children Under Age 7	3,950	1,283	5,233
Construction Year			
1960-1979	7,248	562	7,810
1940-1959	10,779	1,982	12,761
Before 1940	16,575	5,568	22,143
Housing Type			
Single Family	32,428	7,937	40,365
Built 1960-1979	7,091	498	7,589
Built 1940-1959	10,687	1,944	12,631
Built before 1940	14,650	5,495	20,145
Multifamily	2,181	167	2,348
Built 1960-1979	157	64	221
Built 1940-1959	92	38	130
Built before 1940	1,925	73	1,998

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-4
ESTIMATED AMOUNTS OF LEAD-BASED PAINT (LBP)
PER HOUSING UNIT ON EXTERIOR SURFACES
BY SELECTED CHARACTERISTICS FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)
(Amounts Represent Sq. Ft.)

Characteristic	Condition of Exterior Paint: Paint Intact	Condition of Exterior Paint: Paint Not Intact	Total Amount LBP
Total Housing Units Built Before 1980	741	174	915
One or More Children Under Age 7	498	162	660
Construction Year			
1960-1979	481	37	518
1940-1959	697	128	825
Before 1940	998	335	1,333
Housing Type			
Single Family	803	197	1,000
Built 1960-1979	651	46	697
Built 1940-1959	744	135	879
Built before 1940	970	363	1,333
Multifamily	346	26	372
Built 1960-1979	41	17	58
Built 1940-1959	91	38	129
Built before 1940	1,306	50	1,356

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-5
ESTIMATED NUMBER OF PRIVATELY OWNED HOUSING UNITS BUILT BEFORE 1980 WITH LEAD-BASED PAINT BY SELECTED CHARACTERISTICS
(Paint Lead Concentration >= 0.7 mg/sq cm)

Characteristic	Total Housing Units (000) (1)	Housing Units With Lead-Based Paint Anywhere in Building		Number of Housing Units in Sample
		Percent	Number (000)	
Total Housing Units Built Before 1980	77,177	86% (5%)	66,321 (3,745)	284
One or More Children Under Age 7	13,912	82% (9%)	11,358 (1,224)	90
Construction Year				
1960-1979	35,681	80% (8%)	28,545 (2,809)	120
1940-1959	20,476	87% (7%)	17,814 (1,534)	87
Before 1940	21,018	94% (8%)	19,661 (1,685)	77
Housing Type				
Single Family	66,418	86% (5%)	56,953 (3,624)	227
Multifamily	10,759	87% (10%)	9,368 (1,031)	57

(1) Total units data are from the 1987 American Housing Survey.

Note: Numbers in parentheses are approximate half-widths of 95% confidence intervals for the estimated percents and numbers. For example, the approximate 95% confidence interval for the percent of housing units with some lead-based paint is 86% +/- 5% or 81% to 91%.

TABLE B-6
ESTIMATED NUMBER OF PRIVATELY OWNED HOUSING UNITS
BUILT BEFORE 1980 WITH LEAD-BASED PAINT BY SELECTED CHARACTERISTICS
(Paint Lead Concentration >= 1.2 mg/sq cm)

Characteristic	Total Housing Units (000) (1)	Housing Units With Lead-Based Paint Anywhere in Building		Number of Housing Units in Sample
		Percent	Number (000)	
Total Housing Units Built Before 1980	77,177	63% (7%)	48,443 (5,207)	284
One or More Children Under Age 7	13,912	64% (11%)	8,885 (1,519)	90
Construction Year				
1960-1979	35,681	47% (10%)	16,770 (3,505)	120
1940-1959	20,476	74% (10%)	15,152 (2,001)	87
Before 1940	21,018	79% (13%)	16,604 (2,792)	77
Housing Type				
Single Family	66,418	63% (8%)	42,147 (4,993)	227
Multifamily	10,759	59% (14%)	6,296 (1,514)	57

(1) Total units data are from the 1987 American Housing Survey.

Note: Numbers in parentheses are approximate half-widths of 95% confidence intervals for the estimated percents and numbers. For example, the approximate 95% confidence interval for the percent of housing units with some lead-based paint is 63% +/- 7% or 56% to 70%.

TABLE B-7
ESTIMATED NUMBER OF PRIVATELY OWNED HOUSING UNITS BUILT BEFORE 1980 WITH LEAD-BASED PAINT BY SELECTED CHARACTERISTICS
(Paint Lead Concentration >= 2.0 mg/sq cm)

Characteristic	Total Housing Units (000) (1)	Housing Units With Lead-Based Paint Anywhere in Building		Number of Housing Units in Sample
		Percent	Number (000)	
Total Housing Units Built Before 1980	77,177	43% (7%)	32,888 (5,327)	284
One or More Children Under Age 7	13,912	43% (11%)	6,040 (1,567)	90
Construction Year				
1960-1979	35,681	18% (8%)	6,423 (2,698)	120
1940-1959	20,476	52% (11%)	10,648 (2,279)	87
Before 1940	21,018	75% (14%)	15,693 (2,981)	77
Housing Type				
Single Family	66,418	44% (8%)	29,480 (5,151)	227
Multifamily	10,759	32% (13%)	3,408 (1,429)	57

(1) Total units data are from the 1987 American Housing Survey.

Note: Numbers in parentheses are approximate half-widths of 95% confidence intervals for the estimated percents and numbers. For example, the approximate 95% confidence interval for the percent of housing units with some lead-based paint is 43% +/- 7% or 36% to 50%.

TABLE B-8
LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES BY SUBSTRATE FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Substrate	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint)	Amount LBP per Housing Unit With LBP (square feet)
Wood, Smooth	8,296	20%	213
Plaster	6,130	11%	157
Gypsum (Drywall)	3,135	3%	80
Wood, Rough	2,841	78%	73
Metal, Smooth	1,141	35%	29
Wallpaper	594	11%	15
Ceiling Tile	225	11%	6
Concrete Block	100	5%	3
Concrete Cast	59	2%	2
Metal, Rough	30	9%	1
Wainscot	23	10%	1
Other	24	0%	1
Brick	12	19%	0
Total	22,609	9%	580

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-9
LEAD-BASED PAINT (LBP) ON EXTERIOR SURFACES
BY SUBSTRATE FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Substrate	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint)	Amount LBP per Housing Unit With LBP (square feet)
Wood, Smooth	20,860	38%	444
Aluminum Siding (1)	4,033	59%	86
Concrete Block	3,637	53%	77
Metal, Smooth	2,637	31%	56
Other	2,572	64%	55
Brick	2,454	69%	52
Shingle, Wood	2,288	32%	49
Shingle, Asbestos	1,587	47%	34
Vinyl Siding (2)	1,119	28%	24
Stucco	647	9%	14
Gypsum (Drywall)	382	56%	8
Wood, Rough	284	14%	6
Concrete Cast	106	15%	2
Wainscot	50	100%	1
Metal, Rough	38	5%	1
Concrete, Precast	19	5%	0
Stone	1	100%	0
Total	42,715	39%	909

(1) Factory-applied paint on aluminum siding is typically lead-free. However, lead-based paint under aluminum siding will be detected by XRF testing of the siding. The national survey methodology does not permit the disaggregation into lead-based paint on the aluminum siding and under the aluminum siding.

(2) Results for vinyl siding have the same uncertainty as those for aluminum siding.

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-8
LEAD-BASED PAINT (LBP) ON INTERIOR SURFACES
BY SUBSTRATE FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Substrate	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint)	Amount LBP per Housing Unit With LBP (square feet)
Wood, Smooth	8,296	20%	213
Plaster	6,130	11%	157
Gypsum (Drywall)	3,135	3%	80
Wood, Rough	2,841	78%	73
Metal, Smooth	1,141	35%	29
Wallpaper	594	11%	15
Ceiling Tile	225	11%	6
Concrete Block	100	5%	3
Concrete Cast	59	2%	2
Metal, Rough	30	9%	1
Wainscot	23	10%	1
Other	24	0%	1
Brick	12	19%	0
Total	22,609	9%	580

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-9
LEAD-BASED PAINT (LBP) ON EXTERIOR SURFACES BY SUBSTRATE FOR PRIVATELY OWNED HOUSING UNITS
(LBP Concentration >= 1.0 mg/sq cm)

Substrate	National Total Amount of LBP (millions of sq ft)	National Total Amount of LBP (percent of all paint)	Amount LBP per Housing Unit With LBP (square feet)
Wood, Smooth	20,860	38%	444
Aluminum Siding (1)	4,033	59%	86
Concrete Block	3,637	53%	77
Metal, Smooth	2,637	31%	56
Other	2,572	64%	55
Brick	2,454	69%	52
Shingle, Wood	2,288	32%	49
Shingle, Asbestos	1,587	47%	34
Vinyl Siding (2)	1,119	28%	24
Stucco	647	9%	14
Gypsum (Drywall)	382	56%	8
Wood, Rough	284	14%	6
Concrete Cast	106	15%	2
Wainscot	50	100%	1
Metal, Rough	38	5%	1
Concrete, Precast	19	5%	0
Stone	1	100%	0
Total	42,715	39%	909

(1) Factory-applied paint on aluminum siding is typically lead-free. However, lead-based paint under aluminum siding will be detected by XRF testing of the siding. The national survey methodology does not permit the disaggregation into lead-based paint on the aluminum siding and under the aluminum siding.

(2) Results for vinyl siding have the same uncertainty as those for aluminum siding.

Note: Because of rounding, totals may not be exactly the same as the sums of the numbers.

TABLE B-10
ESTIMATED NUMBER OF HOUSING UNITS REQUIRING ABATEMENT UNDER SIX STANDARDS FOR ABATEMENT, BY OWNERSHIP
(Numbers Represent Thousands of Housing Units)

Standard for Abatement	Renter Occupied	Owner Occupied	All Units
Lead in Paint (1)	19,120	38,251	57,371
Lead in Paint and Paint Nonintact (1, 2)	2,558	11,262	13,820
Lead in Paint and Lead Dust Present (1, 3)	3,041	6,910	9,951
Lead in Paint and Child Present (1, 4)	3,871	6,032	9,903
Lead in Paint, Paint Nonintact, and Child Present (1, 2, 4)	836	2,302	3,138
Lead in Paint, Lead Dust Present, and Child Present (1, 3, 4)	426	1,131	1,557

(1) Lead-based paint concentration of at least 1.0 mg/sq cm

(2) At least 5 sq ft of defective lead-based paint.

(3) Lead in dust exceeds 200 ug/ sq ft for floors, or 500 ug/sq ft for window sills, or 800 ug/sq ft for window wells.

(4) Children under 7 years of age.

TABLE B-11
SAMPLE SIZES FOR ESTIMATED NUMBER OF HOUSING UNITS REQUIRING ABATEMENT UNDER SIX STANDARDS FOR ABATEMENT, BY OWNERSHIP

Standard for Abatement	Renter Occupied	Owner Occupied	All Units
Lead in Paint (1)	82	125	207
Lead in Paint and Paint Nonintact (1, 2)	13	33	46
Lead in Paint and Lead Dust Present (1, 3)	11	17	28
Lead in Paint and Child Present (1, 4)	29	38	67
Lead in Paint, Paint Nonintact, and Child Present (1, 2, 4)	7	14	21
Lead in Paint, Lead Dust Present, and Child Present (1, 3, 4)	3	7	10

(1) Lead-based paint concentration of at least 1.0 mg/sq cm

(2) At least 5 sq ft of defective lead-based paint.

(3) Lead in dust exceeds 200 ug/ sq ft for floors, or 500 ug/sq ft for window sills, or 800 ug/sq ft for window wells.

(4) Children under 7 years of age.

TABLE B-12

CORRELATION MATRIX FOR PAINT, DUST, AND SOIL VARIABLES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Paint lead on walls/trim of dry room		.1756	.2475	.2082	.4569	.1771	.1671	.2308	.1202	.1823	.1833	.1336	.2017
		.0019	.0002	.0386	.0001	.0016	.0247	.0333	.0233	.0010	.0019	.0157	.0007
		270	208	73	284	275	139	64	275	284	249	260	253
(2) Dust lead on floor of dry room	.1756		.5089	.3862	.1346	.5573	.3461	.1372	.5463	.1166	.2652	.3083	.2599
	.0019		.0001	.0005	.0135	.0001	.0001	.1439	.0001	.0278	.0001	.0001	.0001
	270		204	70	270	266	136	62	266	270	237	249	241
(3) Dust lead on window sill of dry room	.2475	.5089		.4587	.1588	.3749	.4433	.4534	.4253	.2020	.2499	.3044	.2027
	.0002	.0001		.0001	.0110	.0001	.0001	.0003	.0001	.0017	.0003	.0001	.0026
	208	204		65	208	206	128	55	205	208	187	196	189
(4) Dust lead in window well of dry room	.2082	.3862	.4587		.3463	.3398	.5099	.5390	.3606	.3167	.4167	.4402	.4507
	.0386	.0005	.0001		.0014	.0017	.0002	.0002	.0010	.0032	.0004	.0001	.0001
	73	70	65		73	73	47	39	71	73	62	68	65
(5) Paint lead on walls/trim of wet room	.4569	.1346	.1588	.3463		.1059	.3664	.3047	.1305	.3272	.3650	.2771	.3328
	.0001	.0135	.0110	.0014		.0398	.0001	.0072	.0153	.0001	.0001	.0001	.0001
	284	270	208	73		275	139	64	275	284	249	260	253
(6) Dust lead on floor of wet room	.1771	.5573	.3749	.3398	.1059		.4066	.3140	.4234	.1573	.1538	.1893	.1983
	.0016	.0001	.0001	.0017	.0398		.0001	.0061	.0001	.0045	.0082	.0012	.0009
	275	266	206	73	275		139	63	273	275	243	255	247
(7) Dust lead on window sill of wet room	.1671	.3461	.4433	.5099	.3664	.4066		.4383	.3030	.2105	.2640	.3618	.3079
	.0247	.0001	.0001	.0002	.0001	.0001		.0007	.0002	.0065	.0014	.0001	.0002
	139	136	128	47	139	139		51	138	139	126	130	127
(8) Dust lead in window well of wet room	.2308	.1372	.4534	.5390	.3047	.3140	.4383		.3671	.2280	.4362	.3951	.4342
	.0333	.1439	.0003	.0002	.0072	.0061	.0007		.0016	.0350	.0004	.0009	.0003
	64	62	55	39	64	63	51		63	64	57	60	59
(9) Dust lead on floor of entrance	.1202	.5463	.4253	.3606	.1305	.4234	.3030	.3671		.1870	.2521	.3296	.3334
	.0233	.0001	.0001	.0010	.0153	.0001	.0002	.0016		.0009	.0001	.0001	.0001
	275	266	205	71	275	273	138	63		275	243	255	247
(10) Paint lead on walls of exterior	.1823	.1166	.2020	.3167	.3272	.1573	.2105	.2280	.1870		.4067	.3802	.3964
	.0010	.0278	.0017	.0032	.0001	.0045	.0065	.0350	.0009		.0001	.0001	.0001
	284	270	208	73	284	275	139	64	275		249	260	253
(11) Soil lead at drip line	.1833	.2652	.2499	.4167	.3650	.1538	.2640	.4362	.2521	.4067		.7155	.6793
	.0019	.0001	.0003	.0004	.0001	.0082	.0014	.0004	.0001	.0001		.0001	.0001
	249	237	187	62	249	243	126	57	243	249		246	243
(12) Soil lead near entrance	.1336	.3083	.3044	.4402	.2771	.1893	.3618	.3951	.3296	.3802	.7155		.6099
	.0157	.0001	.0001	.0001	.0001	.0012	.0001	.0009	.0001	.0001	.0001		.0001
	260	249	196	68	260	255	130	60	255	260	246		247
(13) Soil lead at remote location	.2017	.2599	.2027	.4507	.3328	.1983	.3079	.4342	.3334	.3964	.6793	.6099	
	.0007	.0001	.0026	.0001	.0001	.0009	.0002	.0003	.0001	.0001	.0001	.0001	
	253	241	189	65	253	247	127	59	247	253	243	247	

Note: **In each set of table entries, the top number is the correlation coefficient, the middle number is the probability coefficient, and the bottom number is number of observations used in the calculation.**

TABLE B-13
ASSOCIATION BETWEEN LEAD IN SOIL AND EXTERIOR LEAD-BASED PAINT CONDITION FOR PRIVATELY OWNED HOUSING UNITS
(Numbers Represent Thousands of Housing Units)

Presence and Condition of Exterior Lead-Based Paint	Lead in Soil															
	Entrance				Drip line				Remote				Any Location			
	Within Guideline (1)		Exceeding Guideline (1)		Within Guideline (1)		Exceeding Guideline (1)		Within Guideline (1)		Exceeding Guideline (1)		Within Guideline (1)		Exceeding Guideline (1)	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
No LBP	29,436	93%	2,069	7%	29,937	95%	1,567	5%	31,293	99%	211	1%	29,563	94%	1,941	6%
LBP Present, Intact	32,342	90%	3,431	10%	30,322	85%	5,451	15%	32,625	91%	3,148	9%	28,415	79%	7,358	21%
LBP Present, Not Intact	6,030	61%	3,871	39%	4,670	47%	5,232	53%	7,969	80%	1,932	20%	5,145	52%	4,756	48%
Total	67,808	88%	9,371	12%	64,929	84%	12,250	16%	71,887	93%	5,291	7%	63,123	82%	14,055	18%

(1) The guideline is 500 ppm. See EPA, Interim Guidance.

Note: The chi-square tests of association between the soil lead and the exterior lead-based paint condition are: entrance = 14.77; drip line = 27.06; and remote = 12.07. All are significant at the $p = .01$ level.

APPENDIX C

COST ESTIMATION METHODOLOGY

Estimation of the costs of lead-based paint abatement was carried out using data from the lead-based paint abatement demonstration, from the national survey, and from the American Housing Survey.

The first step in the estimation of costs was the collection of data on labor hours and use of materials during the abatement of lead-based paint hazards in Federal Housing Administration-owned units in the Department of Housing and Urban Development's lead-based paint abatement demonstration. Data on labor hours expended were acquired by having industrial hygienists record the activities of each worker onsite at intervals of approximately 2 hours during the course of the working day. The information provided identified the building component and the method of abatement with which each worker was occupied at the time the observation was made. Data on the quantity and cost of materials used on each dwelling unit were supplied by the contractor.

The number of labor hours required to abate lead-based paint hazards was estimated on a per-square-foot basis for each building component type for each method of abatement employed. Estimation of average labor hours per square foot was performed using ratio estimators. For example, the total number of labor hours expended on removal of lead-based paint from the interior walls using chemical strippers was estimated by multiplying the number of observations on workers removing paint from interior walls using chemical strippers by the average interval between observations and summing the results. This quantity was then divided by the total number of square feet of interior walls on which chemical strippers were used to obtain an estimate of the average number of labor hours required to chemically strip an interior wall. The same procedure, using labor hours multiplied by hourly wage rates in the numerator, was used to estimate average costs per square foot for chemical stripping of interior walls.[1]

The classification of worker activities included some that did not identify a specific building component being abated. These activities included mobilization, setup, breaks, and cleanup

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[1]Ratio estimates such as these present a technical problem when it comes to estimating their sampling variance. There is a second-order approximation for the variance which is widely used. Let R denote the ratio estimator:

$$R = x / y$$

and y respectively denote the sample means of costs and square feet for a given building component and abatement method. Then:

$$S^2(R) = (ny^2)^{-1} [S^2(x) + R^2S^2(y) - 2 R \, Cov(x,y)]$$

where S^2 and Cov denote the sample variance and covariance respectively; see William G. Cochran (1977), *Sampling Techniques*, 3rd ed. (Wiley), p. 155.

activities. The labor costs of these other activities were regressed on the labor costs of abatement activities incurred under each of the six unit abatement strategies to obtain estimates of the amounts by which the labor costs directly associated with abatement should be marked up to obtain estimates of total labor costs. In the regression, the constant term which was statistically insignificant, was suppressed to permit full allocation of labor costs to the building components abated.

Data on materials use and prices were provided by the contractors for each dwelling unit abated. Average direct materials costs per square foot were then computed by dividing the total costs of materials used in each method (e.g., encapsulants, chemical strippers, replacement building components) by the total number of square feet abated by that method. The costs of materials which could not be directly attributed to a particular abatement method (e.g., polyurethane sheeting, respirators) were regressed on the number of square feet abated under each of the six unit abatement strategies to obtain estimates of the per-square-foot costs of other materials. Again, the constant term in the regression was suppressed.

The last step in the process involved the computation of overhead and profit for each of the dwelling units. This was done by subtracting estimated labor and materials costs from the contract price. The product of this exercise was a set of per-square-foot cost estimates for each type of building component for each of the possible methods of abatement.

Estimates of the average quantities of components requiring abatement under each of four possible combinations of no dust lead/dust lead and no peeling paint/peeling paint were then obtained from the national survey database. Multiplying the per-square-foot cost estimates for each component type and summing across component types provided the average costs per dwelling unit for each of the four hazard criteria. This was done separately for each of the six unit abatement strategies.

Development of the national cost estimates was carried out using a Markov model of the pre-1980 national housing stock. A 5 x 5 2-year transition probability matrix was constructed from the 1985 and 1987 American Housing Survey data. The square root of this matrix was then obtained to provide the 12-month transition probabilities. The five "states" in the matrix were:

- Owner-occupied: No child under 7 present.

- Owner-occupied: Child under 7 present.
- Rental: No child under 7 present.
- Rental: Child under 7 present.
- Vacant/Off-market/Retired.

This matrix was then converted to a 10 x 10 matrix by introducing the additional dichotomy of lead hazard present/lead hazard not present. The probability that a unit with a lead hazard present would become a unit with no lead hazard present was determined by the annual number of units to be abated and by the number of units with lead hazards. Because this probability may change from year to year, it was necessary to construct 10 such matrices to model the 10-year period 1991-2000.

The model was run for each of the eight possible lead hazard criteria by selecting the constant annual rate of abatement (number of units abated per annum) that would eliminate all lead hazards by the year 2000. In those cases where the definition of a lead hazard includes a requirement that a child below age 7 be present, this means that hazardous units which are occupied by households without children or which are vacant will exist after 2000 and that continuing expenditures will be necessary as these units become occupied by families with children. For each of the scenarios run, the number of child-years of exposure to lead hazards was calculated to provide a measure of efficacy.

APPENDIX D

LEAD-BASED PAINT SCREENING AND MEASUREMENT

Under an Interagency Agreement executed in September 1988 between the Department of Housing and Urban Development (HUD) and the National Institute of Standards and Technology (NIST), NIST carried out studies to investigate the technology available for detecting (screening) and measuring the amount of lead in paint, safety considerations in testing, and the availability of qualified personnel. The results of this research have been published in two NIST reports. The first report[1] is a comprehensive description of the research; the second report[2] is a supplemental report on the evaluation of a spectrum analyzer x-ray fluorescence (XRF) device that was not available for inclusion in the investigations reported in the first publication.

This appendix summarizes the two NIST reports and describes the results of a sodium sulfide spot testing program carried out by HUD in the lead-based paint abatement demonstration in Federal Housing Administration (FHA) housing.

REPORT ONE: METHODS FOR MEASURING LEAD CONCENTRATIONS IN PAINT FILMS

Research Approach

NIST surveyed the literature to identify completed work and to provide the basis for the laboratory testing program. The literature survey identified two techniques for screening: portable XRF analysis and in situ (in place) spot tests using sodium sulfide. Measurement methods identified in the literature include portable and laboratory-based XRF analysis, as well as laboratory-based chemical analyses such as atomic absorption spectroscopy (AAS). The portable XRF analyzer was the only current in situ method identified that had the potential of making both screening and quantitative measurements.

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[1]McKnight, Mary E.; Byrd, W. Eric; Roberts, Willard E; and Lagergren, Eric S. (December 1989), *Methods for Measuring Lead Concentrations in Paint Films* (NISTIR 89-4209), U.S. Department of Commerce, National Institute of Standards and Technology.

[2]McKnight, Mary E.; Byrd, W. Eric; and Roberts, Willard E. (May 1990), *Measuring Lead Concentration in Paint Using a Portable Spectrum Analyzer X-Ray Fluorescence Device* (NISTIR W90-650), U.S. Department of Commerce, National Institute of Standards and Technology.

The NIST research program examined these techniques under controlled laboratory and field conditions for reliability, safety, accuracy, bias, precision, and availability:

- Reliability: Could the tests be repeated to produce similar results?
- Safety: Were there hazards to the workers--either making the tests in the field or performing laboratory analyses?
- Accuracy, bias, and precision: Were the results accurate and to what degree were they dependent on, or independent of, the substrates (surfaces) under the paint or the skill of the testers? Did pipes or other construction components affect the results?
- Availability of samplers and testers: Are there sufficient numbers of qualified testing firms, trained local staff personnel, laboratories, and testing instruments to meet the demand?

Testing for Lead-Based Paint

Given the relatively high cost of testing all surfaces in a dwelling unit for lead-based paint, HUD identified the need for a screening process that could provide a 95 percent level of confidence that no lead concentrations of 1.0 mg/cm^2 or greater (the regulatory limit) were present. Historically, such screening has involved simple and fast procedures, employing chemical spot tests and portable, hand-held XRF analyzers, to see which paint films do not contain lead. With such screening, public housing agencies and other property owners and managers have been able to exclude some units from the expensive measurement and abatement processes.

On the other hand, in units where lead-based paint is suspected or known to be present, a more accurate method is necessary to quantify the lead content to determine whether abatement is required.

The NIST study, therefore, addressed two distinct areas of concern: (a) the identification and evaluation of screening techniques for determining whether or not lead is present on painted surfaces in dwelling units; and (b) evaluation of the methods that measure the amount or concentration of lead in the paint film.

The testing program consisted of three separate phases: (1) NIST laboratory testing, (2) round-robin testing, and (3) field evaluation.

Laboratory testing. Tests were performed under laboratory conditions to measure the effectiveness, bias, and reliability of the various measurement techniques of portable machines as well as chemical analysis. The NIST report discusses preparation of test specimens, testing procedures and findings, and results.

The literature search identified three separate models of portable XRF analyzers. Two are "lead-specific" instruments, designed to measure and report the amount of x-ray radiation in the lead-specific spectrum from exposure to the Cobalt-57 radiation source; the third is a "spectrum" instrument, also using Cobalt-57 as a source, which was designed for the mining industry to provide spectral information from a number of elements. The spectrum instrument was not fully tested in this first report, because it was not available until very late in the testing program. The second NIST report, which is summarized later in this appendix, describes the results of the spectrum analyzer testing program.

The laboratory tests of the lead-specific XRF analyzers included measurements of blank samples (using lead-free, foam plastic materials), various building substrates (materials), and paint samples containing various amounts of lead.

The literature search also identified several procedures for chemical analysis, differing in sample collection, preparation of laboratory samples, and methods of dissolving the samples for analysis. NIST carried out the analysis using American Society for Testing and Materials (ASTM) standard test procedures, and supplemented these with a study of the thermal stability of lead in paint.

Round-robin testing. To provide a second level of findings, NIST requested the Committee on Paints and Coatings of ASTM to form a test group to investigate the possibility of developing a standard guide for using portable XRF instruments in measuring lead-based paint levels. As part of this effort, a number of laboratories conducted tests of the precision and bias of lead-specific portable XRF instruments on identical samples. The results were similar to those in the NIST tests.

Field evaluation. As part of the FHA demonstration, the technical support contractor carried out a pretesting program in Baltimore. Taking advantage of this, NIST carried out a testing and sampling program of its own, as well as analyzing information from the pretesting program. NIST also used results from other studies conducted at the Georgia Tech Research Institute. The results of NIST's own program, as well as the others, provided information on the errors possible in making field tests and on the procedures for collecting laboratory samples. They also provided additional comparative information on portable XRF tests, spot test screening methods, and laboratory chemical tests.

Results of the Testing Program

Accuracy of lead-specific portable XRF analyzers. The NIST report concluded that the best estimate of precision of measurements made over wood, plaster, and drywall is 0.6 mg/cm^2, with an estimated bound for bias of 0.2 mg/cm^2. This finding implies that the true concentration should be within about $\pm$ 1.3 mg/cm^2 of the experimental outcome at a confidence level of 95 percent; the true concentration would be within $\pm$ 0.8 mg/cm^2 of the experimental outcome at a confidence level of 67 percent. Thus, if one needs to achieve a 95 percent confidence level at the regulatory limit of 1.0 mg/cm^2, all portable XRF readings below 2.3 mg/cm^2 must be confirmed by supplemental laboratory tests.

The NIST report also noted that bare substrate (surface) readings in excess of 2.0 mg/cm^2 were recorded in some data sets, suggesting that one way to partially overcome bias due to substrates is to scrape off any surface paint and make initial measurements of the bare substrate material.

Calibration of XRF analyzers. Standard reference paint films for calibration of portable XRF instruments are currently not available.

Accuracy of laboratory methods. The NIST report shows that chemical analysis of paint films for lead using the ASTM standard procedure D 3335, Test Method for Low Concentrations of Lead, Cadmium and Cobalt in Paint by Atomic Absorption Spectroscopy, resulted in the correct concentration for the NIST Standard Reference Material Paint with a precision of 0.3 percent or a coefficient of variation of 0.5 percent. This finding verifies that laboratory procedures can accurately measure very small amounts of lead in paint films.

Safety. The screening and measurement methods are similar to procedures routinely conducted in the field and many laboratories. For example, testers using portable XRF equipment must use proper radiation safety procedures, and those carrying out chemical spot tests and other laboratory analyses similarly must use appropriate safety methods. However, the NIST report concludes that no exceptional hazard is associated with any of the procedures discussed in this report, if the methods are carried out using accepted safety procedures.

Availability of qualified testers and samplers. The NIST report notes that manufacturers of XRF equipment have conducted daylong training courses for an estimated 2,000 people. The American Society for Testing and Materials Directory of Testing Laboratories lists about 350 laboratories equipped to perform standard laboratory analyses for lead concentration in paints. There are currently no certification or accreditation programs or formal training courses specifically designed for personnel measuring lead-based paint.

Additional Sodium Sulfide Testing

Separate from the NIST testing program, but as part of HUD's lead-based paint abatement demonstration in HUD-owned housing (the FHA demonstration), a sodium sulfide solution was used in in situ spot tests to screen for the presence of lead in paint film. This study was designed to examine the reliability of such testing for use as a negative screening method by trained, but inexperienced, technicians. If reliable, a negative reading (a measurement indicating no lead) would exempt a property from additional testing. If, however, the examinations showed a substantial percentage of "false negatives" (a negative reading on a substrate known to contain lead-based paint), then sodium sulfide spot tests would not serve as a reliable screening method because of the possibility that units requiring abatement would be erroneously determined to be lead-free.

In situ sodium sulfide spot tests for lead were performed on 377 painted substrates in 37 vacant single-family dwelling units in Baltimore, MD, and Washington, DC. These substrates had all been tested for lead previously in the laboratory using AAS, the most accurate method of measuring lead concentrations in paint. All substrates with AAS values of 0.7 mg/cm^2 or higher were retested with the sodium sulfide solution.

Four employees of the technical support contractor for the FHA abatement demonstration (all of whom had undergraduate science or engineering degrees, as well as construction experience) performed the tests. Only one of these technicians had any experience with sodium sulfide testing. Using the instructions on sodium sulfide testing contained in HUD's 1989 draft "Lead-Based Paint Hazard Identification and Abatement in Public and Indian Housing," this technician trained the other three. The use of trained, but otherwise inexperienced, technicians reflected HUD's interest in assessing the reliability of sodium sulfide testing as it would probably be implemented outside a research environment.

One-quarter of the sodium sulfide spot tests on wood substrates were false negative reports; almost one-half of the sodium sulfide spot tests on other substrate types were also false negatives.

The high percentage of false negative measurements precludes the use of sodium sulfide spot tests as a negative screening method at this time. Further research is warranted, however, to determine if improved training and/or the use of more experienced testers might significantly improve the accuracy of this method. Finally, although these findings may appear to contradict the NIST report (which estimated the false negative rate using sodium sulfide spot tests to be about 10 percent), that inference is not statistically valid. The NIST report stated that the 95 percent confidence interval of their estimate is 0-23 percent. Furthermore, it is apparent that the negative test rate declines as the level of lead in paint increases. The use of more experienced testers in the NIST study may also account for some of the observed difference.

Relationship of Findings to the HUD Interim Guidelines

The NIST report findings on screening and measurement methods have been considered in developing the HUD Interim Guidelines ("Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing"), published April 1990.[3] Sodium sulfide is not recommended for use as either a negative screening method or a confirmatory test. In the case of lead-specific portable XRF analyzers, the use of statistical sampling methodologies in public housing reduces the necessity for confirmatory laboratory tests. Details of the testing approach are described in Chapter 4 of the HUD Interim Guidelines.

Conclusions on Lead Paint Screening and Measurement

Screening methods. Screening methods are simple fast procedures designed to determine whether paint films have lead concentrations exceeding the regulation limit of 1.0 mg/cm^2. Based on limited data, NIST concluded that an <u>experienced analytical chemistry technician</u> can conduct

[3]U.S. Department of Housing and Urban Development (1990), "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing," *Federal Register* 55 (April 18):14557-14789.

sodium sulfide spot tests to detect lead concentrations in excess of 1.0 mg/cm^2 with a false negative risk of about 10 percent (2 false negatives in 20 samples). Additional research in the FHA Abatement Demonstration on the accuracy of sodium sulfide spot tests found an even higher rate of false negatives. HUD considers these rates of error unacceptable for the use of sodium sulfide as a screening method (a 95 percent confidence level is needed). Since training and the use of experienced testers apparently will affect the outcome of screening, further research is needed.

NIST also concluded that no lead-specific XRF analyzers were capable of screening LBP at the regulatory limit of 1.0 mg/cm^2 without confirmatory laboratory testing.

Measurement methods. Measurement methods are of two types, field-and laboratory-based; as distinguished from detection (screening) methods, they provide a quantitative measure of the content of lead in a paint film.

NIST concluded that, with the possible exception of a method based on the use of the spectrum analyzer XRF device, none of the methods studied in this project are capable of quantitative in situ field measurement of lead in paint films at the level of 1.0 mg/cm^2 without bare substrate measurements and possibly supplemental laboratory testing. The report shows that the bias in XRF measurements due to substrate variations exceeded the range necessary to meet the 95 percent confidence level.

The NIST report concluded that only standard laboratory analysis procedures are capable of measuring concentrations of lead in a paint film of less than 1.0 mg/cm^2. As a result, the HUD Interim Guidelines require the use of laboratory testing to confirm portable XRF measurements that fall into an uncertain range.

Recommendations

The NIST report makes the following recommendations:

- Reference paint film standards are needed for calibrating XRF devices. These standards are also needed in preparing paint films to be used as quality controls for insertion in sample analysis streams.
- The spectrum analyzer should be further studied to improve estimates of its accuracy and precision and to assess its reliability.

- Research should be conducted to improve the precision and accuracy of portable XRF analyzers for conducting nondestructive in situ field measurements.

- Spot tests should be evaluated to determine the causes of erroneous results and to investigate the variabilities in results due to tester experience and properties of the paint film. (This effort will be implemented in 1990 and 1991.)

- Accreditation programs, such as NIST's National Voluntary Laboratory Accreditation Program, should be implemented for laboratories using analytical test methods to measure the lead content of paint films.

- The need for certification of testers for lead-based paint should be considered; if necessary, training courses should be developed leading to certification of testers.

REPORT TWO: MEASURING LEAD CONCENTRATION IN PAINT USING PORTABLE SPECTRUM ANALYZER X-RAY FLUORESCENCE DEVICE

Research Approach

In conducting its evaluation of the portable spectrum XRF fluorescence analyzer, NIST employed the same research methodologies utilized in its evaluation of the lead-specific XRF analyzers (except that no round-robin testing was conducted by ASTM). The results of this evaluation, as presented in the NIST report, are described below.

Precision and Accuracy of Testing Procedures

> For in-situ field measurement of lead concentrations in paint films using a spectrum analyzer portable XRF device using a counting time sufficiently long to ensure that the precision of an individual replicate measurement is no poorer than 0.1 mg/cm^2, <u>it is concluded that the best estimate of precision of a field measurement made over wood and plaster is 0.3 mg/cm^2. The estimated systematic error of the procedure is 0.1 mg/cm^2.</u> (This implies that 95 percent of the time, the experimental outcome should be within $\pm$ 0.7 mg/cm^2 of the the true value and that 67 percent of the time, the experimental outcome should be within $\pm$ 0.4 mg/cm^2 of the true value.) These estimates are based on data obtained from field measurements which have poorer precision than data obtained

in the laboratory using the same measurement procedure. All of these estimates are based upon measurements carried out with only one device. Hence, no estimate of variance associated with the difference between devices was obtained. Estimates based upon data obtained from several devices may be different. In addition, this estimate of precision does not include uncertainty due to sampling. The counting time required to ensure a precision of consecutive individual measurements of 0.1 mg/cm^2 or better depends upon the activity of the radioactive source and increases as the source decays.

Based upon the laboratory data, the precision of measurements made over concrete and brick is expected to be poorer than the precision of measurements made over wood or plaster.

Most Reliable Technology Available for Detecting Lead-Based Paint

Measurement methods are of two types, field- and laboratory-based. It was previously concluded that there are standard laboratory analysis procedures having precision less that 0.1 mg/cm^2 for samples having lead concentrations near 1.0 mg/cm^2. Based upon this study, it is concluded that a measurement result based on one reading of a spectrum analyzer portable XRF device using a counting time sufficiently long to ensure that the precision of an individual replicate measurement is no poorer than 0.1 mg/cm^2 will have poorer precision than a result based upon the standard ASTM laboratory analysis procedure. However, the result based on one such reading of a spectrum analyzer, without a separate substrate correction, will have better precision than that based upon a lead-specific portable XRF device with substrate correction. **The precision of a result obtained using the spectrum analyzer evaluated in this study is expected to be about twice as good as that obtained using a lead-specific device.** [emphasis added]

Recommendations

As a result of this study, the following two recommendations are made:

- Conduct further characterization of spectrum analyzer portable XRF devices to include more instruments, since the confidence that can be placed in estimates of precision and bias on these instruments increases as the number of instruments included in a study increases.

- Develop standard reference films for use in calibration of these devices, since there currently are no standard materials available to both manufacturer and user. (The same recommendation is contained in the first NIST Report.)

APPENDIX E

DEMONSTRATION OF ABATEMENT IN HUD-OWNED (FHA) HOUSING

The Lead-Based Paint Poisoning Prevention Act, as amended, directed the Department of Housing and Urban Development (HUD) to undertake a demonstration in HUD-owned Federal Housing Administration (FHA) properties to determine the most efficient and cost-effective methods for abatement of lead-based paint. The demonstration is designed to test a variety of abatement methods under different circumstances and in different geographic areas. The FHA component of the lead-based paint demonstration utilizes the testing and abatement guidelines developed by the National Institute of Building Sciences (NIBS).

RESEARCH OBJECTIVES

Estimation of costs of abatement. Data must be generated to accurately estimate the costs of various methods of lead-based paint abatement. Estimates will include the costs of setup and cleanup, as well as the costs that vary according to the number and type of substrates to be abated.

Measurement of the efficacy of abatement. The different approaches to abatement must be analyzed in terms of the extent of post-abatement lead hazards. These comparisons will be based on an assessment of the extent to which lead paint has been removed or made inaccessible, on the amount of lead dust residue remaining after abatement and cleanup, and on the increase of lead in the soil due to abatement activity. All measures are taken immediately after abatement and do not address long-term efficacy issues.

Worker protection assessment. Stringent worker protection requirements have been established by the NIBS Guidelines. In the demonstration, these requirements will not vary according to the method of abatement employed. The National Institute of Occupational Safety and Health (NIOSH) is collecting data from monitoring and other measures of airborne lead dust (lead particulates) during the demonstration to determine if the standards can be relaxed when low dust-generating abatement methods are employed.

STRUCTURE OF THE DEMONSTRATION

Section 566 of the Housing and Community Development Act of 1987 called for the demonstration to be carried out in both single-family and multifamily housing owned by HUD.

However, none of the proposed multifamily properties met the criteria for participation in the demonstration because they did not contain lead-based paint, did not have enclosed interior corridors (to measure dust spread), or were occupied (to avoid relocation of residents). Therefore, the public housing abatement demonstration will be used to provide information on the special problems associated with abatement in multifamily housing. A team headed by Dewberry and Davis, a national consulting firm located in Fairfax, VA, was selected in January 1989 as the technical support contractor for the demonstration. The technical support contractor, under HUD's overall supervision, is responsible for the selection and abatement of HUD-owned housing, and for conducting this effort within a highly detailed research design and data collection plan. The Environmental Protection Agency (EPA) actively participated with HUD in developing the research plan.

SITE AND UNIT SELECTION

Seven metropolitan areas were selected as sites for the demonstration: Baltimore, MD; Washington, DC; Birmingham, AL; Denver, CO; Indianapolis, IN; Seattle, WA; and Tacoma, WA. Four of these--Baltimore and Washington and Seattle and Tacoma--were combined into two areas for the purpose of this study (see Table E-1). The primary criteria for selection were: (a) geographic diversity, to meet legislative requirements; (b) sufficient numbers of vacant housing units in the inventory of a given HUD Field Office to justify the consideration of a metropolitan area as a demonstration site; and (c) age of the housing, because older houses are more likely to contain lead-based paint.

HUD initially estimated that some 200 dwelling units would be needed to provide the statistical base necessary for the demonstration. Some 300 single family candidate units were inspected; these were then tested for the presence of lead-based paint, using portable x-ray fluorescence (XRF) analyzers. All painted surfaces on which a portable XRF could be used were tested three times, and the average of the three readings was used as the estimated level of lead hazard. Properties were ranked according to the number of substrates requiring abatement, using a standard of 1.0 milligrams per square centimeter (mg/cm^2) as the threshold requirement for abatement. (In Maryland, pursuant to State statutes, the standard is 0.7 mg/cm^2 for XRF-tested substrates and 0.5 percent for substrates tested by atomic absorption spectroscopy (AAS).)

Eventually 173 properties were selected for abatement, based on a statistical methodology that selected the units with the greatest number of substrates requiring abatement, and with the highest concentration of lead on substrates. This was done to provide a large number of surfaces with high levels of lead upon which to test the cost and efficacy of different abatement strategies. Table E-1 shows the number of units and the number of substrates per unit, for each city.

TABLE E-1

NUMBER OF SUBSTRATES REQUIRING ABATEMENT BY CITY AND BY NUMBER OF UNITS

	Substrates per Unit			
City	**10-29**	**30-59**	**60 or More**	**No. of Units**
Baltimore/Washington	11	14	7	32
Birmingham	8	7	8	23
Denver	21	23	14	58
Indianapolis	21	13	1	35
Seattle/Tacoma	6	8	11	25
Total Units	67	65	41	173

DEMONSTRATION CONTRACTING

To carry out the lead-based paint abatement demonstration efficiently, the technical support contractor developed a source list of local subcontractors and established a contracting process in each metropolitan area. The selection of potential subcontractors started almost immediately on contract award. The development of contract documents was completed after an intensive effort by the technical support contracting team.

Securing competent local subcontractors required a major effort by the technical support contractor. This process involved a number of important steps:

- Seeking subcontractors on an open-market basis and meeting the requirements of the contract with regard to open competition and utilization of small and minority-owned businesses.

- Developing bidding procedures so that subcontractors would be willing to bid on a fixed-price basis for processes and procedures with which they were unfamiliar.

- Preparing contract documents specifying generic materials, processes, and procedures, which allowed for the selection of a variety of manufacturers' products.

- Implementing the NIBS guidelines as the technical protocols for testing, abatement, worker safety, and pre -and post-abatement cleanup in the contract documents.

In general, the technical support contractor developed a contracting process designed to create a new industry--lead-based paint abatement--which fits into standard contracting processes and procedures.

In calling for bids, the contract documents were written with generic specifications; thus, no specific products are called for by brand name or implication. Only the general process (such as chemical stripping or abrasive removal) and specific performance results are stipulated in the documents. As a result, specifications for encapsulants, enclosure, flexible wall covering, chemical stripping, machine sanding, vacuum blasting, heat removal, and removal/replacement of substrate are all generic in nature. The abatement subcontractor was required to bid to the specifications and request approval to use specific products. This approach was intended to encourage competition among the product manufacturers as well as among the subcontractors, an important consideration of the demonstration.

ABATEMENT STRATEGIES

Central to the design of the lead-based paint abatement demonstration is the concept of the "unit abatement strategy," a set of rules which specify, for each substrate type that may be encountered, the abatement method to be employed. Thus, assigning a dwelling unit to a particular strategy has the effect of completely specifying how lead-based paint will be abated in that unit.

Six unit abatement strategies are being used in the demonstration; they correspond broadly to the generic methods of lead-based paint hazard abatement: enclosure, encapsulation, onsite paint removal by mechanical methods, onsite paint removal by chemical methods, onsite paint removal by hand (heat gun), and component replacement.

Each strategy identifies methods to be used, in order of preference. If the first-choice method is not feasible (e.g., sanding ornate surfaces), the strategy specifies second, third, and fourth alternatives. Thus, low-dust-generating methods are substituted for low-dust-generating methods, medium-dust-generating methods are substituted for medium-dust-generating methods, and so on. This approach is designed to maximize the sharpness of the contrasts between the efficacy of different methods, as measured by lead dust residues.

Units were assigned to unit abatement strategies by stratified random sampling to ensure that there is no confounding of the strategy, the number of substrates requiring abatement, and the location of the unit.

DATA ACQUISITION PLAN

In each unit selected for the demonstration, 11 kinds of data are being collected. The timing and frequency with which these data are to be collected are designed to meet the objectives of the demonstration.

1. XRF test readings on all painted surfaces prior to unit selection.
2. AAS test results on all substrates with average XRF readings between 0.2 and 1.8 mg/cm^2 after unit selection, but before abatement.
3. AAS test results on 10 percent of all substrates where paint is removed during abatement, including offsite stripping.
4. Hourly wage rates, fringe benefit costs, unit costs of materials, and hourly costs of equipment used for each substrate abated (by square or linear foot) and for setup and cleanup activities.
5. Level of interior surface lead dust before and after abatement of each unit.
6. Level of lead content in exterior soil before and after abatement in each unit.

7. Blood lead levels of abatement workers on starting and on finishing abatement work; monthly, if working that long.

8. Airborne lead dust concentrations in rooms or areas where abatement is being conducted; data collected by a monitor within the environment.

9. Lead dust levels in air potentially inhaled by workers during abatement; data collected by a monitor attached to the worker.

10. Toxicity of waste materials generated during abatement.

11. Costs of waste disposal.

TESTING METHODS

The original testing program relied on portable XRF analyzers to determine the existence of lead-based paint on surfaces (substrates). Where physically possible, all substrates and candidate units were tested with XRF equipment operated by trained, qualified operators. AAS testing was used on substrates not conducive to XRF testing. AAS testing was initially proposed only where XRF analyses proved inapplicable or where XRF results ranged between 0.5 mg/cm2 and 1.5 mg/cm^2.

During the XRF testing, however, further research was being undertaken by NIST regarding the reliability of XRF. NIST determined that, in the lower range of results, further testing utilizing AAS would ensure a more accurate selection of the substrates requiring abatement. It was therefore determined that all XRF readings between 0.2 mg/cm^2 and 1.8 mg/cm^2 would require backup AAS testing. A followup testing program utilizing AAS procedures was implemented for all candidate units. The number of AAS tests in the demonstration grew from approximately 2,000 to almost 6,000 tests. The combination of the results of both the XRF and AAS testing were then used to determine what substrates required abatement. All AAS results was reported in milligrams of lead per square centimeter (mg/cm^2).

STATUS OF THE DEMONSTRATION

The abatement of all units is complete. Preliminary data on the cost of alternative unit abatement strategies have been collected and analyzed. Findings are described in Chapter 4 of this report. The complete results of the FHA component of the lead-based paint abatement demonstration will be provided to Congress in a subsequent report.

APPENDIX F

LEAD-BASED PAINT AND FEDERAL HOUSING PROGRAMS:

REGULATORY ISSUES

The Lead-Based Paint Poisoning Prevention Act (LPPPA) requires the Secretary of Housing and Urban Development to "establish procedures to eliminate as far as practicable the hazards of lead-based paint poisoning with respect to any existing housing which may present such hazards and which is covered by an application for mortgage insurance or housing assistance payments under a program administered by the Secretary." LPPPA also requires the Secretary to "establish and implement procedures to eliminate the hazards of lead-based paint poisoning in all federally owned properties prior to the sale of such properties when their use is intended for residential habitation." The Department of Housing and Urban Development (HUD) is developing proposed regulations and procedures to implement these requirements. The purpose of this appendix is to provide a preliminary discussion of the issues being considered and the process being followed with regard to both HUD programs and the sale of housing owned by other Federal agencies.

HUD PROGRAMS

On June 6, 1988, HUD published a final rule in the *Federal Register* implementing certain amendments to LPPPA that were contained in the Housing and Community Development Act of 1987. The rule pertained primarily to public housing, but it made two changes in the lead-based paint regulations of nonpublic HUD housing programs. It changed the construction cutoff date to 1978, making the regulations apply to housing built before 1978, instead of 1973 or 1950 as had been the case previously; and it defined "applicable surfaces" to include all intact and nonintact, interior and exterior painted surfaces. Further changes to regulations of programs affecting privately owned housing were delayed until the completion of the abatement demonstration, pursuant to instructions in the legislative history of the Housing and Community Development Act.

Recognizing their importance to the public health, HUD has begun a critical review of these regulations prior to the completion of the analysis of the abatement demonstration. Some of the issues with which this review is concerned are notification; inspection and testing requirements in relation to the capacity of the testing industry (as measured by trained personnel and the availability of reliable methods and equipment); interpretation of the "expected to reside" phrase with regard to occupancy by children under 7 years old; the extent to which elevated blood lead levels in children should be retained as a priority consideration; the possible provision for dust lead testing; methods and procedures for cost-effective and abatement; and the impact of implementation, in terms of financial cost and potential reductions in the number of households assisted under the programs.

Notification. LPPPA requires that HUD provide for "assured notification (using a brochure developed after consultation with the National Institute of Building Sciences) to purchasers tenants of such [HUD-associated] housing of the hazards of lead-based paint, of the symptoms and treatment of lead-based paint poisoning, and of the importance and availability of maintenance and removal techniques for eliminating such hazards." The preparation of a revised notification is well underway and should be completed before March 1991. Other governmental and nongovernmental organizations will be consulted as well as the National Institute of Building Sciences.

Inspection and testing. LPPPA sets forth stringent requirements for inspection and testing of all HUD-associated housing. The relevant passage of the act reads as follows: "The Secretary shall require the inspection of all intact and nonintact interior and exterior painted surfaces of housing subject to this section for lead-based paint using an approved x-ray fluorescence analyzer, atomic absorption spectroscopy, or comparable approved sampling or testing technique. A qualified inspector or laboratory shall certify in writing the precise results of the inspection. If the results equal or exceed a level of 1.0 milligrams per centimeter squared, the results shall be provided to any potential purchaser or tenant of the housing."

The primary question for HUD is how, given the limited availability of testing services, it will be able to respond to these requirements and, at the same time, continue to provide expeditious delivery of program assistance. If testing must be performed prior to approval of a new Federal Housing Administration (FHA) mortgage, the renewal of a Section 8 contract, or the sale of HUD-owned property, the volume of testing that would appear to be required under the legislation quoted above may not be feasible, especially during the next few years, when the requirements for testing in the public housing program alone will generate a substantial increase in demand for testing services. FHA processes annually over 1 million applications for single-family mortgage insurance involving structures built before 1978. The single-family property disposition program sells over 44,000 pre-1978 houses per year. The Section 8 Existing Housing Certificate and Existing Housing Voucher programs currently provide rental assistance to over 1,000,000 families, most of whom reside in structures built before 1978.

The capacity to conduct inspections in privately owned housing may increase in the future, as required public housing inspections are completed and more inspectors are trained and certified. Also, improvements in technology may facilitate faster and and less expensive testing. In the short term, however, testing capacity will be limited.

It should be noted that there is a linkage between notification and testing. If testing is not conducted, for whatever reason, the occupant should be notified of the potential hazard. If testing is conducted and the result is negative, there would seem to be little need for full notification, but the occupants should be told of the favorable findings. A positive test, however, makes full notification essential, and the notification should include the test results.

Child under 7 years of age expected to reside. LPPPA says that HUD shall establish procedures to eliminate lead-based paint hazards in HUD-associated "housing in which any child who is less than 7 years of age resides or is expected to reside." The "expected to reside" phrase can be interpreted in a long-term or short-term sense. If interpreted in the long term, it would encompass virtually all housing that is not designated exclusively for the elderly. Full testing of all such housing may be infeasible. A short-term interpretation would pertain to current or prospective occupants, and would increase the feasibility of meeting the testing requirement currently in the law.

Response to child with an elevated blood lead level. The 1987 amendments to LPPPA require that "procedures established by the Secretary under this section for the detection and abatement of lead-based paint poisoning hazards .... (1) shall be based upon criteria that measure the condition of the housing; and (2) shall not be based upon criteria that measure the health of the residents of the housing." This requirement is appropriately intended to assure that HUD regulations take a preventive approach to lead poisoning, and do not accommodate the practice of waiting until a child is poisoned before testing or abating. While HUD agrees with the requirement, it still intends to assure that program recipients take immediate action when a poisoned child exists, even though the child's residence may not be at the top of a priority action list.

Surface dust. As indicated in Chapter 2, published studies have established that surface dust is the primary pathway of lead exposure for young children, although it is recognized that some children eat paint chips or chew on protruding painted surfaces and suffer severe poisoning as a result. It has also been established that some older houses no longer have lead-based paint but do have lead in surface dust. If HUD requires testing for lead-based paint, it seems reasonable that at some point it should also require concurrent testing of dust, if such tests can be done simply and inexpensively. This may be a longer term consideration that cannot be dealt with in the next regulatory changes.

Methods and procedures for abatement. Some changes to existing regulations may be needed eto require adequate attention to the protection of workers, occupants, and the environment during abatement. However, detailed methods and procedures will be contained in guidelines, such as the recently published HUD Interim Guidelines[1] or similar documents.

Regulatory impact. HUD will attempt to estimate the potential cost of proposed regulations and the impact on the number and characteristics of program participants.

Consultation. As specified in LPPPA, HUD will consult the following organizations before issuing proposed regulations: "the National Institute of Building Sciences, the Environmental Protection Agency, the National Institute of Environmental Health Sciences, the Centers for Disease Control, the Consumer Product Safety Commission, major public housing organizations, other major housing organizations, and the National Bureau of Standards ..."

OTHER FEDERALLY OWNED PROPERTIES

Federally owned properties other than those covered by HUD regulations may include properties to be sold by the Veterans' Administration, the Farmers Home Administration, the General Services Administration, the Department of Defense, the Coast Guard, the National Park Service, and the Resolution Trust Corporation. HUD will seek the advice of these agencies in responding to the requirements of the Lead-Based Paint Poisoning Prevention Act.

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[1]U.S. Department of Housing and Urban Development (1990), "Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public Housing," *Federal Register 55* (April 18): 14557-14789.

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