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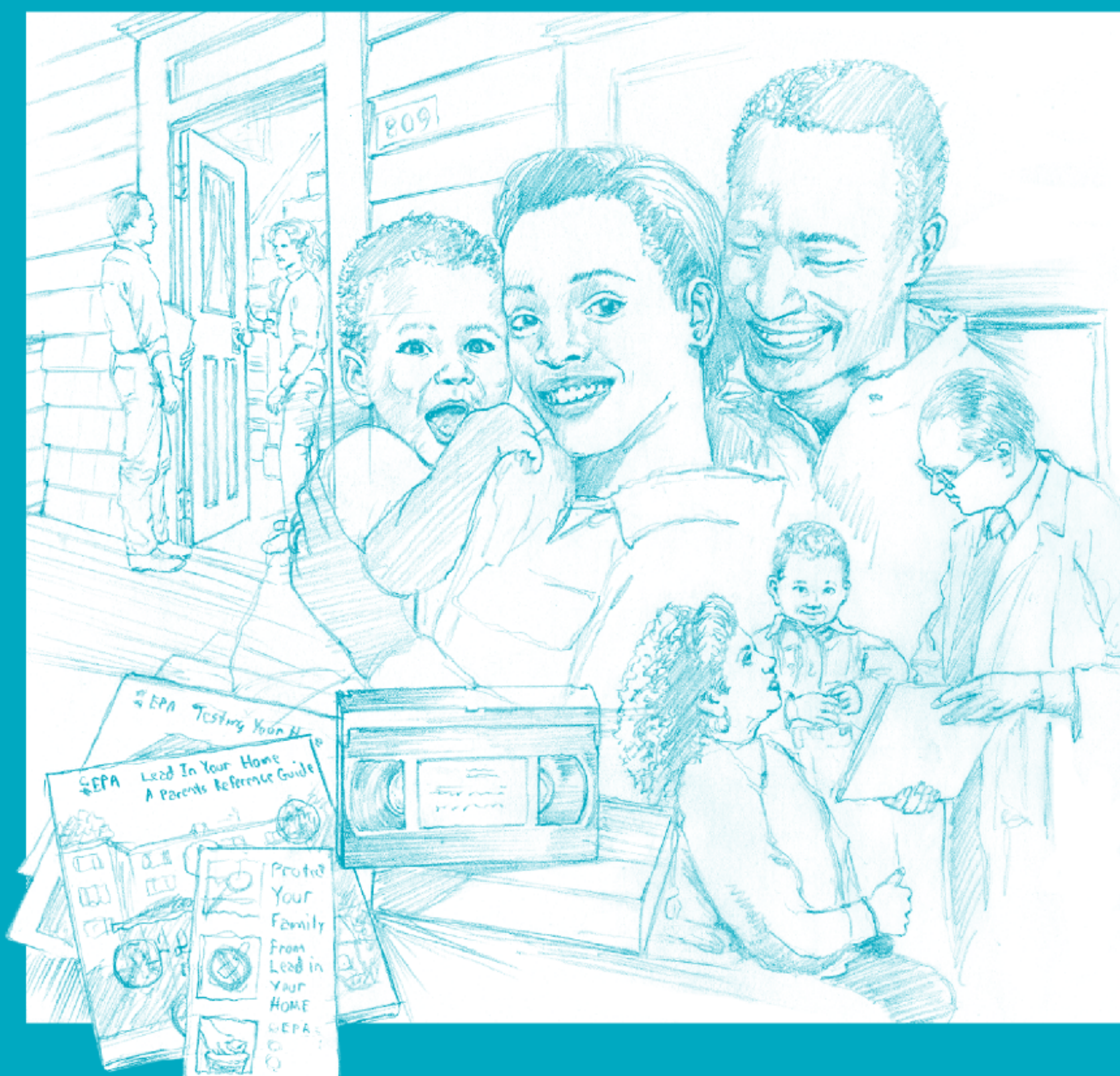
Basis for Educational Recommendations on Reducing Childhood Lead Exposure



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BASIS FOR EDUCATIONAL RECOMMENDATIONS ON REDUCING CHILDHOOD LEAD EXPOSURE

Program Assessment and Outreach Branch
National Program Chemicals Division (7404)
Office of Pollution Prevention and Toxics
U.S. Environmental Protection Agency
Washington, D.C. 20460

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CONTRIBUTING ORGANIZATIONS

This report presents the results of investigations into educational programs on reducing childhood lead exposure and gives recommendations on the content of those programs. Efforts to produce this report were funded and managed by the U.S. Environmental Protection Agency. The report was prepared by Battelle under contract to the U.S. Environmental Protection Agency. Each organization's responsibilities are listed below.

Battelle Memorial Institute (Battelle)

Battelle was responsible for procuring relevant articles and reports, reviewing these publications, and preparing the report.

U.S. Environmental Protection Agency (EPA)

The U.S. Environmental Protection Agency was responsible for providing report objectives, for contributing relevant information for the report, for reviewing the report, and for arranging the peer review of the report. The EPA Work Assignment Manager was Mr. Bradley D. Schultz. The EPA Project Officer was Ms. Sineta Wooten.

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Table of Contents

Page

EXECUTIVE SUMMARY

Education is the primary type of intervention recommended by the Centers for Disease Control and other organizations for households in which children are found to have blood-lead concentrations between 10 and 20 µg/dL. Approximately 90 percent of children with elevated blood-lead levels fall into this range. Thus, education is an important component to the success of lead risk reduction efforts.

EPA is currently undertaking several initiatives to encourage and enhance educational programs nationwide. In order to support these initiatives, there is a need for a comprehensive reference on the scientific basis for educational recommendations. In addition to immediate use in developing new educational programs or re-evaluating current programs, this document provides an ongoing reference for evaluating future research results in the context of existing evidence.

The recommendations made in many existing educational programs operated by state and local health departments and other organizations vary in detail, but they are usually consistent in providing information on cleaning methods; practical ways to reduce exposure to lead in paint, dust, and soil; non-hazardous methods of paint removal; nutrition; and behavioral modifications to reduce lead exposure. This report examines the scientific basis for specific educational recommendations in each of these areas. This report does not attempt to evaluate the overall effectiveness of educational interventions. However, it should be noted that education alone should not be expected to completely eliminate lead hazards, but rather should be viewed as a component of a comprehensive program.

This report indicates that most current educational recommendations are supported by some scientific evidence. Other recommendations correspond to conventional wisdom. Very few changes to the most common educational recommendations are suggested by the scientific evidence reviewed in this report. The most important recommended changes to current education resulting from this review are summarized below.

Many educational programs recommend a trisodium phosphate (TSP) solution for cleaning hard surfaces. Based on the scientific studies reviewed, many cleaning products perform as well as TSP in cleaning lead dust from hard surfaces. These products include common household cleaners or lead-specific cleaning products other than TSP. These findings, along with the environmental concerns associated with using high phosphate detergents, result in not recommending TSP for cleaning hard surfaces.

Most educational programs recommend using a high-efficiency particulate air (HEPA) vacuum for cleaning carpeted areas, although it is recognized that, at present, HEPA vacuum cleaners are too costly for many families to use on a regular basis. If a HEPA vacuum is not available, we recommend that conventional vacuum cleaners be used with “HEPA-type” or “allergy” filter bags, to remove a higher proportion of fine dust particles from carpets and indoor air. Although these bags have not been scientifically tested for lead dust cleaning efficiency, they are designed to capture smaller particle sizes than standard vacuum cleaner bags and, hence, should collect a greater proportion of fine lead dust particles than standard vacuum cleaner bags.

Most educational programs fail to address steam cleaning of carpets, as this method has not been considered effective for removing lead dust. It has been shown, however, that the addition of sodium hexametaphosphate (which is found in products such as Calgon®) to the cleaning solution increases the amount of lead removed from the carpets by steam cleaning. This practice is recommended for consideration in educational programs.

Cleaning is more easily performed on smooth surfaces. Current educational programs often do not suggest simple steps that can be taken to provide smooth, easily cleaned surfaces. These steps include painting window sills with semi-gloss paint, installing aluminum liners in window wells, and sealing wood floors with polyurethane or durable paint. These steps are modest in cost and do not require special equipment.

Given the results of the investigations made in this report, suggestions on the recommended content of educational programs to reduce lead exposure follow. In presenting this list, it is recognized that it will not be practical to cover every item in every educational session. The specific recommendations made in an educational session should be tailored to the location and audience. Rather, the list is intended as a comprehensive summary of reasonable educational recommendations. The list does contain some recommendations that are based on conventional wisdom or only limited scientific study. These recommendations were included, as no evidence was found at this time to suggest they should not be recommended.

Hard Surfaces

- mop floors once a week with soapy water;
- clean window sills and wells once a week with soapy water;
- use paper towels or set aside a sponge for lead cleaning only;
- use separate buckets for wash and rinse water;
- lightly spray floors with water before sweeping;
- seal wood floors to provide a smooth cleanable surface;
- place a blanket or rug on floor when a child plays there;
- keep children and their belongings away from windows; and
- open double-hung windows from the top.

Carpeted Surfaces

- use a HEPA vacuum for cleaning, if possible;
- if a HEPA vacuum is not available, use “HEPA-type” or “allergy” filter bags;
- if these bags are not available, lightly coating new vacuum bags by spreading and vacuuming flour or cornstarch is advised;

- use a vacuum with an agitator head;
- vacuum for an extended time;
- when steam cleaning carpets, consider adding sodium hexametaphosphate (found in Calgon®, for example) to the cleaning solution; and
- use care in removing older carpets that are heavily contaminated with lead dust.

Limiting Paint Exposure

- clean up loose paint chips immediately;
- wipe off loose paint using damp disposable cloths or rags;
- block access to chipping paint with furniture;
- put contact paper over chipping paint;
- hose off porch or place a blanket or rug down when children play there;
- seal or enclose areas with small amounts of chipping paint;
- do not use hazardous methods of removing paint, such as mechanical sanding (without a HEPA attachment), open-flame burning, or chemical removal using methylene chloride;
- recommend safer alternatives for removing paint, such as wet scraping and wet sanding;
- if abatement is required, use a certified abatement contractor;
- if abatement is required, describe what to expect during abatement, ways to protect family and belongings.

Limiting Soil Exposure

- cover bare soil with grass, plants, gravel, or wood chips;
- do not let children play near walls of house or garage or on bare soil;
- have children play in grassy area or sandbox that can be covered;
- wash children's hands after playing outside, or playing with pets;
- remove shoes before entering the house; and
- use a doormat to reduce track-in of outdoor dust and soil.

Nutrition

- provide a balanced diet as recommended by the FDA;
- ensure children receive sufficient amounts of calcium, iron, zinc, and vitamin C;
- reduce consumption of foods high in fat if a lot of fat is eaten, especially foods with little nutritional value;
- prepare or store food in lead-free containers;
- if lead in water is a concern
  - flush pipes for 1 minute before drinking water or using it for cooking; and
  - use only cold water for cooking or preparing infant formula.

Hygiene

- wash children's hands, toys, bottles, and pacifiers often;
- do not allow children to eat food off the floor;
- if parents work or hobby is a source of lead exposure
  - shower at work or change out of work clothes before returning home;
  - wash work clothes separately from other clothes;
  - protect the inside of cars with blankets or sheets;
  - shower or change clothes and shoes after working on hobbies that may be a source of lead; and
  - keep children away from hobby areas.

1.0 INTRODUCTION

The Centers for Disease Control and Prevention (CDC), along with other organizations, recommend family lead education as the primary intervention for children with blood-lead levels between 10 and 20 µg/dL (CDC, 1997a). Approximately 90 percent of children with elevated blood-lead levels fall into this range (CDC, 1997b).

In support of family lead education efforts, the US. Environmental Protection Agency (EPA) provides outreach materials such as the pamphlet, "Protect Your Family from Lead in Your Home" (USEPA, 1999), or the guidebook, "Lead in Your Home: A Parent's Reference Guide" (USEPA, 1998a). Additional materials in the form of an outreach toolkit for public health officials will be available in the near future. In addition to printed materials, EPA has provided family lead education support in the form of grants to encourage educational outreach in under-reached communities. As EPA continued its role in educational outreach, it was recognized that there is a need for a comprehensive reference on the scientific basis for educational recommendations. In addition to immediate use in developing new educational programs or re-evaluating current programs, this report provides an ongoing reference for evaluating research results in the years to come in the context of existing evidence. This report examines the scientific basis for individual recommendations. The overall effectiveness of educational interventions is evaluated in the EPA technical report, "Review of Studies Addressing Lead Abatement Effectiveness: Updated Edition" (USEPA, 1998b).

Ideally, family lead education efforts begin prior to the birth of a child and prior to the diagnosis of an elevated blood-lead level. Specifically, CDC recommends that health care providers educate parents prenatally, and at age 3-6 months, 12 months, and 1-2 years, by providing "anticipatory guidance" at well-child visits in order to prevent lead exposure and elevated blood-lead levels. CDC further recommends that families of all children with blood-lead levels greater than or equal to 10 µg/dL be given prompt and individualized education about the following:

- Their child's blood-lead level and what it means.
- Potential adverse health effects of the elevated blood-lead level.
- Sources of lead exposure and suggestions on how to reduce exposure.
- Importance of wet cleaning to remove lead dust on floors, window sills, and other surfaces; and the ineffectiveness of dry methods of cleaning, such as sweeping.
- Importance of good nutrition in reducing the absorption and effects of lead. If there are poor nutritional patterns, discuss adequate intake of calcium and iron and encourage regular meals.
- Need for follow-up testing to monitor the child's blood-lead level, as appropriate.
- Results of environmental investigation, if applicable.
- Hazards of improper removal of lead-based paint. Particularly hazardous are open-flame burning, power sanding, water blasting, methylene chloride-based stripping, and dry scraping and sanding.

CDC notes that education should be reinforced during follow-up visits and that health departments can often furnish educational materials to the health-care provider. More extensive interventions are recommended for children with blood-lead levels greater than or equal to 20 µg/dL, or when blood-lead levels remain between 15 and 19 µg/dL as indicated by multiple readings at least 3 months apart, along with the education described above (CDC, 1997a). It should be noted that neither education, nor the more extensive interventions recommended for children whose blood-lead levels are elevated to 20 µg/dL or above, have been proven effective in reducing blood-lead levels below 10 µg/dL, the current level of concern. In addition, the effectiveness of an educational intervention is dependent on the willingness and ability of the family to implement the recommended actions.

In addition to the health-care provider, many state and local health departments provide lead poisoning prevention education, often in the form of home visits, as part of case management of lead-poisoned children. The recommendations made in educational sessions vary in detail, but they are usually consistent in providing information on cleaning methods; practical ways to reduce exposure to lead in paint, dust, and soil; non-hazardous methods of paint removal; nutrition; and behavioral modifications to reduce lead exposure. Education in the home usually includes pointing out areas where cracked or peeling paint are commonly found and a demonstration of cleaning methods. Lead educators may recommend that paint and dust be tested for lead in a lead inspection, but normally do not collect samples or perform these tests. Cleaning kits are sometimes distributed and educational materials given to the families.

Many state and local health departments, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Housing and Urban Development (HUD), and nonprofit agencies, such as the National Center for Lead Safe Housing (NCLSH) and Center for Community Action for Primary Prevention of Childhood Lead Poisoning (CCAPP), have prepared educational materials that may be distributed to parents as part of an educational session. These materials take many forms, including one-page fliers, pamphlets, or videos. The purpose of this report is to evaluate the scientific basis of educational recommendations to reduce lead exposure and resulting health effects and to make recommendations for changes based on the scientific evidence.

1.1 OVERVIEW OF REPORT

Chapters 2 - 7 of the report address specific topic areas for educational interventions. Chapters 2 and 3 consider recommendations for cleaning lead dust from hard surfaces and carpeted surfaces, respectively. Chapters 4 and 5 address ways to limit exposure to lead-based paint and soil. Chapter 6 examines the scientific basis for nutritional recommendations to reduce the effects of lead exposure and Chapter 7 considers personal hygiene and occupational hygiene recommendations. For the purpose of this report, hygiene is broadly defined to include any personal habit that may reduce lead exposure to oneself or others. These chapters share a common format, wherein the current content of educational programs is summarized, the scientific basis for educational recommendations is evaluated, and the recommended content of educational programs is presented. Chapter 8 considers topics related to educational intervention, including a brief summary of the current content of educational programs, the effectiveness of educational interventions as documented in the scientific literature, and sources and pathways of lead exposure. Chapter 9 presents the report conclusions in the form of topics that should be covered in a model program. Appendix A summarizes resources available to aid in planning an educational program.

1.2 PEER REVIEW

This report was reviewed independently by members of a peer review panel. In general, the reviewers agreed that the report was comprehensive, accurate, and relevant to current policy concerns. However, the peer reviewers did provide useful suggestions for revisions, as well as important issues to consider when interpreting the results. The major concerns of the reviewers are discussed below.

A concern expressed by more than one peer reviewer was that the report does not address the effectiveness of educational interventions. Although evaluation of the effectiveness of educational interventions is not the objective of this report, we added statements that indicate (1) that neither education, nor the more extensive interventions that are recommended for children with higher blood-lead levels, have been proven effective in reducing blood-lead levels to levels below 10 µg/dL; and (2) that the effectiveness of an educational intervention is dependent on the willingness and ability of the family to implement the recommended actions.

Reviewers also noted that many of the cleaning studies summarized in the report used professional contractors and the results may not be representative of those achieved through resident education. The reviewers are correct. However, we believe these studies do have value in the context of this report, in that the cleaning methods employed by the contractors were similar to those commonly recommended in educational sessions. Thus, the reported results are the best available estimate of what could be achieved following careful, conscientious cleaning at regular intervals by residents. Cleaning studies that employed more extensive interventions were not included in the report.

Finally, one reviewer pointed out the importance of post-intervention clearance testing. This reviewer provided an example from personal experience, stating that in an unpublished study of the effectiveness of Maryland House Bill 760, which requires owners to carry out hazard reduction treatments at turnover but does not require dust testing, a majority of units failed dust tests after having passed the required visual inspection. Although we recognize the importance of clearance testing, we made only minor changes in the report to address this comment, as testing for lead in dust is not usually within the scope of educational interventions.

EPA has established a public record for the peer review under Administrative Record 224. The record is available in the TSCA Nonconfidential Information Center, which is open from noon to 4 PM Monday through Friday, except legal holidays. The TSCA Nonconfidential Information Center is located in Room NE-B607, Northeast Mall, 401 M Street SW, Washington, D.C.

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2.0 REDUCING LEAD DUST ON HARD SURFACES

2.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

Lead-contaminated house dust has been found to be a major source of lead exposure for children. Because it is such a significant exposure source, it has been a major focus of much of the educational programs currently in place. Most, if not all, of the educational programs stress that lead in dust cannot be seen and that because it is heavy, it often remains after other dirt has been removed. On that basis, current educational programs usually make several types of recommendations for protecting children from lead in dust on hard surfaces. Common cleaning recommendations include:

- mopping floors once a week with soapy water or special detergent;
- cleaning window sills and wells once a week with soapy water or special detergent;
- wet wiping furniture once a week using soapy water or special detergent;
- using paper towels or setting aside a sponge for lead cleaning only;
- using separate buckets for wash and rinse water; and
- lightly spraying floors with water before sweeping.

The scientific basis for these cleaning recommendations is considered in this chapter.

Additional recommendations to reduce dust on hard surfaces or provide barriers between the surface and the child are also a part of some educational programs. For example, the booklet “Where is the Lead?” (CCAPP, 1999a) makes specific recommendations for floors and windows.

For floors, it is recommended that doormats be used and shoes be removed on entering the home, in order to reduce the amount of soil and dust tracked in from outdoors. (The scientific basis for recommendations to reduce exposure to lead in soil is examined in Chapter 5 of this report.) Recommendations that provide temporary or permanent barriers between the child and the floor include placing a blanket on the floor, covering floors with rugs, installing linoleum, or sealing wood floors. The latter also provides a smooth, easily cleaned surface. The scientific basis for these and other recommendations to reduce exposure to lead in paint is examined in Chapter 4 of this report.

For windows, the CCAPP recommends that double-hung windows be opened from the top. This advice serves to limit access to window wells, where dust-lead levels are usually greater, and may also make the window area less attractive to children. It is also recommended that children and their belongings be kept away from windows. For example, toys, bottles, and pacifiers should not be placed on window sills, so that lead containing dust is not transferred to the object, and again to make the window area less attractive to children.

2.2 SUMMARY OF SCIENTIFIC EVIDENCE ON REDUCING LEAD DUST ON HARD SURFACES

Scientific research on cleaning hard surfaces (e.g., uncarpeted floors of vinyl, hardwood, or linoleum; walls, cabinets, countertops, wood trim, and window sills) emphasizes that frequent, vigorous scrubbing with a solution of water and some cleaning agent is the best way to loosen and remove lead dust and prevent lead poisoning. The cleaning agents most frequently recommended are dishwashing detergent, common household cleaning agents, TSP, or other lead-specific cleaners (often recommended generically without naming products specifically). It is usually recommended that cleaning be done weekly or biweekly (every two weeks) and should include wet mopping/wet wiping and rinsing with clean water, using separate buckets for wash and rinse water. Hard, scientific evidence from controlled field studies of cleaning agents and cleaning methods tends to be scarce.

2.2.1 Cleaning Agents

Trisodium Phosphate (TSP). For some time, trisodium phosphate (TSP, CAS Registry Number 7601-54-9, chemical formula Na_3O_4P) has been recommended by HUD, EPA, and others as an effective cleaning agent for lead dust. One chemical supplier, for example, Sentinel Products, Inc. (Fridley, MN), markets products such as towels presoaked with a solution of TSP, especially for lead dust cleanup. In its advertisement, the supplier indicates that TSP "meets HUD Guidelines and Maryland Procedures."

According to the HUD Guidelines (1995a), "TSP detergents are thought to work by coating the surface of dusts with phosphate or polyphosphate groups which reduces electrostatic interactions with other surfaces and thereby permits easier removal." The HUD Guidelines note that TSP has some disadvantages, and that environmental concerns have caused some states to restrict the use of TSP. The guidebook *Maintaining a Lead Safe Home* (Livingston, 1997) indicates that TSP can burn skin, damage furniture, and damage paint; can leave a film that is harmful to paint; and can be bad for the environment.

Alternatives to TSP. Recently, questions have been raised on the level of scientific evidence used in making recommendations to use TSP for cleaning lead-dust from surfaces. Cleaning agents other than TSP have been evaluated and recommended for their effectiveness in reducing lead dust on hard surfaces.

A recent EPA-sponsored laboratory evaluation of products used to clean leaded soil and dust from surfaces (USEPA, 1997a) compared 32 commercially available cleaning agents, TSP, and tap water of average hardness. The cleaning agents represented general all-purpose cleaners, hand or machine dishwashing products, laundry detergents, and bathroom, floor, and glass cleaners, plus lead-specific cleaners. Some of these products, such as automatic dishwashing detergent, have been recommended for lead cleaning because of the relatively high phosphate content compared to non-detergent cleaners. The controlled evaluation determined that cleaning using a general, all-purpose cleaner or a cleaner made specifically for lead was as effective as

TSP and more effective than cleaning with tap water alone. EPA noted the aquatic toxicity concerns associated with the use of high-phosphate cleansers such as TSP and concluded that the results "do not support the recommended use of TSP for the reduction of lead dust exposure." EPA educational materials have been updated to reflect these findings.

Milar and Mushak (1982) found sodium hexametaphosphate (marketed as Calgon®) to be effective in reducing the lead content of house dust measured in parts per million. Calgon (CAS Registry Number 68915-31-1) was chosen in part because it has low toxicity. In the Milar and Mushak study, Calgon was used as part of a steam-cleaning procedure on both carpeted and uncarpeted surfaces, as discussed in Section 3.2.3 of this report. The cleaning recommendation appears to be one developed from experience, with limited testing as follows: A single 12×15 foot room was divided into four quadrants. Two quadrants were steam cleaned using a Calgon® solution followed by detergent steam cleaning 24 hours later, resulting in a 61 percent reduction in lead concentration of house dust and a 91 percent reduction in lead loading. The other two quadrants were detergent steam cleaned both times, resulting in a 12 percent reduction in lead concentration and 38 percent reduction in lead loading. Based on this limited testing, it appears that the Calgon/detergent method was selected and applied in additional homes. The authors indicate that lead concentrations were reduced by 30 to 50 percent, and lead loadings were reduced by 60 percent on average in other homes. The number of homes is not stated. The authors also report reductions in blood-lead concentrations following reduction in lead content of household dust. The dust-reduction efforts were probably not limited to carpet cleaning, although this is not explicitly stated in the article.

The HUD Guidelines (1995a) cite Wilson (1993), who performed an independent examination sponsored by the National Center for Lead-Safe Housing. Wilson studied Ledizolv™ as an alternative to TSP for cleaning lead dust from hard surfaces. Ledizolv is an anionic liquid detergent currently on the market. Specific mechanisms of cleaning lead dust by dissolving the lead dust are said to be "acid solubilization, chelation, sequestration, de-flocculation, and suspension" (LSZ, 1999). The report compares the detergent characteristics of Ledizolv and TSP and finds Ledizolv to be superior (Wilson, 1993).

An unpublished report of field research (Pinchin Environmental Consultants, 1995) prepared for a Canadian government agency, the Canada Mortgage and Housing Corporation, describes a study that further compares Ledizolv and TSP for cleaning effectiveness. Twenty uncarpeted test rooms were chosen in houses scheduled for demolition. The painted walls of test rooms were intentionally power sanded to create "very high" dust levels before pre-cleaning dust measurement, cleaning, and post-cleaning measurement. Four cleaning methods were tested:

1. Dry sweep, vacuum with a utility (wet/dry) vacuum.
2. Vacuum with a regular household vacuum, mop with Mr. Clean® solution mixed according to package directions.
3. Vacuum with utility vacuum, mop with Ledizolv solution, rinse with clear water.
4. HEPA vacuum, mop with TSP, rinse with clear water, HEPA vacuum.

Floor concentrations were measured in µg/square meter as determined by wipe sampling. The study showed that Ledizolv and TSP had comparable effectiveness in reducing floor concentrations of lead on uncarpeted floors to below the HUD clearance criteria, and were more effective than simpler methods using combinations of dry sweeping, utility vacuuming, and mopping with a household cleaner. Pinchin also showed that TSP could be effective in achieving lead clearance levels at "a much lower concentration than recommended in the HUD guidelines."

A randomized, controlled field study by Lanphear et al. (1996) showed no significant benefit to providing families with cleaning supplies including Ledizolv, in terms of reducing blood-lead in children with low or moderately elevated blood-lead levels. Families in the "intervention group" were given Ledizolv, along with paper towels and spray bottles. Families also received brief (5-minute) instructions on cleaning methods predicted to reduce lead dust exposure. The intervention in this case was fairly limited in scope, compared to home education outreach methods used in other studies. Blood was sampled in 96 children at baseline and after 7 months. Although the sample size may appear large in comparison to other lead hazard intervention studies, the study had limited power to detect the small differences that would be expected in a population of children with low blood-lead levels, especially with the limited intervention strategy employed. Approximately 75 percent of the children had base-line blood-lead levels at or below 10 µg/dL. Median blood-lead levels were not significantly different for intervention group families who reported using Ledizolv, intervention group families who reported not using Ledizolv, and control group families, who received only a brochure about lead poisoning prevention (no cleaning supplies or other instruction). Ledizolv, however, did appear to have a "marginally [but not statistically] significant" effect in reducing dust lead loadings on window sills. Overall declines were observed in dust lead levels for carpeted and noncarpeted floors and window wells in both groups, but the declines were not statistically significant. It was noted that the average baseline dust lead levels across all house surfaces sampled were 113.2 µg/ft^2 in the intervention group and 160.6 µg/ft^2 in the control group. Median blood-lead levels at baseline were 6.85 µg/dL and 6.10 µg/dL in the intervention and control groups, respectively. These levels are low when compared with lead levels in dust and blood as reported in the literature on residential lead.

2.2.2 Cleaning Practices

One EPA guide to parents (USEPA, 1998a) is representative of many of the prevailing recommendations for cleaning practices: "Use a mop or a sponge with a solution of water and an all-purpose cleaner or a cleaner made specifically for lead to clean up dust. . . . . Use one bucket for a mixture of water and cleaning solution and another bucket for rinse water." The guide recommends changing rags often or using paper towels. Similarly, the Milwaukee Health Department recommends the following temporary measures to help prevent lead poisoning:

- Clean up lead chips and lead dust with a wet mop or a wet cloth.
- Clean your floors and inside window sills with soap. Then rinse areas well and throw out dishrags and/or towels.

- Clean your floors and inside your windows with a high-efficiency particulate air (HEPA) vacuum (City of Milwaukee, 1999).

The Coalition to End Childhood Lead Poisoning (based in Baltimore), also recommends wet cleaning methods using all-purpose household cleaners for window wells and sills, tables and counters, and floors. A HUD field guide on lead paint safety points out that "Lead [paint chips and dust] needs scrubbing, not just wiping" (USHUD, 1999).

These guidelines tend not to cite specific scientific studies to justify their recommendations, but a number of quantitative studies have been published in the area of cleaning methods for removing lead dust from hard surfaces. The studied cleaning interventions were usually conducted by trained workers rather than resident families. Thus, the interventions were not necessarily typical of cleaning that would be performed by a family after receiving lead poisoning prevention education. The studies do, however, provide relevant information on the success of cleaning methods that are usually recommended in an educational session. Studies that evaluated cleaning methods that were clearly more extensive than those commonly recommended by lead educators were not summarized in this report. Some studies point to the benefits of specific cleaning activities, while others found little differences among cleaning methods. The weight of evidence does seem to support the frequent, thorough mopping and wet wiping of hard surfaces.

Sustained Cleaning. In a preliminary report of a controlled field study in 1981 in Baltimore (Charney, 1982), researchers examined the effects of a sustained cleaning program on the blood-lead levels of children having blood-lead levels greater than 30 µg/dL. Homes of the experimental group (about 13 children) were cleaned approximately biweekly by trained personnel, with cleaning methods including thorough wet mopping and washing of window sills in areas where children were said to play and where high levels of lead dust had previously been found. Families of the control group (about eight children) were advised to wet mop their homes. After 20 to 27 weeks of study, the experimental group children had statistically significant and greater reductions in blood-lead compared with the control group children.

In a subsequent article based on the same research, Charney et al. (1983) reported on results involving 14 children in an experimental group and 35 children in a control group. Children in both groups received the lead-based paint intervention that was standard in Baltimore at the time of the study. In addition, twice-monthly lead dust control interventions (wet mopping) were conducted for one year by trained members of a "dust control team" in the homes of the experimental group. The blood-lead levels of the children in the experimental group fell by an average of 6.9 µg/dL, compared with a decrease of 0.7 µg/dL among children in the control group. Charney et al. noted that it took from "several weeks to several months before all homes had a reduction in lead-containing dust that persisted between visits." That is, brief, or infrequent, dust cleaning interventions did not appear to be adequate to keep lead dust from becoming available on windowsills and floors of homes of children having blood levels of between 30 and 49 µg/dL.

Hilts et al. (1995) evaluated the effects of a single intervention — repeated HEPA vacuuming on carpeted and uncarpeted floors — in more than 110 homes in Trail, British Columbia. Trail is the site of a long-time lead and zinc smelting industry that emits 300 kg/day of lead to the air from its stack. The homes of the treatment group (55 children) received seven HEPA vacuumings of all accessible, finished floors over a period of 10 months (once every six weeks). Vacuuming was done a rate of 4 seconds per square meter for noncarpeted floors and between 22 and 32 seconds per square meter for carpeted floors. The researchers reported no statistically significant reduction in geometric mean blood-lead levels. A 40 percent reduction in floor lead loadings was observed immediately after vacuuming, but floor lead loadings returned to pre-vacuuming levels prior to the next scheduled vacuuming. In a follow-on study of recontamination rates following the final vacuuming, it was found that homes became recontaminated with lead dust within 3 weeks.

Vigorous Dust Clean-Up. In a randomized field trial involving 99 children (Rhoads et al., 1999) effects of maternal education and "vigorous dust clean-up" were evaluated. The study was conducted in New Jersey over approximately one year by trained lay workers who wet mopped floors, damp-sponged walls and horizontal surfaces, and vacuumed with a HEPA vacuum. The mopped and wet-wiped surfaces were cleaned with a commercial household cleaning solution that was low in phosphate (<0.1%) in conformance with New Jersey state law. On average, the homes of 46 children in the intervention group were cleaned every 8 to 13 days. On average, blood-lead levels fell 17 percent in the intervention group and did not change in the 53 children in the control group. Household dust and dust lead measures also fell significantly in the intervention group. The willingness of families to cooperate with the cleaning program varied considerably. In children in the intervention group whose homes were cleaned fewer than 10 times, there was no change in blood-lead levels, whereas children in homes cleaned 20 or more times throughout the year had an average blood-lead reduction of 34 percent. The cleaning methods were very intensive, typically 5 person-hours every two weeks.

Dixon et al. (1999) studied the effectiveness of a simpler alternative to the three-step HUD-recommended method for cleaning smooth surfaces (i.e., walls, ceilings, floors, and other horizontal surfaces) following lead hazard control interventions. The HUD method entails HEPA vacuuming followed by wet washing with a TSP solution and then a second HEPA vacuuming. The study findings indicated that HEPA vacuuming followed by wet washing with a lead cleaner was just as effective as the HUD method. The study was conducted in Vermont and looked at lead dust on uncarpeted floors, window sills, and window troughs. It was further found that the second HEPA vacuuming typically took only a small amount of the total cleaning time (10 percent on average), so omitting the third step would not save substantial time or labor costs.

Potentially Effective Methods. In a randomized field study of 63 children with elevated blood-lead levels whose homes were scheduled for abatement, Aschengrau et al. (1998) found that a one-time dust removal and surface cleaning intervention by trained staff reduced mean blood-lead levels, but the differences were not statistically significant. The intervention consisted of (1) HEPA vacuuming all window wells, window sills, and floors, (2) wet washing window well and window sill surfaces with a solution of TSP and water, (3) repainting window well and window sill surfaces, and (4) repairing holes in walls. Small sample sizes and high loss to follow-up were problems in assessing this intervention. Children whose homes were abated during the follow-up period were not included in the analysis.

A field study in New Zealand of various clean-up practices following residential paint removal showed no correlation between any clean-up or disposal practice and blood-lead levels two years later in resident children aged 12 to 24 months (Bates et al., 1997).

2.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

Based on the scientific studies reviewed, it is recommended that cleaning products other than trisodium phosphate (TSP) be used for cleaning lead dust from hard surfaces. However, cleaning products are more effective than water alone. Cleaners may include common household cleaners or lead-specific cleaning products. This recommendation is based on controlled tests in the laboratory (USEPA, 1997a) and in the field (Rhoads et al., 1999), which indicate that other cleaning products are effective in reducing dust-lead levels on hard surfaces. Thus, given the environmental concerns associated with high phosphate detergents, TSP is not recommended for cleaning hard surfaces.

It is recommended that extensive cleaning be repeated frequently, at least biweekly, based on studies in Baltimore (Charney, 1982; Charney et al., 1983) and Trail, British Columbia (Hilts, 1995). In both studies, recontamination occurred within two to three weeks of the cleaning intervention, although dust-lead levels eventually remained low between biweekly cleanings in the Baltimore study. This recommendation is consistent with most educational programs, which tend to recommend weekly cleaning.

Scientific evidence of the effectiveness of other specific cleanup methods, such as changing rags often, using (disposable) paper towels, and using separate buckets for wash and rinse water, was not found. It is reasonable to expect, however, that these actions would serve to reduce redistribution of lead within the home when cleaning. No evidence was found to suggest that these practices should not be recommended.

Similarly, recommendations such as placing a clean blanket or rug under a child playing on the floor, opening double-hung windows from the top, and keeping children and their belongings away from windows, do not appear to have received scientific study. Nonetheless, these recommendations appear to have merit. A blanket or rug placed on the floor provides a clean surface for play and is easily kept clean by machine washing periodically. It is well-established that window sills and wells are problem areas in terms of elevated dust-lead levels. Thus, actions that limit access to these areas or make them less attractive to children make sense.

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3.0 REDUCING LEAD DUST ON CARPETING

3.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

Vacuum methods are emphasized by most current educational programs for cleaning carpets embedded with lead-containing dust. Most educational programs recommend the use of high efficiency particulate air (HEPA) vacuums rather than conventional vacuums for this purpose. HEPA vacuums are designed to collect 99.9 percent of particles greater than 0.3 µm in diameter, whereas most conventional vacuum cleaners are inefficient in collecting fine dust particles. It has been suggested that conventional vacuums may, in fact, exhaust lead dust back into the ambient air, thus creating a potential hazard for occupants.

An historical problem with the recommendation to use HEPA filter-equipped vacuums is that the cost may be prohibitively high for much of the population at greatest risk of lead exposure, although lower-cost (under $200) HEPA vacuums for residential use are becoming available in the marketplace. Some educators recommend that a HEPA vacuum should be rented or borrowed if possible, especially for cleanup following home repair or renovations (USEPA, 1998a). Limited scientific research suggests that extended vacuuming with conventional vacuum cleaners can be effective in reducing surface lead loadings on carpets (Roberts et al., 1997; Roberts and Ruby, 1998). In addition, research suggests that partially filled conventional vacuum cleaner bags are more efficient at collecting small particles than new bags (Figley and Makohon, 1994). These findings have led to the somewhat novel suggestions contained in the booklet “Where is the Lead?” (CCAPP, 1999a), which recommends:

- vacuuming rugs and carpets three times longer than normal;
- coating new vacuum bags by spreading flour or corn starch on the floor and then vacuuming; and
- using allergy-safe vacuum bags manufactured for conventional vacuum cleaners.

The scientific basis for these recommendations is examined in this chapter.

In addition to recommendations concerning vacuuming practices, several other recommendations are made in some of the current educational programs. These recommendations are designed to reduce the accumulation of lead-containing house dust and to keep children from coming into contact with lead on carpeted surfaces. These recommendations include:

- removing very old carpet that cannot be cleaned effectively;
- using a solution containing sodium hexametaphosphate (found in Calgon®, for example) when steam cleaning carpet;
- using a doormat to reduce dust track-in;
- not wearing shoes on carpeted surfaces;
- keeping babies and young children from crawling or playing on carpeted surfaces; and
- placing a clean blanket under the child.

The scientific basis for the first two recommendations, above, is considered in this chapter. The scientific basis for using a doormat and not wearing shoes is examined in Chapter 5 of this report. As noted in the previous chapter, the last recommendations do not appear to have received scientific study. Nonetheless, these recommendations appear to have merit.

3.2 SUMMARY OF SCIENTIFIC EVIDENCE ON REDUCING LEAD DUST ON CARPETING

According to a recent EPA report summarizing scientific studies of lead dust control for carpets, furniture, and air ducts (USEPA, 1997b), "the following variables were found to be statistically significant predictors of dust-lead loadings in carpets: soil-lead concentrations, exterior dust-lead loadings, the practice of removing shoes prior to entry, use of walk-off mats at entrances, and use of vacuums with agitators. The first four predictors imply that a major source of lead dust in carpets is track-in from exterior sources.

The report continues, "The extent that lead within carpet dust is made available to children tends to be heightened when any of the following is present: having shag rugs, using either a canister vacuum (with no agitator) or no vacuum cleaner, using a vacuum cleaner with loose belts or a full dust collection bag, vacuuming less than once per week, location of [housing] unit near heavy traffic, and exposure to remodeling activities, deteriorated paint, or paint removal activities."

This report also says that "behavioral techniques that limit the amount of exterior contamination, such as removing shoes prior to entry and use of walk-off mats, have been found to significantly reduce the likelihood of lead contamination of carpets." Chapter 5 of this report which covers soil dust, and Chapter 7, which covers hygiene, have further information on behavioral approaches to reducing exposure to lead dust.

3.2.1 Vacuum Cleaning Equipment

HEPA Vacuum Cleaners. Most published guidelines for cleanup of lead dust in carpets recommend the use of HEPA-filter vacuum cleaners (e.g., USHUD, 1995a). EPA's guide for parents (USEPA, 1998a) says residents should use a HEPA filter-equipped vacuum cleaner to clean up lead dust during home repair or renovation.

Figley and Makohon (1994) conducted a controlled laboratory test of cleaning equipment and methods for carpets and vinyl floors. Although the data set was not extensive enough to permit detailed statistical analysis, the authors presented general trends and observations. They concluded that central vacuums and HEPA vacuums (with or without agitator heads) had the highest dust mass removal efficiency (57.4% to 65.3%). Conventional portable vacuum cleaners without agitator heads, by comparison, provided between 18.5 and 28.9 percent efficiency. The mass balance of lead in the dust could not be fully quantified. In addition, it was noted that mechanical agitator heads on the conventional portable and central vacuums tended to produce less airborne dust than plain floor cleaning tools. One disadvantage of central vacuum systems is their relatively high cost to install.

The HUD Guidelines note some anecdotal evidence of the effectiveness of HEPA spray cleaner vacuums, which are similar to home carpet-cleaning machines. These spray cleaner vacuums are most effective on carpet in open areas; their usefulness is limited for cleaning hard surfaces such as ceilings, vertical areas, and other hard-to-reach areas (USHUD, 1995a).

Other Types of Vacuum Cleaners. EPA's parents' guide (USEPA, 1998a) is in line with many other published recommendations in claiming that regular residential vacuum cleaners are not effective for removing lead dust particles from surfaces without resuspending them in the air. A common assertion is that conventional vacuum cleaners do not collect particles as small as the sizes commonly seen in lead dust, and that in fact these vacuums can exhaust lead dust back into the ambient air.

An EPA report on dust and dust lead recovery by vacuum cleaners (EPA, 1995a), however, found that relatively little dust escaped via the exhaust of four commercially available vacuum cleaners that were tested in a controlled laboratory setting. Among 13 tests conducted, at most 0.02 percent of the dust was expelled as exhaust emissions. Emissions testing was done with dust of the smallest particle size used in this study (<53 µm). Although these results are encouraging, caution should be taken in generalizing the results, since only a limited number of vacuum cleaners were tested and the dust particle size was large compared to that collected efficiently by HEPA vacuums. In other tests, it was found that most surface dust was collected in the first 40 seconds of vacuuming over an area of 6.8 square feet. Thus, vacuuming for approximately 10 to 20 minutes in a normal size room would be expected to remove most surface dust. Additional vacuuming was found to be effective only for carpets with ground-in dust.

Roberts et al. (1995) compared the lead dust collected by a conventional household vacuum cleaner from the surface of carpets to the dust collected from deep within the carpet. Surface dust was defined as that collected in the vacuum filter bag after eight vacuuming passes, and deep dust was collected after up to 132 additional passes. The researchers concluded that "Less than 10 percent of the total Pb in the carpet would be removed by normal vacuuming," and that "Intensive vacuuming efforts can recover substantial additional dust and lead."

In a laboratory study of new vacuum cleaners and their efficiency at collecting fine particles (0.3 to 0.5 µm in diameter), Lioy et al. (1999) found that vacuums without HEPA filters were highly variable in their collection efficiency. Of the nine non-HEPA vacuums tested with laboratory-generated fine particles in an aerosol, the collection efficiency ranged from 29 to 99 percent, with a mean efficiency of 79 percent. The laboratory-generated aerosol particles used in the study consisted of potassium chloride, ranging in diameter from 0.3 to 3 µm, with the majority of particles being toward the smaller end of that range. Including the two HEPA-filter models, the 11 vacuums tested by Lioy et al. (1999) had retail prices ranging from $200 to $700, which the authors acknowledge to be higher than the prices of vacuum cleaners typically used in many households. Lioy et al. (1999) also evaluated the contribution of motor dust to the emissions from vacuum cleaners, and concluded that a HEPA filter placed downstream of the motor provides the best collection efficiency.

It has often been argued that conventional vacuum cleaners may actually make a lead dust problem worse, by bringing embedded lead dust out of carpeted surfaces and distributing it more widely at the surface, making the lead dust more available to children. According to EPA (1997b), "Repeated vacuuming of old, contaminated carpets may increase lead-loading in surface dust if deeply-embedded dust cannot be removed in its entirety. Carpet removal may be preferable if the carpet is a shag carpet, or if it has been highly contaminated."

One alternative to HEPA and conventional vacuum cleaner technology are vacuums with dirt sensors that indicate whether dirt can be detected in carpets. These devices measure incoming dust and show the user a colored light when no dirt is coming from the carpet. Roberts et al. (1997) tested one of these vacuums and found that extended vacuuming, until the device indicated no dirt was being collected, was found to reduce median surface loading of lead on carpets in nine homes and two offices by 86 percent. The buildings tested ranged in age from 15 to 72 years, and the length of time spent vacuuming ranged from 48 minutes to 15 hours. The authors noted that the vacuum used in the testing cost $330, and that a similar, less efficient model cost $165. The time spent in removing dust with such a vacuum in 11 older Seattle carpets ranged from less than 1 minute to 4.5 minutes per square foot (Roberts and Ruby, 1998).

3.2.2 Vacuum Cleaner Filtration

Adgate et al., in a study of the sources of lead in house dust (1998), indicate that house dust adhering to children's hands is thought to be less than 200 µm in diameter, with the vast majority being less than 10 µm in diameter. By comparison, most conventional vacuum cleaner filter bags are claimed to retain about 99 percent of dust particles greater than 5 µm in diameter (Ristenbatt, 1999). Hilts et al. (1995), in a study of HEPA vacuuming, also noted that regular vacuum cleaners fail to retain fine dust particles (<5 µm in diameter) that typically have higher concentrations of lead.

The standard methods for measuring the effectiveness of vacuum cleaners at removing embedded dirt from carpet are ASTM Standards F608-96 (household vacuum cleaners) and F1284-92 (central vacuum systems). These methods specify that 100 grams of "test dirt" (90 percent sand and 10 percent talcum) be spread on test carpets, and then vacuumed. The effectiveness of the vacuum cleaner is measured using the weight of the dirt collected in the filter bag as compared with the 100 grams of dirt applied to the carpets. The methods do not provide for the measurement of the particle sizes collected by the filtration medium. The methods do stipulate that 96 percent (by weight) of the silica sand in the test dirt consist of particles between 149 and 419 µm (micrometers, formerly known as microns), and that the talcum range from 0.9 to 44 µm. A third ASTM Standard (F494-98) specifies the integrity of the paper bags used in vacuum cleaners, but again makes no reference to particle sizes of the dirt to be retained by the bags.

Figley and Makohon (1994) found that, for standard portable vacuum cleaners and bags, partially filled bags are more efficient at reducing levels of fine dust in the air than are new bags.

Presumably this is because the smaller pores in the bag become clogged with particles of dust, allowing fewer of the finer lead particles to escape the bag.

As noted above, HEPA-equipped vacuum cleaners remove 99.9 percent of particles greater than 0.3 µm, and are required for asbestos, lead, and hazardous waste abatement (Roberts et al., 1997). ULPA (ultra-low penetration air) filters are available that are 99.9995 percent efficient at removing particles of 0.13 µm or greater. The HUD Guidelines note that ULPA vacuums are more expensive and harder to obtain than HEPA vacuums. ULPA vacuums are designed to relieve the symptoms of allergy sufferers by removing house dust, dust mite waste, pet dander, etc., and they could be used to remove fine lead dust particles, but have apparently not been tested for this specific purpose.

3.2.3 Cleaning Practices

As early as 1982, researchers were evaluating the effectiveness of various methods of cleaning lead dust from carpeted surfaces. Milar and Mushak (1982) assessed the effectiveness of steam cleaning both carpeted and uncarpeted surfaces using commercial detergent in a two-step process: steam cleaning, followed 24 hours later by a second steam cleaning. This method was compared to a different method, in which a solution containing sodium hexametaphosphate (Calgon®) was used in the steam cleaning equipment for the first step. Results showed that the Calgon-detergent combination reduced lead concentration in house dust by 61 percent, and the overall quantity of lead per unit area by 91 percent. By contrast, the detergent-detergent combination reduced these values by only 12 percent and 38 percent, respectively. Further detail on the cleaning method is presented in Section 2.2.1.

Based in part on this study, EPA (1997b) advises the use of sodium hexametaphosphate or similar cleaning agents for steam cleaning carpets: "cleaning solutions that contain phosphate or polyphosphate groups . . . . bind to dust particles and reduce the electrostatic interaction between the carpet and lead-dust. The detergents within the solution can remove the dust and the accompanying lead. An accompanying reduction in blood-lead concentration may occur if repeated cleaning is done."

In addition, as an interim dust control measure, EPA recommends that, for carpets that can be lifted from the floor, residents should HEPA vacuum the top, then fold the carpet over and vacuum the backing of the carpet. If there is a pad, residents should HEPA vacuum both sides of the pad the same way, then HEPA vacuum the subfloor under the carpet or pad. For carpets that cannot be lifted, EPA recommends a three-step process: (1) HEPA vacuum the carpet completely in one direction, (2) HEPA vacuum the carpet again at a right angle (90 degrees) to the direction of the first vacuuming, and (3) steam-clean the carpet using detergent specifically for reducing the electrostatic attraction between the carpet material and the lead dust (USEPA, 1998a).

Clark et al. (1988) evaluated differing HEPA vacuuming patterns on residential carpeting as part of the Cincinnati Soil-lead Abatement Demonstration Project. They found that increasing the number of repetitive passes across the carpet with the vacuum cleaner's carpet attachment was effective in reducing the surface dust lead loading. Two, four, and seven up/back passes with the HEPA vacuum reduced lead loadings in three areas of a house by an average of 69 percent, 70 percent, and 84 percent, respectively.

Figley and Makohon (1994) determined that "extended cleaning cycles will result in higher dust mass removal from carpeting." They found that agitator heads on a conventional portable or central vacuum cleaner could achieve a mass removal efficiency of greater than 90 percent when used for 10 to 12 minutes per square meter, acknowledging that that investment of time may prove impractical in most situations.

A report by the U.S. EPA (1997e) on lead hazards from renovation and remodeling activities indicated that high dust-lead levels are associated with carpet removal.

Lioy et al. (1998) conducted a controlled study of home cleaning interventions in homes in New Jersey where children with moderately elevated blood-lead levels were living. In this study, cleaning was done by a trained crew of two persons, who discussed lead exposure and children's play habits with the mother in each household, and cleaned floors and other smooth surfaces with water and a household detergent, especially the areas where children were apt to play. Rugs and carpets were cleaned using a HEPA filter vacuum. The researchers found that HEPA vacuuming of rugs was associated with a substantial decrease (>75%) in house dust and lead loadings.

3.2.4 Carpet Removal

Some scientific research suggests that carpet replacement is preferable to carpet cleaning, especially when the carpet is older and has lead dust deeply embedded. Ewers et al. (1994) evaluated cleaning methods for carpet and for wood and vinyl floors. For the carpets, they cleaned the carpets in the laboratory using HEPA-equipped vacuum cleaners on used residential carpet samples and on new carpet samples with artificially embedded dust. For smooth surfaces, they evaluated HEPA-equipped vacuum cleaner vacuuming speed and numbers of vacuuming cycles, and evaluated the effectiveness of wet washing after the final vacuuming. They concluded that carpets from poorly maintained houses containing lead-based paint could not be cleaned effectively, even with repeated HEPA-filtered vacuum cleaning and/or shampooing. For carpets newly contaminated with dust, HEPA vacuuming for at least 6 minutes per square meter of carpet was required to remove more than 70 percent of the dust. This is the equivalent of spending about 1 hour to vacuum a 9 × 12 ft area rug.

Following a study of the residences near the Bunker Hill CERCLA site in Idaho, CH2M HILL (1991) concluded that it is doubtful that vacuuming and shampooing are viable remedial options if the objective is to substantially reduce lead loadings or concentrations in carpets.

When carpet containing lead dust is to be removed, EPA (USEPA, 1998a) recommends that residents:

1. Mist the surface of the carpet with water
2. Roll the carpet inward
3. Wrap the carpet and pad in thick plastic sheeting
4. Seal the enclosed roll with duct tape
5. HEPA vacuum the subfloor before removing the rolled-up carpet
6. HEPA vacuum the subfloor again after rolled-up carpet has been removed.

3.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

The following practices are generally recommended:

- Buy, rent, or borrow a HEPA vacuum, especially following any type of home remodeling or renovation that has disturbed lead dust in the home.
- If a HEPA vacuum is not available, use "HEPA-type" or "allergy" filter bags on conventional vacuum cleaners, to remove a higher proportion of fine dust particles from the carpets and indoor air.
- If using a conventional vacuum cleaner, try to use a mechanical agitator head or attachment to clean carpets, and try to vacuum for an extended period of time when cleaning carpets contaminated with lead dust.
- When steam cleaning carpets, consider adding sodium hexametaphosphate (found in Calgon®, for example) to the cleaning solution.
- Use care in removing older carpets that are heavily contaminated with lead dust.

The CCAPP suggests that normal housekeeping will not reduce lead dust on carpets and recommends that residents vacuum carpets three times longer than normal in areas where children play (CCAPP, 1999a). Although the specification of "three times longer" appears to be somewhat arbitrary, this recommendation is consistent with the scientific evidence that suggests extensive vacuuming can be effective in reducing lead dust on carpets (Clark et al., 1988; USEPA, 1995a; Figley and Makohon, 1994; Roberts et al., 1997; Roberts and Ruby, 1998). It is not known, however, how long dust-lead levels will remain low following extended vacuuming. For example, if a resident spends one hour vacuuming a single room to reduce lead dust, the time required for subsequent vacuum cleanings may be shorter. The initial, deep cleaning may allow residents to follow up with briefer, maintenance vacuuming.

Vacuum cleaners equipped with HEPA filtration devices are recommended for lead cleaning, as they have greater collection efficiency for small particle sizes consistent with fine lead-dust particles. HEPA vacuums have been tested and shown to be more efficient than conventional vacuum systems in removing lead dust from carpets (Figley and Makohon, 1994; Lioy, 1999). It should be noted that prices for HEPA vacuum cleaners are declining and several models are being marketed for home use. In the future, the question of HEPA versus conventional vacuum cleaners may be of less concern.

A concern with conventional vacuum cleaners is that fine particles of lead dust may blow out through the exhaust and spread through the home. For this reason, “HEPA-type” or “Allergy” filter bags are recommended when HEPA vacuum equipment is not available. Although the use of “HEPA-type” or “Allergy” filter bags on conventional vacuum cleaners has not been tested for lead cleanup, based on manufacturers’ specifications these bags should improve the collection efficiency of conventional vacuum cleaners. And vacuuming even without the special filtration may still be quite valuable, as the exhaust from conventional vacuums may not necessarily contain high dust-lead levels (USEPA, 1995a).

If “HEPA-type” or “Allergy” filter bags are not available, the CCAPP recommends that residents coat new vacuum cleaner filter bags by spreading 1 to 2 cups of flour or corn starch on a clean floor when first using a new bag, then vacuuming the flour or corn starch to “clog up the bag to help it keep in the lead”. This recommendation is based in part on the findings of Figley and Makohon (1994), who found that partially filled bags were more efficient than new bags in trapping small particles. The effectiveness of these specific materials and quantities has not been scientifically tested (Jones, 1999). This quantity of material should not prove inconvenient to the user.

4.0 REDUCING EXPOSURE TO LEAD FROM PAINT

4.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

Peeling and cracking paint is known to be a major contributor to lead in indoor dust, and it can also be a direct source of exposure to children when they place paint chips in their mouths. These two points are made in most of the current lead education programs. These educational programs also emphasize that the threat of lead in paint exists in houses that were built more than 20 years ago, while the threat is greatest in houses built before 1960. Educational programs recommend actions that can be taken to lessen the exposure of children to lead in paint. These recommended actions can be divided into two categories: interior paint and exterior paint.

For interior paint, recommendations are made in educational programs that address cleaning and other methods to reduce or eliminate exposure to peeling or cracking paint and paint chips. Cleaning recommendations that are made include:

- cleaning up paint chips immediately; and
- wiping off loose paint using damp disposable cloths or rags.

Recommendations about reducing exposure to peeling or cracking paint include:

- blocking chipping paint with furniture;
- putting contact paper over chipping paint;
- covering painted floors with carpet or linoleum; and
- sealing or enclosing areas with chipping paint.

Most educational programs also address the issue of removing and repainting areas where paint is chipping. Many of the educational programs warn about hazards associated with sanding, scraping, and burning off old chipping paint. In most cases, the educational program suggests that proper instructions on safe methods of paint removal should be given to those participating in the education program.

Most educational programs focus less on exterior paint than on interior paint. When they do address exterior paint, the programs address paint on the sides of the house and painted porches. The educational programs recommend that children be kept away from the sides of the house and prohibited from playing on the porch. If allowed to play on the porch, measures should be taken to reduce exposure to lead-based paint and lead-containing dust by sealing the porch, hosing off the porch, or placing a sheet, heavy blanket, or plastic sheeting down in the play area. Most programs that address the issue of exterior paint provide either a warning about safe removal of paint or recommend that trained professional painters be hired to perform the removal and repainting.

4.2 SCIENTIFIC BASIS FOR EDUCATIONAL CONTENT

Limited research has been conducted that demonstrates the effectiveness of educational recommendations to limit exposure to lead-based paint hazards. This section examines the scientific basis for recommendations that may be made to (1) limit exposure to lead from paint that is not removed, (2) residents who want to remove small amounts of deteriorated paint themselves, (3) residents whose home will be abated, and (4) residents whose homes will be subject to renovation and remodeling.

4.2.1 Limiting Exposure when Paint is Not Removed

There are circumstances when a child may live in a home that is known to contain lead-based paint and the lead-based paint does not need to be abated. For example, there is evidence to suggest that well-maintained homes that contain lead-based paint pose less of a health risk than those with deteriorated paint (Clark et al., 1985; USHUD, 1995b) and that abatement may be of limited value to children with moderately elevated blood-lead levels, at least for the current resident children (Swindell et al., 1994). Thus, in some cases, it is expected that children will live in a home that contains lead-based paint without reaching severely elevated blood-lead levels. In other cases, abatement of a lead hazard may have been scheduled, but not completed. This section addresses the scientific basis for educational recommendations on limiting exposure to lead-based paint, when the paint is not removed.

Areas with chipping or peeling paint are clearly hazardous. Cleaning recommendations for these areas include wiping off loose paint using damp disposable clothes or rags and cleaning up paint chips immediately. Practical recommendations to limit access, such as careful placement of furniture to form a barrier or covering the area with cardboard or contact paper, are also common. The latter suggestion also provides a smooth, easily-cleaned surface.

Little evidence is available to demonstrate the effectiveness of such educational recommendations on limiting exposure to lead-based paint, when the paint is not removed. A study conducted in Granite City, Illinois, suggested that educational efforts can be effective in reducing lead exposure (Kimbrough et al., 1994). The study findings were limited, however, as no control group was available. Parents of 78 children with elevated blood-lead levels were advised on ways to make lead-based paint inaccessible by installing barriers, such as placing a couch in front of a window sill, or to carefully remove small quantities of paint. In addition, they were instructed on cleaning methods, nutrition, and hygiene. Substantial reductions in blood-lead concentrations were reported one year later in 30 children receiving this intervention, for whom follow-up blood-lead measurements were available. The effectiveness of recommendations that would limit exposure to paint, however, could not be separated from that of other recommendations made in this educational intervention.

More extensive recommendations include covering painted floors with carpet or linoleum and sealing or enclosing areas with chipping paint. These strategies are better studied. It should be noted that in the following studies, floor treatments were not limited to floors previously coated with lead-based paint. Providing a smooth, easily cleaned surface on any floor was considered valuable.

In a pilot project to evaluate experimental abatement practices, dust-lead loadings were greatly reduced on wooden floors that were covered with vinyl tile, or sealed with 1-2 coats of polyurethane or deck enamel (Farfel and Chisolm, 1991).

Substantial reductions in floor, window sill, and window well dust-lead loadings were observed in the Baltimore Repair and Maintenance study (USEPA, 1998c), in which a range of treatments were tested. The lowest cost intervention included installation of a doormat at the main entry, interior paint stabilization and repainting of treated areas, installation of an aluminum cap on window wells, and repainting interior window sills with semigloss paint. The next treatment level included these interventions and, additionally, sealing of wood floors to provide a smooth, easy to clean surface; installation of durable coverings such as vinyl tile on floors that had been painted with lead-based paint; limited use of encapsulant or enclosure methods on interior walls and treads and risers on stairways when lead-based paint was present; treatments to reduce friction on windows and doors where lead-based paint was present; and other treatments to make surfaces smooth and cleanable. Many of these strategies are simple and easily undertaken by individuals and, thus, could be recommended in an educational intervention. The effects of these specific actions cannot be separated from other interventions that were conducted in these homes, yet the combined strategies were clearly effective in reducing dust-lead levels on floors, window sills, and window wells.

4.2.2 Limited Paint Removal by Occupant

There are cases where limited paint removal by the residents has been recommended, for example, in well-maintained homes where small amounts of deteriorated lead-based paint are found.

In educating parents, it is important to point out that many of the traditional methods for paint removal can be hazardous when dealing with lead-based paint. These methods include mechanical sanding (without a HEPA filter) or burning lead-based paint. In a study where blood-lead levels were monitored during the deleading process, it was found that elevations in the blood-lead levels were more likely to occur when dry scraping or sanding (increase of 9.1 µg/dL among children living in 41 homes) or burning with a propane torch (35.7 µg/dL increase in 9 homes) methods were used and the children were not removed from the home (Amatai et al., 1991).

In addition, chemical stripping can be hazardous because the chemicals used are generally toxic. In particular, methylene chloride, a common component of chemical stripping products, is a suspected carcinogen that can cause kidney and liver damage along with carbon monoxide poisoning (ACGIH, 1992; IARC, 1990). It is advised not to use this particular chemical during any paint removal.

Wet scraping/sanding is probably the simplest of the methods recommended by HUD (1995a) for removing lead-based paint. This method is similar to dry scraping/sanding, except that the area being worked on is kept moist at all times. For wet sanding, sanding sponges are useful, since they can be rinsed in a bucket of water periodically to remove paint. Wet scraping or sanding generates less dust than dry scraping/sanding and the dust that is produced is more easily contained. A more detailed description can be found in "Lead Safe Painting" (CCAPP, 1999b) or "Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work" (USHUD, 1999). The scraped chips of paint should be placed on the containment plastic in the work area and cleaned up promptly, making sure that no pieces are tracked throughout the area or outside the area. This method is recommended for small areas working on a few square feet at a time. HUD also recommends limited use of dry sanding/scraping in areas, such as near electrical outlets, where wet sanding/scraping would be dangerous. These methods are most effective with proper set-up prior to the work, clean-up once the work has been done, and continual cleaning long after the job has been completed.

4.2.3 Limiting Exposure During Abatement

Many educational programs provide only limited information on lead-based paint abatement. If an abatement is ordered and the family rents, the parents likely have no control of the abatement. If the family owns the home, they may be tempted to carry out the abatement themselves. In either case, education on what to expect during an abatement and how to protect the family and possessions in parts of the home not undergoing abatement would be useful.

It is strongly recommended that a licensed abatement contractor be hired if paint removal is deemed necessary. It has been found that abatements performed by homeowners/friends posed a greater risk to resident children than abatement performed by contractors using the same methods (Bates, 1997). Improperly performed abatements can lead to further elevations in blood-lead levels (Amitai et al., 1991; Farfel and Chisolm, 1991).

EPA recommends the use of a certified abatement contractor to help safeguard the family before, during, and after an abatement. It is important to find a contractor that is licensed in lead-based paint removal and to check the contractor's credentials and references as suggested by the EPA. Precautions should be taken when having a room or area abated, such as sealing off that portion of the home, removing all furniture from that area, and covering all vents. Because abatement has the potential to generate large amounts of lead containing dust, EPA and HUD recommend that it be followed by specialized cleaning and clearance testing. Recommendations on precautions and steps that should be taken for lead paint removal can be found in pamphlets such as "Lead In Your Home: A Parent's Reference Guide" (USEPA, 1998a) or "Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work" by HUD (1999).

4.2.4 Limiting Exposure During Renovation and Remodeling

EPA has studied a number of renovation and remodeling activities that can cause lead exposure. Guidance on renovation and remodeling activities is found in the pamphlet "Reducing

Lead Hazards When Remodeling Your Home" (USEPA, 1997d). A summary of the renovation and remodeling studies can be found in the report "Lead Exposure Associated with Renovation and Remodeling Activities: Final Summary Report" (USEPA, 2000).

4.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

Most educational programs note that areas with chipping or peeling paint are clearly hazardous. Cleaning recommendations for these areas include wiping off loose paint using damp disposable cloths or rags and cleaning up paint chips immediately. Practical recommendations to limit access, such as careful placement of furniture to form a barrier or covering the area with cardboard or contact paper, are also common. The latter suggestion also provides a smooth, easily-cleaned surface. Limited scientific evidence was found to support these recommendations. No evidence for changing any of these current recommendations was found in the literature.

Cleaning is more easily performed on smooth surfaces. Educational programs often do not suggest simple steps that can be taken to provide smooth, easily cleaned surfaces. These steps include painting window sills with semi-gloss paint, installing aluminum liners in window wells, and sealing wood floors with polyurethane or durable paint. These methods were implemented in the Baltimore R&M study and were effective in reducing dust-lead loadings (USEPA, 1998c). Although contractors performed the work in the Baltimore study, these steps may be simple enough to be undertaken by individuals.

Most programs take care to point out that traditional methods of paint removal can be hazardous when dealing with lead-based paint. These methods include mechanical sanding (without a HEPA filter), burning lead-based paint, or using a heat gun at too high a temperature. In addition, chemical stripping with methylene chloride can be hazardous since methylene chloride is toxic. These recommendations are supported by the scientific evidence and, in some cases, these methods are banned by law.

Given that traditional methods should not be used, some educational programs do not provide recommendations on safe alternatives. Wet scraping or sanding is probably the simplest of the methods recommended by HUD for removing lead-based paint. HUD also recommends limited use of dry sanding/scraping in areas, such as near electrical outlets, where wet sanding/scraping would be dangerous (USHUD, 1995a). These recommended methods should be included in educational programs.

Many educational programs provide only limited information on lead-based paint abatement. It is strongly recommended that a licensed abatement contractor be hired if paint removal is deemed necessary. Education on what to expect during an abatement and how to protect the family and possessions in parts of the home not undergoing abatement would be useful for families whose homes will be abated. Families aware of abatement procedures are more able to take action if the abatement is inadequate or performed improperly. In addition, it is important to make families aware of unsafe renovation and remodeling practices, as outlined in the EPA pamphlet on renovation and remodeling (USEPA, 1997d).

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5.0 REDUCING EXPOSURE TO LEAD FROM SOIL

5.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

Besides the dust and chips from deteriorating lead-based interior and exterior paint, one of the major sources of lead for children is soil and exterior dust. Soil lead, in turn, originates primarily from three sources: (1) lead-based paint; (2) point source emitters [such as mining, smelting, and battery manufacturing facilities]; and (3) leaded gasoline emissions [from the period before lead additives were removed from the market]. Most educational programs offer advice on how to reduce children's exposure to soil.

Current educational programs teach that children can be exposed to lead in soil when they play outdoors. They often note that lead has collected in the soil as a result of fallout from leaded gasoline as well as from erosion of lead-based paint from the exterior walls of the house. Current educational programs make several recommendations on ways to reduce the risk of exposure to lead in soil. These recommendations include:

- covering bare soil with grass, plants, gravel, or wood chips;
- testing garden soil for lead;
- not letting children play near walls of house or garage or on bare soil;
- having children play in grassy area or sandbox that can be covered;
- removing shoes before entering the house; and
- using a door mat to reduce track-in of outdoor dust and soil.

The programs also suggest that parents or caregivers wash children's hands after they have played outdoors. The programs also recommend that children be fed prior to letting them play outdoors because absorption of lead occurs more readily when the child's stomach is empty.

5.2 SUMMARY OF SCIENTIFIC EVIDENCE ON REDUCING LEAD EXPOSURE FROM SOIL

Compared with other routes of exposure and methods of reducing risk, exposure from soil has been less studied, with few scientific evaluations appearing in the literature.

Methods of cleaning up soil dust and interior dust in inner-city areas of Minneapolis and St. Paul were evaluated by Mielke et al. (1994). The interventions resulted in significant reductions in blood-lead levels, especially among children with higher blood-lead levels. Dust control treatment was performed by a contractor, and consisted of (interior): wall washing, HEPA vacuuming, mopping with high phosphate detergent, and some carpet removal; (exterior): covering bare soil with sod or wood chips, addition of sandbox at all residences, and provisions to prevent soil from washing onto sidewalks and being tracked into homes. The cleaning supplies and materials were estimated to cost about $600 per residence. It was found that interior and exterior dust control management and education worked to lower lead exposure in the treatment group.

The impact of soil track-in was investigated by Roberts et al. (1991) in a study of the effectiveness of low cost lead control measures in the home. Results indicated that the lead surface loading of carpets was correlated with the lead concentration of the surface soil near the foundation and wearing shoes indoors. Shoe removal and the use of a walk-off mat were estimated to produce ten- and six-fold reductions, respectively, in carpet lead loadings in a small number of homes. Testing the walk-off doormats indicated that lead levels in the doormat were almost twice that on the floor inside, which further supports the idea of track-in as a major source of floor lead in homes. Shoe removal and doormat use were not suggested as replacement practices for lead paint and soil abatement, but they were highly effective measures that could be implemented while waiting to finance more expensive abatement procedures.

A national survey of homes sponsored by HUD found that soil in the drip line tends to have higher concentrations of lead dust from deteriorating exterior paint, and soil near streets tends to have higher concentrations of lead dust from past use of leaded fuels in vehicles (USEPA, 1995c). This supports the recommendation that exposure to lead from soil can be reduced by not letting children play near the foundation (or drip line) of the house, and also away from the street.

5.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

Recommended ways to reduce exposure to lead in soil include not letting children play near the walls of the house or garage, where soil-lead levels are highest; not letting children play in bare soil by providing a sandbox to play in and covering bare soil with plants, grass, mulch, or wood chips; and reducing soil track-in by removing shoes at the door and providing a walk-off mat. These recommendations are supported by limited scientific evidence. No evidence for changing these recommendations was found in the literature.

6.0 NUTRITIONAL RECOMMENDATIONS

6.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

Many current educational programs address nutritional aspects of lead poisoning. One example is the California "Bright Futures" program of the Childhood Lead Poisoning Prevention branch (CLPPB, 1999). Most educational programs that address nutrition examine it from two angles: foods that help protect against lead poisoning, and nutritional habits that may contribute to lead poisoning.

Educational programs uniformly point out that calcium-rich foods and iron-rich foods can help protect children from lead poisoning. Foods high in vitamin C are also commonly recommended. Calcium and iron work to prevent bodies from absorbing lead. Vitamin C helps the body to absorb more iron. Most programs give examples of foods that are rich in calcium, iron, and vitamin C to assist parents and caregivers to identify foods that should be part of the child's diet. Some educational programs also point out that fatty foods help the body to absorb lead, so they should be controlled within a child's diet.

It is also noted in some educational programs that certain vegetables grown in gardens may contain high levels of lead if there are high levels of lead in the soil of the garden. Also, lead is absorbed more easily when a child's stomach is empty. As a result, most current educational programs recommend that children be fed three meals a day with supplemental snacks.

Recommendations on food preparation and storage may include advice to use containers and dishes that are free from lead, avoid food stored in lead-soldered cans, use only cold water for drinking and food preparation, run water to flush pipes for 1 minute or more, and test all home remedies for lead. That lead in water is only a minor source of lead is noted in many programs, although programs that note that fact also make the preceding recommendations regarding use of water.

In the area of nutrition, educational programs currently recommend that children consume a well balanced diet, paying special attention that daily recommended intakes of calcium and iron are met. In areas where children are at greatest risk for lead exposure, calcium and iron supplementation programs have been implemented. Some programs only address iron in the context of a medical evaluation for sickle cell disease and iron deficiency anemia.

6.2 SCIENTIFIC BASIS FOR EDUCATIONAL CONTENT

There is a large body of research on the relationship between lead and nutritional elements, which has been previously reviewed in articles by Mahaffey (1977, 1981, 1983, 1985, 1986, 1990, and 1995), DeMichele (1984), Goyer (1995), Levander (1977 and 1979), and others. This summary relies heavily on those previous reviews.

6.2.1 Iron

The relationship between iron levels and lead uptake has been widely studied, both in animals and in humans. In a frequently-cited 1972 article, Six and Goyer performed a study on rats to assess the importance of iron in reducing lead toxicity. Lead was given to rats who were either fed a diet with adequate amounts of iron, calcium, and phosphorus or a diet that was deficient in iron. The iron deficient group showed increased retention of lead in liver, kidneys, and bone along with increased excretion of lead in urine. In turn, the increased body burden of lead that results from iron deficiency enhances the biochemical changes that are associated with lead toxicity.

Hammad et al. (1996) studied 299 children 9 months to 5 years in age to investigate the relationship between dietary intake of iron and blood-lead levels. A negative association between blood-lead and dietary iron intake was observed, and the authors concluded that this was sufficient evidence that a higher dietary intake of iron was associated with lower levels of lead in blood. Secondary intervention, such as proper nutrition, was purported to be a possibly valuable tool in reducing blood-lead levels.

Iron supplementation was included as part of a broader intervention strategy undertaken by Markowitz et al. (1996). However, the effect of correcting iron deficiency was not significant at reducing blood-lead levels in the population. The authors suggested this may be due to the high level of lead poisoning in the study population.

Numerous reviews have been published summarizing the large body of research on the effects of iron on lead. DeMichele (1984) concluded that iron stores had an impact on gastrointestinal absorption of lead and may lead to a decrease in lead toxicity. In two reviews of animal studies, Levander (1977 and 1979) found that iron deficiencies increased susceptibility to the toxic effects of lead in animals and that this effect was expected to translate to humans. After a summary of various research over a number of years, Mahaffey (1981, 1983, 1990, and 1995) concluded that an inverse relationship exists between iron intake and lead absorption. Goyer (1995) concluded that research indicated a link between iron deficiency and increased lead absorption to the extent that iron supplementation should be recommended for children, especially those at risk for lead toxicity. Neggers et al. (1986) point out that while good nutrition is not a cure for lead poisoning, adequate amounts of iron are associated with reduced lead absorption. There is a consensus among researchers and various reviewers that iron deficiencies are linked to increased levels of lead absorption. This indicates that an adequate daily intake of iron, or even iron supplementation, is a valuable means of reducing susceptibility to lead toxicity. It should be noted, however, that caution should be taken when recommending dietary supplements as iron toxicity may occur at moderately elevated iron levels.

6.2.2 Calcium

Calcium is another essential nutrient whose relationship with lead has been thoroughly researched. Two surveys of nutrition in children indicate that dietary intake of calcium is inversely associated with blood-lead concentrations. Sorrell and Rosen (1977) evaluated the relationships between lead levels, calcium, and vitamin D. Their findings showed that children in the high blood-lead group had lower mean daily intakes of both calcium and vitamin D. This inverse relationship between calcium and lead was also found in an analysis of the Second National Health and Nutrition Examination Survey (NHANES II) data involving 2,926 African-American and Caucasian children aged 1 to 11 years (Mahaffey et al., 1986). The authors concluded that dietary calcium levels were inversely associated with blood-lead levels.

The relationship between calcium and lead has been widely reviewed. DeMichele (1984) and Neggers et al. (1986) present various studies indicating an inverse relationship between calcium and lead. Goyer (1995) also found this inverse relationship and concluded that insufficient dietary calcium can lead to an increase in lead concentration in critical organs. In various literature reviews over a number of years, Mahaffey (1977, 1981, 1983, 1985, 1990, and 1995) indicates that there is a link between low dietary calcium and increased lead absorption. In his reviews of animal studies, Levander (1977 and 1979) found that deficiencies in calcium resulted in increased body retention of lead and thus an increased likelihood of observing lead toxicity in the animals and suggests that this effect may also occur in humans. Lead appeared to exert a pro-oxidant stress on red blood cells, causing them to be destroyed more rapidly.

Beyond recommending that children eat foods rich in calcium, Bogden et al. (1997) recommended fortification of foods since diet is often inadequate. Goyer (1995), too, suggests calcium supplementation since calcium naturally found in food and dairy products is often inadequate for the prevention of lead toxicity.

In one study of calcium supplements, Bourgoin, et al. (1993) evaluated 70 brands of calcium supplements to determine their lead content. The study determined that 25 percent of the products were above the tolerable level (FDA) for daily lead intake and that less than 20 percent had normalized lead levels that were less than or equal to those found in cow's milk. This information suggests that if supplementation is to be done, then sources with low lead levels should be used, especially in children. Calcium supplements derived from refined calcium carbonate powders had lead content similar to that of cow's milk, while the highest lead levels were found in products derived from bonemeal and other natural sources.

More recently, *Consumer Reports* magazine tested 13 calcium supplements, and found that six of the supplements had less than 1 µg of lead per 1,000 mg of calcium (1999). There are no federal standards for lead in calcium supplements, but the state of California has set a limit of 1.5 µg per 1,000 mg of calcium in supplements or antacids.

6.2.3 Vitamin C (Ascorbic Acid/Ascorbate)

The antioxidant qualities of vitamin C have been investigated to determine if it can offer any protection from the effects of lead. This hope exists because of positive evidence produced in animal studies. Vij et al. (1998) performed a study on the impact of vitamin C supplementation on the reduction of lead induced toxicity in rats. Lead administered intraperitoneally at 20 mg/kg was found to inhibit heme synthesis and drug metabolism, accompanied by the depletion of vitamin C levels in several body systems and by declines in total and non-protein sulfhydryl levels. Oral supplementation of vitamin C restored various blood measures and appeared to reduce the uptake of lead. Vitamin C supplementation also led to a marked reduction in liver and blood-lead concentrations. Indications from this animal study are that vitamin C supplementation is protective against lead's effects on inhibiting heme synthesis and drug metabolism that occur when lead depletes non-supplemented vitamin C levels.

Human studies have provided some evidence of such a link. Simon and Hudes (1999) performed a study using the NHANES III data from 19,578 participants to look at the relationship between blood-lead levels and ascorbic acid. Results showed that serum ascorbic acid level was inversely related to blood-lead levels among adults and children in the population of interest, but that the relationship between dietary ascorbic acid intake and blood-lead levels was not significant.

Hernandez-Avila et al. (1997) found that reduced maternal blood-lead levels and umbilical cord blood-lead levels were associated with orange juice consumption in a study of 1,849 mother-and-child pairs participating in a lead surveillance program in Mexico City.

DeMichele (1984) indicated that dietary *ascorbate* enhances the absorption of lead by binding with it and increasing solubility. It may, however, also enhance the absorption of other minerals that reduce lead absorption, such as calcium and iron, and, thus, have a net positive effect.

6.2.4 Protein

Numerous literature reviews concerning the relationship between lead and protein indicate a general lack of understanding of the influence of protein on lead. DeMichele (1984) noted that protein, along with certain other substances, bound to lead and enhanced its absorption by increasing its solubility. Excessive amounts of protein were shown to lead to increased lead uptake in animal studies reviewed by Levander (1979). However, Neggers et al. (1986) cite research indicating that inadequate protein enhanced susceptibility to lead toxicity. Similarly, Levander’s review (1977) of animal studies found that deficiencies in protein increased susceptibility to the toxic effects of lead in the animals. These opposing findings on the impact of protein intake on lead indicate that further research needs to be done in this area before any nutritional recommendations can be made.

6.2.5 Vitamin D

Vitamin D is another nutrient whose relationship with lead absorption is unclear. Sorrell and Rosen (1977) investigated children who took part in a nutritional survey to evaluate the relationships between lead levels, calcium, and vitamin D. Findings showed that children in the high blood-lead group had lower mean daily intakes of both calcium and vitamin D. A review by

DeMichele (1984) concluded that vitamin D, along with certain other substances, bound to lead and enhanced its absorption by increasing its solubility. In an additional set of review papers, Mahaffey (1981 and 1983) suggests that vitamin D is linked to increased lead absorption. Neggers et al. (1986) suggested that an increase in vitamin D can increase gastrointestinal absorption of lead, but that a dietary deficiency of vitamin D is also associated with high blood-lead levels.

6.2.6 Zinc

A large number of papers have reviewed the effect of zinc on lead toxicity. Mahaffey (1981, 1983, and 1985) cited various research reports indicating a link between low dietary zinc and increased lead absorption. DeMichele (1984) and Neggers et al. (1986) presented various studies indicating an inverse relationship between zinc and lead. Goyer (1995) also cited evidence to support this inverse relationship, but cautioned that the relationship between zinc and lead was not yet as well defined as lead's link with both calcium and iron. Levander (1977 and 1979) presented a review of various animal studies that also found that zinc deficiencies led to a susceptibility to the toxic effects of lead in the animals.

6.2.7 Fat

There appears to be a consensus among researchers that there is a strong relationship between the dietary intake of fat and lead absorption. Lucas et al. (1996) investigated some of the less studied nutritional elements using 296 children as subjects and found a significantly positive correlation existed between blood-lead and dietary fat.

Numerous reviewers also note a link between dietary fat and elevated blood levels. DeMichele (1984) found that fat, along with certain other substances, bound to lead and enhanced its absorption by increasing its solubility. In numerous review papers written by Mahaffey (1977, 1981, 1983, and 1995), a diet high in fat was linked to increased lead absorption. Neggers et al. (1986) cited research showing that increased dietary fat content is also associated with increased lead in animal tissues, and a review of animal studies presented by Levander (1979) concluded that quantity and kind of fat had an impact on increased lead absorption. Specifically, fats containing large proportions of polyunsaturated fats (rapeseed and sunflower oils) had little effect on lead absorption, while butterfat caused the greatest increases in lead absorption.

6.2.8 Total Caloric (Food) Intake

The relationship between total food intake and lead absorption is less clear. Lucas et al. (1996) performed a study of 296 children and found a significant positive correlation between blood-lead and total caloric intake. Schwartz et al. (1986), using the NHANES II data, found a positive relationship between blood-lead levels and total calories. Various reviews of literature point to different relationships. DeMichele (1984) cited research indications of an inverse relationship between total food intake and lead absorption, while Mahaffey (1981, 1983, 1990, and 1995) cited a variety of studies that indicated that the lower the total food intake, the greater the amount of lead absorbed by the body.

6.2.9 Selenium

The impact of selenium on blood-lead absorption is not widely studied. Selenium is a naturally occurring nonmetallic trace mineral that is a by-product of copper smelting. It is also in use as an antioxidant and a dietary supplement. Osman et al. (1998) conducted a study with 157 children in Poland that investigated the possible interactions between lead and less studied elements such as selenium, zinc, and copper. The results showed an association between selenium in whole blood and reduced blood-lead levels, which the authors suggested may indicate an influence of selenium on the kinetics of lead. No other research findings were found in the literature to help support or refute this conclusion. Given the importance of selenium in the diet and the lack of solid evidence of a detrimental effect, it would not seem prudent at this time to recommend controlling selenium in the diet.

6.2.10 Other Vitamins and Minerals

Lactose. A review article by DeMichele (1984) presented various studies that indicated that lactose, along with certain other substances, bound to lead and enhanced its absorption by increasing its solubility. However, this has not been studied in humans. Since lactose is found in milk, which is also high in calcium, the question may arise about whether this impacts upon dietary recommendations related to calcium. However, Hernandez-Avila et al. (1997) found that greater milk consumption was associated with lower blood-lead levels. Thus, lactose recommendations do not seem to have a place in nutritional recommendations at this time.

Vitamin E. Levander (1977 and 1979) reviewed various studies and found that deficiencies in vitamin E increased susceptibility to the toxic effects of lead in the animals in his two separate reviews of research focusing on animal studies.

Phosphorous. In animal studies presented in Levander (1979), a diet low in phosphorous was shown to exaggerate lead toxicity. Mahaffey (1977 and 1983) also reviewed various research that also indicated an inverse relationship between dietary phosphorous and lead uptake.

Sodium Citrate. A review of studies by DeMichele (1984) indicated that dietary sodium citrate enhanced the absorption of lead by binding with it and increasing solubility. Another review of research by Mahaffey (1977) indicated that lead absorption was increased by the presence of sodium citrate and by consuming orange juice.

Copper. Very little is known about copper and its impact on lead absorption. In animal studies reviewed in Levander (1979), exaggerated lead toxicity resulted when animals were fed a diet low in copper. No references to human studies on copper were found.

6.2.11 Food Choices

Freeman et al. (1997) provided some interesting, if inconclusive, insight on the differences in eating habits found for children in two age groups (13-24 months versus 25-36 months). Food-related habits were found to be associated with blood-lead levels. A diet including hamburgers, donuts, peanut butter and jelly (PBJ), and cold cuts was associated with elevated blood-lead levels in 13-24-month olds, while a diet including vitamin supplements, raw vegetables, and yogurt was associated with lower levels in this group. In the 25-36-month old group, a diet including hamburgers and PBJ was associated with elevated levels while yogurt consumption was associated with lower levels. Foods associated with elevated levels tend to be low in nutritional value, high in fat and are "sticky" foods that may pick up lead dust from around the home that is then consumed. The confound between the nutritional value of the food and its exterior "stickiness" limit the ability to draw detailed conclusions. Chapter 7 of this report also indicates that personal hygiene may play a role in interpreting the results of this study.

Hernandez-Avila et al. (1997) performed a study of mother-child pairs in Mexico City and found that maternal blood-lead levels were positively related to the use of lead-glazed ceramic ware and to traffic exposure, and inversely related to the consumption of milk and orange juice. The association between lead and milk intake was unchanged even after taking into consideration other predictors of blood-lead, which suggested that simple intervention could reduce lead burden among women and newborns. Mothers who consumed at least 7 glasses of milk per week had significantly lower blood-lead levels than those that did not. The authors point to this as evidence of the protective effect of milk, especially in terms of the calcium contribution. Other authors have held back on commending the benefits of milk, because the protective effects drawn from the calcium in the milk may be mitigated by the increased absorption effects of the lactose, vitamin D, and fat found in milk. In effect, the true relationship between milk and blood-lead levels remains to be determined. However, the evidence at this time does not preclude recommending milk as a source of calcium.

6.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

Most educational programs address nutrition through recommendations that children consume a well balanced diet, with adequate intake of calcium and iron and not excessive intake of fat. These recommendations are strongly supported by scientific research. In addition, there is substantial evidence that zinc is associated with lower blood-lead levels. Some educational programs also recommend vitamin C. There is more limited evidence to support this recommendation. This is a promising area for future research. These nutrients can be found naturally in the following food items:

- calcium is found in milk, yogurt, and other dairy products, calcium fortified juices, meat, fish, eggs, cereal products, beans, fruits, and vegetables.
- iron is found in meat, poultry, fish, clams, and oysters. Plant sources of iron include iron-fortified cereals, enriched bread and pasta products, nuts and seeds, dark green vegetables, and dried fruits.

- Zinc sources include meat, poultry, seafood, whole grains, fortified cereals, nuts, and milk.
- Vitamin C is found in citrus fruits, tomatoes, potatoes, broccoli, green peppers, and several other fruits and vegetables.
- Fat is found in butter, margarine, cream, french fries, high-fat meat products, and many snack foods. Food preparation methods, such as frying, can add fat to the diet. However, children under age 3 are generally recommended to obtain sufficient fat in their diet and not to be on an extremely low-fat diet.

It is worth mentioning that much of dietary zinc is not absorbed and that less than 20 percent of iron in the diet is absorbed into the body (Merck, 1997). Eating foods rich in vitamin C along with iron-rich foods can help the body absorb more iron. If calcium supplements are considered, an extensive study of lead levels in calcium supplements reported that calcium supplements derived from bonemeal and other natural sources generally contained more lead than those derived from refined calcium carbonate powders (Bourgoin, et al., 1993).

There is evidence to suggest that vitamin E and phosphorus are beneficial, in addition to the nutrients recommended above. These nutrients can be found naturally in the following foods:

- Vitamin E is found in vegetable oil, whole grains, wheat germ, nuts and seeds, leafy vegetables, egg yolks, and legumes.
- Phosphorus sources include milk, yogurt, cheese, meat, poultry, fish, cereals, nuts, and legumes. However, note that many cheeses can be high in fat, much of it undesirable saturated fat.

Of course, the FDA guidelines for daily recommended intake should continue to be followed to maintain overall health.

7.0 HYGIENE RECOMMENDATIONS TO REDUCE LEAD EXPOSURE

7.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

All of the reviewed educational programs contained three recommendations concerning the basic hygiene of children. First, children's hands should be washed frequently. Since exposure to lead in dust and soil usually comes from of hand-to-mouth behavior, keeping a child's hands clean should reduce the exposure to lead. Second, the toys with which the child plays should be washed regularly. As with hands, lead from dust or soil collects on toys. Lead is then passed along to the hands of the children when they touch the toy, or direct ingestion of lead may occur if the child puts the toy to his or her mouth. As a result, a child's exposure to lead can be reduced with clean toys. Finally, the child's hands should be washed after he or she plays with a pet. Dust and soil collect on a pet's coat, and it can be transferred to a child's hands from contact with the pet. Washing the child's hands after contact with a pet should reduce potential exposure to lead in dust and soil.

Adults are often exposed to lead from more sources than is the child. For example, many occupations can be a source of lead and many adults participate in hobbies where there is exposure to lead. Lead that collects on bodies and clothing during work or during hobbies can be a source of lead exposure to children. Because of this, current educational programs provide several recommendations for adults who are exposed to lead at work or from hobbies. These recommendations include:

- showering at work or changing out of work clothes before returning home;
- washing work clothes separately from other clothes;
- protecting the inside of cars with blankets or sheets;
- showering or changing clothes and shoes after working on hobbies that may be a source of lead; and
- keeping children away from hobby areas.

7.2 SCIENTIFIC BASIS FOR EDUCATIONAL CONTENT

7.2.1 Personal Hygiene

Research supports the impact of hand washing and control of soil track-in in the reduction of lead exposure hazards in the home. Gallacher et al. (1984), found that the amount of lead removed from the children's hands with "wet wipes" was related to blood-lead concentration. Samples were drawn from subjects near a high traffic area, near a low traffic area, and in an area heavily contaminated by lead mining. In the most heavily contaminated area, children's hand lead was correlated significantly with blood-lead concentrations. Elevated blood-lead levels occurred in both mothers and children in the old mining area. The authors concluded that in areas with high environmental lead, blood-lead levels may be reduced through improved hygiene practices, both domestic and personal.

Hand washing was also an important element of a study by Charney et al. (1983) in which dust control strategies were implemented in homes of children with blood-lead levels above 30 µg/dL to test whether dust control measures, in addition to home lead reduction, were more effective than home lead reduction alone. Dust control measures included: home cleaning measures of a dust control team, cleaning performed by family members between team visits, avoidance of highly lead contaminated areas of the home, and regular hand washing before meals and at bedtime. Results showed a decline in blood-lead levels, with those children with the highest blood-lead levels initially showing the most marked reduction. It was not possible, however, to isolate the effect of hand washing from other interventions in this study.

No specific evidence was found in support of the recommendation for washing toys or other objects handled by children. However, it is reasonable to expect that the same contaminated dirt that gets on hands can also get on toys.

A slightly different approach was taken in an article by Freeman et al. (1997) in which differences in eating habits and hygiene behaviors were found for two age groups (13-24 months versus 25-36 months). Primary behavior indicators of blood-lead levels were determined by whether the child helped to prepare his/her own food and whether the child ate food that had been on the floor (this factor was dependent on age since children 13-24 months had significantly elevated blood-lead levels if these behaviors were exhibited). As indicated in Chapter 6 above, results also indicated a diet including hamburgers and peanut butter and jelly sandwiches was associated with higher blood-lead levels for both groups while yogurt was linked with lower blood-lead levels for both groups. The hand-held nature of hamburgers and peanut butter and jelly sandwiches has the potential to allow lead contaminated dust to pass from dirty hands to the food surface for consumption. These results suggest a lack of vigilance in personal hygiene and clean food preparation may be associated with elevated blood-lead levels and that attention to proper hygiene practices would be an effective intervention strategy.

7.2.2 Reducing Exposure to Occupational Lead

Lead is an important part of various manufacturing and process industries. Strict standards are followed in the workplace to minimize any harmful lead exposure by the employee. Outside the workplace, a concern is that the worker might carry lead home on their person and expose family members, especially young children who are at most risk for toxic effects of lead. The National Institute of Occupational Safety and Health provides a summary of nearly 80 reports of lead exposure in workers' families, including 34 reports on blood-lead levels in workers' children (CDC, 1995).

A study by Morton et al. (1982) evaluated whether children of workers in lead-related industries had higher blood-lead levels than other neighborhood children whose parents did not work in lead-related industries, and whether personal hygiene practices of workers, such as showering, shampooing, changing clothes and shoes, and personal hobbies affected blood-lead levels in their children. Study subjects were matched for control subjects, and blood-lead concentrations were compared for each pair. Results showed that merely changing clothes and shoes after working in a lead environment was not sufficient for reducing spread of lead contamination. The children of fathers who added the good personal hygiene practices of showering and shampooing, in addition to changing clothes and shoes, had blood-lead levels that were comparable to those of control children. Additionally, children with fathers who had higher lead exposure at work had higher blood-lead levels. These results show strong support for the practice of strict hygiene practices to aid in the reduction of contamination of family members from occupational lead.

Further evidence to support this assumption was found when Piccinini et al. (1986) investigated 6-year old children in Casalgrande, a town in the ceramic tile district in Italy, to study the effects of occupational lead. Children were divided into 3 groups: in group A were children with at least one parent working in lead areas of the tile plant, in group B were children of tile workers who did not work in lead areas, and group C was the control group of children whose parents did not work in a lead environment. Results indicated that blood-lead concentrations were higher among group A than group C, but that differences between groups A and B and groups B and C were not significantly different. The authors concluded that attention should be paid to preventative measures such as changing work clothes and careful personal hygiene after work shifts.

In 1992, OSHA and NIOSH investigated blood-lead levels in workers at an Alabama battery reclamation plant and found that workers were inadequately protected from lead due to many things, including poor hygiene practices (failure to shower at end of shift or change into clean clothes before leaving worksite). Investigators also looked at the effect of lead on families of workers and found their blood-lead levels significantly higher than those of neighborhood children. OSHA obtained a court order to remove all workers with elevated blood-lead concentrations from the premises, making this the first time OSHA has removed an entire workforce due to health violations (CDC, 1992).

OSHA has integrated occupational hygiene standards into their fact sheet aimed at lead exposure in construction. OSHA recommendations on this fact sheet include implementing an effective housekeeping program to remove any lead dust and lead-containing debris from the area, requiring employer to provide washing, changing, and contaminate-free eating areas, lead safe parking for workers' automobiles, proper shower areas, and closed containers for lead contaminated clothing. All of these measures are aimed at reducing not only the workers' on-site exposure to lead, but subsequent exposure to lead by family members (Labor, 1993).

7.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

There is evidence to suggest that washing of hands may reduce lead exposure. While no study has been found in support of washing other objects, especially toys, that young children are apt to put in their mouths, it is reasonable to expect that such measures can only help in reducing chances of further lead exposure. Eating food that had been on the floor was associated with elevated blood-lead levels in young children (Freeman et al., 1997).

Parents who work in a lead-related industry or practice a lead-related hobby should pay special attention to good hygiene practices, including not only changing clothes and shoes after work, but also showering and shampooing to further reduce the chance of lead exposure.

8.0 RELATED TOPICS

8.1 CURRENT CONTENT OF EDUCATIONAL PROGRAMS

According to Alliance to End Childhood Lead Poisoning and the National Center for Lead-Safe Housing (1999), "[n]early all states provide some type of educational intervention, including education focused on lead and lead exposure risks, lead-specific cleaning practices, and nutritional counseling." In addition to materials developed and used by the states, educational material is available from the US EPA, HUD, and non-profit agencies, such as the National Center for Lead-Safe Housing. Because there are so many sources of educational material, there is a large variety in the format and content of the programs.

Despite the diversity in format and content, the programs do have common elements. Most programs present information about exposure to lead from multiple sources. The sources that are most often presented include dust on hard floors, windows, and furniture; dust on carpeted floors; flaking or peeling paint; and soil. Many programs also attribute lead exposure to the occupation and hobbies of the adults in homes with children. Most programs present information about how nutrition affects lead uptake, providing examples of foods that help prevent lead uptake.

In addition to providing information about the sources of lead exposure, most current educational programs also provide recommendations for actions that will reduce or eliminate exposure to various sources of lead in and around the home. These recommendations generally fall into three categories: cleaning practices, protective methods, and methods to help minimize further contributions of lead to the existing sources. Cleaning recommendations are aimed at the problem of dealing with lead on surfaces where dust collects and, to a lesser extent, address chipping and peeling paint. These recommendations provide assistance in identifying cleaning methods and products that are better at removing lead from the affected surfaces. Recommendations about protective measures are aimed at all potential sources of lead. Most of these recommendations present methods of placing barriers between the lead source and the child. The recommended barriers can be temporary, such as blankets placed on floors, or they can be more extensive and longer lasting, such as sealing a floor or repainting. In addition, nutritional counseling and hygiene recommendations may be considered protective measures. Recommendations that help minimize further contributions to existing lead sources include wiping feet on doormats and taking off shoes before entering the house.

Despite the diversity in the manner in which current educational programs are conducted and in the specific content of those programs, the recommendations that are made for addressing lead hazards are consistent between the programs. While some programs present more detailed recommendations for treating lead hazards in more different media than others, specific recommendations are similar across educational programs. For example, although not all programs address lead in water, those that do recommend running water from the tap for a minute or more to flush out any lead that may accumulate in the pipes. Similarly, all programs that address lead in dust on hard surfaces recommend regular cleaning. In fact, there are only two minor disagreements between recommendations among the programs. The first discrepancy in recommendations concerns cleaning dust. Some educational programs recommend using a cleaner that contains TSP, which historically has been thought to be effective for lead cleaning, while others recommend dishwasher detergent or other common household cleaning agents. The second discrepancy in recommendations concerns vacuuming method. Most programs that address cleaning carpeted surfaces advocate the use of HEPA vacuum cleaners. Many programs do not provide alternative advice for families who do not have access to a HEPA vacuum cleaner, while others recommend ways to improve the efficiency of cleaning with conventional vacuum cleaners, such as vacuuming longer, using a "HEPA-type" or "allergy" filter bag, or suggesting methods to coat the inside of new vacuum bags to improve the small particle collection efficiency.

8.2 EFFECTIVENESS OF EDUCATIONAL INTERVENTIONS

Since most children who have elevated blood-lead levels are currently below levels where environmental interventions and medical interventions are recommended, education is an important component of many lead poisoning prevention programs. The effectiveness of educational interventions has received some scientific study, as briefly summarized below. A more detailed review is found in "Review of Studies Addressing Lead Abatement Effectiveness: Updated Edition" (USEPA, 1998b).

A study of the effectiveness of in-home educational interventions in Milwaukee (USEPA, 1996; Schultz et al., 1999) retrospectively examined children who had and had not received an in-home educational intervention. Paraprofessional representatives of the Milwaukee Health Department went to the homes of 187 children whose blood-lead levels were between 20 and 24 µg/dL and described lead hazards, sources of exposure, hygiene, children's nutrition, dust reduction, and cleaning practices. Blood-lead declines of an average of 21 percent were observed in these children after the in-home education. For a reference group of 226 children whose families received only a mailed-out lead education package, a decline of only 6 percent was observed, and the difference between the groups was statistically significant at a p-value of less than 0.001.

A study by Rhoads, et al. (1999) in New Jersey examined 46 children with a geometric mean blood-lead level of 12 µg/dL who received a regular, professionally-performed dust cleaning intervention in a random sample of homes and compared that to 53 children in a randomly selected control group. Dust levels declined by an average of 50 percent or more in the homes where the intervention was done versus little or no decline in the control group. Blood-lead levels declined by 17 percent in the intervention homes versus no change in the control homes. It is noted that the focus of this study was on assistance with household cleaning to reduce lead dust, but maternal education was also part of the intervention. The methods recommended to the residents of the intervention group were consistent with those commonly used in other interventions that did focus on residential lead hazard education per se. The results of the intervention evaluated by Rhoads et al. can be considered optimal, in that each home visit required 5 person-hours. The authors recognized that, if performed by salaried staff, such interventions would be too expensive for most health departments.

A study by Lanphear, et al. (1999) in Rochester, New York, prospectively studied children at six months of age with a geometric mean blood-lead level of 2.9 µg/dL. The study involved 248 urban children 6 months of age at the start of the study. Families in the randomly assigned intervention group received cleaning supplies and equipment (including a detergent containing TSP) and up to eight visits by dust control advisors prior to the children reaching 24 months of age. No statistically significant difference was observed between the study group and the control group. Both blood- and floor dust-lead levels in this study were very low initially. Similar increases in blood-lead levels and similar decreases in dust-lead levels on floors, window sills, and window wells were observed in intervention and control groups. This study indicates that dust control may not always work in routine practice, at least not in preventing slightly elevated blood-lead levels in children (slightly above 10 µg/dL).

A study of 388 households in Granite City, Illinois, representing 490 children under 6 years of age suggested that educational efforts can be effective in reducing lead exposure (Kimbrough et al., 1994). Recommendations were provided to parents on ways to make lead-based paint inaccessible by installing barriers, such as placing a couch in front of a window sill, or by carefully removing small quantities of paint. In addition, parents were instructed on cleaning methods, nutrition, and hygiene. Substantial reductions in blood-lead concentrations (40%) were reported for children receiving this intervention. Of the 490 children, 78 (16%) were found to have blood-lead levels $\geq$10 µg/dL. Among these 78 children, 51 were retested 4 months later, and 30 were tested a third time 1 year later. It was noted that there was no control group for comparison in this study (i.e., the researchers did not evaluate children in families who received no counseling or lead hazard education).

A residential environmental assessment with survey follow-up was conducted in King County, Washington, (Leung et al., 1997). Coaches made home visits to 36 households to identify risks and set priorities for action. Households were selected that had at least one allergy and/or asthma sufferer. They were also selected to avoid persons who had occupational exposure to lead, households with persons who smoked, and households whose residents were planning construction or remodeling, to reduce confounding factors. The educational intervention covered dust and lead control, moisture, hazardous products, indoor air pollution, and special risks. For example, residents were encouraged to encase mattresses, remove contaminated carpet, remove shoes at the door, increase household ventilation, and clean carpet and upholstered furniture frequently. An average of 3.1 behavioral changes were reported by household members in surveys taken three months after the home visits. Participants from all households reported that the intervention was beneficial to them. Residents reported the following barriers to implementation of recommended behavioral changes: lack of time, cost, too much work, and change not needed.

Anecdotal accounts from Pinellas County, Florida, and Manchester, New Hampshire, indicate that educational interventions may have an effect in reducing the blood-lead levels of lead-poisoned children. The approach used in Florida was to provide hazard-reduction information to families, homeowners, landlords, and at-risk communities. Information was given at clinics and physicians' offices. During the evaluation (1993 to 1994), the number of children screened increased from 6,930 to 8,295. The author claimed that the "environmental health follow-up efforts and in-home lead hazard reduction education campaign resulted in a decline in lead levels at the children's follow-up visits." Neither the size of the lead poisoned population nor the extent of the decline relative to baseline levels were quantified in the report (Thoenes, 1992). The New Hampshire program relied on private funding (from the local Rotary Club and one local company) to obtain 90 lead hazard reduction kits, of which 55 were given to families with a lead-poisoned child. The kit contained a bucket, high-phosphate detergent, rubber gloves, rags, a sponge, and duct tape or contact paper. A home visit was made in each case to deliver the kit, instruct families in its use, and provide educational materials. Blood-lead levels were measured before and after the delivery of the kits, and 52 out of 55 children experienced a decrease in blood-lead levels (average decrease 11 µg/dL, range 1 to 28 µg/dL) (Soucy, 1993).

In an examination of the effects of community education, dust control, and case management on children's blood levels in Trail, British Columbia, from 1991 through 1996, Hilts et al. (1998) found no increase in the rate of decline in blood-lead levels following the introduction of interventions in 1991. These interventions were available to all children with elevated blood-lead levels (≥15 µg/dL, or >10 µg/dL for children under 20 months of age). There was no control group in this study. Interventions included counseling on dust control and yard care, provision of entrance mats, sandboxes with clean sand and lids, ground cover materials, and house cleaning supplies and services, such as mops, buckets, detergent, and vacuum cleaners. Services included regular vacuuming, wet wiping, and mopping.

The educational interventions in these studies varied in both content and format. Many of the studies reported declines in dust-lead levels and/or blood-lead levels, especially those for children with higher blood-lead levels or who received more extensive interventions. However, blood-lead concentrations were not consistently reduced to levels below 10 µg/dL. For more information, see USEPA, 1998b.

8.3 SOURCES AND PATHWAYS OF LEAD EXPOSURE

Lead is a heavy, stable element that occurs naturally in the earth's crust. Through natural activity, such as crustal weathering, and human activity, such as mining, this metal has been distributed throughout the human environment. The use of lead as a raw material in various manufactured and refined products is the principal source of lead in the environment. As lead is an element and does not naturally biodegrade, its exposure potential tends to accumulate over time as more and more lead is deposited in the environment.

As data supporting the dangers of lead exposure have been identified, a combination of state and Federal action has curtailed the impact of certain sources and reservoirs of lead in the environment, resulting in a change in the predominance of historically significant sources. The information that follows provides the current status of the sources of lead that have historically been recognized as most associated with elevated blood-lead concentrations in children.

Airborne Lead. Historically, emissions from lead smelters, battery manufacturing plants, solid waste incinerators, and automobiles have made major contributions to airborne lead levels. Fallout of atmospheric lead contributes to lead levels in soil, household dust, and street dust. Lead is deposited on soil, plants, and animals, and thereby is incorporated into the food chain. Until recently, leaded gasoline emissions was one of the primary sources of lead exposure in the United States. Regulatory efforts, however, resulted in a 73 percent reduction in lead consumed in gasoline from 1975 to 1984 (USEPA, 1986) and a 64 percent reduction in national lead emissions from 1985 to 1989 (ATSDR, 1993). These reductions corresponded to similarly dramatic declines in childhood blood-lead concentrations (CDC, 1991; Annest, 1983). The phase-out of leaded gasoline and reductions in industrial emissions have contributed to airborne lead's becoming only a minor lead-exposure pathway for children not exposed to specific point-emitting lead sources such as smelters (CDC, 1991). Airborne lead can still be a source of high-dose exposure in localized areas when activities such as sandblasting bridges take place, or during home renovation or remodeling.

Drinking and Cooking Water. Detectable levels of lead are rare in surface and ground water that serve as sources of drinking water in this country. Typically, lead contamination of drinking water occurs after the water leaves the treatment plant (CDC, 1991). Drinking water can be contaminated by lead pipes, connectors, and solder in service lines and household plumbing. Water can also become contaminated by the lead or brass components of water fountains, coolers, faucets, and other fixtures. Through the authority of the 1986 Safe Drinking Water Act and its amendments, EPA banned the use of lead materials and solders in new plumbing and plumbing repairs, required that public water suppliers notify the public about lead presence in drinking water, and encouraged local government measures to test and remediate lead-contaminated drinking water in schools and day-care centers. As a result, drinking and cooking water from municipal and other large drinking water distribution systems is generally not a predominant source of lead exposure among lead-poisoned children (CDC, 1991). However, due to the high absorption rate of lead in water, lead in drinking water is still considered an important exposure source when present (CDC, 1991).

Food. While production of lead-soldered food and soft drink cans have been virtually eliminated in the U.S., such cans may still be used by other countries who export food to the U.S. In addition, lead can be introduced to food grown in lead-contaminated soil. Improper handling of food in the home (e.g., storing food in containers such as lead-soldered cans and lead-glazed pottery) can cause food to be a source of lead exposure (Blumenthal, 1989-90; Foulke, 1993). While lead exposures through food ingestion have declined considerably in recent years, these exposures can still occur if proper precautions are not addressed. Education is especially important in those communities with traditions of using lead-containing pottery in cooking and preparing folk remedies containing lead. The California "Bright Futures" program (CLPPB, 1999) provides examples of some such products.

Lead-Based Paint. Lead-based paint (LBP) is currently considered the most significant high-dose source of lead exposure in pre-school children (CDC, 1991). From the turn of the century through the 1940s, paint manufacturers used lead as a primary ingredient in many oil-based interior and exterior house paints. Usage gradually decreased through the 1950s and 1960s, as largely lead-free latex paints and exterior paint with lower lead concentrations were manufactured. In 1978, the Consumer Product Safety Commission (CPSC) ruled that paint used for residence, toys, furniture, and public areas must not contain more than 0.06 percent lead by weight. Nevertheless, the presence of lead-based paint in the nation's housing remains high. An estimated 64 million (or 83 percent of) privately-owned, occupied housing units built prior to 1980 contain some components covered with lead-based paint (USEPA, 1995c).

Human exposure to lead from lead-based paint is believed to be higher when the paint is deteriorated or is found on accessible, chewable, impact, or friction surfaces (USEPA, 1986; CDC, 1991). Young children are especially susceptible to lead poisoning from lead-based paint, as they may ingest lead-based paint chips or come into contact with dust or soil that has been contaminated by deteriorated lead-based paint (see below). Both adults and children can be exposed to hazardous levels of lead by ingesting paint-dust during hand-to-mouth activities. The potential for lead-based paint to contaminate a variety of environmental media within a household makes lead-based paint the greatest source of public health concern regarding lead exposure (CDC, 1991).

Contaminated Dust and Soil. While enforcement of national air quality standards continues to reduce the threat of lead exposure via air from point sources, the fallout of atmospheric lead over time has resulted in a continued exposure route through soil (USEPA, 1986). In addition, soil can become contaminated by deteriorated lead-based paint or by the improper removal of lead-based paint from a housing unit. The same soil, once tracked indoors, can become imbedded in carpets or contribute to household dust. Indoors, normal wear of lead-based paint (especially around windows and doors) can contaminate interior dust. Children are exposed to lead from soil or dust in their homes during typical hand-to-mouth activities. Lead-contaminated soil and dust are thought to be the most significant pathway by which young children are exposed to lead from lead-based paint hazards (USEPA, 1986, 1998d).

Lead in Household Products. Several common household products have been shown to contribute, in varying degrees, to childhood blood-lead levels. Imported, non-glossy, vinyl miniblinds were named as a safety concern by the Consumer Products Safety Commission (CPSC) in 1996, when testing indicated that the miniblinds were a source of lead dust (CPSC, 1996). Lead was intentionally added to these miniblinds to stabilize the plastic, enhance color, and prevent deterioration. When exposed to sunlight and heat, the vinyl deteriorated to produce lead dust on the surface of the blinds. Young children may be exposed to the lead dust through mouthing of the blinds or by touching the blinds and then putting their fingers in their mouths. The solution recommended by the CPSC for this problem was to throw out old blinds and replace them with new lead-free blinds. Cleaning was not recommended due to the risk of exposure for the adult cleaner and because a continual and labor-intensive cleaning regimen would be required to ensure a safe environment for the child. Testing blinds for lead was not considered cost-effective since replacement is inexpensive compared to the cost of testing.

Pottery is a lead risk because lead is often used in the ceramic glaze, especially in imported or old pottery. Pottery fired at low temperature can leave lead in the glaze that is available to leach into acidic foods and beverages. As a result, only pottery fired at high temperature should be used for the preparation and storing of food. Leaded crystal can also leach lead and should not be used for the long-term storage of food or liquid, but may still be used to serve food and beverages (Blumenthal, 1989-90; Foulke, 1993).

Lead from Occupational and Hobby Sources. Many occupations put the employee in contact with lead. Among these industries are smelters, battery reclamation plants, stained glass factories, and home and highway construction work, especially in the renovation and remodeling of older homes, performance of lead abatement work, or conduct of large structure (e.g., bridges) repainting projects. Hobbies that can contribute to lead exposure include making pottery, fishing lures, and stained glass work. While most children are not at risk of lead exposure from these sources, exposure can be significant when occupational and hobby sources are present and proper precautions are not taken to limit lead exposure.

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9.0 CONCLUSIONS AND RECOMMENDATIONS

Most current educational recommendations are based on some scientific evidence. Others correspond to conventional wisdom or common sense. Very few changes to the most common educational recommendations are suggested by the scientific evidence reviewed in this report. This chapter points out recommended changes to the content of educational programs (Section 9.1), then summarizes the educational recommendations supported by scientific research (Section 9.2). Care is taken to point out common recommendations that appear to be based on conventional wisdom. Finally, an outline of topics that ideally should be covered in an educational session is provided in Section 9.3.

9.1 RECOMMENDATIONS FOR CHANGE IN CONTENT OF EDUCATIONAL PROGRAMS

Many educational programs recommend a trisodium phosphate (TSP) solution for cleaning hard surfaces. Based on the scientific studies reviewed, many cleaning products perform as well as TSP in cleaning lead dust from hard surfaces. These products include common household cleaners or lead-specific cleaning products other than TSP. This recommendation is based on controlled tests in the laboratory (USEPA, 1997a) and in the field (Rhoads et al., 1999), which indicate that other cleaning products are effective in reducing dust-lead levels on hard surfaces. These findings, along with the environmental concerns associated with using high phosphate detergents result in not recommending TSP for cleaning hard surfaces.

Most educational programs recommend using a HEPA vacuum for cleaning carpeted areas, although it is recognized that, at present, HEPA vacuum cleaners are too costly for many families to use on a regular basis. Since lower cost HEPA vacuums are now on the market for home use, this may be less of a problem in the future. If a HEPA vacuum is not available, however, it is recommended that conventional vacuum cleaners be used with “HEPA-type” or “allergy” filter bags, to remove a higher proportion of fine dust particles from carpets and indoor air. Although these bags have not been scientifically tested for lead dust cleaning efficiency, they are designed to capture smaller particle sizes than standard vacuum cleaner bags.

Most educational programs do not address steam cleaning of carpets, as this method has not been considered effective for removing lead dust. It has been shown, however, that the addition of sodium hexametaphosphate (found in products such as Calgon®) to the cleaning solution increases the amount of lead removed from the carpets by steam cleaning. This practice should be considered as an addition to the cleaning recommendations of educational programs.

Cleaning is more easily performed on smooth surfaces. Current educational programs frequently do not suggest simple steps that can be taken to provide smooth, easily cleaned surfaces. These steps include painting window sills with semi-gloss paint, installing aluminum liners in window wells, and sealing wood floors with polyurethane or durable paint. These methods were implemented in a Baltimore study and were effective in reducing dust-lead loadings (USEPA, 1998c). Although contractors performed the work in the Baltimore study, these steps are modest in cost and simple enough to be undertaken by individuals.

9.2 SCIENTIFIC SUPPORT FOR EDUCATIONAL RECOMMENDATIONS

9.2.1 Cleaning Methods

Most educational programs recommend cleaning hard surfaces, such as floors, window sills, and window wells, weekly using soapy water. The scientific evidence supports this recommendation, although studied cleaning interventions were usually repeated biweekly for cost savings. Studies in Baltimore, Maryland, and Trail, British Columbia, indicated that recontamination can occur within two to three weeks of cleaning (Charney, 1982; Charney et al., 1983; Hilts, 1995), although dust-lead levels eventually remained low between biweekly cleanings in the study by Charney et al., (1983).

Scientific evidence was not found on the effectiveness of other specific cleanup methods, such as changing rags often, using (disposable) paper towels, and using separate buckets for wash and rinse water, but the recommendations appear to be reasonable nonetheless.

For carpets, most educational programs recommend HEPA vacuuming, as noted above. Currently, this remains among the best methods for cleaning carpeted areas and may become more affordable in time. For families that do not have access to a HEPA vacuum cleaner, there is some evidence that use of conventional vacuum cleaners can be at least somewhat effective if the vacuum is properly equipped and used properly. Vacuums with a mechanical agitator brush are recommended. "HEPA-type" or "allergy" bags for conventional vacuum cleaners are designed to remove a greater proportion of fine dust particles than regular bags, although these bags remain to be tested for lead cleaning. If these bags are not available, at least one organization recommends coating new vacuum bags by spreading and vacuuming flour or cornstarch, as it has been shown that partially full bags are more efficient than new bags at filtering small particles (Figley and Makohon, 1994). It was assumed that partially full bags are more efficient because dirt clogs some of the pores, resulting in better retention of fine particles. On the other hand, this does not mean to overload the bag, as this may reduce suction and the vacuum would not pick up dirt as well.

Finally, there is evidence to suggest that extended vacuuming with either a HEPA or conventional vacuum cleaner can substantially reduce surface lead loadings. It is not known whether extended vacuuming offers any long-term benefit for the levels of lead dust in the carpet. For example, if a resident spends one hour vacuuming a single room to reduce lead dust, the time required for subsequent vacuum cleanings may be shorter. The initial, deep cleaning may allow residents to follow up with briefer, maintenance vacuuming cleanings.

Older carpets may be so heavily contaminated that they cannot be cleaned. Many educational programs recommend removing or replacing older carpets. Studies have shown that even repeated HEPA vacuuming and shampooing are ineffective in removing lead dust from some carpets. (Ewers et al., 1994; CH2M HILL, 1991).

9.2.2 Limiting Exposure to Lead in Paint and Soil

Most educational programs note that areas with chipping or peeling lead-based paint are clearly hazardous and should be addressed by wiping off loose paint and cleaning up paint chips immediately. Practical recommendations to limit access, such as careful placement of furniture to form a barrier or covering the area with cardboard or contact paper, are also common. Limited scientific evidence was found to support these recommendations, which, nonetheless, appear to make sense. No evidence for changing any of these recommendations was found in the literature.

Most programs take care to point out that traditional methods of paint removal can be hazardous when dealing with lead-based paint. These methods include mechanical sanding (without a HEPA attachment) or burning lead-based paint. In addition, chemical stripping with methylene chloride can be hazardous due to the chemicals involved. These recommendations are supported by the scientific evidence and, in some cases, by laws banning hazardous methods.

Given that traditional methods should not be used, educational programs should provide recommendations on safe alternatives. Wet scraping or sanding has been recommended as an effective method for removing small amounts of deteriorated lead-based paint (USHUD, 1995a). HUD also recommends limited use of dry scraping or sanding in areas, such as near electrical outlets, where wet methods would be dangerous.

Most educational programs that address lead-based paint abatement recommend that a licensed abatement contractor be hired if paint removal is deemed necessary. Additional education on what to expect during an abatement and how to protect the family and possessions in parts of the home not undergoing abatement would be useful for families whose homes will be abated. Similarly, if home renovations are anticipated, residents should be made aware of unsafe renovation and remodeling practices.

Current educational programs teach that children can be exposed to lead in soil when they play outdoors. Recommendations on ways to reduce the risk of exposure to lead in soil include covering bare soil with grass, plants, gravel, or wood chips; not letting children play near walls of house or garage or on bare soil; having children play in grassy area or sandbox that can be covered; removing shoes indoors and using a door mat to reduce track-in of outdoor dust and soil. These recommendations are based on limited scientific evidence. No evidence for changing any of these recommendations was found in the literature.

9.2.3 Other Means of Reducing Lead Exposure

Some recommendations on reducing lead exposure do not appear to have received scientific study. These recommendations include limiting access to windows, porches, or other areas where lead-based paint is present; opening double-hung windows from the top; placing a clean blanket or rug under a child playing on the floor; and hosing off the porch floor before allowing children to play there. Nonetheless, these recommendations do have merit. Actions that limit access to areas with lead based paint or make them less attractive to children inherently make sense. A blanket or rug placed on the floor provides a clean surface for play and is easily kept clean by machine washing periodically. Similarly, hosing off the porch provides a cleaner play area.

9.2.4 Nutrition

Most educational programs recommend FDA guidelines for daily recommended intake should be followed to maintain overall health, with special attention to ensure that children receive adequate calcium and iron in their diets. Some programs also recommend getting sufficient vitamin C and eating foods low in fat. There is a strong basis of scientific support for the recommendations regarding calcium and iron. There is sufficient evidence that zinc is also beneficial. More limited evidence suggests that vitamin C, vitamin E, and phosphorus are beneficial. Studies have shown that a high fat diet can lead to increased uptake of lead by the body. The evidence relating vitamin D and total food consumption to blood-lead concentration was mixed.

Recommendations on food preparation and storage may include advice to use containers and dishes that are free from lead, avoid food stored in lead-soldered cans, use only cold water for drinking, formula, cooking, run water to flush pipes for 1 minute or more, and test all home remedies for lead. That lead in water is only a minor source of lead is noted in many programs, although programs that note that fact also make the preceding recommendations regarding use of water. At present, these are considered minor sources of lead exposure for most children.

9.2.5 Hygiene

There is evidence to suggest that frequent washing of hands can reduce lead exposure. Although no study examined specific times for handwashing, it is commonly recommended that children wash hands before meals, before going to bed, after playing outdoors, and after playing with pets. No reason to change these recommendations was found. No study was found in support of washing other objects, especially toys, that young children are apt to put in their mouths; but such measures can only help in reducing chances of further lead exposure. Eating food dropped on the floor has been related to increased blood-lead concentrations in young children (Freeman et al., 1997).

Parents who work in a lead-related industry or practice a lead-related hobby should pay special attention to good hygiene practices, including not only changing clothes and shoes after work, but also showering and shampooing to further reduce the chance of lead exposure.

9.3 RECOMMENDED CONTENT OF EDUCATIONAL PROGRAMS

In summary, the recommended content of educational programs is outlined below. In presenting this list, it is recognized that it will not be practical to cover every item in every educational session. The specific recommendations made in an educational session should be tailored to the location and audience. Rather, the list is intended as a comprehensive summary of reasonable educational recommendations. The list does contain some recommendations that are based on conventional wisdom or only limited scientific study. These recommendations were included, as no evidence was found at this time to suggest they should not be recommended.

Hard Surfaces

- mop floors once a week with soapy water;
- clean window sills and wells once a week with soapy water;
- use paper towels or setting aside a sponge for lead cleaning only;
- use separate buckets for wash and rinse water;
- lightly spray floors with water before sweeping;
- seal wood floors to provide a smooth cleanable surface;
- place a blanket or rug on floor when a child plays there;
- keep children and their belongings away from windows; and
- open double-hung windows from the top.

Carpeted Surfaces

- use a HEPA vacuum for cleaning, if possible;
- if a HEPA vacuum is not available, use “HEPA-type” or “allergy” filter bags;
- if these bags are not available, lightly coating new vacuum bags by spreading and vacuuming flour or cornstarch is advised;
- use a vacuum with a mechanical agitator head;
- vacuum for an extended time;
- when steam cleaning carpets, consider adding sodium hexametaphosphate (found in Calgon®, for example) to the cleaning solution; and
- use care in removing older carpets that are heavily contaminated with lead dust.

Limiting Paint Exposure

- clean up loose paint chips immediately;
- wipe off loose paint using damp disposable cloths or rags;
- block access to chipping paint with furniture;
- put contact paper over chipping paint;
- hose off porch or place a blanket or rug down when children play there;
- seal or enclose areas with small amounts of chipping paint;
- do not use hazardous methods of removing paint, such as mechanical sanding (without a HEPA attachment), open-flame burning, or chemical removal using methylene chloride;
- recommend safer alternatives for removing paint, such as wet scraping and wet sanding;
- if abatement is required, recommend using a certified abatement contractor;
- if abatement is required, describe what to expect during abatement, ways to protect family and belongings.

Limiting Soil Exposure

- cover bare soil with grass, plants, gravel, or wood chips;
- do not let children play near walls of house or garage or on bare soil;
- have children play in grassy area or sandbox that can be covered;
- wash children's hands after playing outside, or playing with pets;
- remove shoes before entering the house; and
- use a doormat to reduce track-in of outdoor dust and soil.

Nutrition

- provide a balanced diet as recommended by the FDA;
- ensure children receive sufficient amounts of calcium, iron, zinc, and vitamin C;
- reduce consumption of foods high in fat if a lot of fat is eaten, especially foods with little nutritional value;
- prepare or store food in lead-free containers;
- if lead in water is a concern
  - flush pipes for 1 minute before drinking water or using it for cooking; and
  - use only cold water for cooking or preparing infant formula.

Hygiene

- wash children's hands, toys, bottles, and pacifiers often;
- do not allow children to eat food off the floor;
- if parents work or hobby is a source of lead exposure
  - shower at work or change out of work clothes before returning home;
  - wash work clothes separately from other clothes;
  - protect the inside of cars with blankets or sheets;
  - shower or change clothes and shoes after working on hobbies that may be a source of lead; and
  - keep children away from hobby areas.

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APPENDIX A:

SELECTED WEB SITES FOR INFORMATION ON LEAD DUST AND LEAD POISONING

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Table A-1. Selected web sites for information on lead dust and lead poisoning

Sponsor	Mission/Purpose	URL (Web address)	Physical Address	Telephone
Alliance to End Childhood Lead Poisoning (AECLP)	A national, non-profit public interest organization dedicated exclusively to preventing childhood lead poisoning.	http://www.aeclp.org	227 Massachusetts Avenue, N.E. Suite 200 Washington, DC 20002	202-543-1147
Alliance to End Childhood Lead Poisoning: Global Lead Network	To provide resources and support for those working on lead poisoning prevention around the world	http://www.globalleadnet.org	227 Massachusetts Avenue, N.E. Suite 200 Washington, DC 20002	
Center for Community Action for Primary Prevention (CCAPP)	To provide strategies, training, and educational materials to help communities create sustainable programs for the primary prevention of lead poisoning and other health problems	http://www.leadsafehousing.org/html/capp.htm	6272 Dusty Glass Court Columbia, MD 21044	410-730-8048
City of Milwaukee Health Department Childhood Lead Poisoning Prevention Program	To provide comprehensive services to lead poisoned children as well as innovative primary prevention efforts aimed at preventing lead poisoning from occurring.	http://www.ci.mil.wi.us/citygov/health/lead/index.htm	1230 West Grant Street Milwaukee, WI 53215	414-225-LEAD
Coalition to End Childhood Lead Poisoning (CECLP)	A non-profit organization whose mission is to prevent childhood lead poisoning.	http://www.leadsafe.org/homeindex.htm	B2714 Hudson Street Baltimore, MD 21224	410-534-6447 or 800-370-LEAD
Massachusetts Department of Public Health, Childhood Lead Poisoning Prevention Program (CLPPP)	The prevention, screening, diagnosis, and treatment of lead poisoning.	http://www.state.ma.us/dph/clppp	470 Atlantic Avenue, 2nd Floor Boston, MA 02210	617-753-8400
National Center for Lead-Safe Housing (NCLSH)	To bring the housing, environmental and public health communities together to combat childhood lead poisoning.	http://www.leadsafehousing.org	10227 Wincopin Circle, Suite 205 Columbia, MD 21044	410-992-0712

Sponsor	Mission/Purpose	URL (Web address)	Physical Address	Telephone
National Conference of State Legislatures (NCSL)	Database identifies the main contacts for lead poisoning prevention in the health, environmental and occupational safety agencies in each state.	http://www.ncsl.org/programs/esnr/toxics.htm#lead	1560 Broadway, Suite 700 Denver, CO 80202	303-830-2200
National Lead Information Center	Provide the general public and professionals with information about lead hazards and their prevention.	http://www.epa.gov/lead/nlic.htm	Washington, DC 20460-0003	1-800-424-LEAD
U.S. Agency for Toxic Substances and Disease Registry (ATSDR)	To prevent exposure and adverse human health effects and diminished quality of life associated with exposure to hazardous substances.	http://atsdr1.atsdr.cdc.gov/atsdrhome.html	1600 Clifton Rd. Atlanta, GA 30333	1-888-42-ATSDR
U.S. Centers for Disease Control and Prevention (CDC), National Center for Environmental Health, Childhood Lead Poisoning Prevention Program	Develop programs and policies to prevent childhood lead poisoning, and educate the public and health-care providers about childhood lead poisoning.	http://www.cdc.gov/nceh/programs/lead/lead.htm	Mailstop F42 4770 Buford Highway Atlanta, GA 30341	770-488-7330
U.S. Department of Housing and Urban Development Office of Lead Hazard Control	Lead poisoning prevention. Committed to the goal of providing lead-safe housing to the nation's children while preserving affordable housing.	http://www.hud.gov/lea	451 7th Street, S.W., Room B-133 Washington, DC 20410	202-755-1785
U.S. Environmental Protection Agency Indoor Environments Division	Coordinates research and develops and implements policies regarding the impact of indoor air pollutants on the general public.	http://www.epa.gov/iaq/index.html	Mail Drop 6101 Washington, DC 20460-0003	202-564-9370
U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics	Promoting • Pollution prevention • Safer chemicals • Risk reduction • Public understanding of risks.	http://www.epa.gov/lead/leadtpbf.htm	Mail Drop 7404 Washington, DC 20460-0003	202-260-2090

Sponsor	Mission/Purpose	URL (Web address)	Physical Address	Telephone
U.S. Occupational Safety and Health Administration	To save lives, prevent injuries and protect the health of America's workers.	http://www.osha-slc.gov/SLTC/lead/index.html	200 Constitution Avenue Washington, D.C. 20210	202-693-1999
United Parents Against Lead	A national organization of and for parents of lead poisoned children working to end the continuing threat of lead poisoning through education, advocacy, resource referral and legislative action.	http://home.earthlink.net/~shabazzaupal	PO Box 24773 Richmond, VA 23224	804-714-1618

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Education is the primary type of intervention recommended for children with elevated blood-lead concentrations falling between 10 and 20 µg/dL. Approximately 90 percent of children with elevated blood-lead concentrations fall into this range. Thus, the effectiveness of educational efforts is an important component in the overall success of lead risk reduction efforts. Educational programs operated by state and local health departments and other organizations vary in format, but usually are consistent in providing information on cleaning methods; practical ways to reduce exposure to lead in paint, dust, and soil; hazardous methods of paint removal; nutrition; and behavioral modifications to reduce lead exposure. EPA is currently undertaking a number of efforts to encourage and enhance educational programs nationwide. As part of that effort, this report examines the scientific basis for current educational recommendations.

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