U.S. Department of Housing and Urban Development
Office of Lead Hazard Control

An Extended Study of Interim Lead Hazard Reduction Measures Employed In The Baltimore Clinical Center of The Treatment Of Lead-Exposed Children (TLC)-Clinical Trial

April 2000

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Grant No. MDLHR0019-97

April 2000

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CONTRIBUTING ORGANIZATIONS AND ACKNOWLEDGMENTS

Kennedy Krieger Research Institute (KKRI)

KKRI was responsible for the design and conduct of this study, including the field, laboratory and data analysis activities, and the preparation of this report. The KKRI investigators were Mark R. Farfel, Sc.D., and J. Julian Chisolm, Jr., M.D. Study staff included Merrill Brophy, TLC Project Manager; Jill Litt, Research Assistant and Data Analyst; and Anna Orlova, Ph.D., Visiting Associate Professor. The TLC Housing Assessor/Inspector Donald Cooper collected the dust samples under the supervision of Ken Watts, Housing Coordinator.

U.S. Department of Housing and Urban Development (HUD) Office of Lead Hazard Control

HUD Office of Lead Hazard Control funded the extended environmental follow-up (24 months) in a subset of homes in the Treatment of Lead-exposed Children (TLC)-Clinical Trial.

Maryland Department of the Housing and Community Development

This agency reserved and administered loan funds from a special residential lead paint abatement loan program to finance some of the interventions investigated in this study.

National Institute of Environmental Health Sciences

NIEHS is the funder of the Treatment of Lead-exposed Children (TLC)-Clinical Trial upon which this environmental study is based.

U.S. EPA and the Maryland Department of the Environment

EPA (Region 3) in collaboration with the Maryland Department of the Environment, sponsored the dust monitoring study in TLC houses upon which this extended follow-up study is based.

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GLOSSARY

HUD	U.S. Department of Housing and Urban Development
KKRI	Kennedy Krieger Research Institute
QC	Quality Control
SRM	Standard Reference Material
TLC Trial	Treatment of Lead-exposed Children Trial sponsored by NIEHS

EXECUTIVE SUMMARY

The Treatment of Lead-exposed Children (TLC)-Clinical Trial is investigating the potential benefits of the use of the oral chelating agent "succimer" for the treatment of moderately lead poisoned children (PbB 20-44 Fg/dL) aged 12 to 32 months at the start of treatment. The Trial has four Clinical Centers nationwide and is sponsored by the National Institute of Environmental Health Sciences (NIEHS). The main outcome variable is the child's neurodevelopmental status 36 months and 84 months after the start of treatment (based on a recent extension). The primary TLC research question is whether or not treatment with succimer offers any benefit in addition to that which might occur with reduction of lead exposure in the home. By design, all houses of TLC Trial participants (treatment and placebo groups) received at minimum a professional cleaning prior to the start of treatment so that children could be treated on an outpatient basis and no child would be treated with uncontrolled lead exposure in the home.

The Baltimore Clinical Center of the TLC Trial performed various interim control and repair interventions in the homes of TLC children in addition to professional cleaning. It was not the objective of the TLC Trial to carry out or oversee comprehensive lead-based paint abatement activities. However, in some cases, TLC houses in the Baltimore Clinical Center received more intensive interventions using special forgivable state loan funds for lead-based paint abatement reserved for the Trial by the Maryland Department of Housing and Community Development (MDHCD).

This report is based on wipe dust testing performed before, immediately after, and two years after the implementation of various interventions in a subset of 62 homes of the 213 children enrolled in the Baltimore Clinical Center. Dust samples were collected from floors, window sills, and window wells (troughs) in each house at each campaign and from walls in kitchens and bedrooms two years after intervention.

Longitudinal data analysis was performed using the dust lead loading data from four groups of study houses, *i.e.,* houses that received: (1) professional cleaning where professional cleaning alone was recommended by the TLC housing assessors based on a visual inspection (Clean A); (2) major repairs plus professional cleaning where major repairs were recommended by the TLC housing assessors (Major Repair); (3) professional cleaning where major repairs were recommended but were not done (Clean B); and (4) minor repairs plus professional cleaning where major repairs were recommended but were not done (Minor Repair). The primary reason that recommended repairs were not done in groups 3 and 4 was that some property owners chose not to apply for MDHCD's loan funds. These circumstances provided an opportunity to assess the effectiveness of a range of interventions in structurally-sound houses recommended for major repair and located in high risk urban neighborhoods. This study also assesses the effectiveness of professional cleaning in houses in better condition where repairs were not recommended (Clean A houses).

The main findings are as follows:

C This study supports the effectiveness of major repair interventions for two years after the interventions were performed in houses deemed in need of major repairs (Figs. 1-3). Immediately after intervention and at two years, geometric mean dust lead loadings, as well as most individual sample readings, for floors and window sills in Major Repair houses were reduced to levels below EPA's proposed surface-specific dust lead standards (Tables 8 and 14). Geometric mean lead loadings on window wells were reduced from 29,356 Fg/ft^2 to 99Fg/ft^2 at post-intervention and 351 Fg/ft^2 at two years. Major Repair houses comprised the only study group in which dust lead loadings at two years were statistically significantly lower than pre-intervention levels.

C The study indicates the limited effectiveness of professional cleaning and minor repair interventions in houses initially assessed in need of major repairs. These interventions were associated with short-term reductions in lead loadings but higher rates of reaccumulation of lead in dust two years after intervention compared to Major Repair interventions (Figs. 1-3). Dust lead loadings on sills and wells two years after intervention approached or exceeded pre-intervention levels. Geometric mean dust lead loadings on floors and window sills in Clean B and Minor Repair houses were above EPA's proposed standards two years after intervention. Pronounced differences in window sill and window well dust lead loadings between Major Repair houses and houses in Clean B and Minor Repair groups during follow-up indicate the benefits of window replacement for attaining long-term reductions in lead loadings (Figs. 1-3).

C In houses in better condition (Clean A group), professional cleaning interventions had a persistent effect on the floors and window wells. In contrast, professional cleaning in Clean B houses did not have a lasting cleaning effect on window wells. Clean A houses had geometric mean dust lead loadings, as well as most individual sample readings, below EPA's proposed surface-specific dust lead standards immediately after intervention and two years after intervention (Tables 8 and 10).

C Wipe dust samples collected from kitchen and bedroom walls in all groups of houses generally had low dust lead loadings (90th percentile=23 Fg/ft^2) (Table 15). In children's bedrooms, statistically significant correlations were found between wall lead loadings and lead loadings on the floors and the window sills (Table 17).

C The housing assessors' recommendations on the need for repairs based on their visual inspections of TLC houses is supported by data on dust lead loadings prior to intervention. Specifically, houses where major repairs were recommended had significantly higher pre-intervention dust lead loadings across surface types than houses where major repairs were not recommended based on the visual inspection. Geometric mean pre-intervention dust lead loadings for floors and window sills in houses where major repairs were recommended were above EPA's proposed dust lead standards. On the other hand, geometric mean pre-intervention dust lead loadings were below EPA's proposed dust lead standards in the houses where professional cleaning only was recommended (Tables 10-13).

1.0 INTRODUCTION

This report is based on dust lead loading data collected before, immediately after and 24-months after the implementation of lead hazard control interventions in a subset of the homes of children enrolled in the Baltimore Clinical Center of the Treatment of Lead-exposed Children (TLC)-Clinical Trial. This ongoing Trial has four Clinical Centers nationwide and is sponsored by the National Institute of Environmental Health Sciences (NIEHS) (TLC Group,1998).

The TLC Trial is a long-term investigation of the potential benefits of the use of the oral chelating agent "succimer" for the treatment of moderately lead poisoned children (PbB 20-44 Fg/dL) aged 12 to 32 months at the start of treatment. The primary outcome variable in TLC Trial is the child's neurodevelopmental status 36 months and 84 months after the start of treatment. The primary TLC Trial research question is whether or not treatment with succimer offers any benefit in addition to that which might occur with reduction of lead exposure in the home. Thus, by design all houses of TLC participants (both treatment and placebo groups) received at minimum a professional cleaning prior to the start of treatment so that all children could be and were treated on an outpatient basis and no child would be treated with uncontrolled lead exposure in the home.

The primary goal of the environmental component of the TLC Trial was to reduce the risk of children's exposure to lead-based paint in fair or poor condition and to lead-contaminated house dust during the drug treatment phase (up to six months). The secondary goal of the environmental component was to reduce the risk of lead exposure during the original three-year period of follow-up. The interventions done in the homes of TLC children were intended to supplement, but not replace, any environmental inspection and lead hazard remediation activities required or encouraged by local public health agencies as part of case management. Prior to the initiation of drug treatment, the TLC Trial called for, at minimum, a professional cleaning intervention of the home that consisted of a sequenced combination of wet cleaning and HEPA vacuuming of settled dust and loose chips of paint and possibly minor repairs (Appendix A). It was not the objective of the TLC Trial to carry out or oversee comprehensive lead-based paint abatement activities. However, in some cases, houses in poor condition received more intensive interventions using special state loan funds for lead-based paint abatement reserved for use in the Baltimore Clinical Center of the TLC Trial by the Maryland Department of Housing and Community Development.

The degree to which the TLC Trial's professional cleaning intervention would attain HUD clearance levels for dust lead loadings was not known at the outset due to a lack of research documentation. For this reason, dust lead measurements in the homes of TLC children were not used to monitor contractor compliance unless the lead loadings were seen to increase following cleanup activities. Furthermore, the Baltimore Clinical Center was not required to meet Maryland's interim post-abatement clearance levels when performing interim control interventions but was required to meet them when performing more intensive repair interventions.

NIEHS provided funds for limited dust lead testing pre- and post-intervention in 50 houses of the 213 children ultimately enrolled in the TLC Trial in Baltimore.[a] U.S. EPA (Region 3) provided additional funding to monitor dust lead loadings at pre- and immediately post-intervention in the houses of all the other TLC children. EPA also provided funds to test for dust lead loadings in a subset of 70 houses that became due for 6-12 months testing during the EPA study period.

The EPA-funded study showed that the primary environmental goal was attained in the Baltimore TLC Clinical Center by the application of the various interim control and repair interventions, despite some reaccumulation of lead in dust 6 to 12 months after intervention (Farfel, 1997a). Immediately after intervention, the percentage of dust samples below HUD's clearance levels increased for each group of houses, and most dust samples in all four groups of study houses had lead loadings below HUD's surface-specific clearance levels for lead in house dust at that time (*i.e.,* 100 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills and 800 $\mu g/ft^2$ for window wells) (HUD, 1995). Data in that report were not compared to EPA's proposed residential dust lead hazard standards (*i.e.,* average levels of #50 $\mu g/ft^2$ for uncarpeted floors, average levels of #250 $\mu g/ft^2$ for window sills) because the proposed standards had not yet been released (EPA, 1998).

This report is based on dust wipe testing performed with HUD funding through November 1998 in a subset of 62 TLC houses at 24 months post-intervention. It also includes the corresponding pre- and post-intervention data available for these same 62 houses from the above-mentioned EPA study.

Study Objectives

The objectives of this study were to:

C Compare dust lead loadings at 24 months post-intervention to previously collected data at pre-intervention, immediately post-intervention and 6 to 12 months post-intervention in houses that received different interventions, *i.e.,* (1) professional cleaning where professional cleaning was recommended; (2) major repairs plus professional cleaning where major repairs were recommended; (3) professional cleaning where major repairs were recommended but could not be done; (4) minor repairs plus professional cleaning where major repairs were recommended but could not be done.

C Assess the degree to which dust lead loadings across groups and campaigns were within

[a] Houses of the first 25 children were sampled and after that approximately every tenth house of new enrollees was sampled until a total of fifty houses were sampled.

HUD's clearance standards and EPA's proposed residential dust lead standards.

C Assess the need for cleaning of wall surfaces based on the dust lead loading in a single sample from a child's bedroom wall and a kitchen wall in each house tested at 24 months.

C Characterize the nature of the relationship of dust lead loadings on vertical (wall) surfaces to those found on horizontal surfaces in the same rooms and assess the effect of room type and intervention type on dust lead loadings on vertical surfaces.

This study did not include analysis of clinical data from the TLC Trial.

2.0 STUDY DESIGN AND SAMPLE COLLECTION PROCEDURES

The sections below provide a brief descriptions of the various groups of study houses, the interventions and an overview of the environmental study design followed by a description of procedures for recruitment, enrollment, and dust sample collection.

2.1 Study Groups and Descriptions of the Interventions

TLC housing assessors conducted an initial visual inspection using TLC protocols for assessing overall housing condition and for assessing paint condition, substrate condition and cleanibility of the house components in each room (e.g., windows, floor). The TLC protocol for assessing overall housing condition was similar to the Building Condition Form and the Maintenance Data Form for Rental Dwellings in the HUD Guidelines (HUD, 1995a) and the form used in the national evaluation of HUD's lead-based paint abatement grant program (National Center for Lead Safe Housing, 1998). TLC housing assessors recommended a level of intervention based on the condition of the house and its painted surfaces, and prepared written specifications for the various types of interventions described in a subsection below. Testing for lead in paint was not done as part of the Trial.

In cases where the initial visual inspection revealed that the child's residence was in poor condition, the Baltimore Clinical Center staff attempted to relocate the family to housing in better condition (identified through contacts with collaborating rental property owners and nonprofit housing organizations) or to make repairs in collaboration with the property owner using the state loan funds. Children living in houses in structurally unsound condition or in houses where the inspectors believed that the intervention would not likely reduce exposure for six months were not eligible for the Trial unless they could be relocated to housing in better condition. Fortunately, many families were successfully relocated to housing in better condition that required only a professional cleaning based on a visual inspection. Data are not available on the ages of the houses in better condition. They were, however, generally in the same neighborhoods and therefore were likely to be in the same age group as the other study houses.

One intervention type, professional cleaning, was performed in two groups of houses. The first (Clean A) was a group of houses for which the TLC Housing Assessors deemed that professional cleaning alone was required based on the good condition of the house and its painted surfaces. The second (Clean B) was a group of visually inspected houses for which major repairs were recommended but could not be done in a timely manner or could not be done at all due to a lack of cooperation on the part of the property owner with loan application process. The other two groups of houses received either minor repairs or major repairs in addition to a professional cleaning (Table 1). The houses that received minor repairs in addition to professional cleaning were houses where high level remediation was also recommended but could not be done due to a lack of property owner cooperation. A small number of houses that received moderate repairs costing on average $5,000 (n=3) were included in the major repair group (mean cost=$6,571) for data analysis purposes.

In some cases, houses received more than one intervention. Typically, the first intervention was a professional cleaning so that the TLC Trial could proceed according to pre-established time frames for enrollment and drug treatment. The second intervention typically involved repairs financed by the state loan program for lead-based paint abatement. In fact, nearly all of the high level (major) repair interventions were financed by the Maryland Department of Housing and Community Development through a special loan program for low-income owner-occupants and private property owners who rent their properties to low-income tenants. The maximum allowable loan amount was $7,500. In a few cases, the work was performed as part of the HUD-sponsored Baltimore City Lead-Paint Abatement Program which had more resources to spend per house.

Table 1: Planned and Actual Numbers of Houses Sampled at 24 Months by Group

Intervention Group	**No. Houses Planned**	**No. Houses Sampled (% of target)**
PROFESSIONAL CLEAN A (Professional cleaning of horizontal surfaces where cleaning only was recommended based on a visual inspection.)	25	24 (96%)
PROFESSIONAL CLEAN B (Professional cleaning of horizontal surfaces where moderate to high level repair was recommended but could not be done.)	25	12 (48%)
MINOR REPAIR (Minor repairs followed by professional cleaning of horizontal surfaces where moderate to high level repair was recommended but could not be done.)	17	9 (53%)

MAJOR REPAIR (Repairs costing up to $7,500 followed by professional cleaning of horizontal surfaces.)	20	17 (85%)
Total	87	62 (71%)

All work was performed by contractors and workers who had passed state-approved training courses and had certification from the State of Maryland for lead hazard reduction and lead-based paint abatement work. The housing assessors conducted post-intervention visual inspections and provided households in each group with cleaning kits for their own cleaning efforts. The kits included a bucket, sponge mop, a replacement sponge mop head, sponges, a trisodium phosphate (TSP) cleaning agent, utility gloves, and an EPA brochure entitled "Lead Poisoning and Your Children." Resident cleaning behavior was not assessed and therefore the data analysis could not take this into account.

Brief Description of the Interventions

Professional Cleaning: According to the TLC Trial protocol (Appendix A), the houses of TLC children were to receive at least a 3-step professional cleaning intervention prior to drug treatment as follows: (1) vacuuming of horizontal surfaces and loose peeling paint using a vacuum cleaner equipped with a HEPA filter followed by (2) a wet cleaning of horizontal surfaces with TSP (or an alternative phosphate-free cleaner) followed by (3) a second HEPA vacuuming of horizontal surfaces. Carpets were vacuumed using a HEPA vacuum equipped with an electrical beater bar attachment. Residents were encouraged to dispose of area rugs and vinyl mini-blinds for lead dust control purposes and in many cases this was done.

Minor Repairs plus Professional Cleanup: The scope and nature of the minor repairs varied across houses as determined by the housing assessors. Minor repairs included wet scraping and repainting of surfaces such as doors and frames, windows and other friction points, baseboards, spindles and railings and porch components (rails, posts and ceilings). Some floors and stair treads were enclosed with luan and some stair risers were covered with 1/4 inch plywood. The professional cleaning was done according to the 3-step TLC protocol.

Major Repairs plus Professional Cleaning: To meet loan eligibility requirements, major repairs were performed in houses that had no structural defects and no pre-existing conditions that could impede or adversely affect the work and the safety of workers and field staff (*e.g.*, roof leaks or unsafe floors). This eliminated substandard housing in need of major renovation. Major repairs included stabilization of exterior surfaces, floor treatments to make them smooth and more easily cleanable, door treatments to reduce abrasion of lead-painted surfaces, window replacement and encapsulation of painted exterior window trim with aluminum coverings as the primary window treatment, encapsulation of painted exterior door trim with aluminum, and durable floor and stairway treatments (*e.g.,* installation of vinyl tile). It was generally the case that all windows were replaced in houses in this group.

Table 2 displays descriptive statistics on intervention costs for each of the four groups. It is important to note that these costs may not be generalizable to other settings and time periods due to differences in labor and material costs and overhead rates.

Table 2: Treatment Costs By Group for Houses Sampled at 24-Months [a]

Group	**No. Houses**	**Mean ($)**	**Min. ($)**	**Max. ($)**	**s.d.**
PROFESSIONAL CLEAN A	20[b]	680	373	1,121[c]	183
PROFESSIONAL CLEAN B	12	618	296	897	200
MINOR REPAIR	9	1,063	631	1,898	366
MAJOR REPAIR [d]	16	6,571	792[c]	10,022	2,296

a These data are based on costs incurred by the TLC Trial and/or the state lead-based paint abatement loan program and in some cases do not include intervention costs incurred by the property owners.

b Cost data were available for 22 houses of 24 study houses in Clean A group. Two outliers were excluded from the descriptive statistics: $1,830 and $2,515. The latter was for work performed in a 30-room house.

c Amount appears low because it does not include additional costs incurred by the property owner.

d Includes three houses that received more moderate repairs costing approximately $5,000. In a few cases, the work was performed as part of the HUD-sponsored Baltimore City Lead-Paint Abatement Program which was able to perform work costing more than $7,500. An outlier ($15,000) was excluded from the descriptive statistics.

2.2 Study Design

A total of 87 houses in four study groups were proposed for extended dust testing at 24-months post-intervention (Table 1). Houses were selected from among TLC Trial houses that became available for 24-month sampling between November 1, 1997 and December 1, 1998. First priority was given to collecting 24-month data from houses with pre-, post-, and 6-12 month post-intervention data from the earlier EPA-funded study. Second priority was given to houses with pre- and post-intervention data. Data collection was successfully performed in 62 (71%) of the 87 planned houses. Table 3 indicates the number of houses sampled at 24-months for which pre-intervention, post-intervention and 6-12 month data are available from the earlier EPA study. The relatively small number of houses sampled at 6-12 months precluded the use of these data in the analysis. A total of eight individual dust wipe samples from horizontal surfaces and one field blank sample were collected in each house at each campaign (Table 4).

2.3 Recruitment and Enrollment

TLC houses due for 24-month post-intervention sampling during the study period were selected for recruitment into the extended environmental monitoring study even if the original family with a child in the TLC Trial no longer lived there. A total of 143 houses were approached in an attempt to collect the 24-month data in 87 houses. Sixty-two houses were enrolled and sampled and the other 81 houses were approached but not enrolled. The most frequent reason for not enrolling a house was vacancy (n=48). Vacant houses at 24 months were more likely to be Clean B and the Minor Repair houses than Major Repair or Clean A houses. The second most frequent reason was our inability to make contact with the family after repeated attempts (n=26). A relatively small number (n=7) of families refused participation. Consent for dust testing at 24 months was obtained from participants with forms approved by the Johns Hopkins' Joint Committee on Clinical Investigation.

2.4 Data Collection Procedures

Settled house dust was collected using the HUD wipe method (HUD, 1995). *Little Ones Lightly Scented Baby Wipes* were used initially for dust sampling during 1994-1995. When this type of wipe was no longer available in stores, the *Bigger and Thicker Baby Wash A Bye* Wipes were used (1996-1998). The sampling plan included the collection of dust samples from various household locations as indicated in Table 4. Each individual floor sample was collected using a one square foot (929 cm^2) disposable template. Floor samples were generally collected beneath a window. If a selected floor location was carpeted or covered with an area rug, this information was recorded on the sample collection form and the carpet or rug was sampled. When settled dust was collected from window sills and window wells (troughs), the dimensions of the sampled surface were recorded on the sample collection form. Wall samples were collected using a disposable template taped to the wall at a height within the reach of a young child (3 to 4 feet from the floor) and at a location that was easily accessible to a child. The bedroom wall was sampled near the child's bed and the kitchen wall was sampled near the stove or sink, if possible.

Table 3: Dust Lead Data Available from Earlier Campaigns in Houses Sampled at 24 Months

Intervention group	**Pre-Intervention (No. of Houses)**	**Post-Intervention (No. of Houses)**	**6-12 Months[b] (No. of Houses)**	**24-Months (No. of Houses)**
PROFESSIONAL CLEAN A	20	23	16	24
PROFESSIONAL CLEAN B	12	12	3	12
MINOR REPAIR[a]	9	9	1	9
MAJOR REPAIR	8[c]	17	6	17
Total	49	61	26	62

a This type of intervention was introduced later in the project and consequently few houses were available for sampling at 6 to 12 months post-intervention in the earlier EPA-funded study.

b Excluded from the data analysis in this report due to small numbers of houses in most groups.

c This number is relatively small because some major repair interventions were performed as the second intervention, and pre-intervention wipes were generally not collected for the second intervention.

Table 4: House Sampling Plan for Individual Wipe Dust Samples

Sample Location/Type	No. Samples Included in Original EPA Study per Campaign	No. Samples Included at 24 Months in the Extended Study
Perimeter Floor Dust:		
- Kitchen	1	1
- Child's bedroom	1	1
- Child's play area [a]	1	1
Window Sill Dust:		
- Child's bedroom	1	1
- Child's play area	1	1
- Kitchen	b	b
Window Well (Trough) Dust		
- Child's bedroom	1	1
- Child's play area	1	1
- Kitchen	b	b
Interior Entryway Dust	1	1
No. of Horizontal Surfaces	8	8
Vertical Surfaces:		
- Kitchen wall	0	1
- Child's bedroom wall	0	1
No. of Vertical Surfaces	0	2
Field Blank	1	1
Total No. of Samples	9	11

a The living room was sampled as another activity area if the child's play area was the child's bedroom.

b The kitchen window sill and window well served as backup sampling sites if other locations were not accessible.

3.0 LABORATORY ANALYSIS AND QUALITY CONTROL (QC)

Except for a relatively small number of pre- and post-intervention samples sent to an outside laboratory as per the TLC Trial protocol, all dust samples were analyzed at the Kennedy Krieger Research Institute's Trace Metal Laboratory using a laboratory analytical procedure (LAP) based on Method 3050 (EPA, 1986) modified for the thicker type of wipe used in this study as described elsewhere (Orlova et.al., 1999).

The main differences between our LAP and the HUD procedure (HUD, 1995) are the larger volume (total 20 mL) and the higher concentration of nitric acid (50% HNO_3 for the first addition and concentrated HNO_3 for the second one), the extended time (up to 3 hours) for heating samples on the hot plate and peroxide additions. These modifications were made to achieve better digestion of the thicker wipes and higher lead recoveries for various types of QC samples. To avoid possible cross-contamination of the samples, we did not cut the wipes prior to the digestion as recommended by the HUD procedure.

Instrumentation

Wipe dust samples were analyzed by flame atomic-absorption spectroscopy (FAAS) using a GBC Avanta Flame Atomic Absorption Spectrometer (made in Australia) with GBC FS 3000 Autosampler. Standard analytical procedure for FAAS (flame type: Air-Acetylene) was used for wipe samples analysis (GBC, 1996). The 217 nm wavelength was used to provide maximum sensitivity (0.06 Fg/mL) in the working range of lead concentrations (0.25 to 20.0 Fg/mL). A non-linear calibration curve was used for the analysis. The following standard solutions were used for calibration (ppm): 0.25; 0.5; 1.0; 5.0; 10.0; 20.0. Standard solutions were prepared in 10% nitric acid from GFS Chemicals Lead Standard Solution (1000 ppm lead). The calculated limit of detection was approximately 0.09 Fg Pb/mL which is equivalent to approximately 4.5 Fg/ft^2 for floors and approximately 15 Fg/ft^2 for window sills.

Quality Control

To assure that the sampling and analytical protocols employed in the study yielded data of sufficient quality, a number of different types of QC samples were included in the study design. These samples were designed to control and assess data quality in each phase of the data collection, sample preparation and analysis process, which were potentially subject to random and/or systematic error. Blank samples, including field blanks, reagent blanks and method blanks, were included to assess procedural contamination by lead. Recovery samples, including standard reference materials and spiked samples were used to indicate the accuracy of sample preparation procedures. Duplicate spike samples were used to indicate precision of sample preparation procedure and analyses. Seven QC samples were prepared according to the LAP with each batch of samples for routine analysis (Table 5). QC samples were prepared using the thicker wipes as appropriate.

Table 5: Types of Quality Control Samples Included in Each Sample Preparation Batch

QC Sample Type	Procedure
Standard Reference Materials (SRM): NIST SRM 2589: Powdered Paint (Nominal 10% Lead) NIST SRM 2582: Lead Based Paint (Nominal 0.05% Lead) CRMO 14-050 Baghouse Dust (1914.0 ppm Lead)	 *Bigger and Thicker Baby Wash A Bye* ® wipe plus 0.1 g of NIST SRM 2589 plus all reagents *Bigger and Thicker Baby Wash A Bye* ® wipe plus 0.25 g of NIST SRM 2582 plus all reagents. *Bigger and Thicker Baby Wash A Bye* ® wipe plus 0.25 g of CRMO 14-050 plus all reagents
Spike	*Bigger and Thicker Baby Wash A Bye* ® wipe plus 0.5 mL of Perkin Elmer Pure Atomic Spectroscopy Standard (Lead, 1000 ppm) plus all reagents.
Spike Duplicate	Same as for the Spike
Method Blank	*Bigger and Thicker Baby Wash A Bye* ® wipe plus all reagents
Reagent Blank	Reagents only

Calibration verification samples were used to indicate the accuracy of the analysis. For quality assurance purposes, a check sample of 10 ppm lead was prepared in 10% nitric acid from Perkin Elmer Pure Atomic Spectroscopy Standard (1000 ppm lead) and was run after calibration, following each ten samples in the run and at the end of the run, with the blank sample as the last measurement. If the check sample reading was obtained outside ±0.5 ppm of the target value, the analysis was stopped automatically, a new calibration curve was established and the samples were reanalyzed. SRM 2582 (Lead-Based Paint, nominal 0.05% Lead) was used as a low-lead QC sample and SRM 2589 (Lead-Based Paint, nominal 10% Lead) was used as a high-lead QC sample. Target values of spike samples reflected the middle of the calibration curve and were used to measure accuracy and precision. QC sample results were assessed based on pre-determined warning limits (±20% of target value) and control limits (±30% of target value).

In addition to these internal quality control efforts, the KKRI Trace Metals Laboratory has participated in the Environmental Lead Proficiency Analytical Testing (ELPAT) program (administered through the National Lead Laboratory Accreditation Program) for environmental samples since September 1993. Blind samples are analyzed quarterly; the KKRI Trace Metals

Laboratory has been rated as "proficient" for the evaluation of lead in paint chips, soil, and dust wipes since joining the program.

Statistical Analysis of QC Data

Among the laboratory QC samples included in this study and the previous EPA-funded study (Farfel, 1997a) and prepared in 190 analytical batches, the control limit (±30 percent) was rarely exceeded for any QC parameter. Percent recovery of the three types of SRM, spikes and spike duplicates are reported in Table 6. Precision was high, with no difference on average between spike and spike duplicates. Based on 558 field blanks and 168 method blanks from this study and from the preceding EPA-study, lead contamination was found to be, on average, below the instrument detection limit. No evidence of systematic contamination was observed. Four field blank samples were outliers with readings that ranged from 500 Fg/sample to 181,300 Fg /sample. These four outliers were likely to have been field samples mislabeled during sample preparation.

Table 6: Descriptive Statistics for Percent Recovery on Laboratory QC Samples[a]

QC Sample Type	No. Samples	Mean % recovery	Median % recovery	10th PT	90th PT	s.d.
Spike	173	86	85	79	93	6.1
Spike Duplicate	175	86	85	79	93	6.1
Baghouse Dust[b] CRMO 14-050	128	96	96	88	104	6.2
Powdered Paint SRM2582	172	88	86	80	98	8.4
Powdered Paint SRM2589	163	94	94	85	101	6.1

a This table excludes QC samples from 10 batches prepared without wipes and 4 batches prepared with other protocol deviations (over dilutions (3 batches) and use of centrifugation in lieu of filtration (1 batch)).

b The smaller number of Baghouse Dust samples is due to the later addition of Baghouse Dust to the QC program in order to have a dust matrix SRM.

4.0 DATA PROCESSING AND STATISTICAL ANALYSIS PROCEDURES

Data Processing

Data were derived from field forms and the laboratory instrument. Field data consisted of all data recorded on the dust collection forms. Laboratory data were electronically stored by the flame AAS instrument. Raw data files were transferred to the data manager for management, storage, and later analysis. Electronically stored laboratory data were imported to Paradox® and then converted to ASCII files for uploading and analysis. A SAS® program (version 6.12) read in the laboratory and field data and created SAS® data sets for data analysis.

Data Summary

Dust lead loading data from five surface types (floor, window sill, window well, interior entryway and wall) and three data collection campaigns (pre-intervention, post-intervention, and 24 months) were included in this report. A total of 1,382 dust wipe samples were included in the data analysis: 333 samples collected at pre-intervention, 424 samples collected at post-intervention, and 625 samples collected at the 24 month campaign.

The wipe dust findings are directly comparable to HUD's surface-specific post-abatement clearance levels for lead in house dust in effect at the time of this report (*i.e.,* 100 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills and 800 $\mu g/ft^2$ for window wells) and EPA's proposed residential dust lead standards (*i.e.,* average of 50 $\mu g/ft^2$ for uncarpeted floors and an average of 250 $\mu g/ft^2$ for window sills).

Statistical Analysis

For data analysis purposes, lead values less than the instrument detection limit (IDL) were coded as the IDL/%2 (Hornung, 1990).

The outcome variable was dust lead loading (Fg/ft^2). The main study variables were intervention group, data collection campaign and surface type. As expected, use of the log transformation reduced the amount of skewness in the lead loading data. A characteristic of the data set is the repeated measures from a house over time and multiple measures per house, which violate the assumption of independence invoked for most analyses. To address this issue, a mixed-effects model (SAS PROC MIXED (version 6.09E)) was used for longitudinal data analysis (SAS, 1990) to account for the correlation of samples within a house.

Logistic regression analysis and Fisher's Exact Test were used to determine whether the percentages of samples below HUD's clearance standards or below EPA's proposed standards at post-intervention and at 24-months were significantly different than the percentages of samples below these benchmarks at baseline.

The following models were fit to the log-transformed lead loading (PbD) data. They were run first using all four study groups and a variable for surface type. The models were rerun separately for each main surface type (floor, window sill and window well) using all four study groups.

$$Ln(PbD)_{ijkl} = \beta_0 + \beta_1 * season_{ij} + \beta_2 * group_{ik} + \beta_3 * surfacetype_{im} + \beta_4 * campaign_l + \beta_5\, group_{ik}(campaign_l) + b_i * house_i + \varepsilon_{ijkl} \quad \text{(Eq.1)}$$

$$Ln(PbD)_{ijkl} = \beta_0 + \beta_1 * season_{ij} + \beta_2 * group_{ik} + \beta_3 * surfacetype_{im} + \beta_4 * campaign_l + \beta_5 campaign_l(group_{ik}) + b_i * house_i + \varepsilon_{ijkl} \quad \text{(Eq.2)}$$

where,

"I" refers to house, "j" to season, "k" to study group, "l" to campaign, "m" to surface type and "group(campaign)" to campaign nested within group, "campaign(group)" to group nested within campaign. Following standard practice, regression coefficients corresponding to fixed effects are denoted by Greek letters, while regression coefficients corresponding to random effects are denoted by Roman letters (*e.g.*, b).

5.0 RESULTS

Findings in relation to HUD clearance levels and EPA's proposed residential dust lead standards

Table 7 displays the percentages of individual dust samples that fell below HUD's clearance levels by group, surface type and campaign. Houses in the Clean A group had the highest percentage of samples across all surface types that were below HUD clearance levels at pre-intervention baseline. Except for the window wells, most samples in the Clean A group had lead loadings below clearance at baseline (*i.e.,* 72% for the floors, 81% window sills and 45% for window wells). On the other hand, most samples in the other three groups of houses were above HUD's clearance levels at baseline, except for floors and window sills in the Minor Repair group. Across all groups, window wells had the lowest percentage of samples below HUD's clearance standards at baseline.

All four groups of study houses had increased percentages of samples below HUD's clearance standards immediately after intervention except for floors in the Minor Repair houses. In some cases, the change in percentage was statistically significant (Table 7), *i.e.*, Clean A window wells (from 45% to 80%); Clean B floors (from 34% to 71%) and window sills (from 33% to 67%); and Major Repair floors (from 41% to 70%), window sills (38% to 96%) and window wells (from 18% to 80%). At 24 months, houses in the Clean A and Major Repair groups had the highest percentages of samples below clearance. The percentages of samples below clearance in the Minor Repair group at 24 months were similar to the corresponding percentages at baseline. The percentages of samples below clearance in the Clean B group at 24 months were somewhat higher than at baseline.

The pattern of findings in relation to EPA's proposed residential dust lead standards for floors and window sills was similar to those described above, except that smaller percentages of samples were below EPA's lower standards (Table 8).

Descriptive statistics on dust lead loadings

Table 9 displays median dust lead loadings over time by group and by surface type. Plots of surface-specific median lead loadings over time by group are displayed in Figures 1-3. Note that lines are used to connect the points in these plots for ease of display; these lines should not be taken to indicate that trends in dust lead loadings during the intervals between campaigns are known.

Table 7: Percentages of Samples Below HUD Clearance Standards by Campaign[a,b]

Group	Surface Type	Pre-Interventio n (% Below)	Post-Interventio n (% Below)	24- Months After (% Below)
Professional Clean A	Floor	72	74	82
	Interior Entry	67	71	75
	Window Sill	81	90	76
	Window Well	45	80**	67[BL]
Professional Clean B	Floor	34	71**	57[BL]
	Interior Entry	40	67	60
	Window Sill	33	67*	52
	Window Well	17	45[BL]	38
Minor Repair	Floor	59	57	70
	Interior Entry	38	56	40
	Window Sill	53	63	45
	Window Well	20	48[BL]	20
Major Repair[c]	Floor	41	70*	80**
	Interior Entry	40	67**	71
	Window Sill	38	96	90**
	Window Well	18	80**	73**

a HUD's clearance standards in effect at the time of this report were 100 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills and 800 $\mu g/ft^2$ for window wells (troughs).

b Based on logistic regression analysis for floors, window sills and window wells and on Fisher's Exact test for interior entryways: *=p-value<.05; **=p-value<.01; BL=borderline p-value (.05 to .07)

c All of the samples in this group were below Maryland's clearance standards at post-abatement (*i.e.*, below 200 $\mu g/ft^2$ for floors, 500 $\mu g/ft^2$ for window sills and 800 $\mu g/ft^2$ for window wells). The post-intervention values reflect the first set of post-intervention samples and not subsequent post-intervention samples collected after recleaning was done as needed to meet Maryland clearance standards (Annotated Code of Maryland, 1988) as required by the Maryland Department of the Environment.

Table 8: Percentages of Samples Below EPA's Proposed Dust Lead Standards by Campaign [a,b]

Group	**Surface Type**	**Pre-Interventio n (% Below)**	**Post-Interventio n (% Below)**	**24- Months Post (% Below)**
Professional Clean A	Floor	53	65	71*
	Interior Entry	44	57	60
	Window Sill	67	84	67
	Window Well	n/a	n/a	n/a
Professional Clean B	Floor	21	61**	43*
	Interior Entry	10	56[BL]	40
	Window Sill	28	56	43
	Window Well	n/a	n/a	n/a
Minor Repair	Floor	41	40	50
	Interior Entry	0	11	30
	Window Sill	41	63	35
	Window Well	n/a	n/a	n/a
Major Repair[c]	Floor	29	64*	66*
	Interior Entry	40	56	48
	Window Sill	13	96*	63*
	Window Well	n/a	n/a	n/a

a EPA's dust lead standards are 50 $\mu g/ft^2$ for uncarpeted floors, 250 $\mu g/ft^2$ for window sills. No standard was proposed for window wells (troughs).

b Based on logistic regression analysis for floors, window sills and window wells and on Fisher's Exact test for interior entryways: *=p-value$<$.05; **=p-value$<$.01; BL=borderline p-value (.05 to .07)

c The post-intervention values reflect the first set of post-intervention samples and not subsequent post-intervention samples collected after recleaning was done as needed to meet Maryland clearance standards as required by the Maryland Department of the Environment.

Table 9: Median Dust Lead Loadings (Fg/ft^2) by Surface Type and by Group

Surface Type	**Group**	**Pre-Intervention, Fg/ft^2 (no.Houses)**	**Post-Intervention Fg/ft^2 (no.Houses)**	**24 Months Post Fg/ft^2 (no.Houses)**
Floor	Professional Clean A	122 (20)	25 (23)	38 (24)
	Professional Clean B	292 (12)	38 (12)	50 (12)
	Minor Repair	248 (9)	116 (9)	88 (9)
	Major Repair	415 (8)	67 (17)	49 (17)
Window Sill	Professional Clean A	122 (20)	39 (23)	155 (24)
	Professional Clean B	1,352 (12)	189 (12)	654 (12)
	Minor Repair	747 (9)	135 (9)	1,616 (9)
	Major Repair	462 (8)	15 (17)	206 (17)
Window Well	Professional Clean A	2,683 (20)	64 (23)	373 (24)
	Professional Clean B	81,973 (12)	2,617 (12)	21,718 (12)
	Minor Repair	27,308 (9)	3,728 (9)	57,642 (9)
	Major Repair	57,996 (8)	65 (17)	257 (17)

Fig. 1: Median Floor Lead Loading by Group

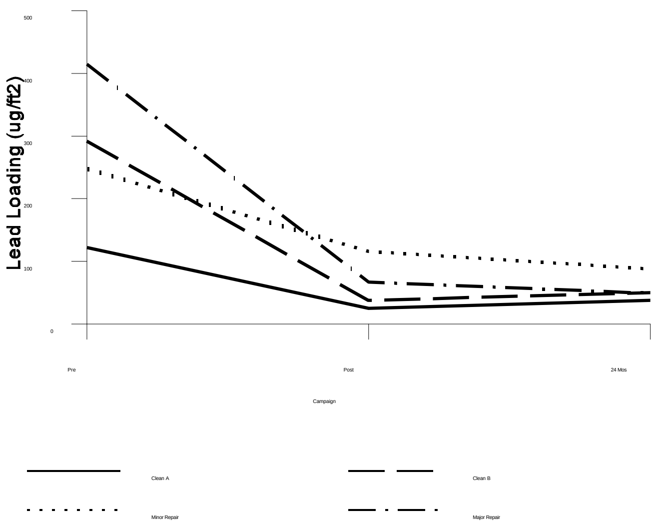


Fig. 2: Median Sill Lead Loading by Group

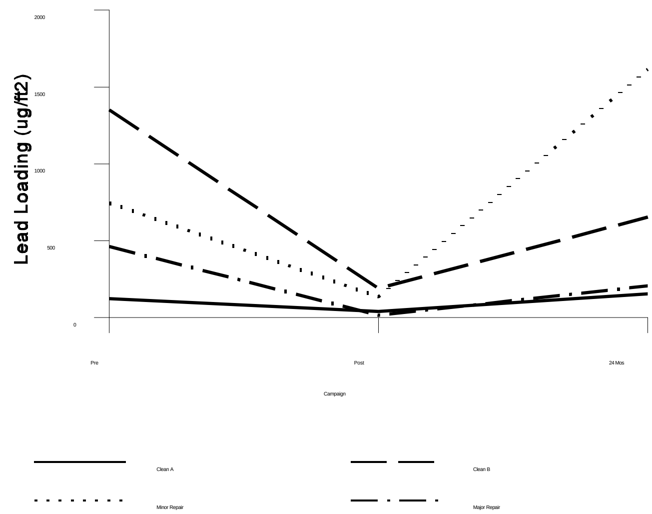
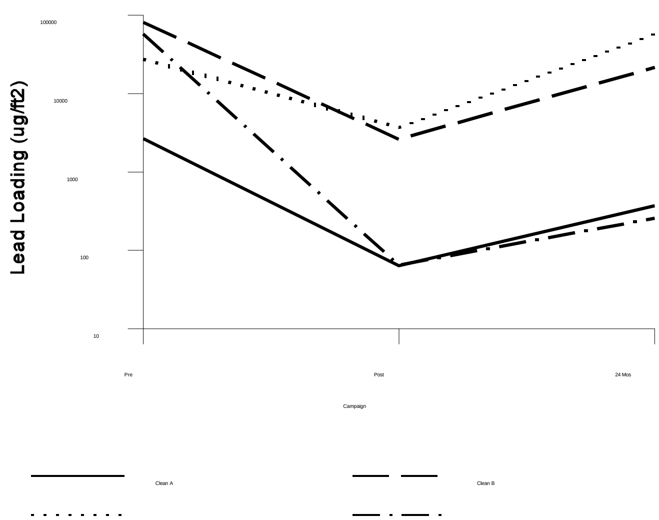


Fig. 3: Median Well Lead Loading by Group



Tables 10-13 provide descriptive statistics (no. of samples, geometric mean, minimum, maximum) on dust lead loadings over time by group and by surface type. These descriptive statistics do not take into account season or any other potential covariates.

Trends in Median Dust Lead Loadings

Trends in median lead loadings are as follows:

- At baseline, median load loadings were lowest in Clean A houses for floors (122 $\mu g/ft^2$), window sills (122 $\mu g/ft^2$) and window wells (2,683 $\mu g/ft^2$). The other three groups had median levels from 248 $\mu g/ft^2$ to 415 $\mu g/ft^2$ for floors; from 462 $\mu g/ft^2$ to 1,352 $\mu g/ft^2$ for window sills and from 27,308 $\mu g/ft^2$ to 81,973 $\mu g/ft^2$ for window wells.

- At baseline and after intervention, lead loadings tended to be highest for window wells, intermediate for window sills and lowest for floors.

- Median dust lead loadings across surface types show a pattern of maximally reduced levels at post-intervention. This pattern is most pronounced for groups that had the highest pre-intervention floor and window sill lead loadings.

- At 24 months, median lead loadings had increased over post-intervention levels (except for floors in the Major Repair and Minor Repair groups); however, the 24-month median levels tended to remain below baseline levels in all groups except for Minor Repair.

Descriptive Statistics by Campaign

Surface-specific geometric mean lead loadings at 24-months were consistently lowest for Major Repair and Clean A groups and intermediate or highest for Clean B and Minor Repairs (Table 14).

Table 10: Dust Lead Loadings Over Time By Surface Type -- Professional Clean A

Surface Type	Campaign	No. Samples	Geometric Mean ($\mu g/ft^2$)	Minimum ($\mu g/ft^2$)	Maximum ($\mu g/ft^2$)	s.d. on log scale
Floor	Initial	58	32	<IDL	2,364	8.13
	Post-Intervention	74	30	<IDL	2,486	6.38
	24-Months	66	28	<IDL	2,471	4.03
Interior Entryway	Initial	9	57	<IDL	890	5.24
	Post-Intervention	14	37	<IDL	9,172	16.8
	24-Months	20	32	<IDL	219	3.77
Window Sill	Initial	21	92	<IDL	8,734	13.50
	Post-Intervention	31	44	<IDL	20,675	9.65
	24-Months	42	104	<IDL	16,865	7.99
Window Well	Initial	29	1,680	<IDL	382,098	25.2
	Post-Intervention	40	66*	<IDL	22,613	16.5
	24-Months	43	755	<IDL	692,287	15.8
Wall	24-Months	43	3	<IDL	52	3.37

* This value was statistically significantly different from the initial value (see Results Section, page 28).

IDL = Instrumental Detection Limit

Table 11: Dust Lead Loadings Over Time By Surface Type -- Professional Clean B

Surface Type	Campaign	No. Samples	Geometric Mean ($\mu g/ft^2$)	Minimum ($\mu g/ft^2$)	Maximum ($\mu g/ft^2$)	s.d. on log scale
Floor	Initial	38	204	<IDL	22,997	7.08
	Post-Intervention	38	58	<IDL	6,774	6.64
	24 Months	37	88	<IDL	5,818	6.66
Interior Entryway	Initial	10	128	<IDL	1,610	3.91
	Post-Intervention	9	50	<IDL	2,149	7.78
	24 Months	10	101	<IDL	2,363	4.54
Window Sill	Initial	18	790	11	16,248	7.23
	Post-Intervention	18	223	17	3,012	4.26
	24 Months	23	431	<IDL	62,600	12.4
Window Well	Initial	23	21,000	<IDL	1,791,181	21.8
	Post-Intervention	20	964*	<IDL	310,770	18.0
	24 Months	24	7,147	49	1,671,194	26.6
Wall	24 Months	18	12	<IDL	30,530	11.0

* This value was statistically significantly different from the initial value (see Results Section, page 28).

IDL = Instrumental Detection Limit

Table 12: Dust Lead Loadings Over Time By Surface Type -- Minor Repair

Surface Type	**Campaign**	**No. Samples**	**Geometric Mean ($\mu g/ft^2$)**	**Minimum ($\mu g/ft^2$)**	**Maximum ($\mu g/ft^2$)**	**s.d. on log scale**
Floor	Initial Post-Intervention 24 Months	41 35 30	112 84 58	<IDL <IDL <IDL	223,089 7,997 1,699	13.5 6.19 5.81
Interior Entryway	Initial Post-Intervention 24 Months	8 9 10	131 163 119	57 27 11	440 2,296 657	1.94 4.05 3.38
Window Sill	Initial Post-Intervention 24 Months	17 16 20	513 75 687	<IDL <IDL 11	56,203 13,519 25,897	9.92 26.5 7.87
Window Well	Initial Post-Intervention 24 Months	20 21 20	9,161 782* 13,777	23 <IDL 31	331,071 377,267 381,935	17.0 24.2 17.1
Walls	24 Months	18	13	<IDL	886	5.05

* This value was statistically significantly different from the initial value (see Results Section, page 28).

IDL = Instrumental Detection Limit

Table 13: Dust Lead Loadings Over Time By Surface Type -- Major Repair

Surface Type	Campaign	No. Samples	Geometric Mean ($\mu g/ft^2$)	Minimum ($\mu g/ft^2$)	Maximum ($\mu g/ft^2$)	s.d. on log scale
Floor	Initial Post-Intervention 24 Months	17 47[a] 64	154 30[BL] 30[BL]	<IDL <IDL <IDL	5,871 986 1,048	6.75 5.92 4.69
Interior Entryway	Initial Post-Intervention 24 Months	5 9[a] 21	116 47 61	<IDL <IDL <IDL	1,812 536 528	16.6 4.34 4.47
Window Sill	Initial Post-Intervention 24 Months	8 23[a] 40	1,186 18* 119*	23 <IDL <IDL	61,628 7,291 27,934	13.4 5.27 5.17
Window Well	Initial Post-Intervention 24 Months	11 20[a] 41	29,356 99* 351*	292 <IDL <IDL	739,917 9,326 106,816	13.6 7.66 6.86
Walls	24 Months	35	3	<IDL	120	4.86

[a] Some of the major repairs were performed as the second intervention in the house, and new baseline dust lead levels were not obtained in most cases. Consequently, the number of post-intervention observations is larger than the number of pre-intervention observations.

* This value was statistically significantly different from the initial value (see Results Section, page 28).

[BL] This value had borderline statistical significance when compared to the initial value (see Results Section, page 28).

IDL = Instrumental Detection Limit

Table 14: Geometric Mean Lead Loadings by Surface Type and by Group at 24-months

Surface Type	**Group**	**Geometric Mean (Fg/ft^2)**
Floor	Professional Clean A	28
	Professional Clean B	88
	Minor Repair	58
	Major Repair	30
Window Sill	Professional Clean A	104
	Professional Clean B	431
	Minor Repair	687
	Major Repair	119
Window Well	Professional Clean A	755
	Professional Clean B	7,147
	Minor Repair	13,777
	Major Repair	351

Dust Lead Loadings on Walls

Table 15 displays descriptive statistics on lead loadings from walls in kitchens and children's bedrooms, excluding one outlier as noted. The mean wall lead loading in the kitchen (33 $\mu g/ft^2$) was higher than the mean wall lead loading in the child's bedroom (13 $\mu g/ft^2$), but the difference was not statistically significant. The distributions of the kitchen and bedroom wall lead loadings were nearly identical in terms of the minimum value and various percentiles through the 95th percentile (Table 15). The higher mean value for the kitchen walls is due to the higher extreme values in the kitchen (maximum=886 Fg/ft^2; second highest value=590 Fg/ft^2) compared to the bedroom (maximum=219 Fg/ft^2).

Table 16 displays mean wall dust lead loadings (for both wall types combined) at the 24-month campaign by group. Mean wall lead loadings were lowest in the Major Repair and Clean A houses, intermediate in Clean B houses, and highest in Minor Repair houses; however, the relationship between wall lead loadings and intervention type did not reach statistical significance.

In children's bedrooms, statistically significant correlations were found between wall lead loadings and lead loadings on the floors and the window sills (Table 17). Insufficient data were available to assess the correlations between lead loadings from walls and other surfaces in the kitchens.

Longitudinal Data Analysis

Study group, campaign and the interaction between study group and campaign (*i.e.,* nesting of study group within campaign and nesting of campaign within study group) were found to be statistically significant in the longitudinal data analysis model, after controlling for season and with house as a random effect. The significant interaction between study group and campaign indicates that the relationship between group and campaign is not the same across the four study groups. Season did not have a significant fixed effect (p-value #.05) in the model.

Interpretation of the estimates obtained by the mixed model obey the usual rules of interpretation of regression coefficients, *i.e.,* the coefficient of a covariate is the expected change in the response variable associated with a unit change in the covariate in the presence of the other covariates. When the covariate is a dummy variable, a unit change in the covariate corresponds to the expected difference between the response at the level of the covariate compared to the omitted level.

Table 15: Wall Dust Lead Loadings ($\mu g/ft^2$) at the 24-Month Campaign by Room Type*

Room Type	No. Samples	Mean **	Min.	10th PT	25th PT	50th PT	75th PT	90th PT	95th PT	Max.	s.d.
Kitchen	57	33	< IDL	< IDL	< IDL	< IDL	11	23	52	886	139
Child's Bedroom	59	13	< IDL	< IDL.	< IDL	< IDL	11	23	71	219	33

*Excludes outlier of 30,530 $\mu g/ft^2$ in a Clean B house.
** The t-test p-value =0.31.

Table 16: Arithmetic Mean Wall Dust Lead Loadings at 24-Months by Group*

Group	No. Samples	Mean ($\mu g/ft^2$)	s.d.
Clean A	54	14	35
Clean B	17	43	142
Minor Repair	17	76	215
Major Repair	30	11	25

*Excludes outlier of 30,530 $\mu g/ft^2$ in a Clean B house.
Note: This table includes two samples collected in rooms that were not the child's bedroom or kitchen.

Table 17: Correlations Between Dust Loadings in Child's Bedroom at 24-Months
Pearson Correlation Coefficient (r) / Number of Observations (n)

Surface Type		Floor	Window Sill	Window Well	Wall
Floor	r	-	-0.06	0.15	0.28*
	n		55	45	59
Window Sill	r	-	-	0.36**	-0.000
	n			44	50
Window Well	r	-	-	-	0.41**
	n				39

* p-value < .05 ** p-value < .01

The main findings of the longitudinal model, when controlling for season and including random effects for houses, are listed below.

Comparison of Groups at Specific Campaigns (Cross-Sectional Comparisons)

- Pre-intervention dust lead loadings on floors, window sills and window wells were lowest in Clean A houses. Differences at baseline between Clean A houses and houses in each of the other three groups were either statistically significant (alpha=.05) or borderline statistically significant. Pre-intervention lead loadings across the other three groups were not statistically different from each other for floors, windows sills and window wells.

- At post-intervention and 24 months, window well dust lead loadings were statistically significantly lower in Clean A and Major Repair houses than in Clean B and Minor Repair houses. For window sill lead loadings, differences between houses in the Clean A and Major Repair groups and the other two groups were either statistically significant or of borderline significance. For floors, the differences between houses in the Clean A and Major Repair groups and the other two groups tended to be non-significant or of borderline significance, except for the difference between Clean A and Clean B at 24 months. At post-intervention and 24-months, the surface-specific differences between Clean A and Major Repair houses and the surface-specific differences between Clean B and Minor Repair houses were not statistically significant.

Changes Over Time Within Groups

- Clean A, Clean B, Minor Repair and Major Repair houses tended to have reduced floor dust lead loadings at post-intervention and at 24 months compared to baseline, but the changes were not statistically significant. In the case of floors in Major Repair houses, the changes at post-intervention and 24 months reached borderline statistical significance.

- For window sills, all four groups of houses had reduced dust lead loadings at post-intervention and 24 months, except for Minor Repair houses at 24 months. The changes were statistically significant only in Major Repair houses.

- For window wells, all four groups of houses had reduced dust lead loadings at post-intervention and at 24 months, except for Minor Repair at 24 months. The changes at post-intervention were statistically significant for window wells in all four groups of houses. Window well dust lead loadings at 24 months were statistically significantly lower than pre-intervention levels in Major Repair houses only.

6.0 DISCUSSION

Houses of children in the Baltimore TLC Trial Clinical Center were located in census tracts with median year of construction either 1939-1946 or 1946-1958 (Figure 4) and therefore were likely to contain lead based paint. At the outset, Clean A houses (recommended for professional cleaning only) were in the best condition and were most likely to have had replacement windows, smooth floors and intact paint. The other houses of children in the Baltimore Clinical Center of the TLC Trial were deemed by the housing assessors to need major or moderate repairs in addition to professional cleaning.

Housing conditions were assessed visually on a room-by-room basis and overall. The dust lead findings validated the housing assessors' recommendations in that pre-intervention lead loadings were significantly higher for all surface types in houses where major repairs were recommended than in Clean A houses. In fact, pre-intervention dust lead loadings for floors and window sills in Clean A houses were, on average, below EPA's proposed dust lead standards, whereas average baseline lead loadings in the other three groups were above EPA's proposed standards (Tables 10-13). The finding of a relationship between housing condition and dust lead loadings is consistent with past studies (Bornschein *et. al*, 1986. Chisolm, 1986; Farfel 1991).

The major repair interventions were implemented after owners successfully applied for forgivable special state loans for reducing residential lead-based paint hazards. Otherwise, houses for which major repairs were recommended but not done received professional cleaning or minor repairs plus professional cleaning. In most of the latter cases, recommended repairs could not be done because the property owners chose not to apply for the state loans. These circumstances provided an opportunity to assess the effectiveness of three types of interventions in structurally-sound houses recommended for major repair and located in low-income urban neighborhoods at high risk of lead poisoning, as well as the effectiveness of professional cleaning in houses in better condition where repairs were not recommended.

Effectiveness of Interventions

In houses where major repairs were recommended, major repair in combination with professional cleaning was found to be more effective at post-intervention and at 24 months than either professional cleaning or minor repair plus professional cleaning (Tables 10-14). This was also the case at 6 to 12 months post-intervention based on the earlier EPA-funded study (see Appendix C adapted from Farfel, 1997a). Differences in post-intervention and 24-month dust lead loadings between Major Repair houses and houses in the Clean B and Minor Repair groups were most pronounced for window wells and window sills, indicating the benefits of window replacement in such houses (Figs. 1-3).

Major Repair houses had the least amount of reaccumulation of lead in dust and comprised the only study group in which dust lead loadings at 24-months were statistically significantly lower than pre-intervention levels. Moreover, the findings indicate that EPA's proposed standards for average lead loadings in floor and window sill dust can be attained in the short and longer-term (24 months) when major repairs followed by professional cleaning are performed in older houses in high risk urban neighborhoods, and when Clean A type houses are professionally cleaned (Tables 10 and 13). Professional cleaning interventions in Clean A houses had a persistent effect on the floors and window wells. In contrast, professional cleaning in Clean B houses did not have a lasting cleaning effect on window wells. Only houses in the Major Repair and Clean A groups had geometric mean dust lead loadings, as well as most individual sample readings, below EPA's proposed surface-specific dust lead standards immediately after intervention and at 24 months. The latter is likely due to the similarity of the conditions of Clean A houses and Major Repair houses following intervention.

It should be noted that a relatively small number of dust samples in the Major Repair houses, most commonly floor samples, had clearance testing failures that were corrected after recleaning. Some initial clearance failures, that also tended to occur most often for floors, were found in houses treated under HUD's lead-based paint hazard control grant program (National Center for Lead-Safe Housing, 1998).

The study also indicates the limited short-term effectiveness of professional cleaning and minor repair interventions in houses initially assessed in need of major repairs. Minor repair and professional cleaning interventions (performed by trained contractors with quality control oversight by the housing assessors) in houses in need of major repairs were least likely to attain HUD's clearance standards or EPA's proposed residential dust lead standards (Tables 7 and 8). Additionally, these interventions were found to have limited or no long-term effectiveness, particularly with regard to the control of dust lead loadings on window surfaces. Reaccumulation of lead in dust at 24 months was greatest in Minor Repair houses and intermediate in Clean B houses, particularly on window sills and window wells (Figs. 1-3). It is important to note that median dust lead loadings at 24 months for the window sills and window wells in Minor Repair houses were higher than the corresponding pre-intervention baseline levels (Table 9). Median window sill and window well dust lead loadings in Clean B houses at 24 months were higher than immediate post-intervention levels, but remained below pre-intervention levels (Table 9). In future work, we plan to analyze TLC data on housing type and condition to better understand changes in lead loadings associated with the various interventions implemented in the Baltimore Clinical Center.

Dust lead loadings across all four groups of study houses at 24 months were most similar for floors compared to window sills and window wells (Figs. 1-3). A similar pattern of surface-specific findings was also found in the *Lead Paint Abatement and Repair and Maintenance Study in Baltimore* (Farfel, 1997b) over time following various levels of interim control interventions implemented in houses in older low-income urban neighborhoods (Farfel, 1997b). This pattern of findings might be related in part to the presence of study houses in neighborhoods where most of the housing is likely to contain interior and exterior lead-based paint hazards (Fig. 4). Such neighborhoods are likely to have similar ambient lead levels and similar rates of track-in of ambient lead. The finding of higher dust lead loadings at interior entryways compared to interior floors (Tables 10-13) is also likely related to the track in of ambient lead.

Dust Lead Loadings on Walls

Little information is available on the distribution of dust lead loadings on walls in various types of houses or the relationship between children's blood lead concentrations and wall lead loadings. Across the four groups of study houses under investigation, dust lead loadings were found to be low (90th PT=23 Fg/ft^2) for walls in kitchens and children's bedrooms at 24 month post-intervention (Table 15). The small number of relatively high values (maximum=886 Fg/ft^2) on kitchen walls may reflect dust adhering to greasy wall surfaces, and the outlier (30,530 Fg/ft^2) might be due to a paint chip in the sample. This study, however, was not designed to determine the source of the lead in wall dust.

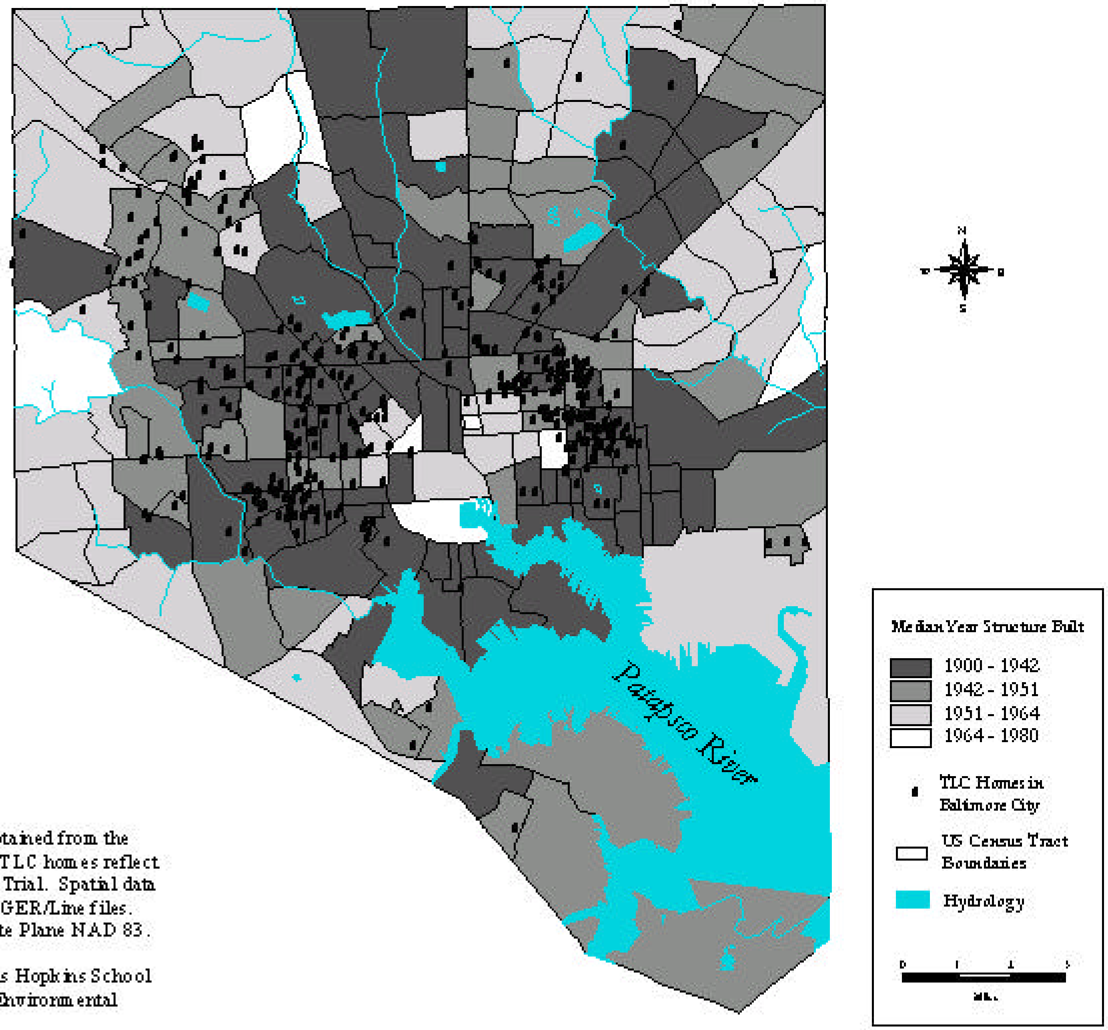
Wall lead loadings tended to be lowest in the Major Repair and Clean A groups, but the relationship between wall lead loadings and intervention type did not reach statistical significance. This may be due in part to the relatively small number of houses in the Minor Repair and Clean B groups. Lower wall lead loadings in Major Repair and Clean A houses might be related to the better conditions of these houses and the fact that walls in the Major Repair houses had been repainted at the time of the intervention. The moderate correlation found between lead loadings on the walls and floors in the children's bedrooms suggests that testing and/or cleaning walls might be considered as part of the risk assessment process if floor dust lead loadings are found to be high. However, this issue requires further study.

Generalizability

The study findings apply to the Baltimore Clinical Center of the TLC Trial and not necessarily to the other centers in this multi-center Trial. The intervention costs reported in Table 2 may not be generalizable to other parts of the country due to differences in labor and material costs. It should also be recognized that study houses were either the homes of children with blood lead levels from 20 to 44 Fg/dL at the time of enrollment or were houses into which such children were relocated (*i.e.*, Clean A houses). The dust lead loadings in the various groups of study homes cannot be compared to those in Baltimore City homes in general due to a lack of systematic data on residential dust lead levels in the city. The longitudinal data analysis performed in this study accounted for season and the clustering of the data. Unfortunately, data were not available on other potential mediating variables such as the cleaning practices of residents.

Figure 4

Figure 4: TLC Homes in Baltimore City (1994-1998) and Median Construction Year of Housing



Notes: Data on housing were obtained from the 1990 US Census STF 3A file. TLC homes reflect homes identified in the Clinical Trial. Spatial data were obtained from the 1995 TIGER/Line files. Map projection is Maryland State Plane NAD 83.

Map created by Jill S. Litt, Johns Hopkins School of Hygiene and Public Health, Environmental Health Policy Group

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APPENDIX A

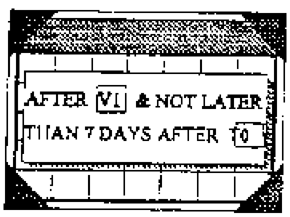
TLC CLEANING PROTOCOL

Home Cleanup (H2)

The purpose of H2is to reduce risk of environmental exposures attributable to lead-based paint in fair or poor condition and lead-contaminated house dust and to reduce exposure during treatment (up to 6 months). At H2 the Environmental Cleanup Team will clean the housing unit of study participants.

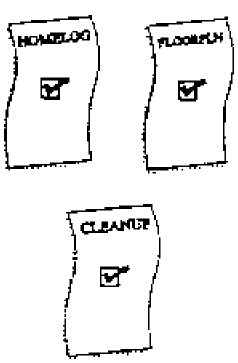
This section of the Manual of Operations *covers the minimum activities to be adhered to by all clinical centers. If warranted and resources permit, centers may elect to go beyond these minimums. The TLC cleanup protocols are not substitutes for the legally mandated activities carried out by local or state agencies.*

Efforts should be made to use existing Health Department regulations, procedures and resources wherever possible and to the extent that they offer greater risk reduction than procedures recommended in this protocol. It is important that Health Department mandated and/or landlord initiated lead paint abatement activities be carried out in a timely fashion and in a manner that does not increase exposures. Parents are asked to notify the TLC project staff immediately of any paint abatement activities. Thorough cleaning should be carried out immediately after any paint abatement activities. In states where there are no regulations governing lead abatement, Health Departments may do some hazard reduction or hire others to do the work. If this work occurs after TLC hazard reduction, there should be special environmental sampling to assess the quality of that work.



WHEN: After Pre-Randomization Clinic Visit 1 (V1) and before Treatment Visit (T0) plus 7 days. Home cleanup should be completed no later than seven days after first Treatment Visit (T0).

WHO: **Environmental Cleanup Team** consisting of at least two people who will perform cleanup.



FORMS:

- HOMELOG (Home Assessment Sheet) from the H1 inspection
- FLOORPLN (Floor Plan) from the H1 inspection
- CLEANUP (Home Cleanup Report)

EQUIPMENT:

- Vacuum cleaners-- must be equipped with a HEPA filter.
  Approved vacuum cleaners include:

  a. Nilfisk GS80

  b. Wap 767

  c. Other HEPA-equipped vacuum cleaners

- Vacuum Cleaner Accessories:
  -- for woodwork (ledges): a round brush with combination rubber holder
  -- for non-carpeted floors: the standard floor tool
  -- for crevices: a narrow crevice tool
  -- spare secondary filters
  -- spare vacuum cleaner bags

- Beater Bar for Vacuum Cleaner
  -- Kenmore Model #116 or any other electrically driven beater bar

- Detergent
  -- high phosphate detergent (tri-sodium phosphate (TSP))
  -- equivalent non-TSP cleaning substance
  -- other cleaning agents developed specifically for removing lead

- Floor Mop
  -- must be equipped with a replaceable cellulose sponge cleaning head (with optional towel) and a wringing device.

- Cellulose sponge cleaning heads for mops
  Some centers may choose to use towels wrapped around mop heads in place of sponge cleaning heads. Towels should be discarded after use. The sponge cleaning or towel head should be replaced after each room.

- 4 mil polyethylene bags

- 6 mil plastic sheet (for deteriorated carpet disposal)

- #1 pencils

- Watch

- Duct tape
- Towel (for brushing loose paint)
- Contact paper (optional)
- Cleaning sponges (must be cellulose-type sponge)
- 2nd stage HEPA filters (replacement)
- Many vacuum cleaner bags
- Spray bottles
- 2 or more sponge buckets (1 for wash, 1 for rinse)
- 2 or more mop buckets (1 for wash, 1 for rinse)
- Brushes
- Waterproof gloves (for using TSP wash)
- Eye protection
- Portable eyewash kit
- Uniforms for Environmental Cleanup Team to wear during working hours and a facility for changing clothes and shoes and cleaning-up at the end of the day to negate the possibility of carrying lead dust into their cars and/or home.
- Name tags and other identification
- Respirators and other safety equipment and supplies, as appropriate.

BEFORE HOME CLEANUP (H2):

Coordinator schedules visit with residents. Family is reminded that they will be asked to prepare living unit for cleanup, including packing of small items; that all children should be moved to another location outside the housing unit during cleanup; that a responsible adult should be in unit during cleanup. A letter is mailed to the parent or legal guardian confirming the date and time and requesting that the home is properly prepared. Here is a suggested letter:

Dear ________________

Since you are a part of the ______________ TLC (Treatment of Lead-Exposed Children) Trial, your home will receive a professional cleanup in an effort to reduce lead dust and paint hazards.

My name is ______________ and I work for the ______________ TLC Program.

This is a reminder that on _______________ at _____________ our contractor will be coming to your home to do the work that we discussed. It is important that you prepare your home so that the cleaning team can do the work quickly and completely.

- Pack up any small articles in the boxes or bags that we will give you so that all the furniture can be moved for cleaning. We will bring boxes or bags to your home on ________.
- Pick up any small things from the floor so that the floor can be cleaned well.
- Be sure to put all valuable and breakable items away to a safe place.
- Empty kitchen sink or bathtub of all items so that our workers can easily get water.
- Be finished with the kitchen and bathroom by _______a.m. so that our workers can start on time.
- Use the attached check list to make sure your home is ready for clean up.

If you have any questions, please call me at _______________.

Please help us help your children. Thank you!

Here is a checklist you might want to send with the letter...

Cleanup CHECKLIST

To Prepare for Lead Cleanup in Your Home

House ID ____________ Address ______________________________

Date of Cleanup ____________ Time Begin _______ Total # Rooms ____

WINDOWS:

_____ Remove plants

_____ Remove fans

FURNITURE:

_____ Clear small items off tops so that furniture can be moved

CLOTHES, TOYS, SMALL ITEMS, PICTURES, AND OTHER BREAKABLE THINGS:

_____ Pack in boxes or bags and put on sofas or beds, if possible

_____ Clear off as much floor surface as possible

_____ All objects you can more should betaken off the floor (examples are toys, clothes, shoes, boxes, etc.)

_____ Put away valuable things.

WALLS:

_____Remove items/pictures/mirrors off walls, if possible.

ROOMS:

_____ Empty all sinks and bathtub.

One business day before cleanup, coordinator calls family to remind them of scheduled cleanup and to remind them to have children out of unit, small articles packed, and windows cleared. Name of designated adult who will be present during the cleanup is confirmed if known or obtained.

Provide Environmental Cleanup Team with directions to unit, names and phone numbers of responsible family member, plus copy of FLOORPLN, HOMELOG, and specifications of work to be performed.

AT HOME CLEANUP (H2):

Identify yourself by name as the contractor or staff for the TLC Trial who will be doing the cleanup. Show identification.

Ask to speak to designated adult whose name has been given. Review with this adult what will be done during cleanup.

Verify that arrangements have been made for all children to be out of living unit during cleanup, if possible. If this is not possible, ask that all children be relocated into one room until at least one of the rooms is cleaned and the children use that room.

Initial Steps

Videotaping of all rooms and contents prior to start of cleanup is optional depending on clinic funds. If the cleaning crew will be videotaping resident belongings, this should be done before the cleaning starts. The crew should ask permission of the adult present before beginning videotaping.

If feasible, all furniture and personal belongings should be moved from areas to be cleaned.

Rooms to which furniture is moved, should be given one pass by the vacuum to minimize tracking lead dust into them.

Order of Cleaning

The Environmental Cleanup Team should review FLOORPLN and HOMELOG before the visit to determine best method and order of cleaning.

Cleaning of rooms should be sequenced to avoid passing through rooms already cleaned, and should proceed so that common areas and the entryway to the dwelling are cleaned last.

Cleaning within each room should begin on the ceilings and end on the floors.

Cleaning Procedures

The HEPA/Wet Wash/HEPA Cycle

The cleaning cycle is called the HEPA/Wet Wash/HEPA cycle and is applied to each area as follows:

--first, the area is HEPA-vacuumed;

--next, the area is washed down;

--after drying, the area is HEPA-vacuumed again;

The third HEPA vacuuming can be omitted when floors are smooth and intact.

The rationale for this three pass system is as follows:

-- the purpose of the first pass HEPA vacuum is to remove all dust and remaining debris that is available to the vacuum;

-- the wet wash works to further dislodge dust from surfaces, but the mopping or washing process may not pick up all the dislodged dust particles;

-- the final HEPA cycle removes any remaining particles dislodged but not removed by the wet wash. This is optional if floor is smooth and intact (e.g. linoleum, vinyl, tile). Wooden floors, while they may be smooth and intact, may have large cracks in the tongue and groove that trap particles. Such floors *should* get a final HEPA cycle.

HEPA Vacuuming Procedures

Surfaces to be cleaned include horizontal surfaces except ceilings (for example, floors, window sills and wells). Areas of loose or peeling paint, such as those on floors, ceilings, walls, windows and doors, will also be cleaned. Other items -- HVAC equipment (such as heating diffusers, radiators, pipes, vents), fixtures of any kind (light, bathroom, kitchen), built-in cabinets, appliances and other dust traps -- should be vacuumed. The Home Assessment Inspector when doing the H1 inspection visit should note in the comments section on HOMELOG which particular parts of the home need to be carefully cleaned.

When vacuuming carpets, the HEPA vacuum must be equipped with an electrically driven beater bar (agitator head) fixed to the cleaning head to aid in dislodging and collecting deep dust and lead. This bar should be used on all passes on the carpet face during dry vacuuming.

!

> *EMPTYING THE HEPA VACUUM -- Operators should use extreme caution when opening the HEPA vacuum for filter replacement or debris or vacuum bag removal, due to the high potential for accidental release of accumulated dust into the environment. For example, this can occur if the vacuum's seal has been broken and the vacuum's bag is disturbed. HEPA vacuum filter replacement should be performed in an area to prevent contamination of dwelling unit or off site, and care should be taken that the dust does not spread. If the vacuum cleaner bag breaks while a vacuum cleaner is operating or if a vacuum cleaner is operated without a bag, the second stage filter must be changed prior to any further use of the vacuum cleaner.*

Wet Detergent Wash

Several types of detergents have been used to remove leaded dust. Detergents with a high-phosphate content (containing at least 5% tri-sodium phosphate, also known as TSP) have been found to be effective when used as part of the final cleaning process. Some TSP detergents can damage existing surface finishes.

Proper procedures for using high phosphate detergents also apply to most other types of detergents and include the following steps:

Manufacturer's Dilution Instructions
Users of high-phosphate detergents should follow the specific manufacturer's instructions for the proper use of the product, especially the recommended dilution ration. Even diluted, tri-sodium phosphate is very irritating to the skin and should be used only with water-proof gloves. Eye protection should be worn; portable eyewash facilities should be available.

Appropriate Cleaning Equipment
Since the high-phosphate detergent mixture is used to wash down a variety of surfaces, several kinds of application equipment are needed, including cleaning solution spray bottles, sponge buckets, mops, variously sized hand sponges, brushes and towels. Using the proper equipment on each surface is essential to the quality of the wash process.

Proper Wet Cleaning Procedures
At the conclusion of the first HEPA vacuuming, all surfaces that were HEPA vacuumed should be thoroughly and completely washed with a high-phosphate solution or other cleaning agents and rinsed. As is the case for HEPA vacuuming, work should proceed from top to bottom and sequenced to avoid passing though rooms already cleaned.

Changing Cleaning Mixture

Many manufacturers of cleaners will indicate the surface area that their cleaning mixture will cover. To avoid recontaminating the area by using overly dirty water, users should follow the surface area limits provided by the manufacturer. **Regardless of manufacturer recommendation, the cleaning mixture should be changed after each room.**

! *Dirty water should be disposed in the toilet and then flushed.*

Specific Cleaning Instructions

Walls and Frames

Loose, peeling paint can be gently brushed with a damp towel or damp sponge to remove the flakes or removed with a vacuum cleaner with an appropriate attachment. Work crews should not engage in any paint removal activities such as scraping or sanding. Contact paper, duct tape or a coat of paint can be applied over the deteriorated surface to provide a short term stabilization of the surface. All loose chips must be vacuumed and the surrounding surfaces washed with the detergent solution.

Carpets

The surface of the carpet should be vacuumed as follows: The carpet is folded in half and the bottom side of the carpet is vacuumed, along with the floor which was exposed. The carpet is then folded to the opposite side of the room and the other half of the floor and the other half of the bottom of the carpet is vacuumed. The carpet is replaced to its original position. If there is padding beneath the carpet, it should be cleaned in a manner similar to the carpets if possible. Cleaning or disposal of the carpet and/or pad is at the discretion of the Home Assessment Inspector, and always with the permission of the adult owner. The last step in the cleaning process will be the final vacuuming of the carpet. The carpet should be vacuumed **a total of three times at the rate of three minutes per square yard each time** (required). Calculate area of rugs in room to nearest square yard to determine the amount of vacuuming required. Workers should have a watch in their possession to monitor the amount of vacuuming. At the completion of the vacuuming, the furniture and personal belongings will be replaced in their original positions. All carpets should be vacuumed with an approved HEPA equipped vacuum and an approved beater bar.

Badly deteriorated carpets should be permanently removed if possible. When disposal or replacement of carpets is indicated, the existing carpet should be rolled into a tight roll and wrapped with 6 mil polyethylene plastic and taped securely with duct tape or a similar durable strapping tape prior to removal from the room. If new carpet is to be installed, it should not be installed until all cleaning and paint stabilization in the housing unit have been completed.

In rooms where the carpeting is permanently installed, as in wall-to-wall carpeting, the carpeting will not be folded back and the floor will not be cleaned underneath the carpeting. It should, however, still be vacuumed at the rate indicated above.

Wood, Tile, Vinyl and Linoleum Floors

If there is no carpeting on the floor, the floor is vacuumed at the rate of **one minute per square yard**. After the first vacuuming, the floor should be damp mopped with a detergent solution, and then vacuumed a second time at the same rate. The second vacuuming may be omitted if the floor surface is intact and smooth.

For washing floors, a two bucket system is recommended. The cleaning solution should be mixed in one bucket. Rinse water for cleaning the mop head is in the second bucket. Water in the rinse bucket should be changed whenever dirty. The cleaning solution bucket and rinse bucket should be changed after cleaning approximately every 75-100 square feet (8-10 square yards) of floor **and** after each room is completed.

A cellulose sponge mop head should be used for washing floors. The sponge may be covered with a rag. The rag (or sponge, if one was used) will be changed after each room. The cellulose sponge will be changed after each house. Sponges and rags should not be discarded at the subject's house.

Other Areas

All ledges e.g. sills, tops of baseboards, etc. should be washed with a sponge and the detergent solution.

Window wells, if accessible to Environmental Cleanup Team, should be vacuumed to remove paint chips and dust and then washed with a damp sponge and detergent solution.

Other dust traps such as venetian blinds, cold air return registers, forced air heating registers, radiators, and base boards must be inspected and cleaned. These dust traps should be noted on HOMELOG by the Home Assessment Inspector when at H1.

Any duct work with visible accumulation of dust should be vacuumed if covering can be easily removed.

The family should be encouraged to wash curtains and dispose of old carpets and blinds.

Abatement Procedures

- It is not the objective of the TLC Trial to carry out or oversee comprehensive lead paint abatement activities. However the interim dust control procedures will be rapidly negated if no attention is given to deteriorated painted surfaces. If the deterioration is extensive and proper paint abatement not an immediate possibility, then relocation must be sought. If the deterioration is localized to one or two surfaces, such as on window sills or frames, then in-place management is an appropriate interim option to be carried out under this study if resources permit.

- If funds permit, other encapsulation procedures may be employed.

- Door mats at the interior entry to housing units can be used to minimize the amount of dust that enters the living space. They need to be periodically cleaned or replaced to prevent them from becoming a reservoir of lead-dust that can contaminate the house. Outdoor mats, e.g. indoor-outdoor carpet are recommended. The thickness of indoor mats and their placement must not interfere with the normal opening of the entry door. If otherwise, they likely will be removed by the resident. Some sites will offer new doormats as replacements. If this is the case, try to get the old one disposed

Completion of Cleanup

- All carpets and furniture should be put back in place. Boxes or bags of small articles should be returned to appropriate rooms, although occupants should be asked to unpack.

- Wipe smooth surfaces of furniture before they are returned to cleaned rooms.

Damage to Occupant's Property/Liability

- For TLC sites who are employing a cleaning contractor, the contract should address the issue of breakage. It is obvious that the Environmental Cleanup Team will need to move occupant's belongings during the course of the cleaning work. Every attempt will be made on the part of the TLC staff to encourage the families to consolidate their belongings so that movement by the Environmental Cleanup Team is kept to a minimum.

- Continued compliance on the part of the families is of paramount importance to the TLC Trial. In this regard, the Environmental Cleanup Team needs to be extremely careful in performing work at the work site. If any item is obviously broken during cleanup, it needs to be replaced immediately, the same day if possible. Other claims should be handled on a case-by-case basis. Each sites is required to write reimbursement procedures including who is responsible for reimbursement.

Safety and Health

- A strict series of contamination control procedures must be in force throughout the dust abatement process to ensure that cleaning materials and removed from the site to a designated disposal site without loss or spread of contaminated materials.

- Any dirt or dust removed from the work site, including bags from the vacuum cleaners, must be placed immediately in plastic trash bags, a minimum of 4 mil in thickness, of sufficient size to allow the bag top to be twisted and sealed securely with a locking device. These bags must be securely anchored in the transport vehicle to prevent any spillage as the workers travel from work site to work site or to a dump site.

- All cleaning equipment, especially cellulose sponge mop heads, rags and towels, must be removed from the home when the cleaning crew leaves in order that the resident is not tempted to use these possibly lead contaminated materials for regular household chores.

- All vacuum cleaning attachments and other cleaning tools should be wiped before leaving site.

- To prevent any contamination of work sites, all vacuum cleaners will be emptied and fitted with a new bag prior to entering a work site.

- Carpeting removed from a work site may not be left unattended on the street curb, especially overnight. After removal from the work site, it must be guarded or secured to prevent loss until it is transported to the designated dump site. This is not hazardous waste and does not have to be transported to a secured land fill, but it must be removed from the site. We are trying to prevent people from "helping themselves" to lead-contaminated materials.

- Wash water (both detergent solution and rinse water) should be disposed of in the toilet. It should not be disposed of in other places such as sinks, bath tubs, street gutters, or back yards.

- Crew should clean up any mess or spills created during cleanup or disposal of materials.

Cleanup Monitoring

- Environmental Cleanup Team performance should be monitored by a post-cleanup visual inspection by the Home Assessment Inspector. The first 25 housing units and every 10th home thereafter will be inspected. The inspection process can take place concurrently with the Post-Cleanup Wipe Sampling as part of the Monitoring Residential Lead Dust.

- It is not known if this cleanup protocol is adequate to attain HUD clearance levels. HUD guidelines, therefore should not be used to monitor contractor performance. In addition there is no basis for specifying a particular percent reduction in lead loading. Therefore, lead measurements in the home should not be used to monitor contract compliance unless the lead loadings are seen to increase following cleanup activities.

Here is a suggested checklist for centers who wish to monitor the work of the Environmental Cleanup Team:

LEAD CLEANING CHECKLIST

(This section filled out by the Environmental Cleanup Team.)

House ID _________ Address ____

Date _________________ Total # Rooms ______________

Preparation of Areas to be Cleaned

____ Remove pictures, etc. from walls, if possible.

____ Quick vacuum of entire unit.

Ceiling

____ Vacuum loose paint chips.

Walls

____ Vacuum loose paint chips.

Baseboards

____ Use vacuum then wipe with damp cloth to remove dust.

Windows

____ Use vacuum to clean tops of window, ledge and trim.

____ Use vacuum to clean inside wells and sills.

____ Wipe sills, ledges, trim and glass with damp cloth and cleanser.

Doors

____ Use vacuum to clean top of door trim.

____ Wipe door trim with damp cloth and cleanser.

Radiator or Air Return Registers

____ Use vacuum to clean radiator or register.

____ Wipe with damp cloth.

Surfaces

____ Wipe all horizontal surfaces with damp cloth.

Cleaning Procedures

____ Water changed frequently and flushed down toilet.

Floors

____ Vacuum all floor surfaces.

____ Vacuum carpeted areas four times in varying directions.

____ Wet mop all hard floor surfaces.

Final Cleanup

____ Pack up cleaning equipment; check for all items.

____ Seal cleaning debris and remove from premises.

____ Return furniture to original positions.

LEAD CLEANING CHECKLIST (*continued*)

(This section filled out by Environmental Cleanup Team and signed by the adult present.)

The TLC Environmental Cleanup Team cleaned this home on (date)_____________. The following repairs were done:

____

____

____

____

The following items were thrown away:

____

____

____

Comments:

Signed ______________________________

Date ____________________

AFTER HOME CLEANUP (H2):

- Environmental Cleanup Team completes form CLEANUP with a #1 pencil and returns it to clinic coordinator.

CLEANUP is a data form. No identifying information, other than the child's Study ID Number, should appear on the form. A copy is made for the child's file and the original is mailed to the Data Coordinating Center.

- Environmental Cleanup Team returns forms HOMELOG and FLOORPLN to coordinator for clinic files.

- Coordinator makes copy of CLEANUP for clinic files and sends original to Data Coordinating Center.

Post-Cleanup Wipe Sampling: Monitoring Residential Lead Dust

- Post-cleanup wipe samples will be collected from each of the homes inspected for contractor monitoring, that is, the first 25 housing units plus every 10th home thereafter. These are the same homes with Lead Dust samples from the Home Assessment. For more information, see the section on "Monitoring Residential Lead Dust" in the *Manual of Operations*.

APPENDIX C

Geometric Means Dust Lead Loadings (Fg/ft^2) by Surface Type and by Group Based on the Earlier EPA-funded Study (Farfel, 1997a) [a]

Surface Type	Group	Pre-Interventio n Fg/ft^2 (no. Houses)	Post-Intervention Fg/ft^2 (no. Houses)	6-12 Months Fg/ft^2 (no. Houses)
Floor	Professional Clean A	26 (97)	16 (91)	21 (58)
	Professional Clean B	92 (62)	31 (62)	43 (19)
	Minor Repair [b]	129 (47)	76 (47)	75 (6)
	Major Repair [c]	117 (13)	24 (37)	24 (14)
Window Sill	Professional Clean A	107 (97)	35 (91)	54 (58)
	Professional Clean B	535 (62)	164 (62)	197 (19)
	Minor Repair	1,706 (47)	126 (47)	585 (6)
	Major Repair	444 (13)	18 (37)	75 (14)
Window Well	Professional Clean A	962 (97)	91 (91)	320 (58)
	Professional Clean B	13,759 (62)	452 (62)	2,111 (19)
	Minor Repair	29,648 (47)	1,258 (47)	16,199 (6)
	Major Repair	4,153 (13)	44 (37)	296 (14)

a These data are not limited to study houses sampled at 24 months.

b This type of intervention was introduced later in the project and consequently a small number of houses were available for 6 to 12 month sampling during the study period.

c The number of houses at post-intervention is larger because some major repair interventions were performed as the second intervention, and pre-intervention wipes were generally not collected for the second intervention.

Median Dust Lead Loadings (Fg/ft^2) by Surface Type and by Group Based on the Earlier EPA-funded Study (Farfel, 1997a) [a]

Surface Type	Group	Pre-Intervention Fg/ft^2 (no. Houses)	Post-Intervention Fg/ft^2 (no. Houses)	6-12 Months Fg/ft^2 (no. Houses)
Floor	Professional Clean A	29 (97)	17 (91)	45 (58)
	Professional Clean B	165 (62)	39 (62)	60 (19)
	Minor Repair [b]	324 (47)	180 (47)	127 (6)
	Major Repair [c]	328 (13)	43 (37)	39 (14)
Window Sill	Professional Clean A	109 (97)	21 (91)	73 (58)
	Professional Clean B	538 (62)	147 (62)	227 (19)
	Minor Repair	2,074 (47)	159 (47)	1,152 (6)
	Major Repair	490 (13)	19 (37)	77 (14)
Window Well	Professional Clean A	1,165 (97)	57 (91)	216 (58)
	Professional Clean B	34,879 (62)	1,391 (62)	6,662 (19)
	Minor Repair	105,655 (47)	2,668 (47)	26,229 (6)
	Major Repair	6,710 (13)	50 (37)	479 (14)

a These data are not limited to study houses sampled at 24 months.

b This type of intervention was introduced later in the project and consequently a small number of houses were available for 6 to 12 month sampling during the study period.

c The number of houses at post-intervention is larger because some major repair interventions were performed as the second intervention, and pre-intervention wipes were generally not collected for the second intervention.