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The Longer-Term Effectiveness of Residential Lead Paint Abatement

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Residential lead-based paint and settled dust are important sources of lead exposure in U.S. children. Scant information exists on the long-term effectiveness of alternative lead abatement practices. In this extended (1.5–3.5 years) follow-up study of comprehensive abatement, 179 wipe dust samples were collected in 13 occupied dwellings for which pre- and immediately postabatement (clearance) dust lead data were available. Dust lead loadings (mg/m^2) 1.5 to 3.5 years postabatement were 16, 10, and 4% of preabatement levels for floors, window sills, and window wells, respectively. Furthermore, 78% of readings remained within Maryland's interim clearance standards, indicating that sustained reductions of dust lead hazards were achieved in comprehensively abated dwellings located in older unabated housing areas. © 1994 Academic Press, Inc.

INTRODUCTION

We have studied both effective and ineffective practices for abatement of residential lead paint hazards. Ineffective practices involved limited removal of leaded paint by burning and sanding, improper cleanup, and other hazardous practices which were associated with significantly increased lead loadings in surface dust (PbD mg/m^2) immediately postabatement. At 6 months postabatement, PbD levels were similar to preabatement levels which were highly elevated (Farfel and Chisolm, 1990).

As previously reported in this journal, comprehensive abatement practices designed to address the deficiencies of past practices were effective in reducing PbD to low levels which persisted at 6–9 months of follow-up (Farfel and Chisolm, 1991). Salient features of these abatements included the following: (a) fixing water leaks and other impediments to abatement; (b) treating all lead painted surfaces primarily using replacement and enclosure methods and minimal on-site paint removal; (c) installing vinyl replacement windows; (d) making floors smooth and easily cleanable; and (e) cleaning with wet washing and high efficiency particle accumulator (HEPA) vacuums.

We now report the results of an extended follow-up study to see whether these comprehensive abatements are associated with longer-term (1.5–3.5 years) reductions in house dust lead hazards, an important source of lead exposure in toddlers via the hand-to-mouth route of ingestion (Sayre *et al.*, 1974; Bornschein *et al.*, 1986; Brunekreef *et al.*, 1987).

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MATERIALS AND METHODS

Thirteen dwellings (20.6%) were selected from a group of 63 Baltimore city dwellings abated according to Maryland regulations (COMAR, 1988) by local pilot projects between 1988 and 1991. Eligibility criteria were as follows: (a) availability of at least 6 pairs of pre- and immediately postabatement PbD measurements taken from the same floor and window locations at each time period (actual range: 6–13 pairs), (b) no major renovations performed since abatement, and (c) occupancy by a family providing written informed consent. Home visits were made to the 25 dwellings which met criterion (a) above. Two families refused to participate and seven others could not be contacted after multiple attempts. Owing to limited funding, 13 of the remaining 16 dwellings were recruited (i.e., 52% of those meeting criteria for baseline PbD). One study dwelling was abated during the early phase of the pilot projects in which on-site paint removal by caustic chemicals was used.

This study was approved by the Joint Committee of Clinical Investigation of the Johns Hopkins Medical Institutions.

Data Collection and Laboratory Methods

Wipe-dust samples (n = 179) were collected in most rooms in study dwellings during December and January 1992. The number of samples per dwelling ranged from four to six for floors and window sills and two to five for window wells. Where possible, dust samples were collected from the same surfaces that had been sampled pre- and immediately postabatement. Sample collection and lead analysis was done by the same methods employed previously (Farfel and Chisolm, 1990, 1991). One composite sample of the top 1.27 cm of soil was collected close to the foundation of each dwelling using a 15.24-cm stainless steel probe. Soil was digested in nitric acid in a microwave oven (two samples vented and were lost) and analyzed according to EPA SW846 Method 7420 for flame atomic absorption spectrophotometry (IL Model 551).

At the time of sampling, the conditions of the abated surfaces were assessed by staff familiar with the original abatement work.

Data Analysis

Since the wipe method used produces only lead loading measurements (i.e., mass of lead/unit surface area), dust lead loadings were compared across time. All data available for each dwelling were used in the statistical analysis after transformation using natural logarithms (ln), as these data tended to be log-normally distributed. GEE software for longitudinal data analysis was used since it can handle multiple observations per house (i.e., clustering) (Karim and Zeger, 1988). In the GEE method, "house" is treated as a random effect. The model was fitted to the data separately for each surface type

$$\ln(\text{Wipe})_{ijk} = \ln(\alpha) + h_i + \beta_k \text{Time}_k + \ln(E)_{ijk}, \quad (1)$$

where Wipe_{ijk} = Wipe PbD for jth reading within house$_i$ at Time$_2$; α = Constant; h_i = ith study house; Time$_0$ = 1 if preabatement, 0 otherwise; Time$_1$ = 1 if postabatement, 0 otherwise; E_{ijk} = random error term assumed to follow a lognormal distribution.

RESULTS

Table 1 displays descriptive statistics on dust lead loadings by surface type for each time period. Geometric mean (GM) PbD levels 1.5 to 3.5 years postabatement were significantly different from pre- and immediately postabatement levels. Dust lead loadings at this extended follow-up were 16, 10, and 4% of preabatement levels for floors, window sills, and window wells, respectively. Despite some reaccumulation of lead in dust, 78% of all dust lead loading measurements remained within Maryland's interim postabatement clearance standards (see Table 2 and Table 1 footnote). Over half (21/39) of the PbD readings above the clearance levels at extended follow-up were from window wells. Three of four window wells abated by caustic chemicals had the highest lead loadings (range 125–162 mg/m^2).

The abatement treatments were found to be intact and in good condition. Only minimal and routine maintenance work was needed, most often the resealing of wood floors originally treated with polyurethane. Soil lead concentration which ranged from 209 to 1962 μg/g (GM = 688 μg/g, SD on log scale = 0.69) was not a significant covariate in the statistical model.

DISCUSSION

This study shows that comprehensive lead paint abatement is associated with the longer-term control of residential dust lead hazards, despite the presence of

TABLE 1

DUST LEAD LOADINGS (PbD, mg Pb/m^2) OVER TIME BY SURFACE TYPE

Surface type	Preabatement PbD	Postabatement PbD[a]	1.5–3.5 years Postabatement PbD
Floor			
GM	2.73	0.15	0.44
95% CI	[1.54, 4.86]	[0.08, 0.27]	[0.27, 0.74]
Range	(0.17–136)	(0.03–1.71)	(0.03–30.2)
n	42	47	71
Window sill			
GM	11.21	0.14	1.11
95% CI	[5.83, 21.6]	[0.08, 0.24]	[0.71, 1.73]
Range	(0.04–377)	(0.02–1.62)	(0.11–22.1)
n	53	54	59
Window well			
GM	153	0.37	6.46[b]
95% CI	[79, 299]	[0.24, 0.57]	[3.71, 11.2]
Range	(2.86–3245)	(0.09–2.51)	(0.12–162)
n	31	41	49

[a] All PbD values are within Maryland's postabatement clearance standards, equivalent to <2.15 mg/m^2 for floors, <5.38 mg/m^2 for window sills, and <8.61 mg/m^2 for window wells.

[b] Excluding the three highest values where caustic chemicals were used: n = 46, GM = 5.32 mg/m^2, 95%CI [3.62, 7.81], range (0.12–74.6 mg/m^2).

TABLE 2
MODEL ESTIMATES OF THE RATIOS OF 1.5- TO 3.5-YEAR FOLLOW-UP DUST LEAD LOADINGS (PbD) TO THOSE PRE- AND IMMEDIATE POSTABATEMENT

	PbD ratio* [95%CI]	
	1.5 to 3.5 years	1.5 to 3.5 years
Surface type	Immediate postabatement	Preabatement
Floor	3.0 [1.5, 6.3]	0.17 [0.09, 0.31]
Window sill	8.2 [4.4, 15]	0.10 [0.05, 0.20]
Window well	17 [9.1, 31]	0.04 [0.02, 0.08]

* *P* values associated with the *z* scores for these GEE estimates were all <0.001.

lead in soil at levels of concern (>500–1000 ppm) (Bornschein *et al.*, 1986), the locations of the dwellings in older housing areas where nearly all housing remains unabated of lead paint, and some reaccumulation of lead in dust.

These findings lend support to the suggestion that occupants can maintain low dust lead levels with ordinary housecleaning methods once smooth surfaces are provided in the context of this comprehensive abatement. Our inspections identified the need for periodic maintenance to keep some floors smooth and easily cleanable. Reaccumulation of lead in dust was greatest for window wells and may reflect the deposition of particulate lead from exterior sources and a lack of wintertime cleaning of these surfaces by occupants. The findings of high dust lead loadings on surfaces abated by caustic chemicals and differences in lead loadings across surface types (see Table 1) are consistent with those of our previous study (Farfel and Chisolm, 1991).

Abatement of lead in residential paint and dust is an important component of the prevention and management of childhood lead poisoning (CDC, 1991). It is important to continue documenting the effectiveness of these comprehensive abatement practices and less costly alternatives, including the need for and costs of ongoing work to maintain the integrity of the original abatement treatments. We plan to periodically reevaluate the dwellings reported here, in particular during nonwinter months when occupants' use of windows and foot traffic patterns may differ from wintertime patterns.

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