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U.S. Children's Exposure to Residential Dust Lead, 1999-2004: I. Housing and Demographic Factors

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Disclaimer:

The opinions expressed in this paper do not necessarily represent those of the U.S. government.

Abbreviations:

AM- Arithmetic Mean

DL – Detection Limit

GM – Geometric Mean

GSE – Geometric Standard Error

µg – microgram

µg/dL – microgram per deciliter

µg/ft^2 – micrograms of lead per square foot of surface area

NHANES – National Health and Nutrition Examination Survey

PbB – Blood lead Level

PbD – Dust Lead Loading

PIR – Poverty Income Ratio

R^2 –the proportion of variability in the dependent variable accounted for by the model

SE – Standard Error

U.S. CDC – U.S. Centers for Disease Control and Prevention

U.S. EPA – U.S. Environmental Protection Agency

U.S. HUD – U.S. Department of Housing and Urban Development

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Abstract

Background: Lead-contaminated house dust is a major source of lead exposure for children in the U.S. In 1999-2004, the National Health and Nutrition Examination Survey (NHANES) collected dust lead loading (PbD) samples from the homes of children aged 12-60 months.

Objectives: To compare national PbD levels with existing health-based standards and to identify housing and demographic factors associated with floor and window sill PbD.

Methods: NHANES PbD data (n= 2,065 from floors and n=1,618 from window sills) and covariates were used to construct linear and logistic regression models.

Results: The population weighted geometric mean floor and window sill PbD were 0.5 $\mu g/ft^2$ (GSE=1.0) and 7.6 $\mu g/ft^2$ (GSE=1.0), respectively. Only 0.16% of the floors and 4.0% of the sills had PbD at or above current Federal standards of 40 and 250 $\mu g/ft^2$, respectively. Income, race/ethnicity, floor surface/condition, window sill PbD, year of construction, recent renovation, smoking, and survey year were significant predictors of floor PbD (R^2 = 35%). A similar set of predictors plus the presence of large areas of exterior deteriorated paint in pre-1950 homes and the presence of interior deteriorated paint explained 20% of the variability in sill PbD. A companion article describes the relationship between children's blood lead and PbD.

Conclusion: Most houses with children have PbD far below Federal standards. Factors associated with PbD in our population-based models are primarily the same as factors identified in smaller at-risk cohorts. PbD on floors and window sills should be kept as low as possible to protect children.

Introduction

The U.S. Centers for Disease Control and Prevention (U.S. CDC) estimates that 310,000 children between the ages of one and six in the U.S. have blood lead levels $\geq$ 10 micrograms per deciliter (µg/dL) (U.S. CDC 2005). The health effects associated with blood lead levels (PbB) at or above this level of concern have been well documented, including learning and behavioral problems (NAS 1993). Evidence suggests that children with PbB lower than 10 µg/dL also experience notable adverse effects and that no safe level of lead exposure exists (Canfield et al. 2003; Lanphear et al. 2000, 2005b; Schwartz 1994; U.S. CDC 1991). This study identifies factors associated with childhood residential lead dust (PbD) exposure.

Lead exposure can occur through a variety of sources, including air, bare soil, home remedies, drinking water, toy jewelry and others (Levin et al. 2008). However, the major pathway of exposure for children is from deteriorated lead-based paint and lead-contaminated dust in the home that is ingested during normal hand-to-mouth behavior (Lanphear et al. 1998; U.S. CDC 2007). The importance of lead dust from lead paint was recognized very early (Gibson 1904) and early work was done in an attempt to quantify its exposure contribution (Sayre et al. 1974).

Although banned from residential use in 1978, approximately 38 million older housing units in the U.S. contain lead-based paint and an estimated 24 million housing units contain significant lead hazards as of 2000 (Jacobs et al. 2002). While intact paint does not generally result in significant immediate exposure, all paint eventually deteriorates; lead-based paint that is chipping, peeling, or flaking or otherwise separating from its substrate presents a hazard. In addition, lead-contaminated settled dust, which is often found in houses with deteriorated lead-based paint, is a significant lead hazard (Lanphear et al. 1998). PbD can also be generated from the friction and impact of lead-painted surfaces (Dixon et al. 2007) and during housing renovation and repair projects where lead-based paint is present and proper precautions are not in place (Lanphear et al. 2005a; Reissman et al. 2002). The use of leaded gasoline, which peaked in the early 1970s, has also contaminated soil around the home (Mielke 1999). Multiple studies, employing a variety of research designs, have demonstrated that soil-lead concentrations are a significant contributor to PbD and children's PbB (Bornshein et al. 1987; Clark et al. 2004; Dixon et al. 2007; Lanphear et al. 1998). Numerous cross-sectional (Lanphear et al. 1998) and longitudinal studies (U.S. HUD 2004) have firmly established the correlation of settled PbD and children's PbB. In an effort to protect young children from adverse effects of lead, current Federal health-based hazard standards indicate that floor and window PbD should not exceed 40 micrograms per square foot ($\mu g/ft^2$) and 250 $\mu g/ft^2$, respectively (U.S. EPA 2001).

Through an interagency agreement with the U.S. CDC, the U.S. Department of Housing and Urban Development (U.S. HUD) Office of Healthy Homes and Lead Hazard Control sponsored the collection of lead dust wipe samples and housing-related data through the National Health and Nutrition Examination Survey (NHANES) from 1999 through 2004, marking the first time that NHANES has collected both health and housing environmental data. Using these national survey data, we investigated PbD in homes to explore the feasibility of lower dust lead standards. Here, we present the demographic and housing characteristics associated with floor and window sill PbD. We used linear regression modeling to predict natural log-transformed floor and window sill PbD and logistic regression modeling to predict the log odds of PbD at various levels. A companion article in this issue presents the analysis of NHANES data with respect to childhood blood lead levels. Together these data identify the important risk factors and the relationship between PbD and children's PbB in the US in recent years.

Methods

Study Population. We examined three waves of NHANES (1999-2000, 2001-2002, 2003-2004) data for children aged 12 to 60 months with measured PbB. Included in this population were homes of 2,155 children, of which 2,065 had floor PbD data and 1,618 had window sill PbD data. NHANES is a nationally representative cross-sectional household survey, which uses a complex, stratified, multi-stage probability sampling design to track the health of the non-institutionalized civilian U.S. population. Details of the NHANES protocol, survey and analytical procedures, and handling of samples are available elsewhere (NCHS 2006a, 2006b, 2006c).

Demographic and Housing Characteristics. NHANES interviewers collected demographic and housing information through a structured household interview. Characteristics included child's race/ethnicity, household and family income, type of home (e.g., mobile home or trailer, one family house detached, one family house attached to one or more houses, apartment or "other"), number of apartment units in building, year of construction, number of years the family lived in the home, ownership status, and smoking in the home. Parents of participants reported the race and ethnicity of their child based on lists that included an open response. We used a composite race-ethnicity variable for this analysis: non-Hispanic white; non-Hispanic black; Hispanic (composed mostly of Mexican-American due to oversampling); or other race or ethnicity. The poverty income ratio (PIR) is the ratio of income to the family's appropriate poverty threshold (OMB 1978). PIR values below 1.00 are below the poverty threshold while PIR values of 1.00 or greater indicate income above the poverty level. Variables on smoking behavior included the presence of smoking in the home, number of smokers, and the number of cigarettes smoked in the home per day. An adult member of the household reported the presence of peeling, chipping, or flaking paint (i.e., deteriorated) inside and outside the home. The household member categorized the paint condition inside the house as: no deteriorated paint; deteriorated paint but no large areas; large areas of deteriorated paint in one room; or large areas of deteriorated paint in more than one room. Similarly, the household member classified the exterior paint condition as: no deteriorated paint; deteriorated paint but no large areas; or large areas of deteriorated paint. Large areas inside the home were defined as areas larger than one sheet of a newspaper and large areas on the outside of the home as areas larger than a door.

The household member also reported if their home had been repainted, if they had scraped old paint or if there had been renovations of windows, cabinets, and/or walls in the past 12 months.

PbD Measurements. Interviewers collected separate single-surface floor and window sill PbD samples from the room where the family member reported that children spent most of their time while awake, typically the living room or play room. Floor PbD wipe samples were collected from a measured one square foot area in 2,065 homes using a standard procedure for moist wipes (ASTM E-1728-03). Floor PbD were measured using Graphite Furnace Atomic Absorption Spectroscopy and reported in $\mu g/ft^2$. Window sill PbD in 1,618 homes was also reported as $\mu g/ft^2$ using information on the length and width dimensions of the window sill wiped area. The laboratory detection limits (DL) for the moist wipe samples were 0.16 µg for floors and 2 µg for window sills. Blank samples were collected in 10% of the sampled homes. Robust laboratory quality control procedures were followed (NCHS 2006d, 2006e, 2006f).

Floor and sill PbD values that were below the DL were assigned the value of $DL/\sqrt{2}$ in the NHANES dust analysis dataset. Forty-four percent of the sill loadings and 12.5% of the floor loadings were below the DLs. Although sill loadings are generally higher than floor PbD, the surface area of window sills is typically less than the one square foot sampled on floors, resulting in more sill loadings below the DL. The effects of the high percentage of sill loadings below the DL in the linear model are limited because the surface areas of sills sampled varied and consequently the loadings varied.

We categorized the floor's surface and condition as: uncarpeted smooth and cleanable; uncarpeted not smooth or not cleanable; low pile carpet; or high pile carpet. Window sill conditions were characterized as either smooth and cleanable or not. The modeling presented here also examined room cleanliness, presence of clutter, and room location as reported by the individual collecting the wipe sample.

Statistical Methods. Data were analyzed using SAS (SAS System for Windows, Version 9.1.3) and SUDAAN software (SUDAAN, Version 9.0.0).

We used linear regression models to predict natural log-transformed PbD and logistic regression models to predict the probability that a home's PbD exceeds various thresholds (10 $\mu g/ft^2$ for floors and 100 and 250 $\mu g/ft^2$ for window sills). Models for 10 $\mu g/ft^2$ for floors and 100 $\mu g/ft^2$ for window sills were selected because analyses in the companion article indicate that 95% of children aged 1-5 years would have PbB$\leq$ 10µg/dL at these dust lead levels. Because only three homes in the dataset had floor PbD exceeding the federal hazard standard of 40 $\mu g/ft^2$, we could not use logistic regression modeling to predict the probability that floor PbD exceeded the standard. The models adjusted the parameter estimates for the clustering and unequal survey weights within NHANES. The modeling employed Taylor series expansion theory without degrees of freedom adjustments. Backward elimination of insignificant independent variables ($p>0.10$) was followed by additional steps to allow addition and/or removal of variables. For certain variables, there was a high percentage of missing values (e.g., 28% of the study sample did not have year of construction documented). We fit an intercept term for the study participants that had a missing value so that we could include these homes in the analysis. For categorical variables, the p-value for the test that there is a significant difference in the dependent variable between the category of interest and the comparison category, where the comparison category is the category with parameter estimate of zero, is reported. The overall p-value is the Type 3 F-test that captures the overall statistical significance of each variable included in the model. For categorical variables with missing values, the "missing" level was not included in this hypothesis test.

Because the surface area and concentration of lead paint is higher in pre-1978 and particularly pre-1950 housing (Jacobs et al. 2002), our models allowed the effects of paint deterioration, renovation, repainting, and paint scraping in the past 12 months to be modified by the year of construction. This allowed paint deterioration, renovation, repainting, and paint scraping to only have effects on PbD in homes constructed before 1978 or before 1950.

Model diagnosis is complex for the analysis of data from a clustered multi-frame survey with unequal weights, such as NHANES. Thus for the linear models, residual analysis to assess the validity of the assumption of normality of the error was based on models with the same predictors, but ignoring the clustering and survey weights.

For the logistic model, we used analysis of deviance (McCullagh and Nelder 1989) to assess the goodness of fit of the model. Although this measure accounts for the survey weights, it does not account for the effects of clustering.

Results

Characteristics of the Study Population. Tables 1 and 2 provide descriptive statistics for the continuous and categorical variables that were significant in predicting floor and window sill

PbD in the linear and logistic regression models. The geometric means for floor and window sill PbD were 0.52 μg/ft^2 and 7.64 μg/ft^2, respectively. Only 0.16% of the weighted floor dust samples and 4.00% of the window sill dust samples were at or above the current Federal hazard standards. Most floor and sill samples (84.3%) were collected in family rooms, living rooms or dens. Nearly ten percent of the samples were collected in bedrooms, 1.7% from kitchens, 1.4% from dining rooms, and 3.10% from another room. Floor dust samples were primarily from carpeted areas (80.12%). Only 1% of floor dust samples and 10% of window sill samples were from non-smooth or non-cleanable hard surfaces. However, uncarpeted floor surfaces that were not smooth or not cleanable had higher geometric mean PbD than did smooth and cleanable surfaces (1.7 μg/ft^2 vs. 1.0 μg/ft^2). Floor PbD from smooth and cleanable surfaces were more than double PbD on low and high-pile carpeted surfaces (1.0 μg/ft^2 vs. 0.46 μg/ft^2 and 0.35 μg/ft^2, respectively). Approximately 21% of homes had smoking occurring inside the home, 22% of homes had reported areas of deteriorated paint inside the home, 52% of homes were built prior to 1978, and 4% of homes were constructed before 1950 and had recent renovations. Only 1.7% of homes reported exterior deteriorated paint, possibly due to the large surface area required for this category.

Floor PbD Linear Model. Table 3 provides the parameter estimates and associated standard errors for the linear model that predicts natural log-transformed floor PbD.

Floor PbD was not significantly different between housing built from 1978-1989 and 1990 to present, although the difference between pre- and post-1978 was significant ($p<0.001$). The difference in PbD by race/ethnicity was also significant, with non-Hispanic blacks having significantly higher levels than non-Hispanic whites ($p<0.001$). PbD in Hispanic homes was not significantly different than non-Hispanic white homes ($p=0.864$). A higher poverty income ratio was significantly associated with lower PbD ($p=0.021$). Higher window sill PbD was significantly associated with higher floor PbD ($p<0.001$). Floor PbD in the 1999-2000 NHANES was significantly higher than floor PbD in the 2001-2002 or 2003-2004 waves (both $p<0.001$). The presence of a smoker in the home was associated with significantly higher floor PbD ($p<0.006$), as was window, cabinet or wall renovation in pre-1950 homes ($p=0.056$).

Although floor PbD on uncarpeted non-smooth or non-cleanable floors was higher than on smooth and cleanable floors, this difference was not statistically significant ($p=0.170$). This may be because there were only 25 homes with uncarpeted floors that were not smooth and cleanable.

This multivariate statistical model explains 35% of the variability in a home's floor PbD. If a variable was significant in either the linear or logistic model but not the other model, the cells for that variable in the model that did not contain the variable in Table 3 contain a dash ("-").

Floor PbD Logistic Model. Only 1.92% of homes had floor PbD $\geq$ 10 $\mu g/ft^2$ (Table 2). The parameter estimates for the log-odds that floor PbD is $\geq$ 10 $\mu g/ft^2$ are shown in Table 3. Our results indicate that PbD from high or low pile carpet is much less likely to exceed 10 $\mu g/ft^2$ than PbD from smooth and cleanable floors ($p<0.001$ and 0.024, respectively). Floor PbD in homes of non-Hispanic blacks was higher than in homes of non-Hispanic whites ($p=0.088$). Year of construction, home-apartment type, and sill PbD were also significant predictors of floor PbD $\geq$ 10 $\mu g/ft^2$. Several variables, including poverty income ratio, smoking in the home, renovation, and survey year were significant in the linear regression model, but were not significant in the logistic model.

Window Sill PbD Linear Model. Table 4 provides the parameter estimates and associated standard errors for the linear model that predicts natural log transformed window sill PbD.

Homes built after 1950 had lower window sill PbD, compared to before 1950 ($p<0.001$). The presence of deteriorated interior paint was associated with higher sill PbD ($p=0.028$). Pre-1950 homes that had large areas of deteriorated paint on the outside of the home also had higher sill PbD than other homes ($p=0.076$). Homes of non-Hispanic blacks had significantly higher sill PbD than homes of non-Hispanic whites ($p<0.001$). Sill PbD in homes of Hispanics were not significantly different than homes of non-Hispanic whites ($p=0.298$). Smoking inside the home was also positively associated with sill PbD ($p=0.001$). Samples taken from surfaces that were not smooth or not cleanable had significantly higher PbD compared to samples taken from smooth and cleanable surfaces ($p=0.009$), as was the case for floors. Similar to the linear floor PbD model, the year of the survey was statistically significant. The sill PbD in 1999-2000 was higher than in the 2001-2002 or 2003-2004 waves ($p=0.006$).

The multivariate statistical model explains 20% of the variability in natural-log transformed window sill PbD.

Window Sill PbD Logistic Regression Models. Only 8.90% of the homes had window sill PbD $\geq$ 100 $\mu g/ft^2$ and 4.00% of homes yielded window sill PbD $\geq$ 250 $\mu g/ft^2$ (Table 2). The parameter estimates for the log-odds that a window sill PbD is $\geq$ 100 $\mu g/ft^2$ and $\geq$ 250 $\mu g/ft^2$ are shown in Table 5.

In both logistic models, smoking in the home and year of construction were statistically significant predictors. If someone smoked inside the home, the odds that the sill PbD was $\geq$ 100 or $\geq$ 250 $\mu g/ft^2$ were nearly 90% higher than if no one smoked inside the home.

Interestingly, in the logistic model for PbD $\geq$ 100 $\mu g/ft^2$, the odds that sill PbD was $\geq$ 100 $\mu g/ft^2$ for homes with large areas of exterior deteriorated paint was about three times higher than homes with no exterior deteriorated paint. In the logistic model for PbD ≥ 250 $\mu g/ft^2$, if the interior paint deterioration was large in two or more rooms, the odds that sill PbD was ≥ 250 $\mu g/ft^2$ were about three times higher than if there was no interior paint deterioration.

Most variables that achieved statistical significant did so in more than one of the three sill PbD models, making these findings robust. For example, smoking and year of building construction were significant in all three models. Paint scraping in the last 12 months and the years lived in the home were only significant in the logistic model for PbD ≥ 100 $\mu g/ft^2$. Window surface condition was only significant in the linear model.

Discussion

Consistent with other national data (Jacobs et al. 2002), we confirm that the year of construction is a strong predictor of PbD and that post-1978 housing has significantly lower PbD than older housing. Housing units built after 1950 have significantly lower floor PbD than older housing. Furthermore, floor PbD in houses built between 1940 and 1949 are not significantly different than the pre-1940 houses. This is consistent with the concentration of lead in paint. Prior to 1940, this concentration typically ranged from 10-50% (Rabin 1989; U.S. HUD 1995). However, in 1955, a voluntary paint industry standard limited the concentration to 1%, although the degree of compliance with this standard is unknown (ANSI 1955). In 1978, the Consumer Product Safety Commission and Congress banned the use of lead paint for residential use, limiting lead in new house paint to 0.06% by weight (CPSC 1977).

Pre-1950 homes with window, cabinet or wall renovation within the past 12 months had higher floor PbD than other homes. Renovation activities completed without using lead-safe work practices can generate significant amounts of lead dust (Jacobs et al. 2003). U.S. EPA has recently promulgated a final regulation in an attempt to control exposures from renovation (U.S.

EPA 2008). Replacing windows in a lead-safe manner can help control lead dust and may have large economic benefits (Nevin et al. 2008). Compared to other housing components, windows are known to have the highest levels of lead-based paint and lead-contaminated dust (Jacobs et al. 2002).

We found that dust wipe samples taken from homes with chipping, peeling, or flaking (i.e., deteriorated) paint had higher window sill PbD than homes without deteriorated paint, which is consistent with other research (U.S. HUD 2004; Wilson et al. 2006). While we expected to see similar findings for floors, we did not. This could be due to other factors included in the model. For example, poverty income ratio and recent renovation were significant in the floor model, but not in the window sill model, which could have masked the effect of deteriorated paint. In addition, it is more likely that floors are more regularly cleaned than window sills.

The homes of non-Hispanic blacks had significantly higher PbD than the homes of non-Hispanic whites, even after controlling for other factors. Many prior studies have shown that African American children are at higher risk compared to white children (U.S. CDC 2005). For example, similar to our findings, other studies (Lanphear et al. 1996, 2002) found that African American children were exposed to higher lead dust loadings and worse housing conditions than white children.

Previously published studies suggest that rental units were more likely to have lead-based paint hazards than owner-occupied housing (Jacobs et al. 2002; Lanphear et al. 2005a). While we found that homeownership status was a significant predictor of floor PbD in bivariate analysis, after controlling for other factors such as poverty income ratio, renovation, and the presence of deteriorating paint, it was not significant in the final models. Because low-income families are more likely to rent, the fact that home ownership was not significant in the model (but poverty was) is not surprising. Moreover, the type of home had a significant association with PbD in bivariate analysis, but not in the final models, again probably due to the confounding influence of poverty.

A prior study found a relationship between exposure to environmental tobacco smoke exposure and the blood lead levels of young children that were included in the NHANES III (1988-1994) (Mannino et al. 2003). Because lead is a component of tobacco smoke, such a relationship between blood lead levels and tobacco smoke exposure is not surprising. That smoking in the home was a significant predictor of floor and window sill PbD, even when controlling other factors, suggests that lead in secondhand smoke is a significant contributor to lead on interior surfaces, at least at the relatively low surface loadings documented in this study.

We found that the surface condition from which the PbD samples were taken significantly influences the reported PbD. Other studies have found that uncarpeted smooth and cleanable surfaces have significantly lower PbD after cleaning, compared to rough uncarpeted surfaces (Dixon et al. 1999; Ettinger et al. 2002). Although our results indicated floor PbD on uncarpeted non-smooth or non-cleanable surfaces was not significantly higher than floor PbD on smooth and cleanable surfaces, the trend was in the expected direction. It is possible that our findings were not statistically significant due to the small number of dust samples taken from non-smooth or non-cleanable floor surfaces in this dataset.

The presence of carpeting also influenced reported PbD. We found that PbD on carpeted floors was significantly lower than lead loadings on hard surfaced floors. This observed difference in lead loading by flooring type is likely due to the fact that wipe sampling was the methodology used in this study. Wipe sampling only captures dust adhering to the tops of the carpet fibers, whereas most of the dust in the carpet matrix is located deeper in the pile. A study that reported much higher PbD in vacuum samples from carpet compared to adjacent wipe samples (Bai et al. 2003) supports this idea. The significance of this observation with respect to children's lead exposure is not well understood. Our findings do not clarify whether or not carpet contributes to higher or lower exposures.

The NHANES survey year was significantly associated with PbD. Although PbD should decline with time as the ratio of post-1978 to pre-1978 homes increases, the magnitude of the decline (14%) for the floor PbD between the first and second waves was much larger than expected. Similarly, the magnitude of the decline (43%) between the first and second waves for window sill PbD is unlikely to be explained only by temporal changes in national PbD. Although many housing characteristics were included in the model, other significant factors, which we were unable to control for, may exist (for example, different waves of NHANES sampling may occur in different geographic regions). Thus, the year of survey variable may reflect geographic differences in the three study wave locations that could account for the observed trend in floor PbD.

We used data from a large national survey that combined housing and environmental data, which is a strength of our study. However, the housing data included in this study may not be representative of the national housing stock. The sampling and weighting methodology used in NHANES is population not geographic based; thus, the survey includes a nationally representative sample of the U.S. population, but not a representative sample of U.S. housing. Integrated health and housing surveys that are representative of both the population and the housing stock are needed in the U.S.; such surveys were completed recently in eight European cities (Bonnefoy et al. 2003). Finally, a limitation of the NHANES PbD data is that they are based on a single floor and a single window sill PbD measurement in a given home. The HUD

Guidelines for the Evaluation and Control of Lead-Based Paint Hazard in Housing recommend that six to eight floor and sill samples be taken to help reduce spatial variability, which could not be assessed here (U.S. HUD 1995). Despite these potential limitations, the study results presented are largely consistent with earlier findings.

PbD on floors and window sills should be kept as low as possible to protect children from lead exposure. The current standards for floor and window sill PbD were set in 1999-2001 to protect 95% of children from developing a blood lead level ≥ 15ug/dL (the environmental intervention level established by U.S. CDC), in light of feasibility and measurement limitations. These findings show that in most children's homes, PbD is well below the current standards, making it feasible to lower the current standards and thus afford more protection for children.

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Table 1. Descriptive statistics for continuous housing and demographic variables (NHANES 1999-2004)

Variable	Levels	N	Weighted	
			GM(GSE)	AM(SE)
Floor PbD	Missing	90	-	-
by floor surface/condition	Smooth &cleanable	453	0.99(1.11)	3.16(0.56)
	Not smooth & cleanable	25	1.70(1.47)	4.92(2.11)
	Carpeted, low pile	1381	0.46(1.06)	0.91(0.11)
	Carpeted, high pile	206	0.35(1.10)	0.62(0.08)
	All non-missing	2065	0.52(1.05)	1.34(0.14)
Window sill lead loading	Missing	537	-	
by window surface condition	All non-missing	1618	7.64(1.07)	57.79(9.42)
	Smooth & cleanable	1453	6.98(1.07)	47.57(5.30)
	Not smooth & cleanable	165	16.9(1.24)	146.6(69.35)
Poverty income ratio[a]	Missing	136	-	-
	Non-missing	2019	-	2.07(0.05)
Years lived in home[a]	Missing	23	-	-
	Non-missing	2132	-	2.64(0.04)

[a] Geometric Mean and Geometric Standard Error are undefined due to zero values.
N= Number of Units, GM= Geometric Mean, GSE= Geometric Standard Error, AM = Arithmetic Mean, SE = Standard Error

Table 2. Descriptive statistics for categorical housing and demographic variables (NHANES 1999-2004)

Variable	Levels	N	Weighted Percent Missing Included	Weighted Percent Missing Excluded
Floor PbD loading ≥ 40 µg/ft^2	Missing	90	3.68	-
	No	2062	96.17	99.84
	Yes	3	0.15	0.16
Floor PbD loading ≥ 10 µg/ft^2	Missing	90	3.68	-
	No	2006	94.40	98.00
	Yes	59	1.93	2.00
Floor surface/ condition	Missing	90	3.68	-
	Smooth & cleanable	453	18.18	18.87
	Not smooth & cleanable	25	0.96	1.00
	Carpeted, low pile	1381	66.08	68.60
	Carpeted, high pile	206	11.1	11.52
Window sill PbD loading ≥ 100 µg/ft^2	Missing	537	24.17	-
	No	1465	69.07	96.00
	Yes	153	6.75	4.00
Window sill PbD loading ≥ 250 µg/ft^2	Missing	537	24.17	-
	No	1538	72.8	91.10
	Yes	80	3.03	8.90
Window surface condition	Missing	537	24.17	-
	Smooth & cleanable	1453	68.00	89.67
	Not smooth & cleanable	165	7.83	10.33
Room dust sampled	Missing	90	3.68	-
	Living room, family room or den	1700	81.20	84.30

	Dining room	29	1.31	1.36
	Kitchen	33	1.66	1.73
	Bedroom	250	9.17	9.52
	Another room	53	2.98	3.10
Year of construction	Missing	840	28.1	-
	1990 to present	287	19.61	27.28
	1978 to 1989	265	14.84	20.64
	1960 to 1977	304	14.35	19.96
	1950 to 1959	168	7.43	10.34
	1940 to 1949	82	4.27	5.94
	Before 1940	209	11.39	15.84
Window, cabinet or wall renovation in pre-1950 home	Missing	174	5.97	-
	Yes	70	3.98	4.23
	No	1911	90.05	95.77
Anyone smoke inside the home	Missing	23	1.50	-
	Yes	430	20.78	21.09
	No	1702	77.73	78.91
Year of survey	1999-2000	624	30.23	30.23
	2001-2002	765	34.08	34.08
	2003-2004	766	35.69	35.69
Extent of peeling, flaking, or chipping paint outside	Missing	392	15.88	-
	No deteriorated paint	1376	64.57	76.75
	Deteriorated paint but no large areas	309	15.98	18.99
	Large areas of deteriorated paint	78	3.58	4.26
Presence of large area of deteriorated paint outside in pre-1950 home	Missing	283	10.42	-
	Yes	27	1.55	1.73
	No	1845	88.03	98.27

Extent of paint deterioration inside	Missing	28	1.45	-
	No deteriorated paint	1596	76.73	77.86
	Deteriorated paint but no large areas	439	18.75	19.03
	Large areas of deteriorated paint in 1 room	65	2.33	2.36
	Large areas of deteriorated paint in ≥ 2 rooms	27	0.74	0.75
Presence of paint deterioration inside	Missing	28	1.45	-
	Yes	531	21.82	22.14
	No	1596	76.73	77.86
Paint scraped when home Repainted in last 12 months	Missing	1423	59.59	-
	Yes	197	10.63	26.44
	No	535	29.57	73.56
Race/ethnicity	Non-Hispanic white	618	57.09	57.09
	Non-Hispanic black	634	15.32	15.32
	Hispanic[a]	837	23.82	23.82
	Other	66	3.77	3.77

N= Number of Units.

[a] 66% of Hispanics are Mexican-Americans

Table 3. Model results for floor PbD

Variables		Linear Model for log PbD ($R^2 = 35\%$) Overall P-value	Estimate (SE)	P-value	Logistic Model PbD ≥ 10 µg/ft^2 ($R^2 = 7\%$ [a]) Overall P-value	Estimate (SE)	P-value
Intercept		0.235	-0.239(0.199)	0.235	<0.001	-6.179(0.834)	<0.001
Floor surface/condition	Smooth & cleanable	<0.001	0.000	.	<0.001	0.000	.
	Not smooth & cleanable		0.354(0.254)	0.170		0.449(0.740)	0.547
	Carpeted, low pile		-0.634(0.094)	<0.001		-2.147(0.401)	<0.001
	Carpeted, high pile		-0.868(0.110)	<0.001		-2.868(1.229)	0.024
Log window sill PbD loading	Intercept for missing	<0.001	0.409(0.090)	<0.001	<0.001	0.000	.
	Slope		0.172(0.027)	<0.001		0.732(0.106)	<0.001
Race/ethnicity	Non-Hispanic white	<0.001	0.000	-	0.009	0.000	-
	Non-Hispanic black		0.373(0.086)	<0.001		0.900(0.516)	0.088
	Hispanic		-0.015(0.087)	0.864	-	-	-
	Other [b]		-0.194(0.129)	0.140	-	-0.492(0.581)	0.402
Poverty income ratio	Intercept for missing	0.028	0.036(0.120)	0.768	-	-	-
	Slope		-0.047(0.020)	0.021	-	-	-
Year of construction	Intercept for missing	<0.001	-0.136(0.141)	0.338	<0.040	-0.032(0.665)	0.962
	1990 to present		-0.795(0.128)	<0.001		-	-
	1978 to 1989		-0.714(0.149)	<0.001		-	-
	1960 to 1977		-0.410(0.137)	0.004		-	-
	1950 to 1959		-0.366(0.177)	0.044		0.872(0.723)	0.234
	1940 to 1949		-0.393(0.242)	0.118		1.284(1.015)	0.213
	Before 1940		0.000	-		0.000	-
	1960 to Present		-	-		-1.519(0.775)	0.056
Anyone smoke inside the home	Intercept for missing	0.006	-0.352(0.344)	0.312	-	-	-
	Yes		0.253(0.087)	0.006		-	-
	No		0.000	.		-	-

Window, cabinet or wall	Intercept for missing	0.056	-0.113(0.116)	0.334	-	-	-
renovation in a	Yes		0.355(0.181)	0.056		-	-
pre-1950 home	No		0.000	.		-	-
Year of survey	1999-2000	<0.001	0.429(0.093)	<0.001	-	-	-
	2001-2002		0.067(0.091)	0.470		-	-
	2003-2004		0.000	.		-	-
Home-apartment type	One family house detached		-	-	0.042	1.032(0.550)	0.067
	One family house attached		-	-		1.397(0.739)	0.066
	Apartment (1-9 units)		-	-		1.964(0.604)	0.002
	Apartment (10+ units)		-	-		0.000	.

[a] Estimated using Cox/Snell Methodology,
[b] "Other" includes Hispanics for the logistic model.
SE = Standard error.

Table 4. Linear model results for log window sill PbD (R^2=20%)

Variable	Levels	Overall P-Value	Estimate(SE)	P-value
Intercept		<0.001	2.670(0.190)	<0.001
Race/ethnicity	Non-Hispanic white	0.001	0.000	-
	Non-Hispanic black		0.521(0.114)	<0.001
	Hispanic		0.145(0.138)	0.298
	Other		-0.234(0.241)	0.338
Year of construction	Intercept for missing	<0.001	-0.777(0.234)	0.002
	1990 to present		-1.616(0.249)	<0.001
	1978 to 1989		-1.442(0.216)	<0.001
	1960 to 1977		-1.332(0.221)	<0.001
	1950 to 1959		-1.072(0.315)	0.001
	1940 to 1949		-0.715(0.410)	0.088
	Before 1940		0.000	-
Window surface condition	Smooth & cleanable	0.001	0.000	-
	Not smooth & cleanable		0.759(0.213)	0.001
Anyone smoke inside the home	Intercept for missing	0.001	0.664(0.824)	0.425
	Yes		0.460(0.130)	0.001
	No		0.000	.
Presence of large area of deteriorated paint outside in pre-1950 home	Intercept for missing	0.076	-0.422(0.200)	0.040
	Yes		0.992(0.545)	0.076
	No		0.000	-
Presence of paint deterioration inside	Intercept for missing	0.028	-0.413(0.649)	0.528
	Yes		0.361(0.159)	0.028
	No		0.000	-

Year of survey	1999 -2000	0.020	0.330(0.144)	0.027
	2001-2002		-0.100(0.114)	0.382
	2003-2004		0.000	-

SE = Standard Error.

Table 5. Logistic model results for window sill PbD

		PbD≥ 100 µg/ft^2 (R^2=7%[a])			PbD ≥ 250 µg/ft^2(R^2=7%[a])		
Variable	Levels	Overall P-Value	Estimate(SE)	P-value	Overall P-Value	Estimate(SE)	P-value
Intercept		<0.001	-1.289(0.385)	0.002	<0.001	-2.502(0.352)	<0.001
Race/ethnicity	Non-Hispanic white	-	-	-	0.002	0.000	-
	Non-Hispanic black		-	-		1.127(0.297)	<0.001
	Other [b] -	-			0.049(0.569)	0.932	
Year of construction	Intercept for missing	0.005	-1.162(0.354)	0.002	<0.001	-1.161(0.386)	0.004
	1990 to present		-2.194(0.805)	0.009		-3.201(0.812)	<0.001
	1978 to 1989		-1.852(0.542)	0.001		-2.038(0.895)	0.028
	1960 to 1977		-1.603(0.365)	<0.001		-1.705(0.464)	0.001
	1950 to 1959		-1.045(0.507)	0.045		-1.009(0.624)	0.113
	1940 to 1949		-0.193(0.521)	0.713		-0.121(0.576)	0.834
	Before 1940		0.000	-		0.000	-
Anyone smoke inside the home	Intercept for missing	0.041	-0.336(1.046)	0.749	0.059	10.472(0.895)	<0.001
	Yes		0.623(0.296)	0.041		0.625(0.323)	0.059
	No		0.000	.		0.000	-
Extent of paint Deterioration inside	Missing	-	-	-	0.005	-10.017 (0.385)	<0.001
	No deteriorated paint		-	-		0.000	-
	Deteriorated paint but no large areas		-	-		-0.044(0.417)	0.916
	Large areas in 1 room		-	-		-1.402(1.058)	0.192
	Large areas in ≥2 rooms		-	-		1.458(0.669)	0.035
Extent of peeling, flaking, or chipping paint outside	Intercept for missing	0.005	-0.530(0.456)	0.251	-	-	-
	No deteriorated paint		0.000	-		-	-
	Deteriorated paint but no large areas		-0.317(0.364)	0.389		-	-
	Large areas of deteriorated paint		1.303(0.586)	0.031		-	-
Paint scraped when home Repainted in last 12 months	Intercept for missing	0.053	0.433(0.293)	0.146	-	-	-
	Yes		0.899(0.451)	0.053		-	-

	No		0.000	-		-	-
Years lived in the home	Intercept for missing	0.076	0.000	-	-	-	-
	Slope		-0.227(0.124)	0.076		-	-
Year of survey	1999 -2000	0.050	0.534(0.229)	0.024	-	-	-
	2001-2002		-0.087(0.306)	0.776	-	-	-
	2003-2004		0.000	-	-	-	-

[a] Estimated using Cox/Snell Methodology.
[b] "Other" includes Hispanics.