Framework for Identifying and Evaluating Lead-Based Paint Hazards from Renovation, Repair, and Painting Activities in Public and Commercial Buildings

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Contents

Figures

Acronyms and Abbreviations

Acronym / Abbreviation	Stands For
AERMOD	American Meteorological Society (**A**MS) and the U.S. Environmental Protection Agency (**E**PA) **R**egulatory **M**odel **I**mprovement **C**ommittee (AERMIC) Model
COFs	Child-Occupied Facilities
EPA	U.S. Environmental Protection Agency
IQ	Intelligence Quotient
OSHA	U.S. Occupational Safety and Health Administration
P&CBs	Public and Commercial Buildings
PbB	Blood Lead
RRP	Renovation, Repair, and Painting
SAB	Science Advisory Board
TSCA	Toxic Substances Control Act

1. Introduction

The U.S. Environmental Protection Agency (EPA) is currently in the process of determining whether or not lead-based paint hazards are created by renovation, repair and painting (RRP) activities in public and commercial buildings (P&CBs), as required under section 402(c)(3) of the Toxic Substances Control Act (TSCA). For those renovation activities in P&CBs that create lead-based paint hazards, TSCA directs EPA to address the hazards through regulation.

This document will explain, in general terms, how EPA could define what constitutes a "lead-based paint hazard" for P&CBs undergoing renovations. EPA refers to this as "hazard identification", pursuant to TSCA section 403[1]. This document also discusses how EPA could assess the expected impact of renovation activities in P&CBs in order to determine whether or not RRP activities would be expected to create a hazard. EPA refers to this as "hazard evaluation", pursuant to TSCA section 402(c)(3)[2]. If the analysis indicates that hazards are created, EPA is directed by TSCA section 402(c)(3) to propose appropriate regulatory controls to reduce or prevent exposure.

In two separate rulemakings, EPA has previously defined lead-based paint hazards in residences and child-occupied facilities (COFs), and evaluated whether such hazards would result from RRP activities of those buildings. For P&CBs, EPA is considering an approach that is different from our previous residential and COF approach, both in the timing and the sequence of events, as well as in the manner in which the Agency defines and evaluates hazards. EPA previously took a uniform approach to identifying and evaluating hazards under TSCA for residences and COFs. This document describes a more tailored approach that could be used for P&CBs. In addition, for P&CBs EPA would combine the identification of hazards, the evaluation of whether hazards occur and any proposed regulatory requirements, if appropriate, in one proposed rule. Because of these differences, EPA is providing an early opportunity, prior to any proposal, for interested parties to review, consider, and provide feedback on the approach described herein.

Because EPA is providing this information and opportunity for public comment prior to issuing any proposed rule, the information contained in this document is limited and does not represent or constitute an Agency decision or regulatory proposal. Additionally, this document does not provide significant detail regarding modeling inputs and results, how EPA might apply the results of any analyses, or a discussion regarding what magnitude of deleterious health effect would be considered to be adverse. Further details and the results of such analyses would be provided for review and comment in any future proposal. In addition, EPA plans to make public, and provide for peer review of any such analyses.

[1] 15 U.S. Code § 2683

[2] 15 U.S.C. § 2682(c)(3).

2. Background

2.1. Previous Approach for Residences and COFs

2.1.1. Identifying Hazards

For residences and COFs, EPA promulgated a uniform standard under TSCA 403 defining a level of lead in various media (i.e., dust, soil, paint, etc.) that EPA would consider to be dangerous, as a persistent condition, based on available scientific literature about the health effects of lead to adults and children and expected exposure in residences and COFs. In 2001, EPA promulgated a regulation that identified, for residential dwellings and COFs, three different types of lead-based paint hazards: paint-lead hazards, dust-lead hazards, and soil-lead hazards (EPA 2001). EPA relied on the Centers for Disease Control (CDC) "level of concern" at the time[3], as well as other information as described in the preamble to that (403) rule, to inform our decision about what health endpoint and magnitude would be considered an adverse health effect. At the time, the CDC level of concern was defined as a blood lead level for children greater than or equal to 10 µg/dL (CDC, 1991). The EPA residential and COF hazard standards were developed to provide a relatively low chance that an individual child would experience a blood lead level at or above 10 µg/dL.

2.1.2. Evaluating Hazards

TSCA section 402(c)(3) requires EPA to evaluate whether or not renovation activities create lead-based paint hazards. For residences and COFs, the hazard finding was made by first determining the dust-lead levels that would be generated by renovation activities and then comparing these levels to the hazard standard. This approach was used for the 2008 RRP Rule (US EPA, 2008), wherein EPA compared the observed dust-lead levels from the renovations tested in the Dust Study (US EPA, 2007) to the dust-lead hazard standard promulgated in 2001 (i.e., 40 µg/ft^2 on floors or 250 µg/ft^2 on interior window sills). Any renovation activities that created dust-lead levels that exceeded the dust-lead hazard standard for floors were considered to create hazards. This approach formed the basis for EPA's determination that all renovation activities that disturb paint in target housing and COFs create lead-based paint hazards.

2.2. Considerations for an Approach for P&CBs

The 2001 hazard standards apply only to target housing and COFs. EPA has explored setting hazard standard(s) for P&CBs. Attempting to identify and apply a "one size fits all" numerical dust-lead level or

[3] Since EPA promulgated the hazard standards in 2001, CDC has updated its recommendations on children's blood lead levels. Experts now use a reference level of 5 micrograms per deciliter to identify children with blood lead levels that are much higher than most children's levels. This new level is based on the U.S. population of children ages 1-5 years who are in the highest 2.5% of children when tested for lead in their blood.

other media metric, however, may not be appropriate for P&CBs. Exposure times in P&CBs are much more varied than those in homes and COFs. Children and adults may spend only a few minutes in certain P&CBs, while other exposure may last much longer, such as in a school or similar facility for children 6 years and older, and workplaces for adults. P&CBs where children under 6 years spend significant amounts of time are already regulated under the 2008 RRP rule. The tailored approach described in this Framework avoids the creation of a uniform hazard standard that may be more protective than necessary in some cases and not protective enough in others.

In addition, P&CBs vary greatly in terms of their size, shape, and room configurations, compared to residences and COFs. EPA hopes to take this broad variability into account and is therefore considering an approach to more appropriately account for risk. The approach described in this document, referred to as the "scenario-specific approach", is designed to account for the variable amounts of time spent in P&CBs, the broad heterogeneity in building sizes and configurations, and the short-term nature of the exposure resulting from renovation activities in order to assess risk.

If selected, the scenario-specific approach described in this document would be used to make a hazard finding inside P&CBs resulting from renovations of the same, or nearby P&CBs. This approach would be used to support a hazard finding for these situations inside P&CBs where existing hazard standards do not exist. As described here, the analytical approach and analysis plan would not address hazards to passers-by or individuals that could be exposed to lead outside of P&CBs through air, soil, or other media, or for exposure at homes and COFs where hazard standards are already established.

3. Discussion of a Potential P&CB Approach

Using the tailored approach, EPA would model exposure to lead from renovations in a wide distribution of building types, resulting from various renovation activities and taking into consideration the different age groups of occupants and the varied exposure times that might occur. This distribution of activities would allow EPA to characterize risk across all the exposure conditions and situations that may occur. Once this probabilistic distribution is developed EPA would review the modeling results including estimates of blood lead changes and appropriate health endpoints, such as IQ decrements for young children. To inform the hazard finding, EPA would consider the magnitude of any predicted deleterious health effects as well as how frequently that exposure situation is likely to occur. This approach allows EPA the ability to take into account the varied exposure times for individuals, and the variability in buildings and renovations when characterizing risks. This tailored approach would provide the ability to apply any regulatory requirements to only those situations that most closely resemble those modeled scenarios in which the probabilistic modeling predicted that an adverse health effect would occur. This allows EPA the ability to limit the scope of any regulatory intervention in a way not possible when relying on a uniform hazard standard.

The adaptability and tailored nature of the scenario-specific approach is evident when reviewing the results of the preliminary analysis shown in Appendix C. However, preliminary analysis results are not representative of all scenarios that could be analyzed, and the modeling inputs and parameters have not been finalized. Therefore, the preliminary findings reported in Appendix C should not be construed as final and may change pending subsequent and more comprehensive analyses. The preliminary analysis trends displayed in Figure 5 of Appendix C, indicate that, where other factors such as room size are held equal, renovations in buildings where children spend longer amounts of time result in considerably larger deleterious health effects (Incremental IQ change) than do renovations in buildings where children spend shorter amounts of time. As another example, reflected in Figure 6 of Appendix C, the preliminary analysis indicates that, where other factors such as time of exposure are held equal, renovations that take place when children are in the renovation workspace and renovations in smaller rooms result in larger adverse health effects (Incremental IQ change). The advantage of using this approach is that it is possible for EPA, by modeling exposures specific to different scenarios, to avoid reliance on a uniform hazard standard that may be more protective than necessary in some cases and not protective enough in others. As a result, EPA expects that the scenario specific approach would enable the Agency to evaluate risk and target the application of any potential regulatory requirements to situations in a more efficient and appropriate manner. In addition, EPA would be able to more accurately ascertain if there are renovation situations in which regulatory intervention is necessary because the risk to building occupants or visitors is particularly significant.

3.1. Hazard Identification

The scenario-specific approach would define lead-based paint hazards inside P&CBs in terms of exposures created by P&CB renovation conditions that result in adverse health effects.

TSCA Section 401(10) defines a "lead-based paint hazard" as:

> any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects established by the Administrator under this title.[4,5]

Under this approach, EPA would consider the health implications of lead exposure and define lead-based paint hazards – solely for the purposes of evaluating exposures from renovations in P&CBs – as any condition that causes exposure to lead-based paint dust that would result in health effects that the Agency finds to be adverse. The determination of whether or not a health effect is adverse would be

[4] 15 U.S.C. § 2681(10) (stating that EPA must classify as a lead-based paint hazard, "any condition that causes exposure to lead from lead contaminated dust, lead-contaminated soil, lead contaminated paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects" as established by EPA).

[5] The definition in section 401 encompasses both exposure and effects, which by definition are components of a risk assessment.

informed by a variety of considerations including available scientific literature, measurability, frequency of occurrence, biological significance, etc.

EPA is currently evaluating the literature and the conclusions included in both the *Integrated Science Assessment for Lead* (US EPA, 2013) and the *National Toxicology Program Monograph on Health Effects of Low-Level Lead* (NTP, 2012) to develop the concentration-response functions for the health effects, such as renal and cardiovascular, associated with lead exposure for both older children and adults. As appropriate, those concentration-response functions and the magnitude of associated health effects resulting from incremental changes in blood lead level from the modeled renovation scenarios would form the basis for EPA's identification of hazard. For children, intelligence quotient (IQ) change and possibly other endpoints would be evaluated as a quantifiable health effect. However, EPA notes that most P&CBs where children under 6 years would spend longer amounts of time are already regulated under the 2008 RRP rule as COFs[6].

For example, EPA might find that a particular IQ decrement in young children is an adverse health effect. A hazard, then, would be identified as any renovation condition that causes exposure to lead-based paint dust that would result in that particular IQ decrement for children. A similar identification could be made for adults based on other health endpoints as well.

3.2. Hazard Evaluation

Under this approach, EPA would evaluate whether or not exposure to leaded dust from specific renovation scenarios in P&CBs would result in the health effects identified as adverse. For those that do, EPA would determine that lead-based paint hazards are created. To perform this analysis, EPA would assess elevations in lead exposure resulting from a broad range of scenarios, considering variations in types of renovation activities, building types, sizes and configurations, use and occupancy patterns, cleaning frequencies, etc., which are designed to be reflective of actual P&CB settings. EPA could evaluate those exposures to both children and adults and consider the implications on blood lead levels and health effects. For those scenarios where our modeling predicts that the magnitude of health effect change due to the renovation activity is significant enough to be considered adverse, EPA would make the finding that lead-based paint hazards are created. EPA would consider how to generalize the results of the analysis and craft any regulatory requirements to apply only to those renovation activities and P&CB categories where exposure is reflective of the modeled scenarios in which a hazard was found.

[6] 40 C.F.R. 745.80 Child-occupied facility means a building, or portion of a building, constructed prior to 1978, visited regularly by the same child, under 6 years of age, on at least two different days within any week (Sunday through Saturday period), provided that each day's visit lasts at least 3 hours and the combined weekly visits last at least 6 hours, and the combined annual visits last at least 60 hours.

3.3. Hazard Evaluation With Monte Carlo Analyses

EPA would utilize a Monte Carlo method to evaluate hazards inside P&CBs if using a scenario-specific approach. The Monte Carlo analysis is described in Appendix A.2 and the variables under consideration are described in Appendix B. The Monte Carlo analysis would repeatedly sample from distributions of these variables to create a probabilistic distribution of exposure for each renovation scenario. EPA would then consider these single scenario exposures within the overall context of the general population. To do so, the variability within each exposure scenario and the probability of occurrence for each exposure scenario would be estimated.

For children, EPA would estimate the resultant IQ level changes due to lead exposure from both RRP activities and background sources (from non-renovation activities), and then subtract out the IQ change related to background alone. The magnitude of the incremental IQ change may be affected by background levels, since the background level affects the shape of the concentration-response curve. However, in evaluating distributions of results for the scenario-specific approach, only the renovation-related (incremental) exposures and effects would be considered in making a hazard finding. For IQ change in children, or for any other health effect chosen for the analysis, the concentration-response function can be used to create a distribution of incremental health effect changes.

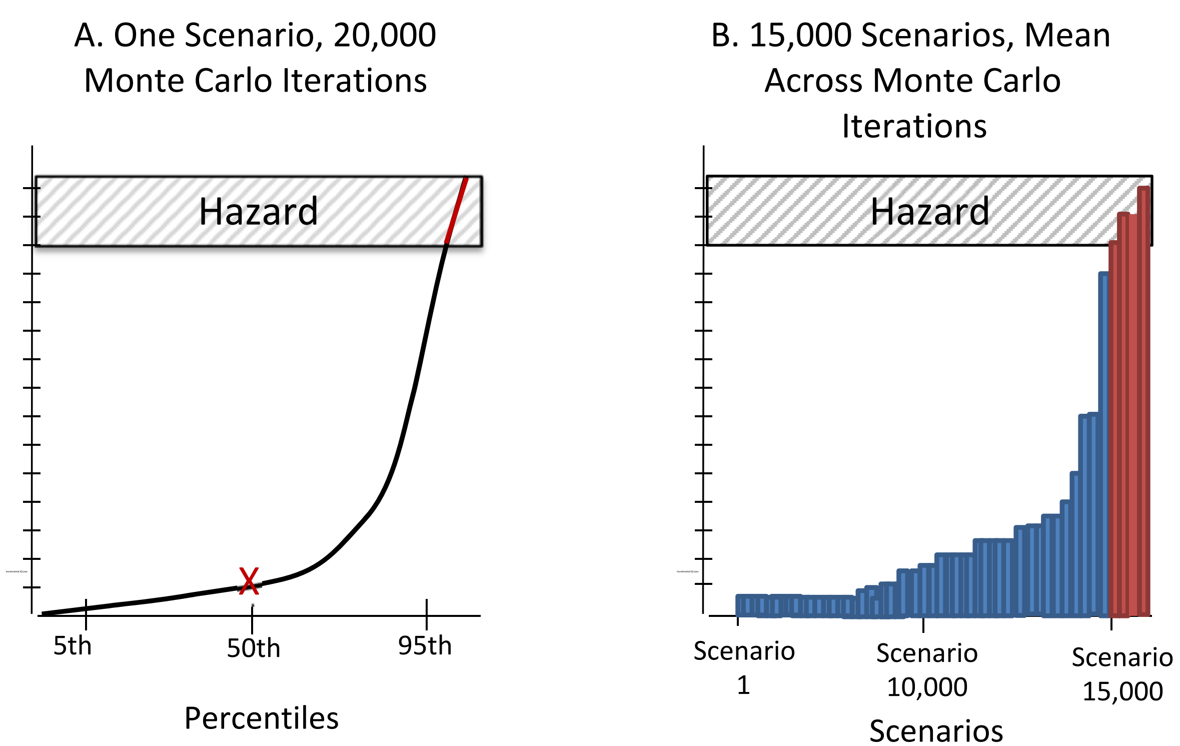
The task of identifying adverse adult health effects for exposure scenarios anticipated to occur during renovation of P&CBs presents some unique difficulties. The median blood lead level in the general US population, based on the latest NHANES data, is now approximately 1 µg/dL, and the 95th percentile is 3.5 µg/dL (CDC, 2013). However, the literature on health effects at this exposure level is sparse, especially for adult health endpoints. It is expected that renovation exposure scenarios in P&CBs would result in a short-term increase in exposures while the renovation is underway, and then the exposures will quickly decline after the work is completed. The contribution of short-term exposures to total blood or bone lead concentration can be modeled, but the overall impact of the changes to total blood and bone lead from P&CB renovation scenarios is expected to be quite small.

3.4. Hazard Evaluation Using Child's IQ Decrements

EPA would use Monte Carlo predictions of incremental IQ decrements for children to evaluate hazards to children and make the hazard finding for exposure inside P&CBs from interior and exterior renovations. Many scenarios could return small mean IQ changes related to the renovation. Relatively larger IQ changes, however, may occur in two different situations. In the first case, consider a scenario resulting in a small mean IQ change (Figure 1A). The Monte Carlo simulation provides an estimate of the distribution of IQ changes for that scenario, and the mean might be the point shown with the "X" in the figure. When examined based on percentiles, however, the higher percentiles could represent a lead hazard (the red portion of curve within the "Hazard" shaded area). Thus, the mean exposures can be low, but a certain fraction of the population in that exposure scenario is expected to have IQ changes that result in a hazard. In the second case, consider the mean IQ changes across all the different scenarios (Figure 1B). Most of the mean IQ changes (the blue bars) may not result in a hazard. The IQ changes from some fraction of those scenarios, however, could result in a lead hazard (the red bars that reach the "Hazard" shaded area).

To analyze potential hazards, EPA would examine the various distributions across percentiles in a single scenario (Figure 1A) and across different scenarios (Figure 1B). The collection of these distributions helps account for the total variability in exposure owing to environmental, lifestyle, and biokinetic differences across the population. EPA would place the less frequent, high incremental IQ changes within the context of expected (mean) incremental IQ changes. Because each scenario is not equally likely, EPA would provide a discussion of the relative frequency of these high incremental IQ changes. The hazard finding would be made based on an overall judgment of the frequency and magnitude of incremental health effect changes resulting from P&CB renovations.

Figure 1. Evaluation of Hazard across Monte Carlo Percentiles and Scenario Means



3.5. Considerations for Using a Scenario-Specific Approach

3.5.1. Applicability/generalizability of Modeled Scenarios

The scenario-specific approach seeks to more accurately address hazards and minimize regulatory burden. However, if appropriate, EPA must also be able to use the approach to propose and implement regulatory requirements that can be understood and adopted by the regulated community. It is possible that the analysis could indicate hazards in scenarios that are unlikely to occur, or occur in only very limited instances affecting a small number of people. EPA would consider how to generalize the hazard findings from the scenario-specific analysis to assess the effects of a potential regulation on the population (and on sensitive sub-populations) in considering regulatory options.

3.5.2. Selection of Risk Reduction Measures

The exposure modeling construct of the scenario-specific approach allows a more targeted way for EPA to evaluate the effect of a variety of mitigation measures in reducing exposures that occur inside P&CBs. For example, this approach can examine the effectiveness of potential regulatory requirements, such as preventing occupants of P&CBs from being present in the workspace during the renovation, the use of plastic barriers, prohibiting certain work practices and requiring the use of HEPA dust capture systems on equipment, and cleaning requirements to contain or otherwise limit exposure to leaded dust. This is accomplished by including separate model simulations implementing each work practice option and estimating the resulting difference in incremental blood lead levels or health effect changes with and without the various regulatory options.

3.5.3. Exposure at Residences and COFs

The lead dust created during P&CB renovations can move downwind to surrounding COFs, residences and P&CBs. This dust can penetrate these buildings via air infiltration. In addition, dust can deposit on the ground or hard surfaces, leading to elevated lead levels and subsequent track-in of dust which would contribute to interior dust levels. These elevated media concentrations may impact the children and/or adults within these nearby buildings. EPA is considering how to evaluate hazards created in nearby residences and COFs as a result of exterior renovations of P&CBs. Because, as discussed earlier, there is an existing hazard standard that applies to residences and COFs, EPA could evaluate whether hazards are created inside nearby residences and COFs by comparing estimated dust lead levels to the existing residential and COF hazard standard of 40 $\mu g/ft^2$ for floors, and 250 $\mu g/ft^2$ for interior window sills.

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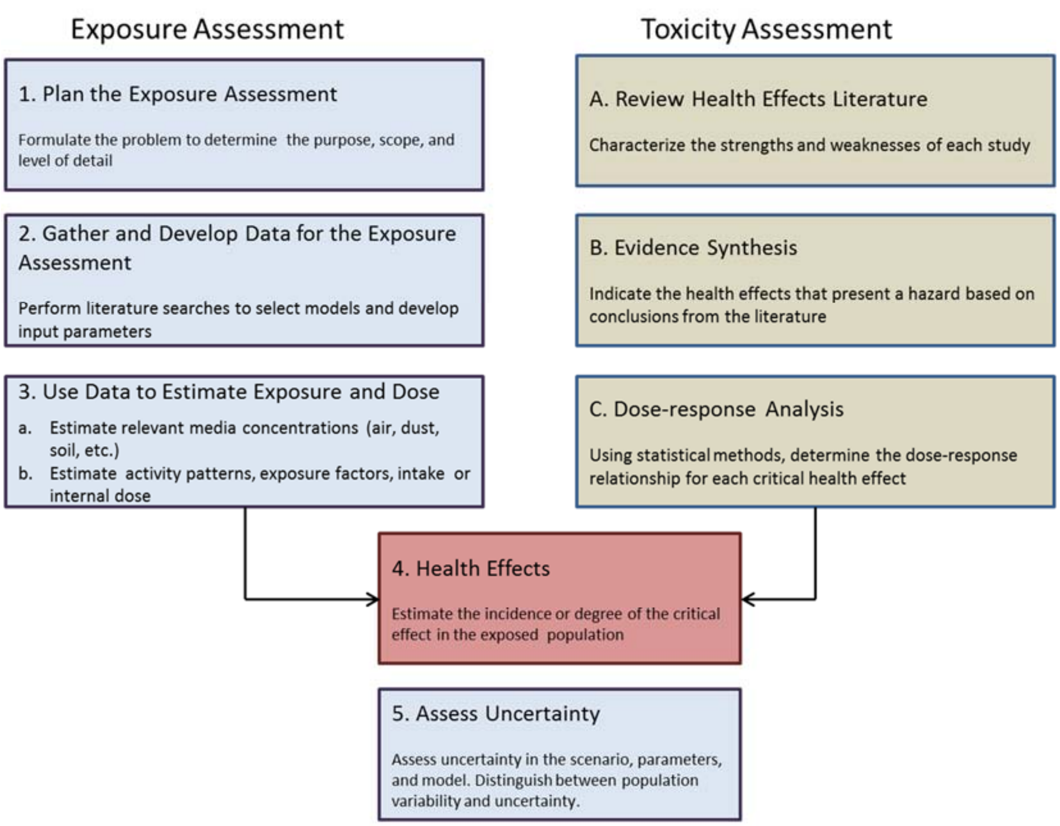
Appendix A. Exposure and Risk Characterization

A.1. Exposure Assessment Process

The left-hand portion of Figure 2 shows the exposure assessment process, as described in EPA's *Guidelines for Exposure Assessment* (US EPA, 1992). Each numbered box represents a separate step in the assessment, from planning, to finding models and input values, to estimating media concentrations and dose, to characterizing uncertainty. The right-hand portion of the figure incorporates the analysis of health effects and characterization of risk as described in EPA's *Framework for Human Health Risk Assessment to Inform Decision Making* (US EPA, 2014). The Framework takes into account recommendations on risk assessment processes described in the National Research Council's (NRC) 2009 report, *Science and Decisions: Advancing Risk Assessment* (NRC, 2009) to use a risk-based approach to establish whether a hazard exists from renovations of P&CBs with lead-based paint. The figure indicates how health effects and concentration-response relationships are developed so that the exposure assessment metrics (intake or dose) can be linked to specific health effects.

Figure 2. Schematic of EPA's Exposure and Risk Assessment Process



Sources:
EPA Guidelines for Exposure Assessment; Federal Register 57(104):22888-22938
EPA Draft Framework for Risk Assessment to Inform Decision Making; Docket ID: EPA-HQ-ORD-2012-0579

A.2. Risk Characterization Inside P&CBs

This section describes how EPA would assess the hazard, exposure, and risk to the U.S. population inside P&CBs from the renovation, repair, and painting of P&CBs using the scenario-specific approach[7]. Lead dust can persist in the room being renovated or migrate to nearby rooms, even after the renovation is complete. The level of exposure to children and adults will depend on, among other things, the extent to which they spend time in the renovation room or an adjacent room, either during or after the renovation (or both), and the amount of time they spend in the building.

Potential P&CB exposures can be characterized by estimating the media concentrations (soil and dust) for each renovation situation and combining these concentrations with age-dependent and building specific activity patterns to estimate the resulting blood lead levels. Finally, these levels may be linked to appropriate, measureable, and quantifiable health effects *via* concentration-response functions, derived from empirical studies (if available and appropriate for the analysis). Incremental blood lead level changes and health effect changes resulting from the renovation will be developed by subtracting the estimated blood lead level due to background exposure from the full renovation model simulation.

Each individual has some exposure to lead via sources other than renovation activities, and this background exposure will vary across the population. The specific health effects, such as incremental IQ change in children, can be estimated by comparing the expected background effect to the expected post-renovation effect via appropriate concentration-response functions. The change in IQ for each unit change in blood lead (PbB) level is proportionately larger for children with lower background exposures. Thus, background exposure is an important piece in estimating any lead-related health effect.

Variability would be accounted for by performing a probabilistic Monte Carlo analysis as part of the overall exposure analysis framework (see Appendix A). First, EPA would determine a set of scenario variables and representative ranges of values for these variables, to which the exposure estimates are highly sensitive. EPA would also determine a range of values for each scenario variable (see Appendix B). EPA performed some preliminary analyses to determine the impact of different variables on incremental IQ and PbB level changes for children. This analysis helped identify variables that require characterization using distributions (higher impact variables) versus variables that can be parameterized using a single point estimate. Additional information is provided in Appendix C.

To perform the Monte Carlo analysis, each scenario would be run 20,000 times (where each run is referred to as an “iteration”). Preliminary testing indicates that 20,000 iterations would be appropriate in order to optimize the combination of accuracy and run-time efficiency. Each different scenario would be defined by a specific combination of values for the scenario variables listed in Appendix B. For each of the 20,000 iterations within each scenario, a value would be selected randomly for every Monte Carlo variable from its associated distribution. After all iterations are completed, the exposure estimates would be averaged to estimate a mean value, and other summary statistics, for that exposure scenario.

[7] For information on how EPA has previously assessed hazards using the hazard standard approach please refer to the preamble to the 2008 final Renovation, Repair, and Painting Rule (US EPA, 2008).

Note that each model iteration is essentially a hypothetical but demographically representative individual's exposure within that scenario. The distribution of characteristics of these 20,000 hypothetical individuals per scenario will, by design, mimic the expected distributions of those characteristics in the US population. After all 20,000 hypothetical individuals have been generated and evaluated (for expected background blood lead levels and for expected post-renovation blood lead levels), the mean and other summary statistics for these blood lead levels (or for their health effect endpoints, via concentration-response functions) will be calculated. At this point these summary statistics are describing the distribution of the population-level response to the particular exposure scenario.

To estimate the total population exposure, EPA would determine the probability of occurrence of each exposure scenario based on both population and building survey data. The final population exposure estimate represents the population-wide estimate of exposure to lead due to P&CB renovations. EPA would use the distributions from the Monte Carlo analysis among the various scenarios to evaluate whether a hazard exists inside P&CBs.

EPA would conduct sensitivity analyses to determine the influence of each variable on the model outputs. Uncertainties associated with many variables would also be documented and described in the analysis.

A.3. Models Being Considered for Use in the Full Analysis

EPA has three specific goals for the models expected to be used in the analysis:

1. To use peer-reviewed models wherever possible,
2. To avoid models that require more inputs than can be realistically determined using existing data, and
3. To remain consistent with the 2008 RRP analysis while updating any models that have been improved since then.

For the exterior analysis (Figure 3), EPA will likely use the AERMOD (US EPA, 2009) modeling system to model the dispersion of the lead-containing dust downwind of the renovated building. AERMOD is an EPA-recommended (http://www.epa.gov/scram001/dispersion_prefrec.htm) Gaussian dispersion model that incorporates meteorological and land-use characteristics, and adjustments for obstructions.

To estimate the indoor dust lead loadings resulting from the airborne renovation-derived lead at nearby receptors (Figure 4), a mass-balance indoor dust model that the Science Advisory Board (SAB) originally reviewed in 2010 (US EPA, 2010b) is likely to be used. The model incorporates air exchange between the indoor and outdoor environments, indoor deposition, indoor re-suspension, cleaning frequency and efficiency, and track-in of dust from outdoor soil.

A Monte Carlo model can be developed using the Python programming language. The model would consist of several modules that perform lookups, sampling, and calculations based on input files specifying the distributions of parameter values, such as the AERMOD air concentration files, indoor dust lead and outdoor soil lead concentration files, and the Leggett response surface tables. Each lookup and calculation step would be designed as a separate function in the code. These modules would provide the overall model with data about how environmental concentrations vary over time, and how hypothetical individuals of different ages come into contact with these environmental concentrations based on age-driven activity patterns and exposure factors. After verifying the calculations being performed, test cases would be run in the model, and trends across model scenarios would be examined, for the purposes of further quality assurance, to ensure the trends and magnitudes of results match expectations. The code would use a random number seed to ensure reproducibility of the model results.

EPA will likely use the Leggett model (Leggett, 1993) as the PbB model for estimating both childhood and adult changes in PbB level. The Leggett model, in contrast with the EPA Integrated Exposure Uptake Biokinetic (IEUBK) model, allows incorporation of short-term (less than one month) changes in exposure levels and modeling of both children and adults. EPA is considering updating the tissue volumes and key age-dependent pharmacokinetic parameters used in the Leggett model. If these revisions are made, model performance will likely be validated using key bone and PbB data sets, including the National Health and Nutrition Examination Survey (NHANES).

Figure 3. Modeling Framework for Exterior Renovation Activities

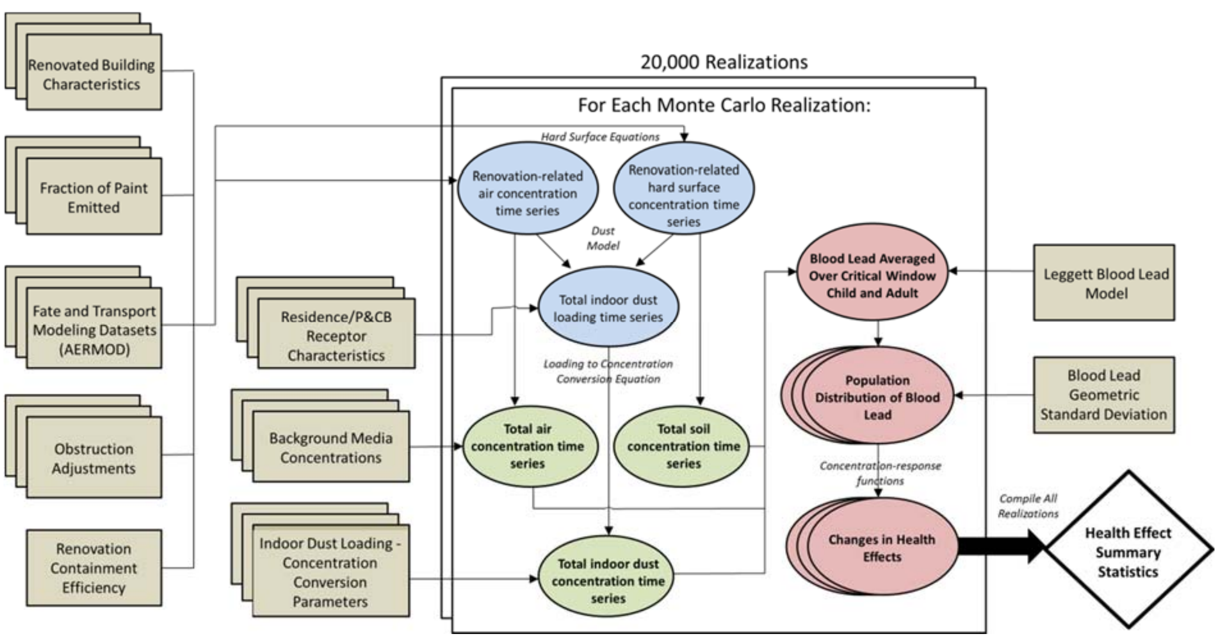
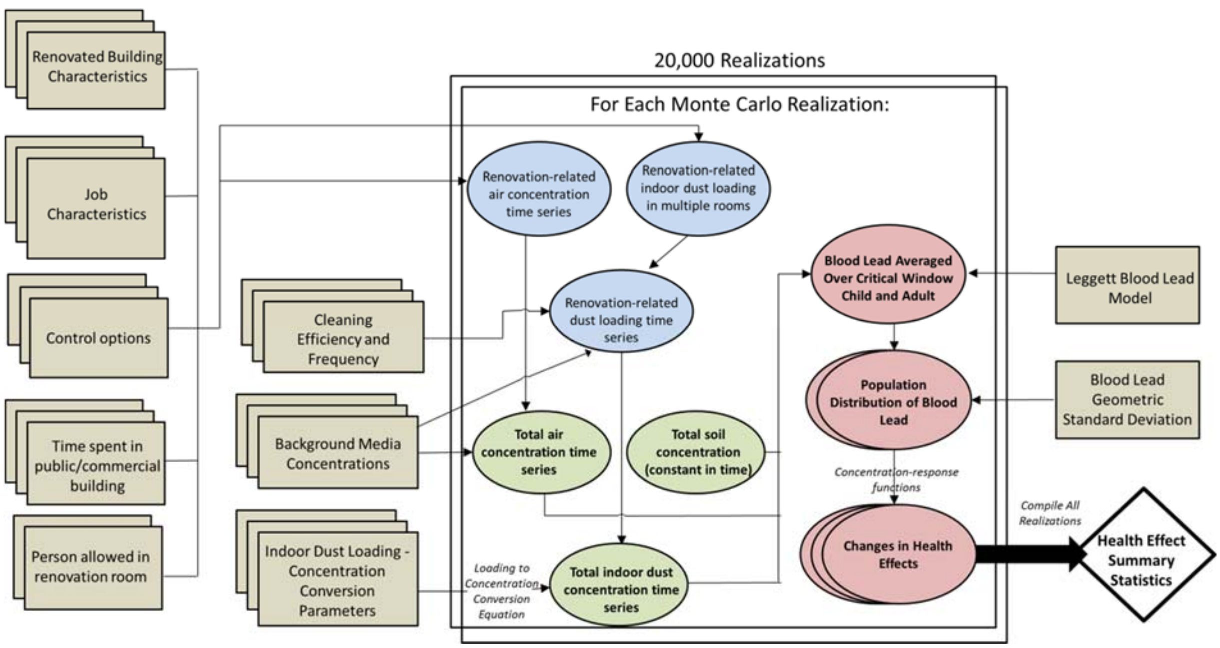


Figure 4. Modeling Framework for Interior Renovation Activities



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Appendix B. Variables Being Considered for Use in the Analysis and Designation of Scenario or Monte Carlo Variables in the Model Framework

Variable	Scenario or Monte Carlo (MC)	
	Exterior	Interior
Renovation Characteristics:		
Renovation Activity	Scenario	Scenario
Containment options	Scenario	Scenario
Containment efficiency	MC	MC
Size of crew performing renovation	MC	
Fraction emitted as aerosol by renovation activity	MC	N/A[8]
Fraction emitted as bulk by renovation activity	MC	
Work room loading per square foot disturbed, post work	N/A[9]	MC
Work room loading per square foot disturbed, post cleaning		MC
Renovated building characteristics:		
Use type of renovated building		Scenario
Job size within renovated building		Scenario
Location of person within building (in workspace or adjacent)	N/A	Scenario
Time spent in building		MC
Location of job in building		MC
Size of renovated building	Scenario	N/A
Fraction of renovated building that is glass	MC	N/A
Containment Area	MC	

[8] Variable not Required for Interior Analysis
[9] Variable not Required for Exterior Analysis

Variable	Scenario or Monte Carlo (MC)	
	Exterior	Interior
Vintage of renovated building	Scenario	Scenario
Lead content in paint	MC	MC
Layers of paint on wall	MC	N/A
Climate region	MC	
Rain frequency	MC	N/A
Obstruction Adjustment	MC	
Receptor building characteristics:		
Distance of receptor from renovated building	Scenario	N/A
Receptor use type	Scenario	Same as renovated building use type
Time spent in building	MC	Same as renovated building time spent
Ceiling height	MC	MC
Area of building	MC	N/A
Receptor location (urban or rural): NEW	Scenario	
Location of receptor relative to renovated building	MC	
Vintage of receptor building	MC	N/A
Height of receptor building	MC	
Ground type (hard surface or soil): NEW	MC	
Background Media Concentrations:		
Background air concentrations	MC	MC
Background dust lead loadings by vintage	MC	MC
Background soil concentration by vintage	MC	MC

Variable	Scenario or Monte Carlo (MC)	
	Exterior	Interior
Dust Model Variables:		
Cleaning frequency	MC	MC
Percentage of receptor that is carpeted	MC	Scenario
Floor dust lead loading to concentration conversion	MC	MC
Floor cleaning efficiency (carpets and hard surfaces)	MC	MC
Air Exchange Rate	MC	N/A
Particulate Track-in Rate	MC	
Fraction of Particulate on Doormat	MC	MC
Fraction Bulk	MC	MC
Track-in Porosity	MC	MC
Track-in Depth	MC	MC
Track-in Rain Efficiency	MC	MC
Dust Model Penetration	MC	N/A
Dust Model Resuspension	MC	
Dust Model Deposition	MC	
Volume of building	MC	
Blood Lead Model Variables:		
Blood lead model inputs	MC	MC
Concentration Response Curves:		
IQ equation	MC	MC
Other health endpoint equations	MC	MC

Appendix C. Preliminary Analysis

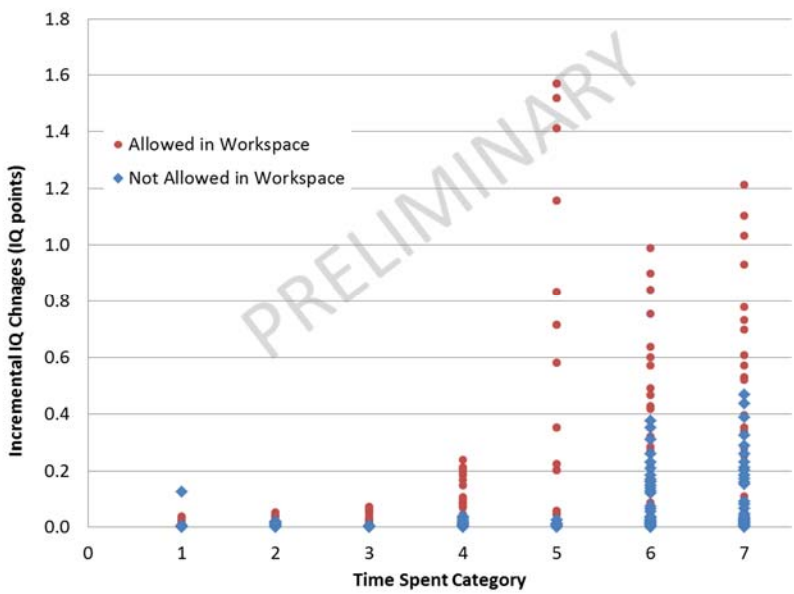
EPA performed a limited set of preliminary analyses to determine the impact of different variables on incremental IQ and blood lead (PbB) change estimates for children. EPA is considering similar analyses for adults. The preliminary analysis was deterministic and does not fully account for variation in scenarios evaluated. Therefore, preliminary analysis results are not representative of all scenarios that could be analyzed. This analysis provided an initial assessment of the variables that may require characterization using distributions (higher impact variables) versus those variables that may be parameterized using a single point estimate. See Appendix B for the proposed characterization of variables as scenario - requiring only a point estimate at each proposed value for the scenario - or Monte Carlo (MC) - requiring an entire distribution to describe the important range of the variable. EPA will determine whether these preliminary results are reproducible once more robust analyses are performed. Therefore, the preliminary findings reported herein should not be construed as final and may change pending the subsequent and more comprehensive analyses.

Figures 5 and 6 show the range of results from the interior analysis, where trends based on the time spent in the building and the square footage of the room are shown. The data points are separated by color according to whether or not the exposed child was allowed in the workspace during the renovation. These metrics are represented as “incremental” changes, indicating they represent the change related to the renovation. The metrics are incremental IQ change, averaged over ages 1 through 7, for a child who experiences a renovation at age 1. In other words, the hypothetical child experiences the renovation at age 1, which results in a short-term spike in blood lead. The child's blood lead then returns to the pre-renovation level, typically within 1 year. For this preliminary analysis, the child's AVERAGE blood lead, over ages 1 through 7, is then used to approximate the actual long-term impact on the child's IQ.

Figure 5 shows that the incremental IQ changes and PbB levels are highly sensitive to the amount of time the exposed person spends in the building. The amount of time that children spend in P&CBs will vary. Most P&CBs where young children would spend longer amounts of time are COFs, and are already regulated. The ranges of time spent values in Figure 5 represent a hypothetical range from low to high, and would be refined for the final analysis.

Figure 6 shows that exposure concentrations that lead to incremental IQ and PbB changes tend to increase with decreasing room size, although this is not strictly observed across all the different room sizes. In addition to the room sizes varying, the ceiling heights were also varied in an effort to represent actual room types. Examples include hospital rooms (smaller area, higher ceiling), offices (smaller area, lower ceiling), and larger retail spaces (larger area, higher ceiling). Thus, the trend is due to both the floor area and the ceiling height.

Figure 5. Trends in Incremental IQ Change & Time Spent for Children Inside P&CBs (Preliminary Analyses)



Time Spent Key:

1: 1 hour per month

2: 1 hour per week

3: 1 hour per day, 2 days per week for four weeks

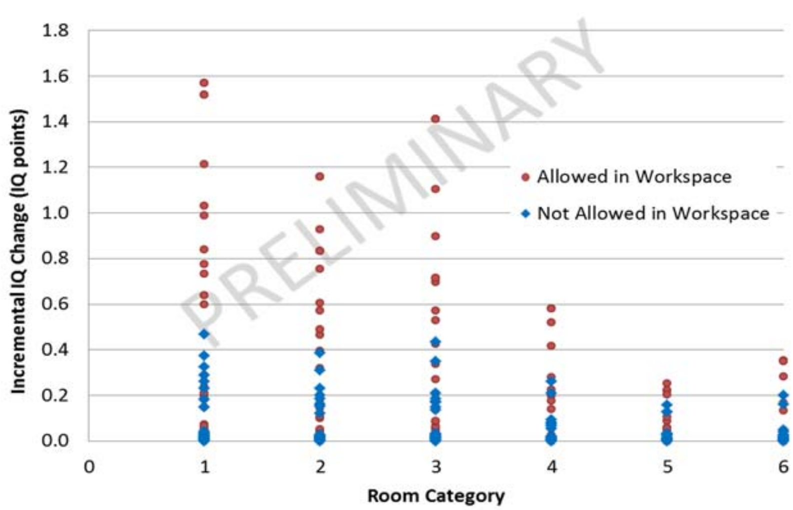
4: 2 hours per day, 3 days per week, for 8 weeks

5: 59 hours straight

6: 2.75 hours per day, 7 days a week

7: 24 hours a day, 1 day per week

Figure 6. Trends in Incremental IQ Change & Room Size for Children Inside P&CBs (Preliminary Analyses)



Room Size Key:

1: 15 m^2

2: 30 m^2

3: 35 m^2

4: 135 m^2

5: 825 m^2

6: 1600 m^2