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SHORT SHEET: OVERVIEW OF THE IEUBK MODEL FOR LEAD IN CHILDREN

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U.S. ENVIRONMENTAL PROTECTION AGENCY
TECHNICAL REVIEW WORKGROUP FOR LEAD

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Overview of the IEUBK Model for Lead in Children

What is the IEUBK Model for Lead (Pb) in Children?

The Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children is used to predict the risk of elevated blood lead (PbB) levels in children (under the age of seven) that are exposed to environmental lead (Pb) from many sources. The model also predicts the risk (*e.g.,* probability) that a typical child, exposed to specified media Pb concentrations, will have a PbB level greater or equal to the level associated with adverse health effects (10 µg/dL). Prior to the development of the IEUBK model, a single slope factor constant had been used to predict risk from exposure to lead, as is done for other chemicals. The slope factor approach assumed a linear relationship between environmental concentrations and risk levels. Although, for Pb, the rate relationship is close to linear at lower PbB levels, it is non-linear at higher levels, invalidating the linear approach. Additionally, the linear approach did not adequately address the site-specific variability and multi-media nature of exposure to lead. The IEUBK model is the primary tool used in determining risk-based cleanup levels at Pb contaminated sites. The following modules are utilized in predicting PbB concentrations, and risks in the IEUBK model: Exposure, Uptake, Biokinetic, and Probability Distribution.

Exposure Module. This module uses Pb concentrations in the environment and the rate at which a child breathes or ingests contaminated media to determine Pb exposure. Media that can act as sources of Pb for a child include air (both indoor and outdoor), which enters the body through the lungs, and water, soil, dust (indoor), diet, and other sources (*e.g.,* lead paint), which enter the body through the gastrointestinal (GI) tract. The Exposure Module estimates how much Pb enters a child's body by calculating media-specific Pb intake rates using the following equation:

*Pb Intake Rate = Media Pb Concentration * Media Intake Rate*

The values used for media Pb concentrations and media intake rates are either derived from site-specific data or standard default values established by EPA. The media intake rates are age-specific. The Exposure Module calculates the intake of Pb from each medium for use in the Uptake Module.

Uptake Module. This module modifies the Pb intake rates calculated by the Exposure Module using absorption factors to predict the uptake of Pb from the lungs and GI tract. Uptake is defined as the fraction of the total Pb intake that crosses from the lungs or GI tract to the bloodstream. Lead that enters the body through the lungs is either absorbed through lung membranes into the blood, transferred to the GI tract, or eliminated from the body via exhaled air. Most Pb enters the body through the GI tract, by either ingestion or movement from the nose, throat, and lungs. From the GI tract, Pb is either absorbed into the blood or eliminated from the gut via the feces. The Uptake Module calculates media-specific Pb uptake rates using the following equation:

*Pb Uptake Rate = Pb Intake Rate * Absorption Factor*

The Pb intake rates are calculated by the Exposure Module, and the absorption factors are typically standard default values established by EPA. The Pb intake rates and absorption factors are both age- and media-specific. Absorption factors reflect the percentage of Pb that enters the bloodstream after intake from a specific medium. The overall Pb uptake value can be obtained by summing the media-specific Pb uptake values, up to a certain Pb intake concentration. However, at high doses, the absorption factors must be modified to account for saturation effects. The total rate of Pb uptake is calculated for use in the Biokinetic Module.

Biokinetic Module. This module addresses the transfer of absorbed Pb between blood and other body tissues; the elimination of Pb from the body via urine, feces, skin, hair, and nails; and the storage and/or disposition of Pb in the extra-cellular fluid, red blood cells, liver, kidney, spongy bone, compact bone (femur), and other soft tissue. The total amount of Pb in each body compartment is age dependent and calculated using total Pb uptake derived by the Uptake Module.

The Biokinetic Module estimates transfer rates for Pb moving between compartments and through elimination pathways. A variety of complex equations are used to calculate compartmental Pb transfer times. Based on site-specific environmental exposures input by the user, a geometric mean PbB concentration is predicted.

Probability Distribution Module. This module estimates a plausible distribution of PbB concentrations that is centered on the geometric mean PbB concentration calculated by the Biokinetic Module. From this distribution, the model calculates the probability or risk that a child's PbB concentration will exceed a user-selected PbB level of concern (typically 10 µg/dL). In running this portion of the model, the user specifies a PbB level of concern and a geometric standard deviation (GSD). For most sites EPA recommends use of the default values for both the GSD and PbB level of concern.

Media Concentrations for Input		
Soil	Soil must be sampled. Site-specific data required.	Refer to the IEUBKwin User's Guide and 1994 Guidance Manual for additional information on this input parameter.
Dust	Site-specific data required or input value can be derived from soil concentration using multiple source analysis.	Refer to the IEUBKwin User's Guide and 1994 Guidance Manual for additional information on this input parameter.
Air (default)	0.1 µg/m^3	Ratio of indoor to outdoor air Pb conc. is 30%. Site-specific data may be substituted.
Drinking Water (default)	4 µg/L	Site-specific data may be substituted.

Media Intake Rates (Pb Intake Rate = Media Pb Concentration * Media Intake Rate)		
Soil/Dust	0-1 yr 0.085 g/d 1-2 yrs 0.135 g/d 2-3 yrs 0.135 g/d 3-4 yrs 0.135 g/d 4-5 yrs 0.100 g/d 5-6 yrs 0.090 g/d 6-7 yrs 0.085 g/d	Default intake values recommended. The default intake value for total soil and dust ingestion is a ratio of soil ingestion (45%) to dust ingestion (55%).
Air	0-1 yr 2 m^3/d 1-2 yrs 3 m^3/d 2-5 yrs 5 m^3/d 5-7 yrs 7 m^3/d	Default values recommended.
Drinking Water	0-1 yr 0.2 L/d 1-2 yrs 0.5 L/d 2-3 yrs 0.52 L/d 3-4 yrs 0.53 L/d 4-5 yrs 0.55 L/d 5-6 yrs 0.58 L/d 6-7 yrs 0.59 L/d	Default values recommended.
Diet	0-1 yr 5.53 µg Pb/d 1-2 yrs 5.78 µg Pb/d 2-3 yr 6.49 µg Pb/d 3-4 yr 6.24 µg Pb/d 4-5 yrs 6.01 µg Pb/d 5-6 yrs 6.34 µg Pb/d 6-7 yrs 7.00 µg Pb/d	Site-specific data may be used to augment the default intake rates.
Alternative Sources	Site-specific data may be used to account for intakes of Pb in sources such as Pb paint.	Refer to the IEUBKwin User's Guide and 1994 Guidance Manual for further discussion.

What are the module input and default values?

Exposure Module. Input values include media concentrations and media intake rates. As shown in the table above, EPA has established default concentrations for Pb in various media and ingestion rates for air, drinking water, soil/dust, diet, and alternative sources. The media intake default values are based on data for children in most instances, with Pb exposures that are characteristic of children in the U.S. since about 1980. While these studies have not resolved all of the uncertainty in childhood Pb exposure, they do provide a realistic basis for quantitative modeling. The media intake default parameters selected for use in the IEUBK model were selected from the central portions of the ranges of values observed in the different studies.

Use of the model defaults is recommended unless adequate, site-specific monitoring data exist to define values that are higher or lower in magnitude. For example, site-specific data for locally caught fish or home-grown vegetables can be utilized to augment the diet default values. This is especially significant for sites where home-grown produce or local game represents a large portion of dietary intake. Site-specific data are commonly used in place of the model default values for Pb concentrations in soil, dust, air, and water.

Site-specific soil data should be entered as an arithmetic mean soil Pb concentration. In the absence of site-specific data on other indoor sources of Pb, dust Pb concentrations may be calculated from the arithmetic mean soil concentration according to a default mass fraction ration of 0.7 (multiple source analysis). Concentrations of Pb in air and water are also measured at some sites. If a representative number of samples is collected, arithmetic mean concentrations should be calculated for use in the model. (See the IEUBKwin User's Guide and 1994 Guidance Manual for technical discussion of input parameters.)

Uptake Module. Input values include media-specific intake rates and absorption factors, as explained above. The age-specific and media-specific intake rates are calculated by the Exposure Module. EPA has established standard default values for absorption factors that are age- and media-specific. In cases of very high exposure to Pb, absorption is characterized by saturable and non-saturable components. The IEUBK model utilizes absorption factors which reflects the relative bioavailability of Pb in specific media. The model assumes that 50% of the Pb intake from drinking water and food is absorbed and that 30% of the Pb intake from soil and dust is absorbed. These absorption factors were estimated from the best available studies of Pb uptake in children and adults. Some site-specific conditions (*e.g.,* the species of Pb present) may warrant changing the absorption default values. However, detailed site-specific studies are required to document the conditions that would justify changing these values. (See TRW short sheet on bioavailability: http://www.epa.gov/superfund/programs/lead/products/sspbbioc.pdf.)

Biokinetic Module. There are no input values for this module. The values utilized in this module have been incorporated into the program code for the model and cannot be changed.

Probability Distribution Module. Input values for this module are the PbB level of concern and GSD. The recommended default value for the PbB level of concern is 10 µg/dL. This level is based on health effects criteria. The GSD is a measure of the relative variability in PbB concentrations for a child of specified age or children from a hypothetical population whose Pb exposures are known. It is intended to encompass the variability resulting from biological and behavioral differences, measurement variability from repeat sampling, sample location variability, and analytical error. The recommended default value for GSD is 1.6. This value is based on analyses of data from neighborhoods with paired data sets for environmental concentrations and PbB data. The GSD default value should be appropriate for all sites, unless there are great differences in child behavior and Pb biokinetics. Model users should not substitute alternate values for the default GSD without detailed site-specific studies designed to document the difference that would justify changing the default value.

When should I use site-specific data instead of model default values?

Site-specific data are recommended because there may be potentially important differences among sites. Hence, use of site-specific data would be expected to result in more accurate predictions of PbB. However, such data should be evaluated for merit prior to their use. Model defaults should only be replaced when site-specific data are more representative than the default values. Model default values should never by adjusted simply to attain a better match between model predictions and empirical PbB data.

How similar are modeled and empirical blood lead (PbB) concentrations?

The IEUBK model was calibrated against two different community PbB and environmental Pb studies. Subsequent comparisons involving well-conducted blood and environmental Pb studies have demonstrated reasonably close agreement between mean observed and predicted PbB concentrations, and between observed and predicted exceedances of 10 µg/dL, for children with adequate exposure characterizations. These studies focused on communities with at least 15% of the children having PbB concentrations greater than 10 µg/dL. Future comparisons will feature study groups that have less than a 15% probability of exceeding 10 µg/dL.

What are the limitations of the IEUBK model?

While the IEUBK model provides a fairly good estimate of risk from exposure to Pb, as with all models, it has limitations to its use. First, the model should not be relied upon to predict PbB accurately above 30 µg/dL. Above this concentration, the relationship between absorbed Pb and children's PbB concentrations has not been characterized. However, this should not cause any difficulties for the IEUBK model in risk assessment applications, as this value is well above the level of concern of 10 µg/dL. Additionally, the model should not be used for exposure periods of less than three months, or in which a higher exposure occurs less than one per week or varies irregularly. Finally, it is not the goal of the IEUBK model to match the measured PbB of a specific child. The model is designed to predict an average PbB concentration for an entire population, or the probability that a child with a specific exposure scenario would have an elevated PbB.

Whom should I contact for more information?

More detailed information regarding the IEUBK Model can be obtained through the following:

- *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children* (Publication 9285.7-15-1).
- *Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead in Children* (Publication 9285.7-22).
- *User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® version* (Publication 9285.7-42).
- *System Requirements and Design for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® version* (Publication 9285.7-43).
- *Reference Manual: Documentation of Updates for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® version* (Publication 9285.7-44).
- Reviewing the Technical Review Workgroup for Lead (TRW) home page (http://www.epa.gov/superfund/programs/lead).
- Calling EPA's IEUBK Technical Support Center (1-866-282-8622).