SHORT SHEET:

Why Does The IEUBK Model Use Central Tendency Exposure (CTE) Input Parameters?

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Technical Review Workgroup Lead (Pb) Committee

Office of Land and Emergency Response

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The IEUBK model differs from other non-lead CERCLA risk assessment methods by using CTE rather than Reasonable Maximum Exposed (e.g., 90th percentile of the exposure distribution) input parameters. Inputs to the IEUBK Model are exposure point estimates that are intended to represent time-averaged central tendency exposures. The output of the model is a central tendency estimate of blood lead concentration for children who might experience the simulated exposures. These CTE blood lead concentrations are then used to predict the probability of exceeding a target blood lead level, as summarized below. Based on the mass balance between uptake and elimination rates, RME intakes would likely overpredict the geomean blood lead levels.

The CTE inputs are intended to represent reasonable estimates of lead ingested and inhaled per unit time. The concentration term should represent a central estimate of the lead concentration in residential soil[1]. The arithmetic mean is an unbiased estimator of the mean of a population regardless of the underlying distribution. Therefore, it is recommended that a simple average or arithmetic mean of soil lead concentrations from a representative area in residential yard frequented by children, and an average of dust lead concentrations (when available) from representative areas frequented by children inside the house be used as IEUBK inputs[2]. In this context, exposure is presumed to occur on a routine, repeated basis (i.e., at least 1 day per week for at least 13 consecutive weeks).

The exposure component of the IEUBK model simulates intake of lead for inputted exposures to lead in air, drinking water, soil-derived dust, and diet as well as their intake rates (e.g., breathing rates). The model uses lead uptake rates to calculate the lead masses in each of the body compartments and simulates the change in blood lead concentration over time. The uptake component model is a mathematical expression of the movement of the absorbed lead throughout the body.

The biokinetic component of the model includes a central compartment, six peripheral body compartments, and three elimination pools. The model uses transfer coefficients to simulate the movement of lead between the internal compartments (e.g., organs) to the excretion pathways.

The CTE environmental exposure data are exposure point estimates intended to represent time-weighted averages. The output of the IEUBK model is a central tendency estimate of blood lead concentration for children who might experience the inputted exposures. However, within a group of similarly exposed children, blood lead concentrations are expected to vary as a result of interindividual variability in media intakes, absorption and kinetics.

The model simulates the combined impact of these sources of variability as a lognormal distribution of blood lead concentration for which the geometric mean (GM) is given by the central tendency blood lead concentration output from the biokinetics model, and the geometric standard deviation (GSDi) is an input parameter, which represents interindividual variability. This is due to the model using a lognormal probability distribution to characterize the variability in blood lead concentrations from behavioral, home environment and physiological differences as seen in studies where both exposure information and blood lead data were available for populations seen in children.

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[1] Residential land use areas are defined in US EPA Updated Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities (2024); available online at https://semspub.epa.gov/src/document/HQ/100003435.

[2] For additional information, refer to OSWER 9200.1-78 (2007), Short Sheet: Estimating the Soil Lead Concentration Term for the Integrated Exposure Uptake Biokinetic (IEUBK) Model.

The resulting lognormal distribution also provides the basis for predicting the probability of occurrence of a given blood lead concentration within a population of similarly exposed children. The model can be iterated for varying exposure concentrations (e.g., a series of increasing soil lead concentrations) to predict the media concentration that would be associated with a probability of 5% for the occurrence of a blood lead concentration exceeding a target blood lead level (e.g., 5 µg/dL).

See Figure 1 for an illustration of the IEUBK model's exposure, input, biokinetic and outputs.

More information on the IEUBK model is available in White et al., 1998 (https://ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.98106s61513).

Information on the evaluation of the IEUBKv2 is available in Brown et al., 2023 (Evaluation of the integrated exposure uptake biokinetic (IEUBK) model for lead in children - PubMed) and Advancing Pb Exposure and Biokinetic Modeling for U.S. EPA Regulatory Decisions and Site Assessments Using Bunker Hill Mining and Metallurgical Complex Superfund Site Data (2021).

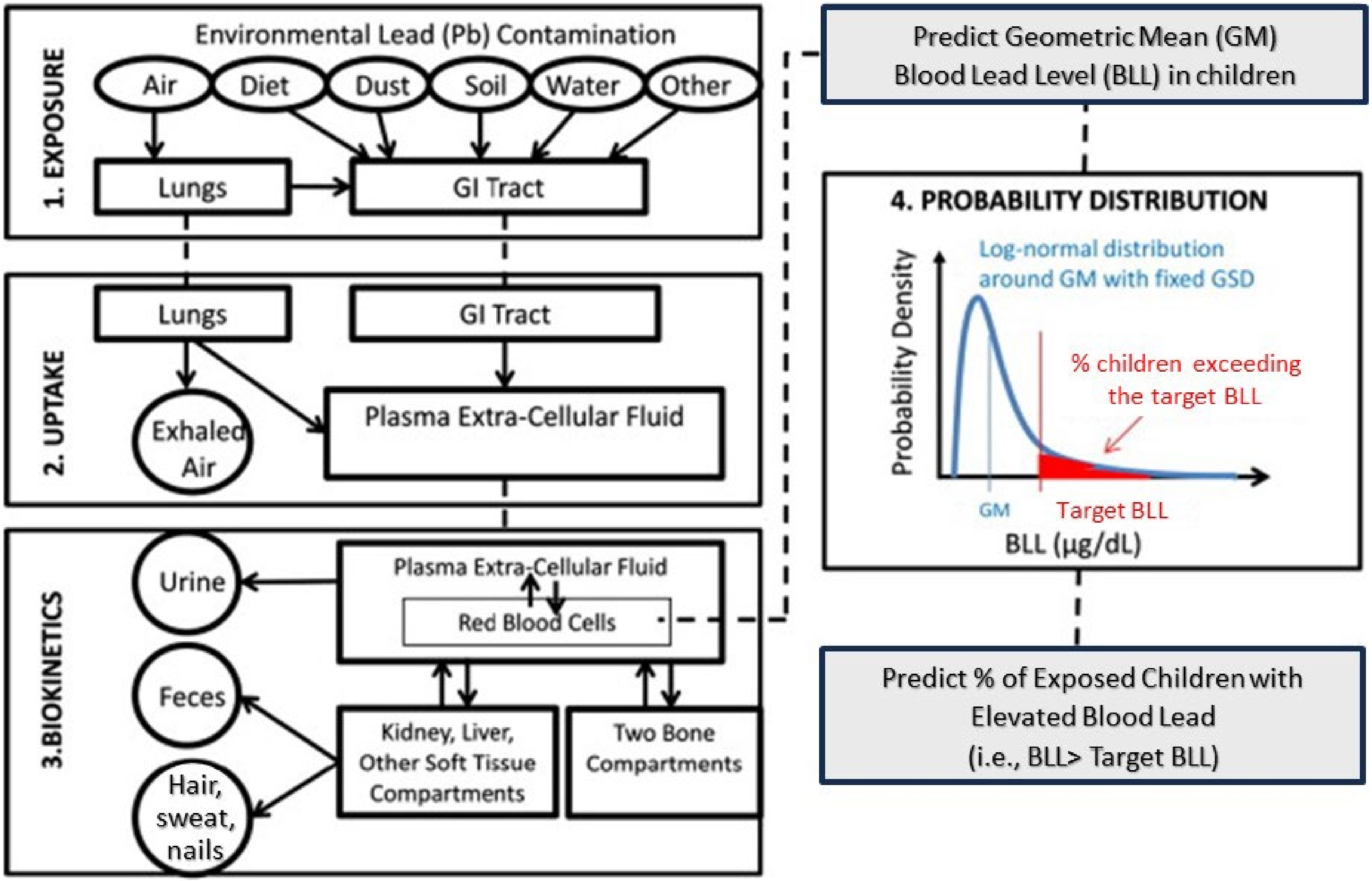

Figure 1. The IEUBK model estimates a probability distribution curve of blood lead concentrations for an individual child or population of similarly exposed children using the GSD and predicts the probability (expressed as a percent) of exceeding the target blood lead level.