2025 SOT Annual Meeting & ToxExpo
Session: Risk Assessment I
Poster: L637
Monday, March 17, 2025
1:45 PM – 4:15 PM

GRADIENT

A Comparison of Blood Lead Models Used to Evaluate Intermittent Lead Exposure in Children and Adults

Steven R. Boomhower, Ph.D.; Rosemary Mattuck, M.S.; Kyle J. Colonna; Ph.D., M.P.H.; Barbara D. Beck, Ph.D., DABT, ATS, AAAS Fellow

Background and Purpose: In August 2024, the United States Environmental Protection Agency (US EPA) released guidance on assessing intermittent or variable exposures to lead (Pb) using the Integrated Exposure Uptake Biokinetic (IEUBK) model and the Adult Lead Methodology (ALM). In general, the guidance focuses on the soil/dust pathway and provides recommendations for the assessment of cumulative lead risks when exposures occur at multiple contaminated sites, including primary residences, non-residential sites, and secondary non-residential sites. The guidance also describes a time-weighted averaging (TWA) approach to incorporate Pb intakes into the IEUBK model and ALM, since both only permit the user to input daily, continuous exposures. Conversely, the All Ages Lead Model (AALM) allows users to specify intermittent as well as continuous exposures and can estimate blood lead levels (BLLs) across the lifespan (*e.g.*, infancy, childhood, and adulthood). Considering the new US EPA guidance, we evaluated the similarities and differences among the IEUBK model, ALM, and AALM with respect to predicted BLLs from hypothetical, intermittent Pb-exposure scenarios in children and adults.

Methods: To investigate the potential impacts of intermittent Pb exposures on BLLs, we used two hypothetical case studies. In the first case study, we modeled intermittent Pb exposures for a child aged 1-6 years using the IEUBK model and the AALM. We assumed a child visited a park three days per week and remained at her residence the remaining days. The soil Pb concentration at the park was 1,800 ppm, and the soil Pb concentration at the residence was 70 ppm. For the IEUBK modeling, we used a TWA soil concentration of 809 ppm, according to US EPA guidance. In the second case study, we modeled intermittent Pb exposure in an adult worker aged 25 years using the ALM and the AALM. We assumed a male worker spent three days per week outdoors at a contaminated site and two days per week indoors at the site. The soil Pb concentration at the contaminated site was 1,200 ppm, and the indoor dust Pb concentration was 400 ppm. Residential Pb exposure was incorporated into the scenario as a baseline BLL of 0.9 µg/dL. For the ALM, we used a TWA soil concentration of 880 ppm, according to US EPA guidance. For all modeling, we estimated the geometric mean BLL and the probability of exceeding target BLLs. For the child case study, we used target BLLs of 5 µg/dL and 3.5 µg/dL. For the adult case study, we used target BLLs of 5 µg/dL and 2.6 µg/dL. A target BLL of 5 µg/dL is the default value for both the IEUBK model and ALM. A target BLL of 3.5 µg/dL is the Centers for Disease Control and Prevention (CDC) blood lead reference value (BLRV), which is based on the 97.5th percentile of the BLL distribution in US children aged 1 to 5 years using data from the National Health and Nutrition Examination Survey (NHANES) for the 2015-2016 and 2017-2018 cycles. A target BLL of 2.6 µg/dL is the 95th percentile of the BLL distribution in US adults aged 20+ years using data from NHANES for the 2017-2018 cycle. The geometric standard deviations (GSDs) used were 1.6 and 1.8 for the child and adult scenarios, respectively. The GSD of 1.6 is the IEUBK model default, and the GSD of 1.8 is the ALM model default from an analysis of NHANES 2009-2014.

Results: Overall, the AALM predicted slightly lower BLLs for both case studies of intermittent Pb exposure compared to the IEUBK model and ALM. For the child case study, the AALM predicted a

geometric mean BLL of 3.2 µg/dL, a 16% probability of exceeding 5 µg/dL, and a 41% probability of exceeding 3.5 µg/dL. The IEUBK model predicted a geometric mean BLL of 3.8 µg/dL, a 28.7% probability of exceeding 5 µg/dL, and a 57% probability of exceeding 3.5 µg/dL. For the adult case study, the AALM predicted a geometric mean BLL of 2.8 µg/dL, a 16% probability of exceeding 5 µg/dL, and a 55% probability of exceeding 2.6 µg/dL. The ALM predicted a geometric mean BLL of 3.9 µg/dL, a 34% probability of exceeding 5 µg/dL, and a 76% probability of exceeding 2.6 µg/dL.

Conclusions: Under these intermittent exposure scenarios, the AALM predicted slightly lower BLLs in children and adults than the IEUBK model and ALM. This is likely due to several differences among the blood lead models. For example, the AALM uses an age-specific absorption factor that decreases with age, whereas the IEUBK model uses a default absorption factor for all ages. In addition, the ALM uses a biokinetic slope factor, while the AALM is a more biologically accurate pharmacokinetic model that accounts for transfer rates between body compartments. Some of the difference in exceedance probability between the child and adult scenarios in the AALM are due to differences in the GSD value, which represents the variability in the blood lead distribution across an age group. The child and adult case studies demonstrate that the AALM can simulate a more realistic exposure pattern when evaluating the impacts of intermittent Pb exposure on predicted BLLs. Overall, each blood lead model has advantages and disadvantages related to ease of use, exposure parameters (*e.g.*, intermittent *vs.* continuous exposure), biological accuracy, and other factors that should be considered in evaluating Pb exposure and risk assessment.