Development and Evaluation of a New Air Exchange Rate Algorithm for the Stochastic Human Exposure and Dose Simulation Model

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Previous exposure assessment panel studies have observed considerable seasonal, between-home and between-city variability in residential pollutant infiltration. This is likely a result of differences in home ventilation, or air exchange rates (AER). The Stochastic Human Exposure and Dose Simulation (SHEDS) model is a population exposure model that uses a probabilistic approach to estimate personal exposures for simulated individuals of a defined population, based on ambient concentrations, literature-based distributions of residential AERs and particle infiltration parameters (i.e., penetration factors and deposition rates), and time spent in various microenvironments (e.g. home, office, school, vehicle) from a large database of human activity diaries.

A new AER algorithm was incorporated into SHEDS based on the Lawrence Berkley National Laboratory Infiltration model, with stochastic sampling of inputs added. However, this model only accounts for the leakiness of a home and does not include natural (opening of windows) or forced (air conditioning use) ventilation that can greatly influence AERs. We therefore developed a methodology to adjust for the opening of windows based on the prevalence of air conditioning and outdoor-indoor temperature differences. We compare the estimated AERs with measured AERs in four different cities: Los Angeles, CA, Detroit, MI, Elizabeth, NJ, and Houston, TX.

Using study-specific inputs, SHEDS underestimated the measured AERs for Detroit (0.7 vs. 1.5 1/h, for SHEDS vs. measured values), LA (0.9 vs. 1.4) and Elizabeth (0.9 vs. 1.4), and overestimated AERs for Houston (0.7 vs. 0.6). Measured AERs were between the median and 95th percentile of the modeled SHEDS AER distributions. The algorithm was also evaluated using nationally available input data. SHEDS AER distributions using these national inputs were lower compared to the study-specific inputs, and were also evaluated against other AER distributions used for exposure modeling.