Developing a Conceptual Scientific Workflow to Estimate Chemical Exposures

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Need for a workflow to address gaps

Holistic evaluation of chemical impacts requires integration of disparate data streams, modeling of interactions among physical and biological systems, and consideration of tradeoffs associated with management decisions. Environmental health scientists have developed a variety of models that use available data with other mechanistic information to understand how chemicals in products move through the natural and built environment. Each new problem incrementally advances data, models, and understanding. To efficiently address problems of increasing complexity and enable greater insights, more nimble modeling methodologies are required to assess important chemical exposure scenarios and pathways across the chemical/product lifecycle. A scientific workflow executes a series of data handling and computational steps to provide outputs that support decision-making. For chemical assessments, scientific workflows are useful tools for efficient and transparent analyses, especially for considering impacts in complex systems. To demonstrate this approach, we use relatively data-rich chemicals as test cases to drive conceptual workflow development including flame retardants and ethoxylated solvents. The goal is to advance the workflows for efficient evaluation of a variety of chemicals and a range of decision contexts.

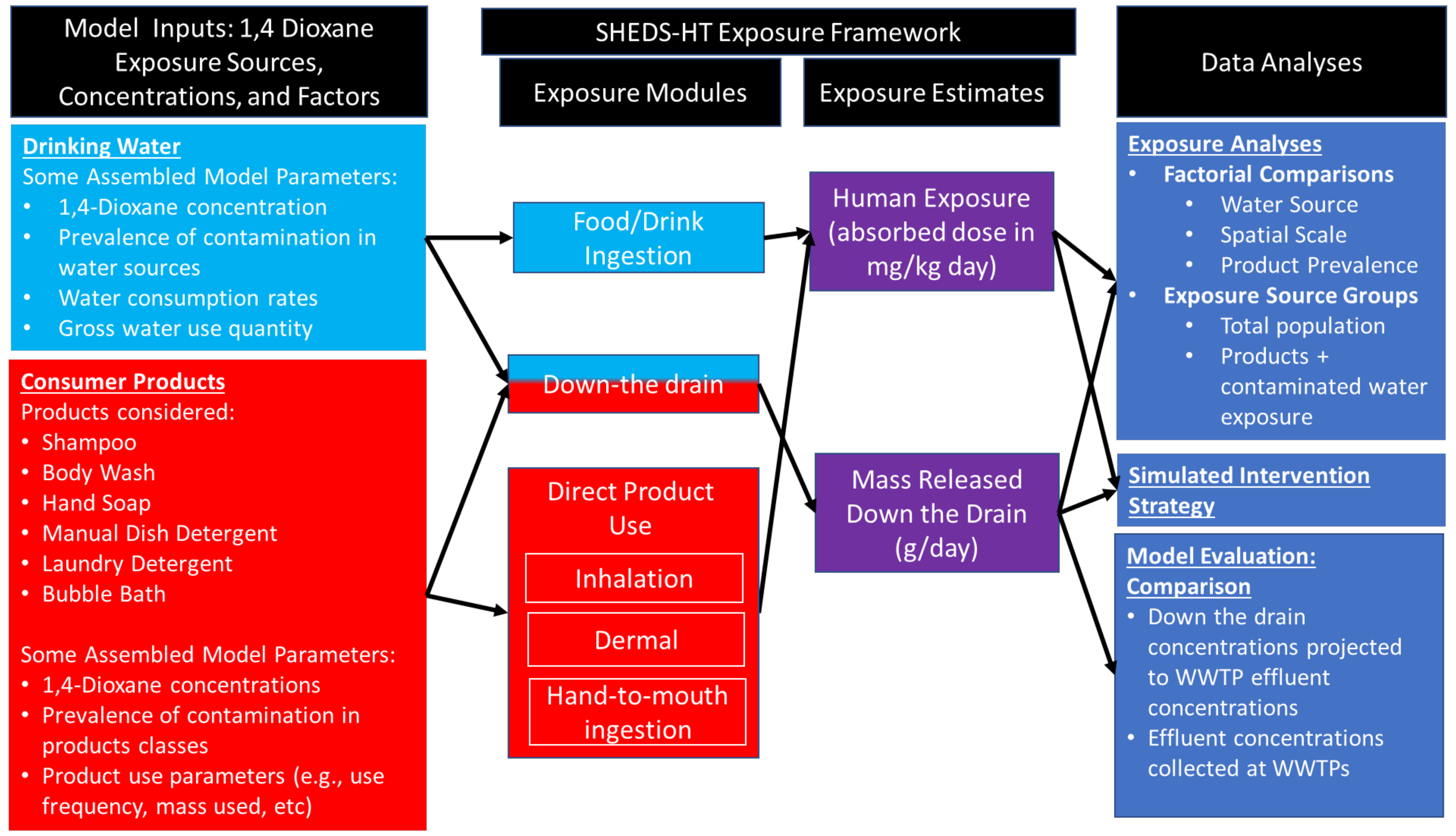


Figure 1. Our first workflow uses **SHEDS-HT** to conduct an exposure assessment of 1,4-dioxane via two non-occupational exposure pathways* **(See Poster 3943)**:
- Consumption of drinking water contaminated with 1,4-dioxane
- Use of consumer products contaminated with 1,4-dioxane via ethoxylated ingredients

- Simulation outputs are exposure units, i.e., mg/kg/day.
- Water data *sources:* Groundwater (GW), Surface water (SW), Mixed Sources (MX)
- Geographic *scale:* US National (US) or state of California (CA)
- Prevalence of 1,4-dioxane in product classes ($Prevalence_{products}$): High or Low
- Parsed outputs by population: Total simulated population ("Total"), those only exposed via products ("Products-Only"), and those exposed via both products and contaminated water ("Both").

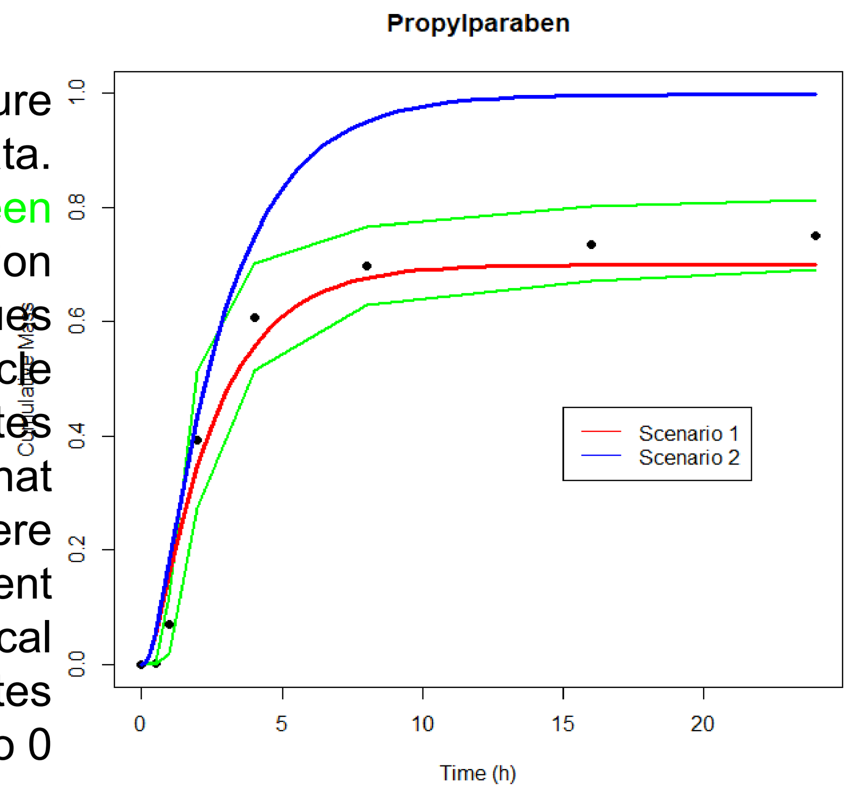
Note: Full study results of Dawson et al. (IN PRESS). An assessment of non-occupational 1,4-dioxane exposure pathways from drinking water and product use. *Environmental Science & Technology.*

Enhancements to conceptual workflow currently being developed

Dermal Exposure (See Poster 3310)

We have begun by developing and evaluating a well-mixed model to predict dermal absorption for a set of chemicals used in cosmetic formulations. Mass-transfer coefficients and ordinary differential equations describe the concentration of a given chemical over the exposure period in four separate compartments: the vehicle, stratum corneum, living tissue, and receptor fluid. **Evaluation**: Model predictions for a set of 26 chemicals used in cosmetic formulations are compared to experimental *in vitro* measurements of penetration into and through human skin. **Parameterization**: Key experimental system characteristics , e.g., exposure area, vehicle evaporation, and receptor fluid transport. **Binning**: According to how well the model outputs agreed with experimental data. By looking at the properties of the chemicals in each group, we attempt to better understand which parameters may play an important role in model accuracy for a given chemical.

Figure 2. Model predictions for two exposure scenarios plotted against experimental data. Dots show experimental means, with green lines showing the range of 1 standard deviation
- Scenario 1 assumes the chemical continues to absorb into the skin after the vehicle evaporates
  - Flux across the top layer is equal to what it would be if a saturated vehicle were present
- Scenario 2 assumes the remaining chemical does not absorb after the vehicle evaporates
  - Flux across the skin is set to 0



Lorber-Egeghy-East Method R Package (See Poster 3958)

To address the publication of sparse summary statistics of concentration for emerging pollutants, the *Lorber-Egeghy-East Method R package* (LEEM-R) was developed to provide lognormally distributed exposure estimates for any entered media. To date:
- A water intake exposure case example was performed for children, women, and children.
- The LEEM-R is available for pre-release and use for other exposure and concentration scenarios.

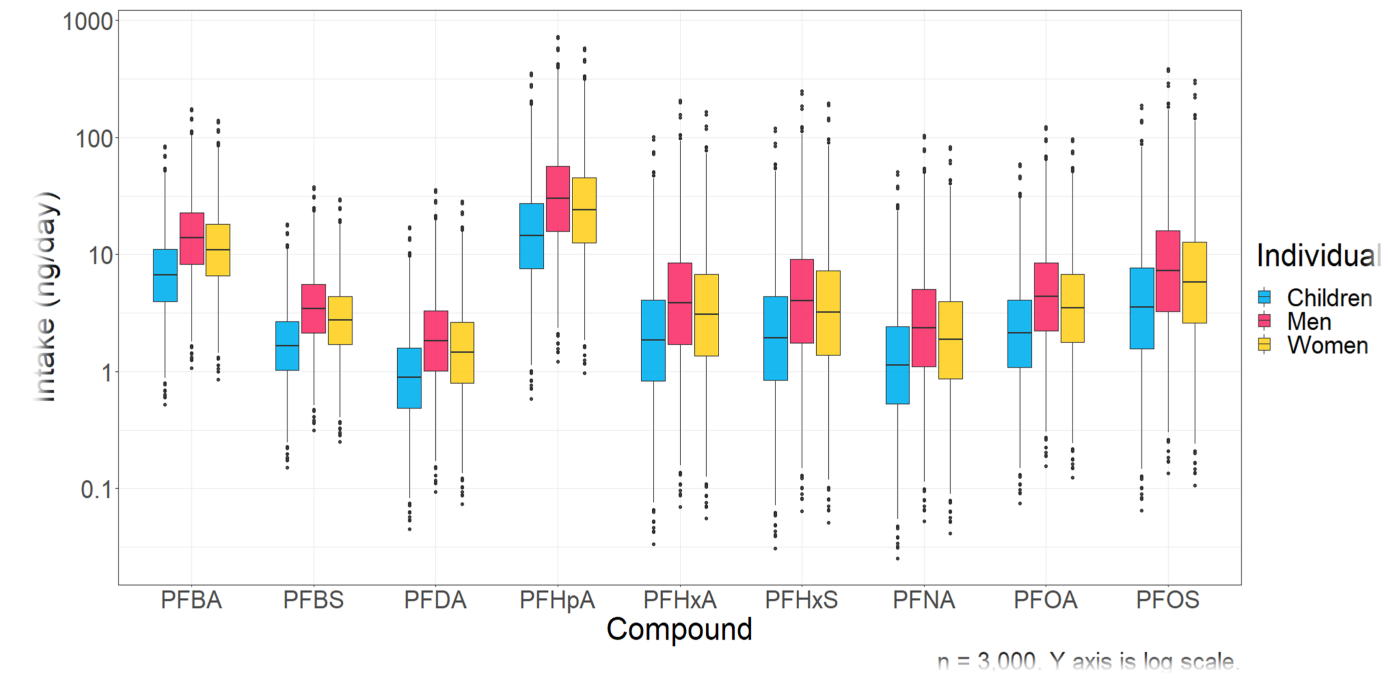


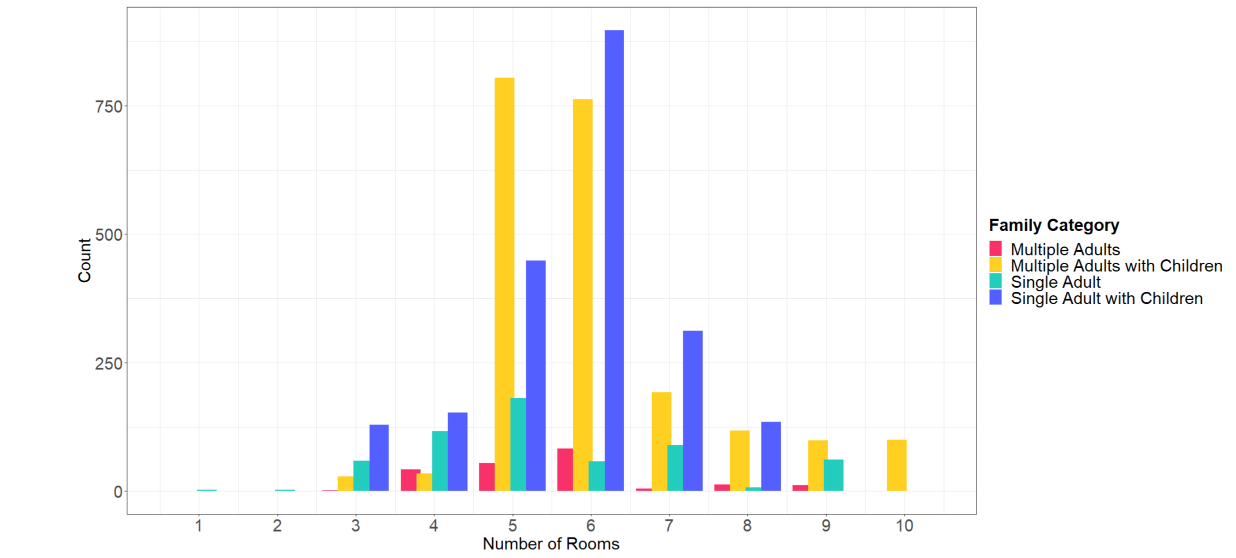
Figure 3. Example LEEM-R **output of** water intake exposure estimates for adults, women, and children across PFAS. For additional information on PK models and PFAS, see **Poster 3120**)

Combined Human Exposure Modules (See Posters 3962 and 3958)

The modules of the Combined Human Exposure Model (CHEM) continue to be updated. The Product Use Module estimates exposure from consumer products. Output is passed to Source-to-Dose (S2D), which estimates down-the-drain release and exposure. This evaluates the applicability of a simulation model in complex product-use longitudinal exposure scenarios. The Residential Population Generator (RPGen) draws an internally consistent population from the US census and surveys of home characteristics.

Figure 4 gives an example of RPGen output of a generated population that varies across components such as family category and the number of rooms in a household, which influence product use and indirect exposures depending on characteristics of the co-inhabitants and the residence.

Figure 4. Counts of Rooms across Family Category in RPGen output



Summary

- Scientific workflows provide a way to integrate data and algorithms from various knowledgebases and to identify gaps in data needed to estimate aggregate exposures. Such gaps include more reliable dermal models, paucity of data for PFAS and other emerging contaminants, uncertainties in human activities and exposure scenarios, and product use parameters. To address these gaps, EPA has built a conceptual workflow that is being populated by improved tools and data.
- References are available upon request at vallero.daniel@epa.gov.