

# The Role of the Combined Human Exposure Model (CHEM) for Estimating Aggregate Exposure to Methyl, Ethyl, Propyl, and Butyl Parabenzoic Acid

Daniel A. Vallero<sup>1</sup>, Ciara Dalton<sup>1\*</sup>, Alexander East<sup>1\*</sup> and Paul Price<sup>1\*</sup>

<sup>1</sup> U.S. Environmental Protection Agency, Office of Research and Development, Center for Computational Toxicology and Exposure, Research Triangle Park, NC, USA

\* Formerly with Agency



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*This presentation does not necessarily represent the views or policies of EPA.*

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# Outline

**01 Combined Human Exposure Model (CHEM) Overview**

**02 Paraben Example**

**03 Summary**

## Combined Human Exposure Model (CHEM)

- Originally created to support sustainable chemistry
- Repurposed to address aggregate exposures for Office of Pollution Prevention and Toxics (OPPT)
- A suite of computer modules:
  - Residence-Person Generator
  - Product Use Scheduler
    - ✓ Agent based model of human activity patterns
  - Source-to-Dose Module
    - ✓ Concentrations calculations

# Combined Human Exposure Model (CHEM)

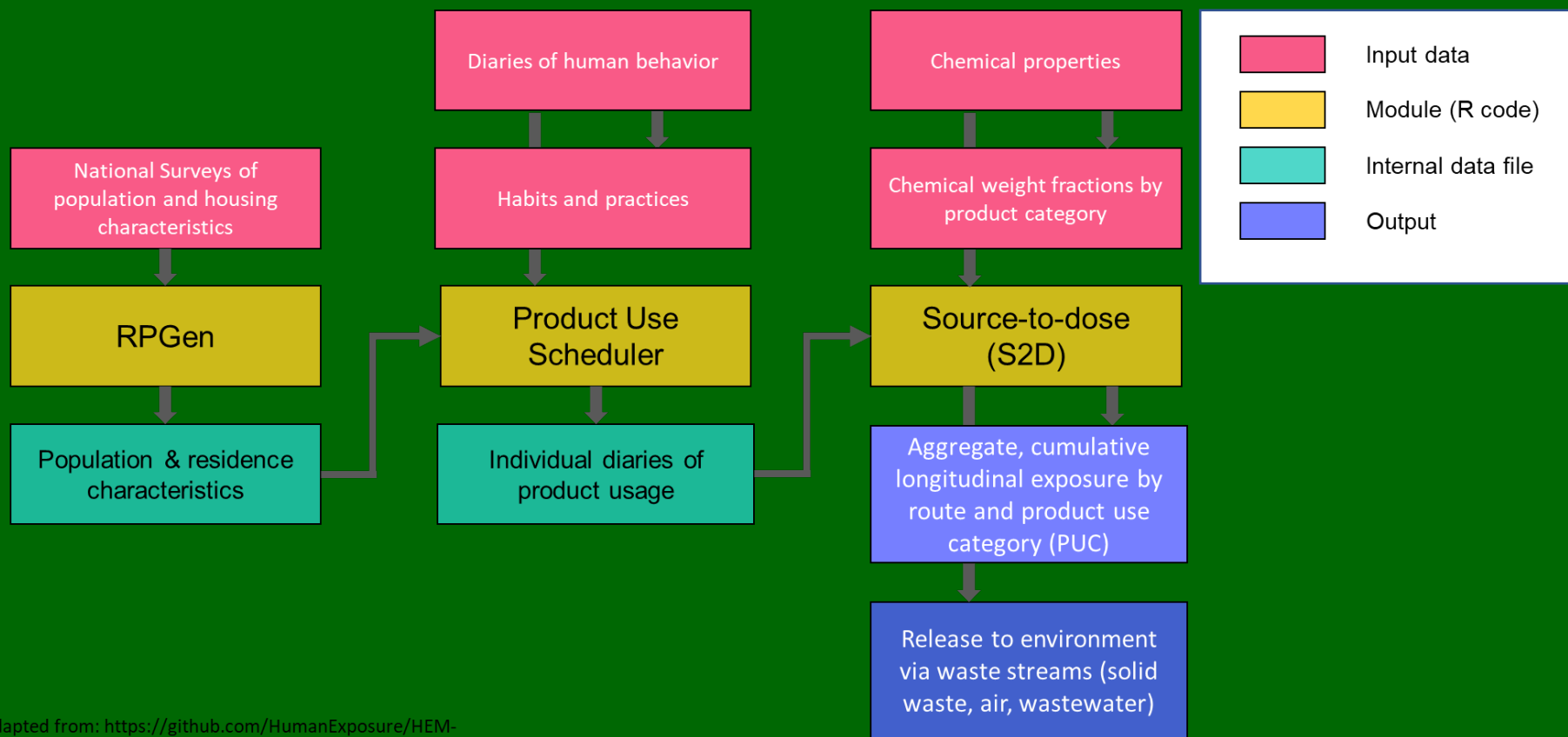
Models daily exposures an individual over a year

Models different types of doses

- Based on dermal loading
- Based on average air concentration
- Systemic oral, dermal, and inhalation doses

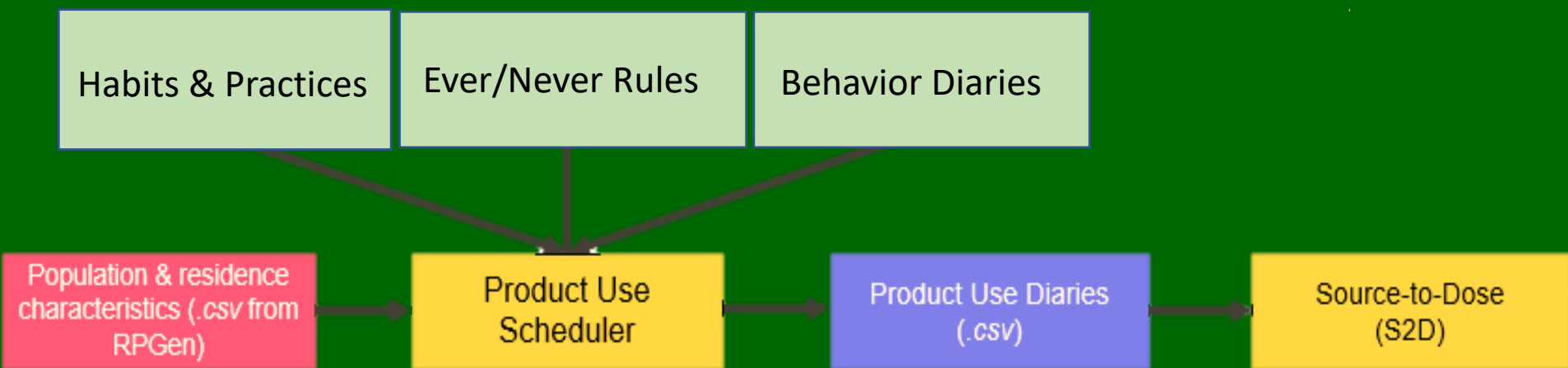
Models exposures from direct and indirect use

# CHEM Modules



adapted from: [https://github.com/HumanExposure/HEM-Documentation/blob/master/HEM\\_UserGuide\\_2018August28.pdf](https://github.com/HumanExposure/HEM-Documentation/blob/master/HEM_UserGuide_2018August28.pdf)

# CHEM Modules



# CHEM Module Inputs

Input	Source	Description	Number of Records
<i>FullIENT.csv</i>	Written for PUS	Determines ever/never rules.	224 (one for Each PUCID)
<i>PUC_use_data.csv</i>	Table 8 of Isaacs et al. 2014	Assigns clusters, defines use parameters in the population (frequency, mass)	546
<i>Activity_diary_pool.rds</i>	Agent-Based Model of Human Activity Patterns (ABMHAP) (Brandon, Dionisio et al. 2018)	Contains example behavior diaries for working adults, not working adults, school age children, and younger than school age children with four behavior patterns: sleeping, working/school, commuting, and 'other.' Diaries are written for 364 days, or one year.	1024 activity diaries, 256 per group.
<i>Pophouse.csv</i>	RPGen	Contains 126 variables describing a population with housing, residential, demographic, and physiological characteristics.	RPGen user determined



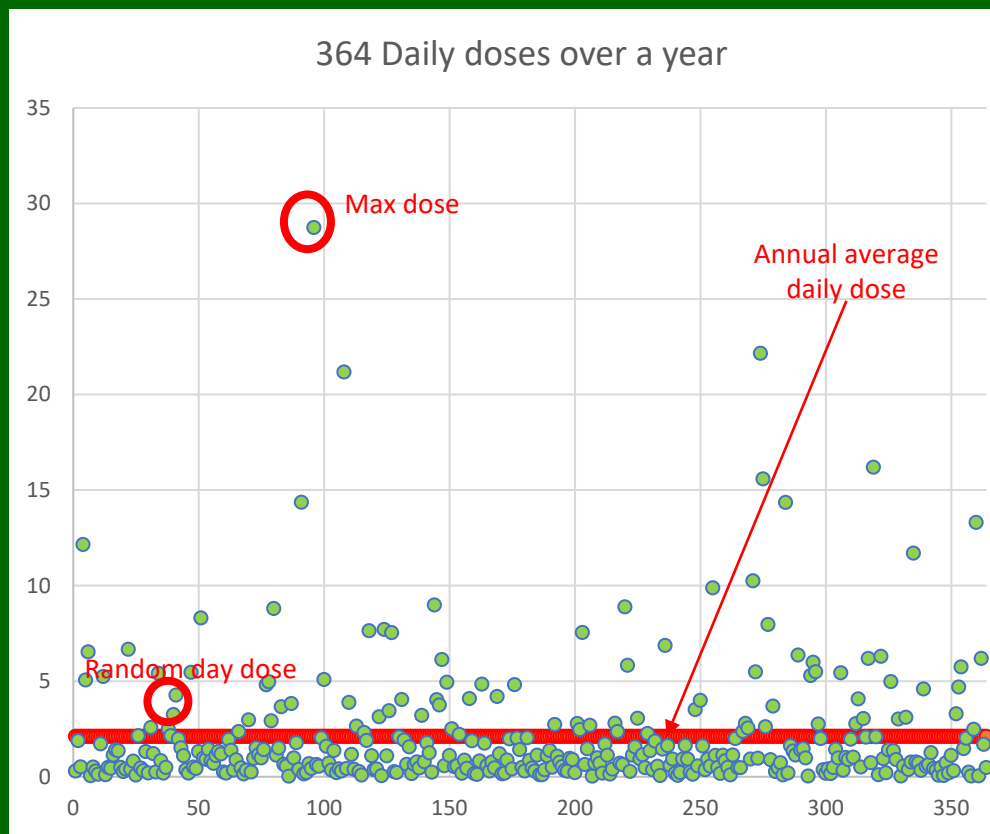
# Three Measures of Dose

Model generates 364 daily doses

Three doses are tracked

- Maximum daily dose (largest of the 364)
- Annual average daily dose
- Random day daily dose

All data presented is random day data



- PUS shows the differences in usage
- Based on the chemical prevalence in products
- Observations of low or high incidence of exposure.

# Parabens Example

## How can CHEM and paraben research be combined?

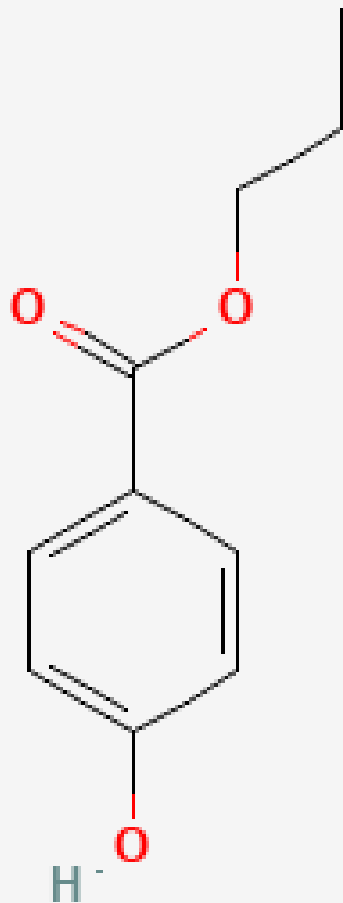
- For example, determines the prevalence of the four parabens in a home.
- The total dosage per day in mg/kg for the four parabens calculated using CHEM.



# Parabens

- Due to their favorable qualities and low toxicity historically, parabens are of the most extensively used preservatives in food, pharmaceuticals and personal care items.
- However current research suggest that parabens may behave as endocrine disrupting compounds (EDCs) and are thus classified as chemicals of growing concern with negative human health impacts with women being disproportionately affected by these chemicals.

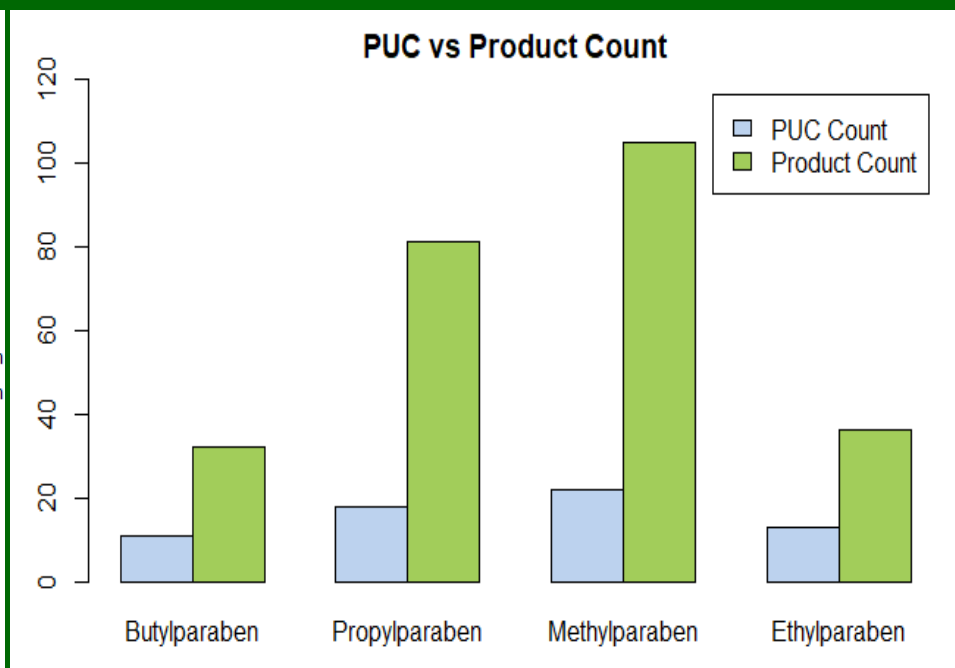
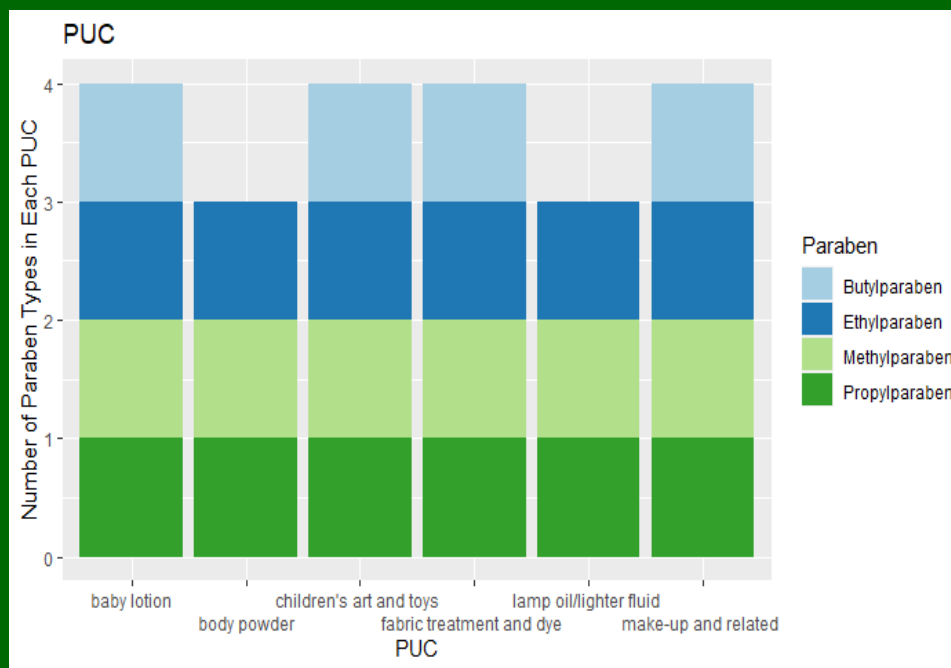
# Importance of Paraben Research



- 2005-2006 National Health and Nutrition Examination Survey (NHANES) found widespread exposure to parabens
  - Methylparaben and propylparaben highest concentrations found in participant urine.
- Females showed several-fold higher paraben concentration than males.
- Also found non-Hispanic black people showed greater exposure to methylparaben than non-Hispanic white people under the age of 60.

Image source: National Center for Biotechnology Information (2022). PubChem Compound Summary for CID 7175, Propylparaben. Retrieved September 9, 2022 from <https://pubchem.ncbi.nlm.nih.gov/compound/Propylparaben>.

# Paraben Runs



- Prediction and Evaluation of Aggregate Exposures to Parabens from Use of Consumer Products\*
- Compared estimates of interindividual variation in the aggregate exposures to the four parabens using exposure estimates from simulation modeling (CHEM) and biomonitoring (NHANES).
- NHANES biomonitoring survey tested for the metabolites of four parabens in urine samples collected in 2005 and 2006 (Calafat et al., 2010) and in an earlier smaller survey (Ye et al., 2006).
- Used CHEM to generate a distribution of single day aggregate systemic doses in 1,000 simulated adults. Adults were modeled since they are known to have higher exposures to parabens than children.

\* Thanks to Kristin Isaacs – EPA/ORD/CCTE

# Nomenclature

Chemical Exposure:

*One source and one chemical  
(most regulatory programs)*

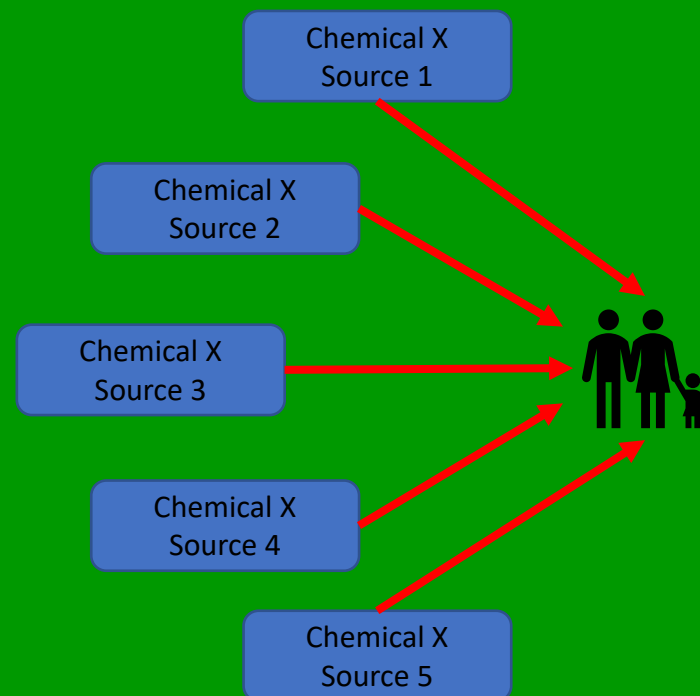
Chemical X  
Source 1





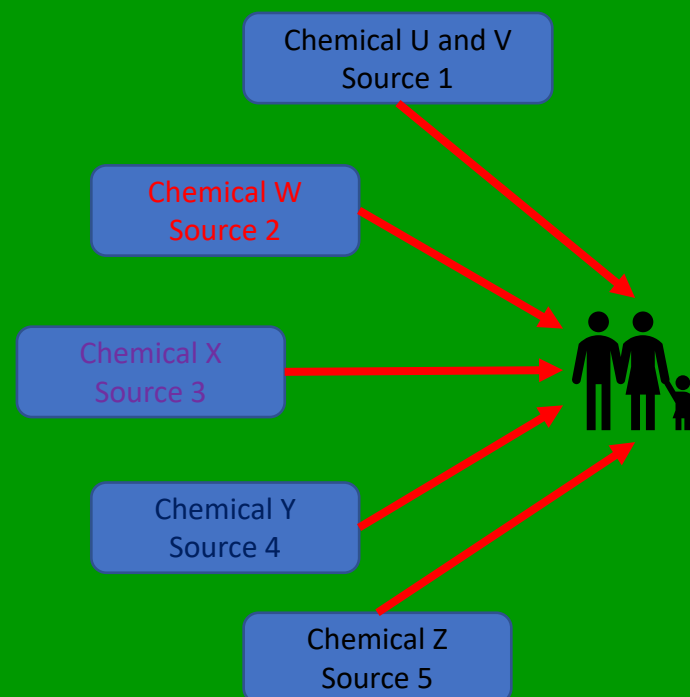
# Nomenclature

Aggregate exposure:  
*Single chemical multiple  
sources*



# Nomenclature

Cumulative Exposure:  
*Multiple chemicals from  
multiple sources*



# Nomenclature

Exposure to discrete mixtures:  
*Cumulative exposure to  
multiple chemicals from a single  
source*

Chemicals V,  
W, X, Y, Z





## **Cumulative and aggregate chemical exposures from use of consumer products**

- Nearfield sources of chemicals often result in larger doses than the far-field sources (air and water pollution and hazard waste sites)
- Cumulative exposures occur because:
  - Each product is a mixture of chemicals
  - Individuals use multiple products
- Aggregate exposures occur because one chemical can be in multiple products
- Different individuals use different products
  - Function of age, gender, and ethnicity
  - Function of housing stock, region of a country, and season
- One person's use of a product can affect an entire household's exposures
- Correlations exist between the use of different products

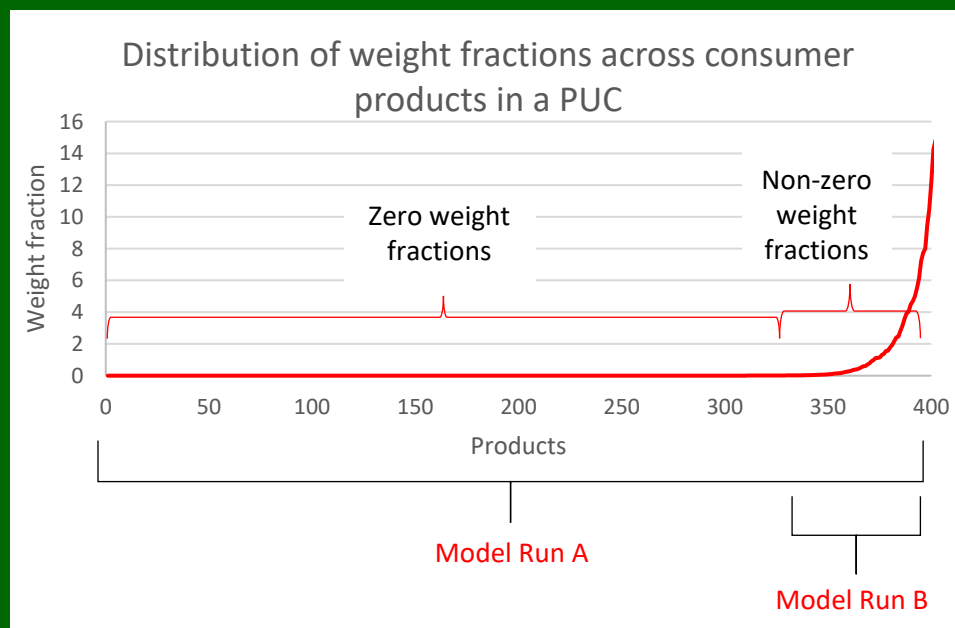
# Uncertainty in Data on Product Composition

EPA has data on composition of several hundred products in each PUC from CPDat

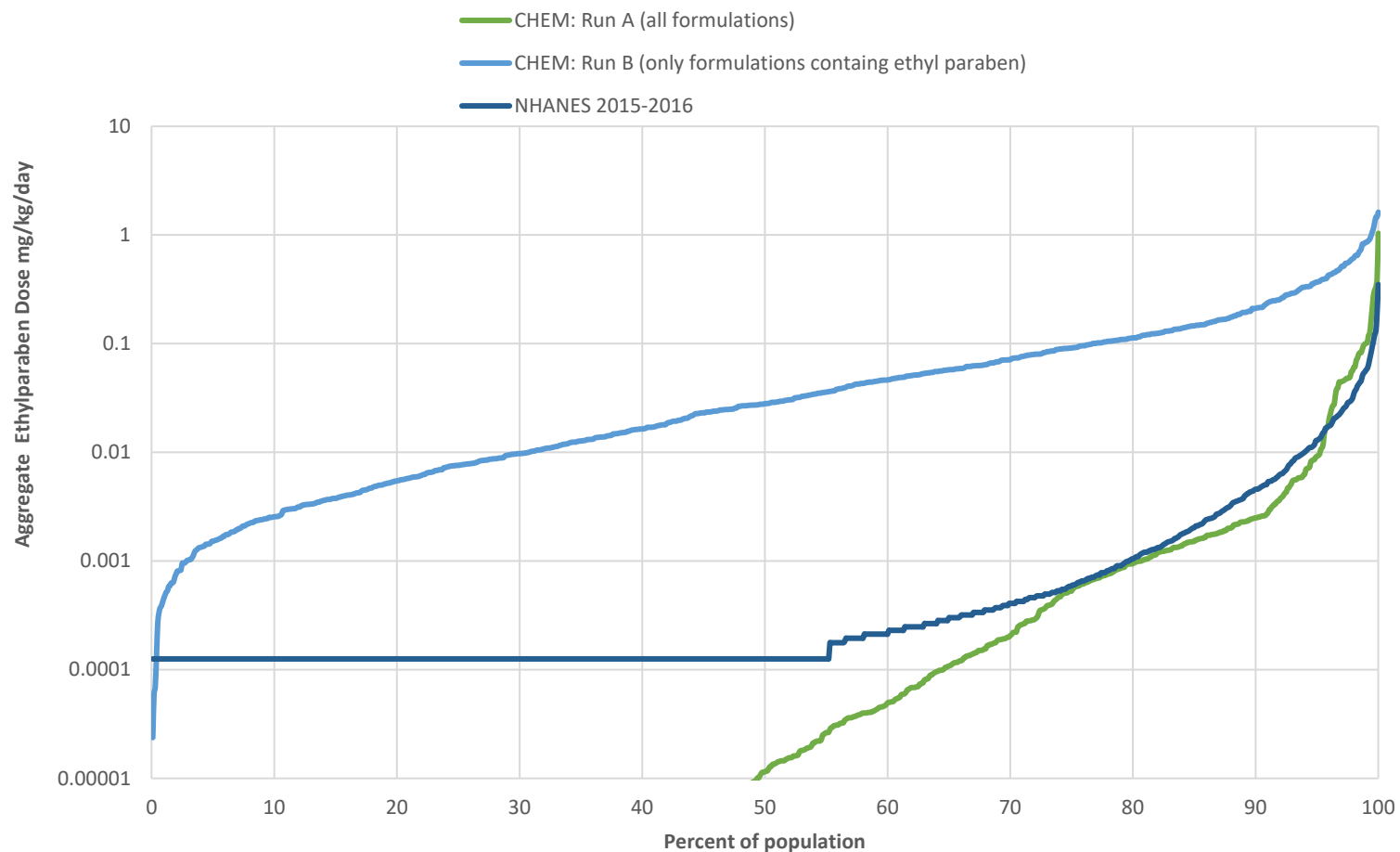
*But are the data representative?*

Run A – Random selection of formulae from all composition data

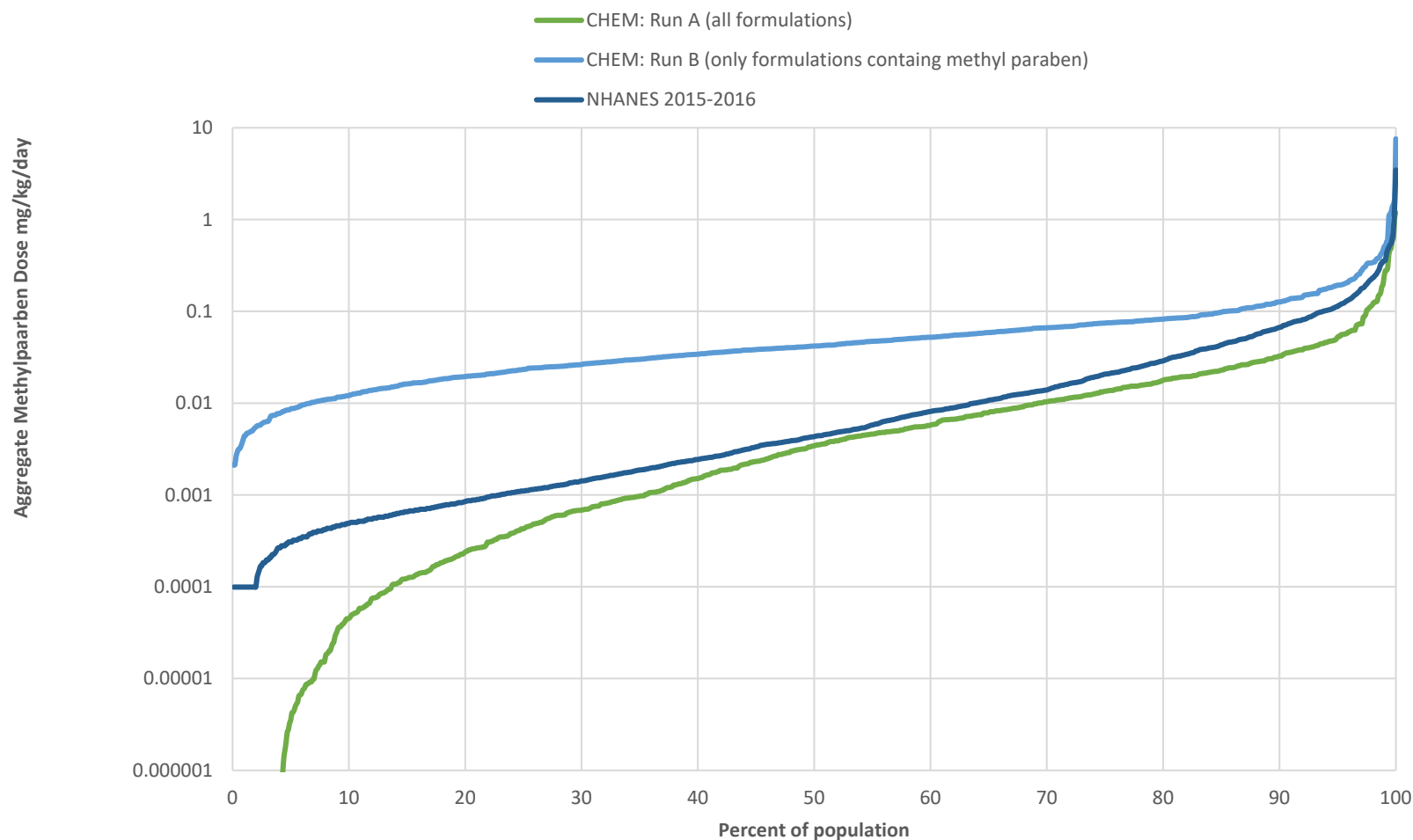
Run B – Random selection of formulae from composition containing the chemical (higher doses)



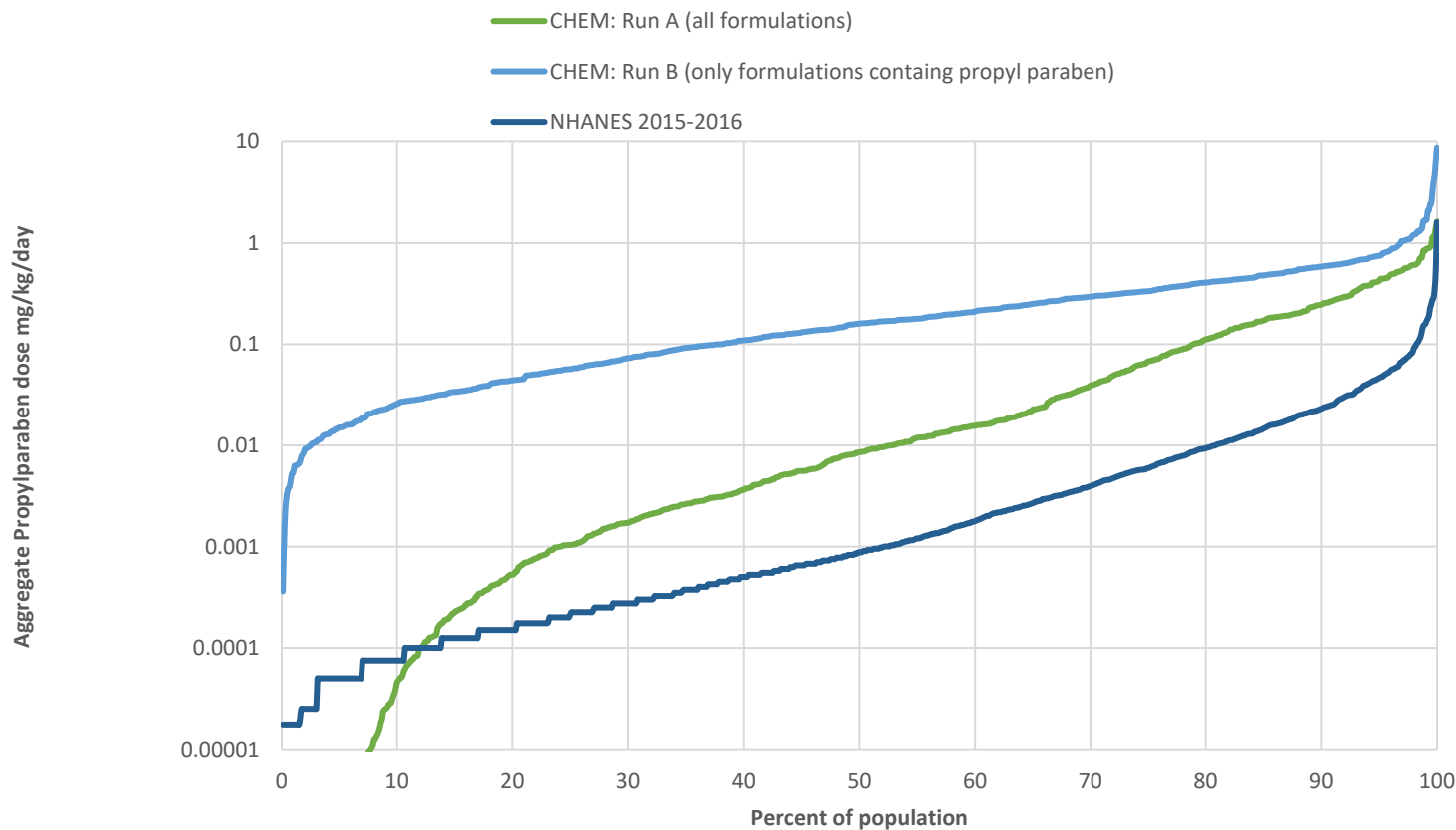
## ETHYLPARABEN



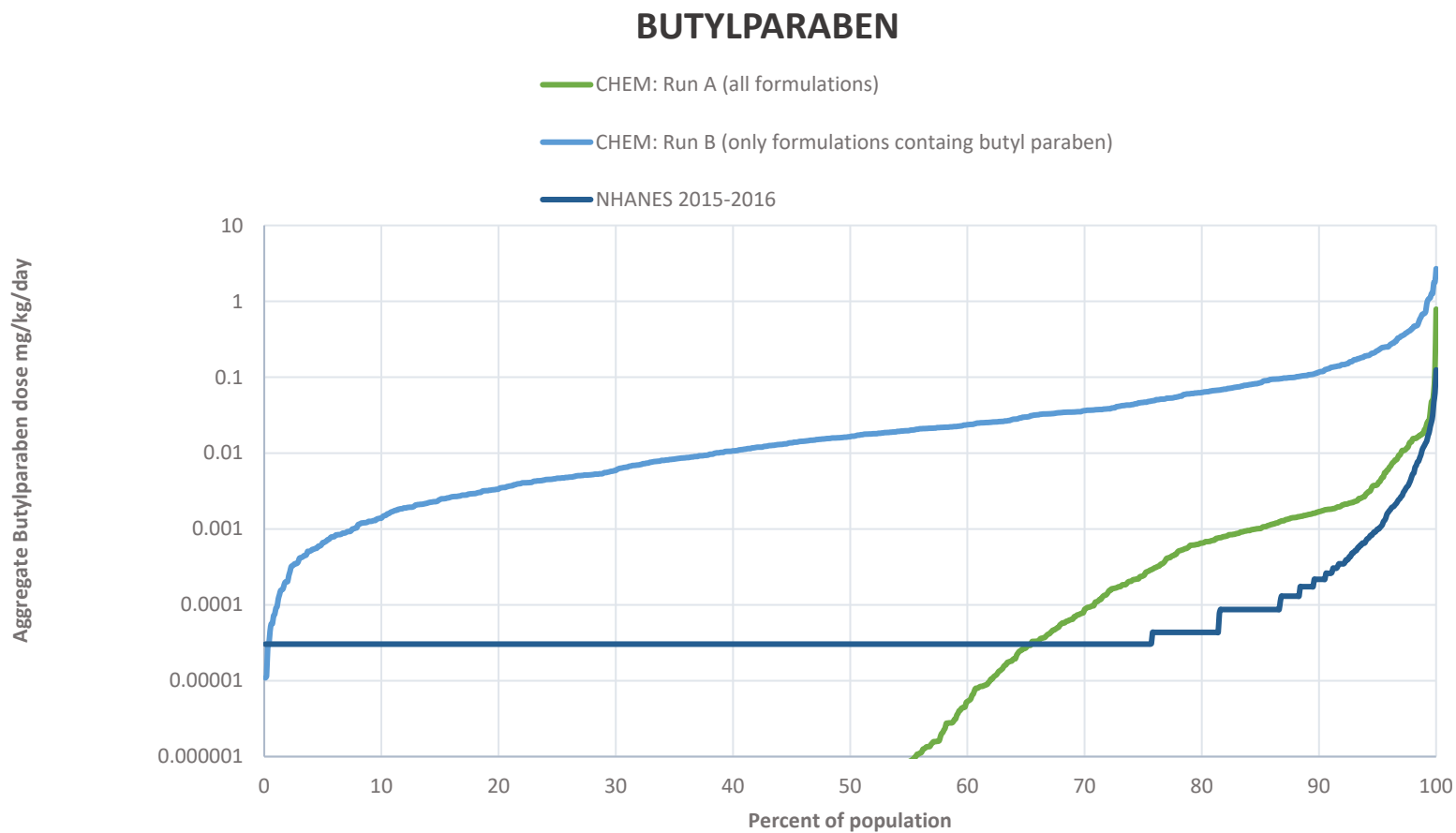
## METHYLPARABEN



## PROPYLPARABEN







# Ongoing Research

- Update information/data for parabens
- Improve data formatting and simplicity of use in CHEM
- Add more identifying characteristics into PUS due to greater risks of exposure

Ratio of modeled doses to doses estimated from biomonitoring data				
Percentile	Methyl Paraben	Ethyl Paraben	Propyl Paraben	Butyl Paraben
50th	2.89	ND*	0.33	ND*
75th	2.29	2.01	0.19	3.22
90th	2.39	2.06	0.16	1.66
95th	2.52	1.20	0.19	1.99
*Not detected in the 50th percentile				

Ratio of modeled doses to doses estimated from biomonitoring data				
Percentile	Methyl Paraben	Ethyl Paraben	Propyl Paraben	Butyl Paraben
50th	1.14	ND*	0.09	ND*
75th	1.31	1.98	0.08	0.00
90th	1.81	2.84	0.09	1.319905213
95th	1.91	2.49	0.10	1.314404432
*Not detected in the 50th percentile				

1. Found that high level of exposure from the use of a single product and not the combined exposures from the use of multiple products.
2. While the chemicals were widely used, they are not very common, so lessened the potential for aggregate exposure.
3. The Combined Human Exposure Model, used inputs from multiple EPA ORD projects, including biomonitoring.
4. Predicted interindividual in aggregate exposures to parabens in adults.

# Thank You!

