Consumer product chemicals in indoor dust

Implications for human exposure and health

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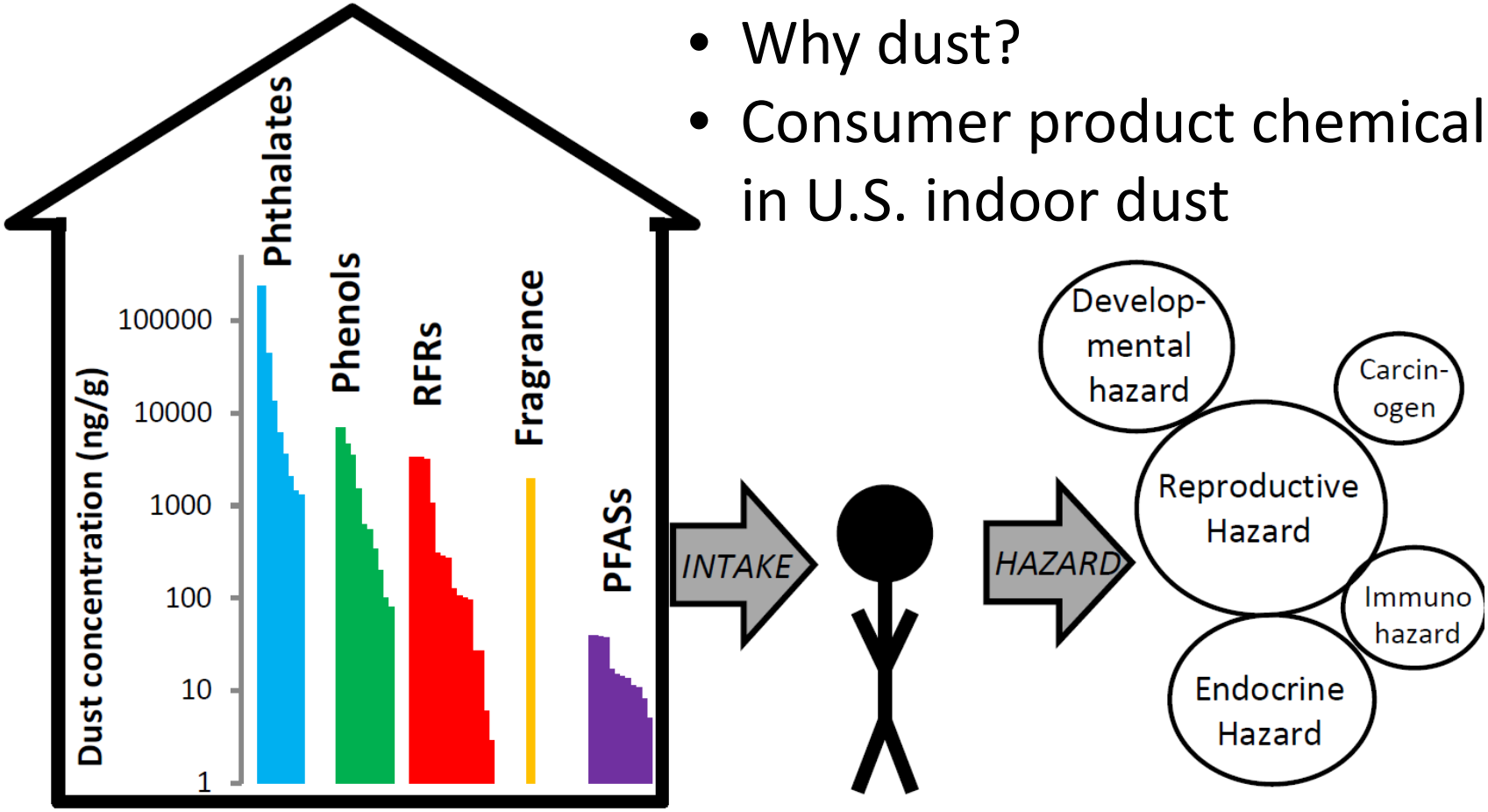
Health & Environment Program

Outline

- Public health and indoor environmental quality
- Why dust?
- Consumer product chemicals in U.S. indoor dust

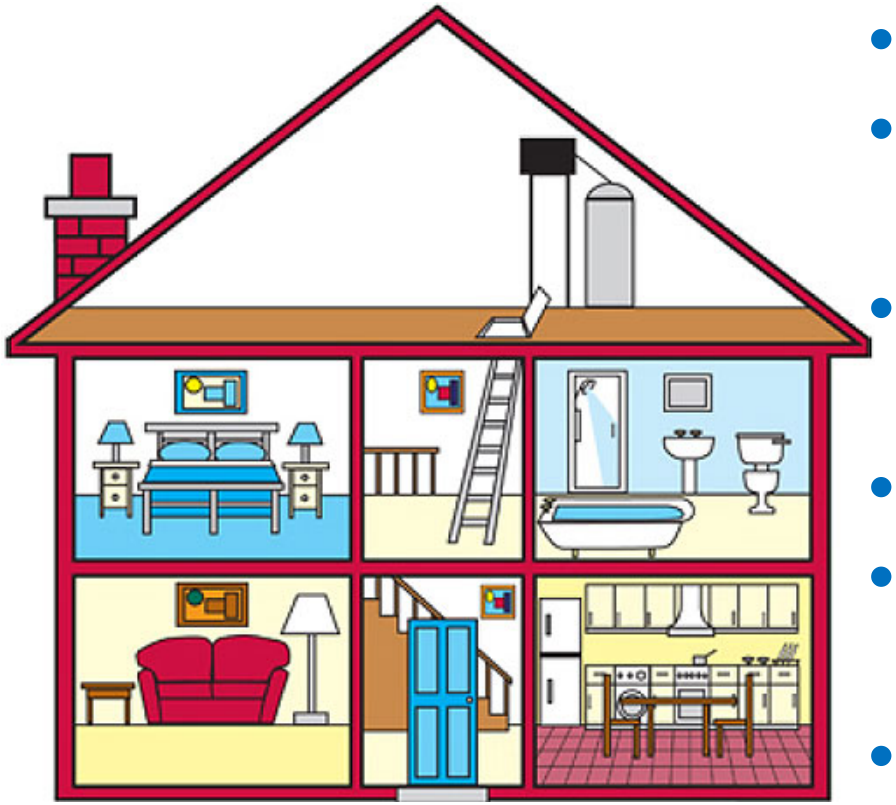


People in developed countries spend
~90% of time indoors

Klepeis 2001

Chemicals from products affect **indoor environmental quality**

- **Furniture**
- **Electronics**
- **Flooring**
- **Building insulation**
- **Personal care products**
- **Cleaning products**



- **Formaldehyde**
- **Toluene**

- **Flame retardants**
- **Phthalates**
- **Fluorinated chemicals**
- **Fragrance**

Weschler 2009; Rudel 2009; Bolden 2015

Chemicals from products: **human exposure**

Environmental Science & Technology

Article

pubs.acs.org/est

High-Throughput Models for Exposure-Based Chemical Prioritization in the ExpoCast Project

John F. Wambaugh,[*,†] R. Woodrow Setzer,[†] David M. Reif,[†] Sumit Gangwal,[†] Jade Mitchell-Blackwood,[‡] Jon A. Arnot,[§,∥] Olivier Joliet,[⊥] Alicia Frame,[†,#] James Rabinowitz,[†] Thomas B. Knudsen,[†] Richard S. Judson,[†] Peter Egeghy,[‡] Daniel Vallero,[‡] and Elaine A. Cohen Hubal[†]

~2,000 chemicals

Strongest predictor of detection in human biomonitoring:

Indoor/ consumer product use

Wambaugh 2013

Exposure in the indoor environment:
Product → Emission → **Exposure**

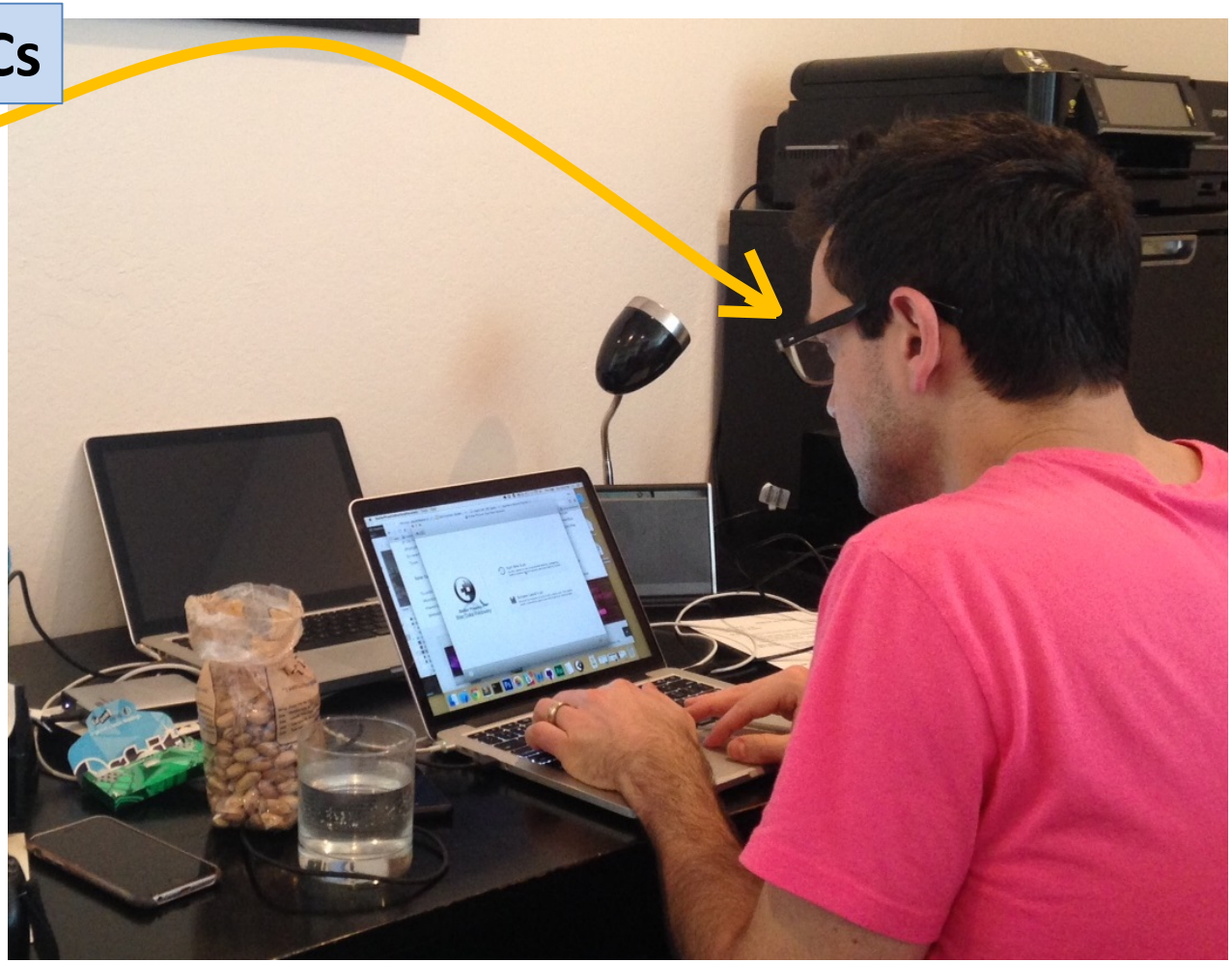
VOCs

A I R

Inhalation
Air-to-skin

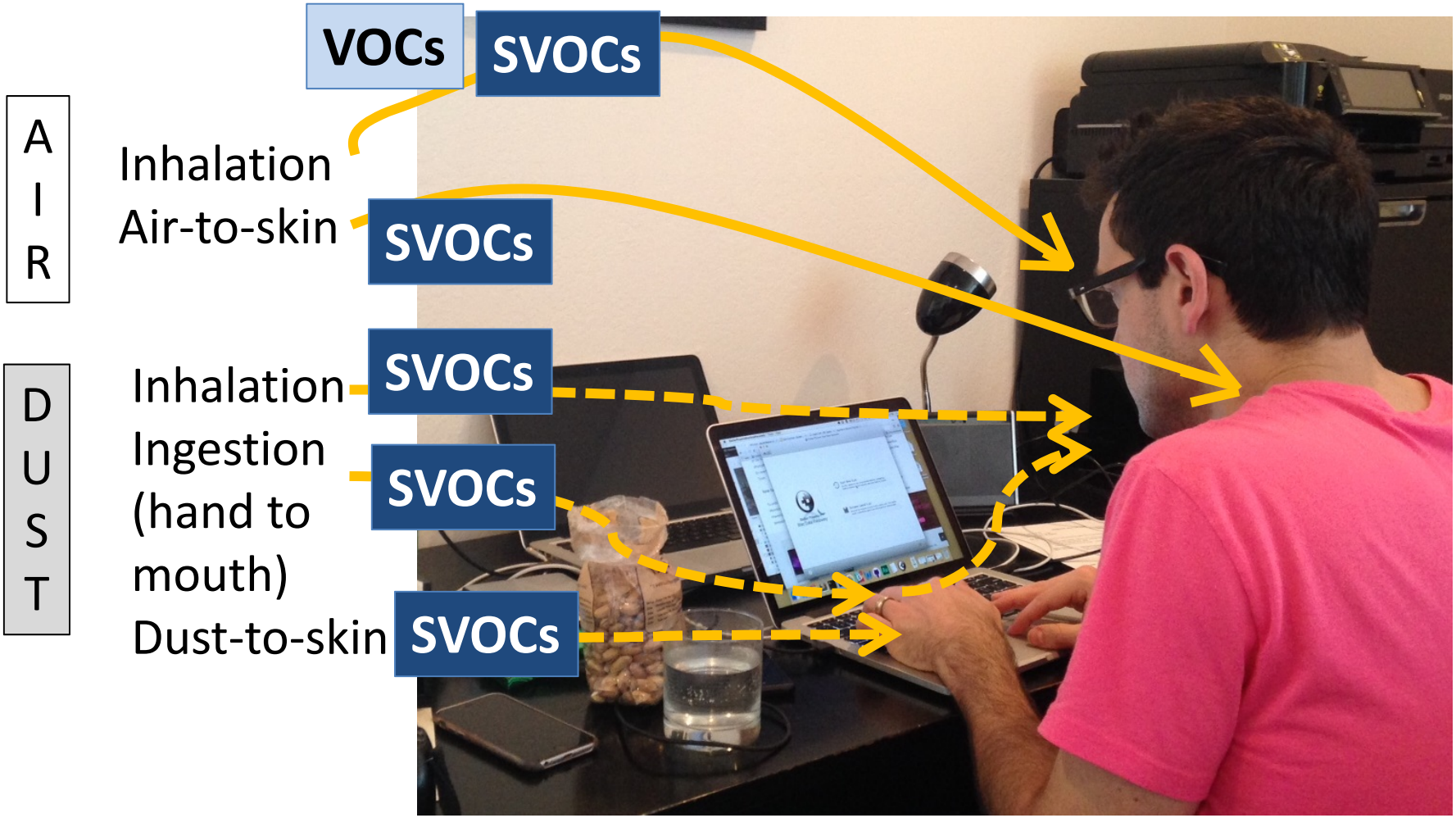
D U S T

Inhalation
Ingestion
(hand to
mouth)
Dust-to-skin



Weschler & Nazaroff, 2008; Weschler 2012; Rudel 2003

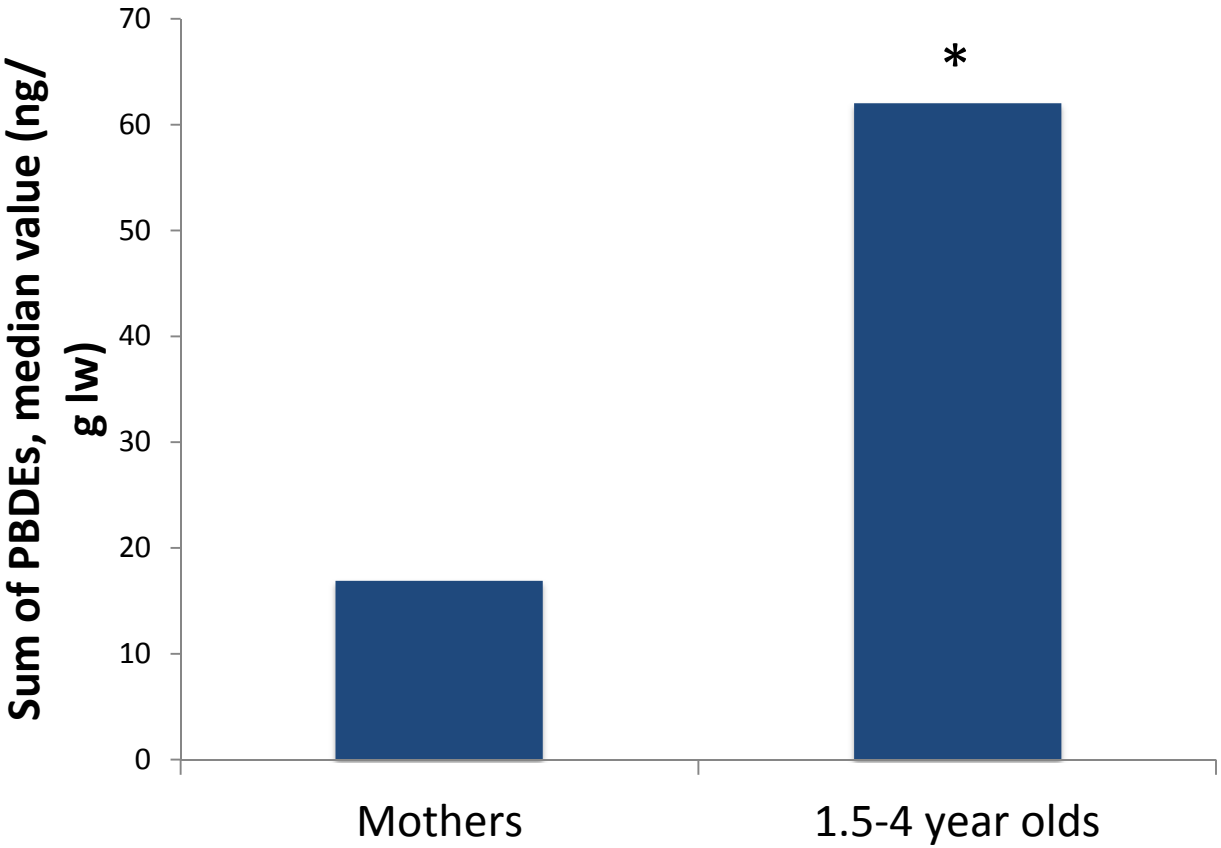
Exposure in the indoor environment: Product → Emission → **Exposure**



Weschler & Nazaroff, 2008; Weschler 2012; Rudel 2003

Why dust?

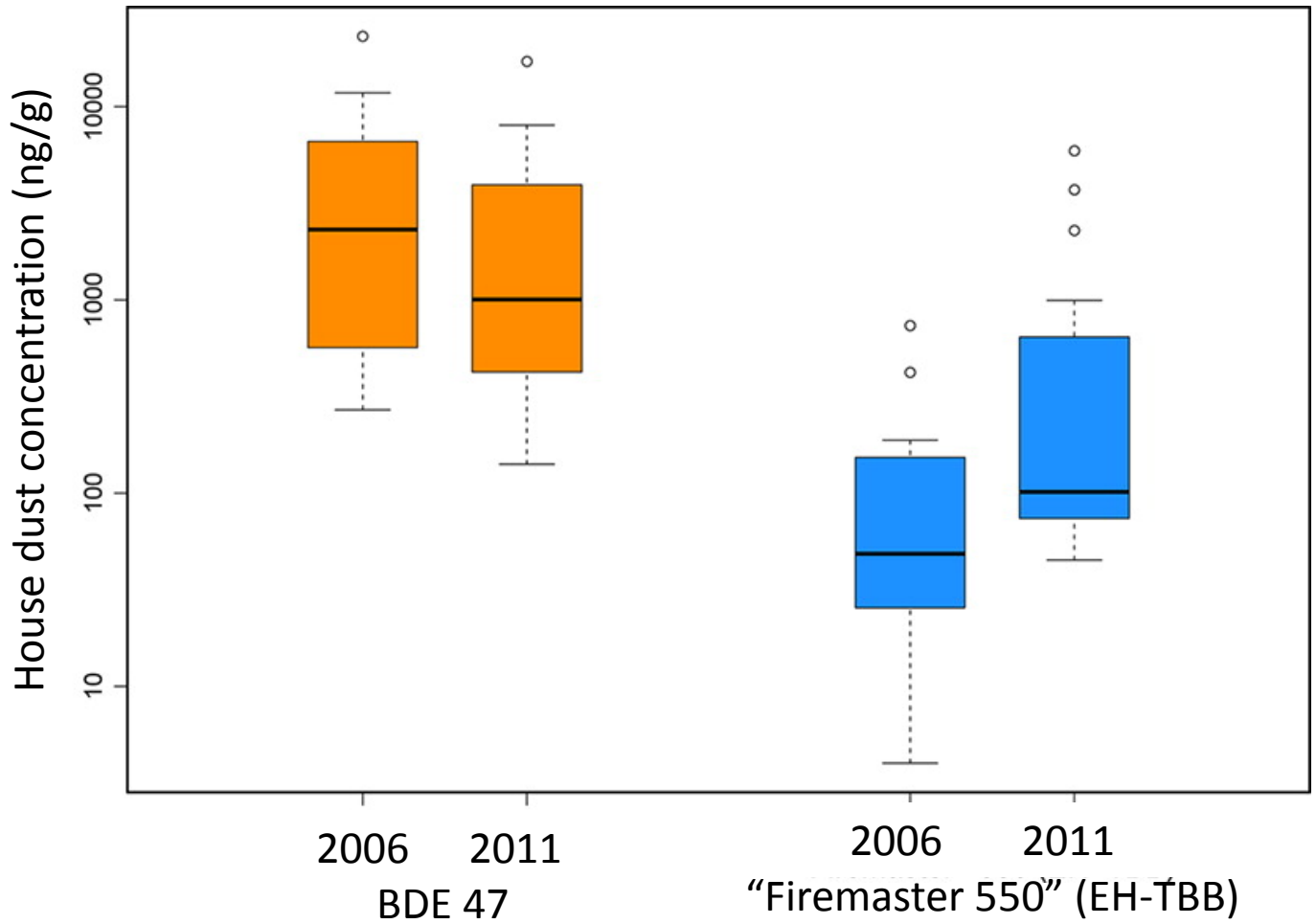
Young children vulnerable to exposures from dust



Lunder 2010; Bradman 2012

Why dust?

Informs on a shifting marketplace



Also found:

TDCIPP

TCEP

TCIPP

TPHP

HBCD

DBDPE

BTBDE

-

-

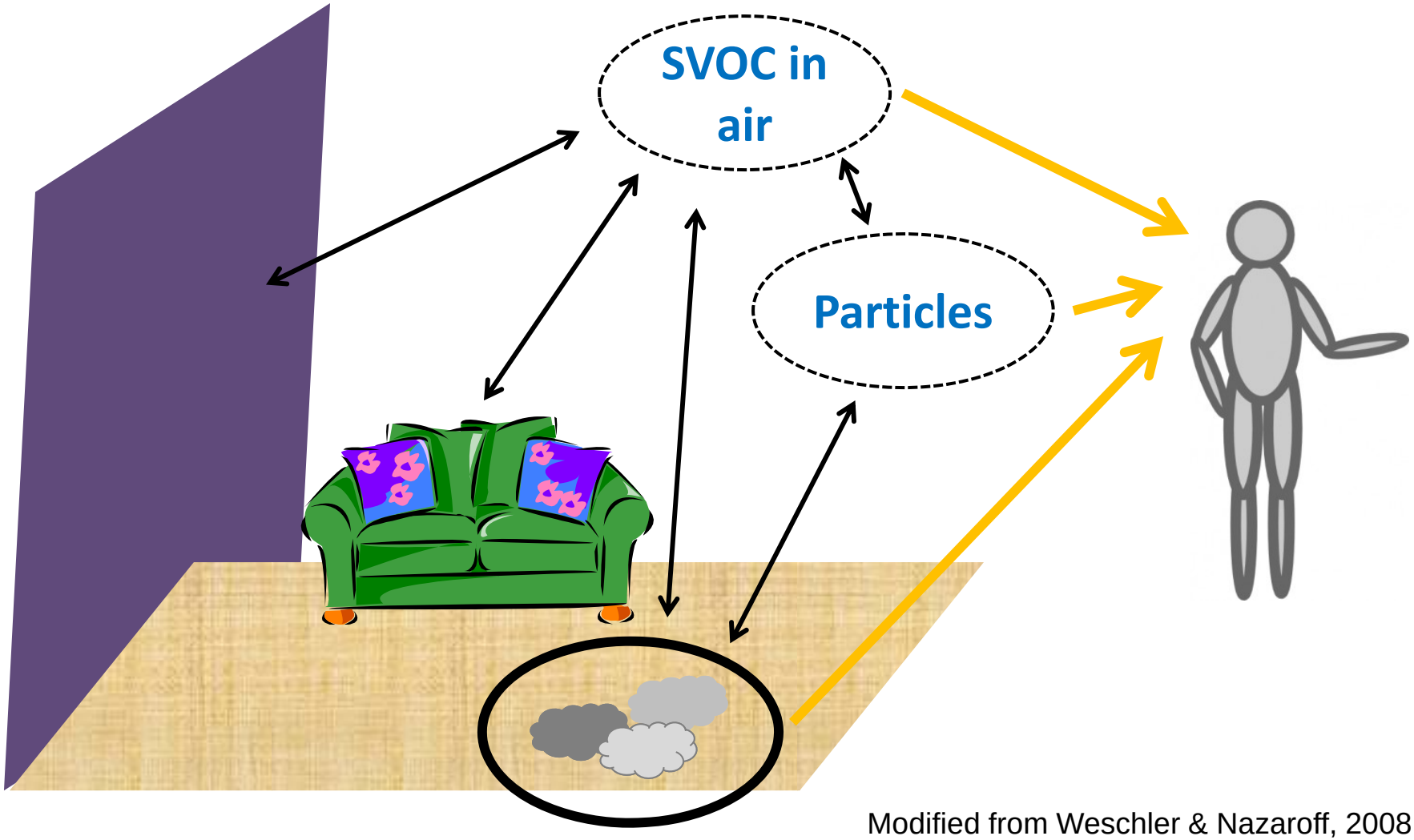
-

Dodson 2012

Why dust?

Reservoir for SVOC chemicals in indoor environment

Pathways for human exposure



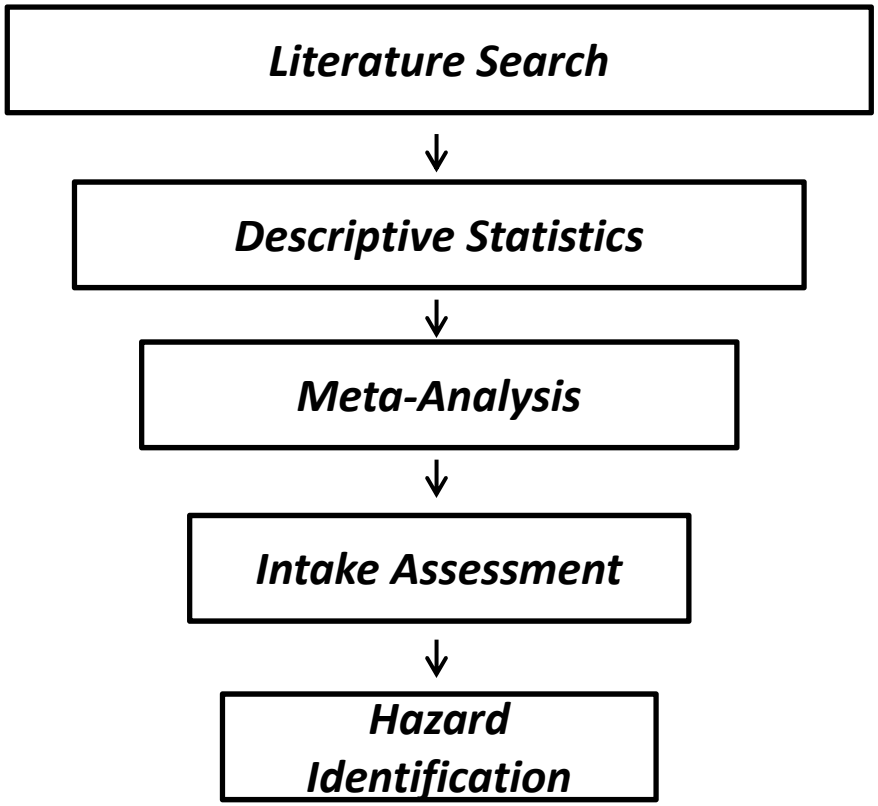
Modified from Weschler & Nazaroff, 2008

Consumer product chemicals in indoor dust: a quantitative meta-analysis of U.S. studies

Susanna D. Mitro, Robin. E. Dodson, Veena Singla, Gary Adamkiewicz, Angelo F. Elmi, Monica K. Tilly, Ami R. Zota

Environmental Science & Technology, 2016

Our approach



Criteria

- SVOC consumer product chemicals
- Current use
- Dust from U.S. indoor environment
- Vacuum cleaner collected

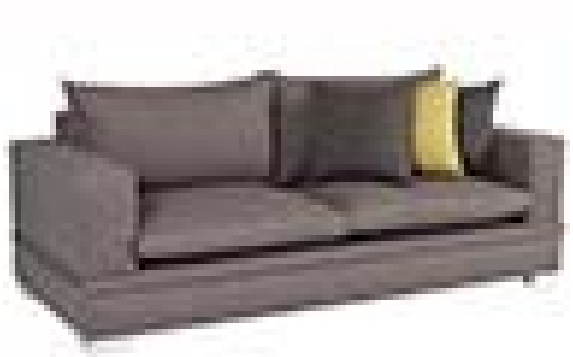
5 SVOC consumer product chemical classes

Phthalates and alternatives

Environmental phenols

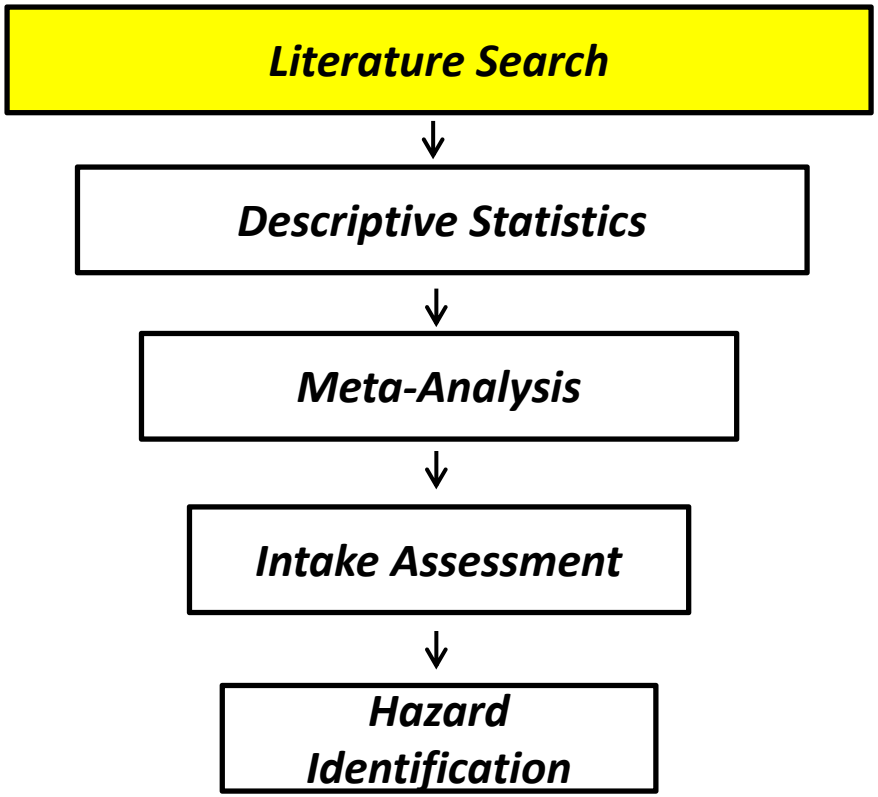
Fragrance

Replacement flame retardants



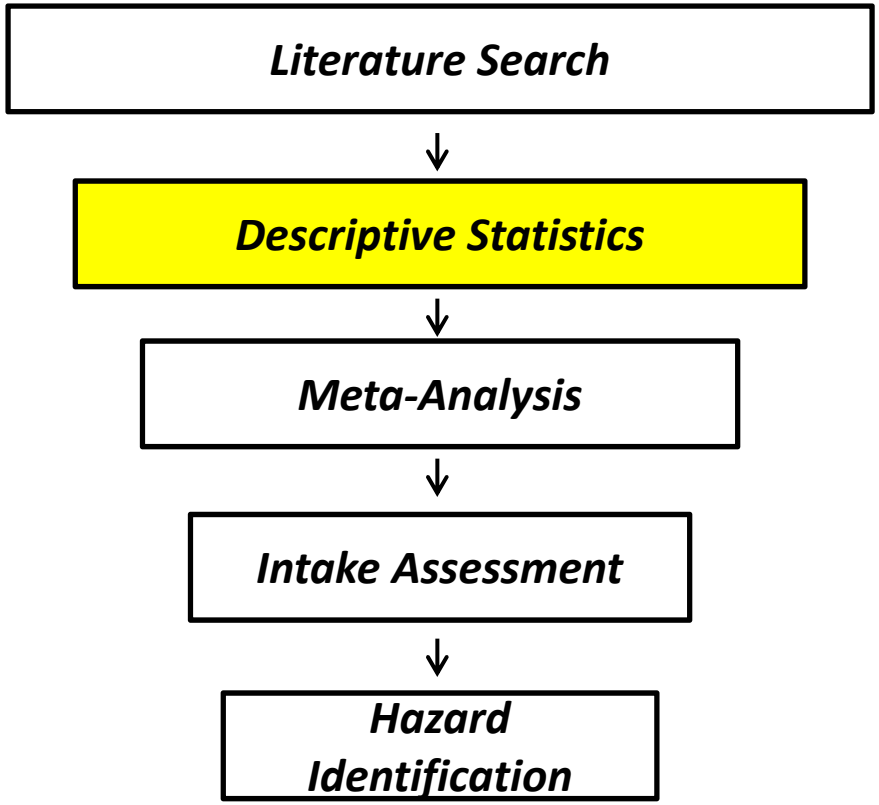
Fluorinated chemicals (PFAS)

Systematic literature search: **172 chemicals**

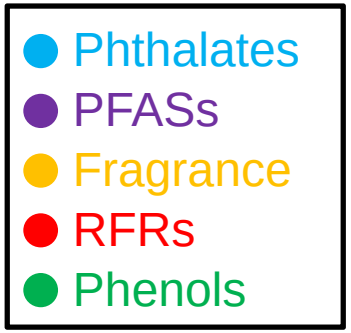


- 31 studies
- Phenols, flame retardants = classes with most unique chemicals

Descriptive info and statistics: **74 chemicals**



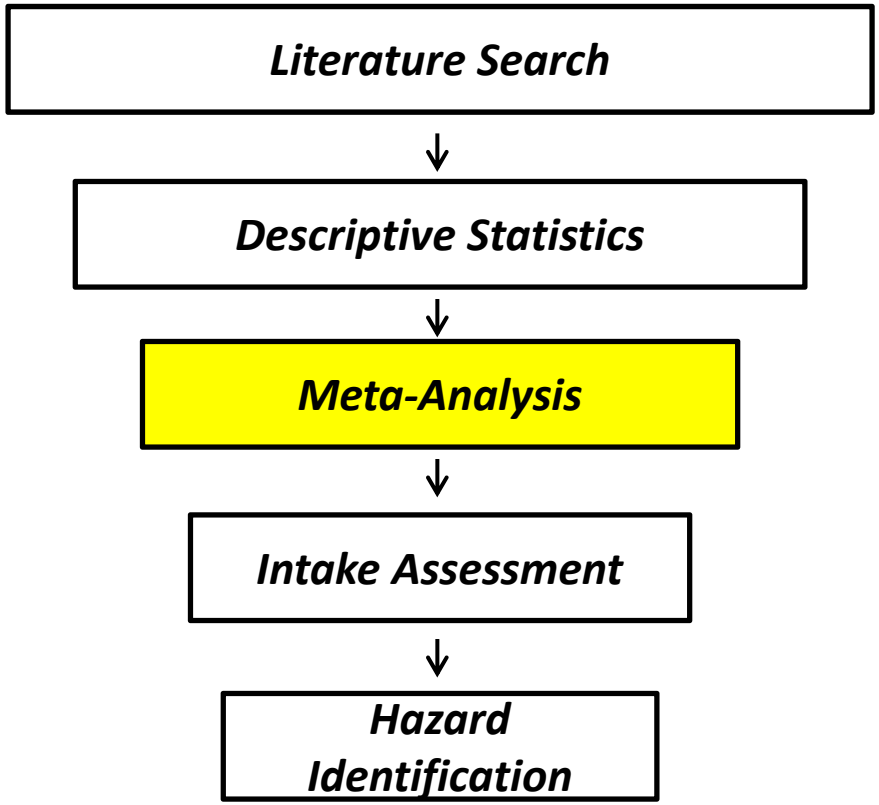
- Chemicals measured in ≥2 datasets
- 96% fragrances measured in only 1 dataset



Descriptive information

- Geographic location, type of indoor environment
- Dust sieve size
- Storage container
- Storage temperature
- Analytical method
- QA/ QC
  - SRM, internal standard, lab blank, field blank

Meta-analysis: **45 chemicals**



- Chemicals measured in ≥3 datasets
- Geometric Mean (GM) and Geometric Standard Deviation (GSD) available
- Calculated pooled GM and 95% Confidence Interval

- Phthalates
- PFASs
- Fragrance
- RFRs
- Phenols

45 chemicals in meta-analysis: **flame retardants**

	RFRs	PFASs	Phenols	Phthalates	Fragrance
Chlorinated Tris	TCIPP	8:2 FTOH	NP2EO	DEHP	HHCB
	TDCIPP	PFOS	4-NP	BBzP	
	TCEP	PFOA	NP1EO	DnBP	
Firemaster ingredients	TPHP	PFHxS	MeP	DEHA	
	EH-TBB	PFNA	OP2EO	DiBP	
	BEH-TEBP	PFHpA	OP1EO	DEP	
Tetrabromo-bisphenol-A →	TBBPA	PFDoA	2,4-DHBZON	DnOP	
Building insulation	aHBCDD	PFHxA	BPA	DHP	
	bHBCDD	PFDA	BuP		
	gHBCDD	PFBA	EtP		
	∑HBCDD	PFBS			
DecaBDE replacement →	BTBPE				
	DBDPE				
Dechlorane Plus	aDDC-CO				
	sDDC-CO				

45 chemicals in meta-analysis: **PFASs**

	PFASs	Phenols	Phthalates	Fragrance
C10	PFDoA	NP2EO	DEHP	HHCB
C10	PFDA	4-NP	BBzP	
C9 →	PFNA	NP1EO	DnBP	
C8	PFOS	MeP	DEHA	
C8	PFOA	OP2EO	DiBP	
C7 →	PFHpA	OP1EO	DEP	
C6	PFHxS	2,4-DHBZON	DnOP	
C6	PFHxA	BPA	DHP	
C4	PFBS	BuP		
C4	PFBA	EtP		
	8:2 FTOH			

45 chemicals in meta-analysis: **Phenols**

	Phenols	Phthalates	Fragrance
Alkylphenols & ethoxylates	4-NP	DEHP	HHCB
	NP1EO	BBzP	
	NP2EO	DnBP	
	OP1EO	DEHA	
	OP2EO	DiBP	
Parabens	MeP	DEP	
	EtP	DnOP	
	BuP	DHP	
	BPA		
	2,4-DHBZON		

45 chemicals in meta-analysis: **Phthalates** and **Fragrance**

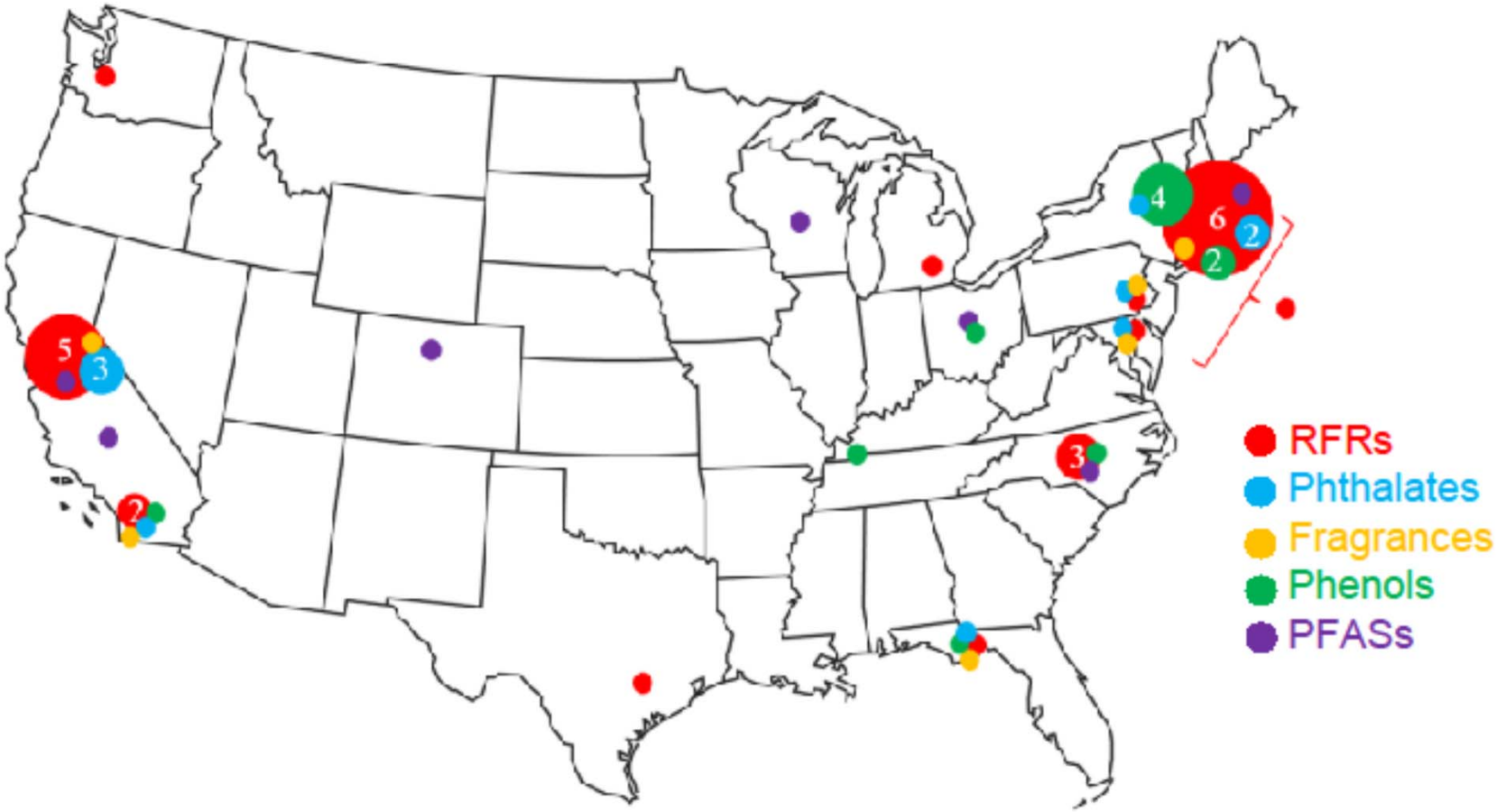
Phthalates	Fragrance
DEHP	HHCB
BBzP	
DnBP	
DiBP	
DEP	
DnOP	
DHP	
DEHA	

Galoxilide
Synthetic musk

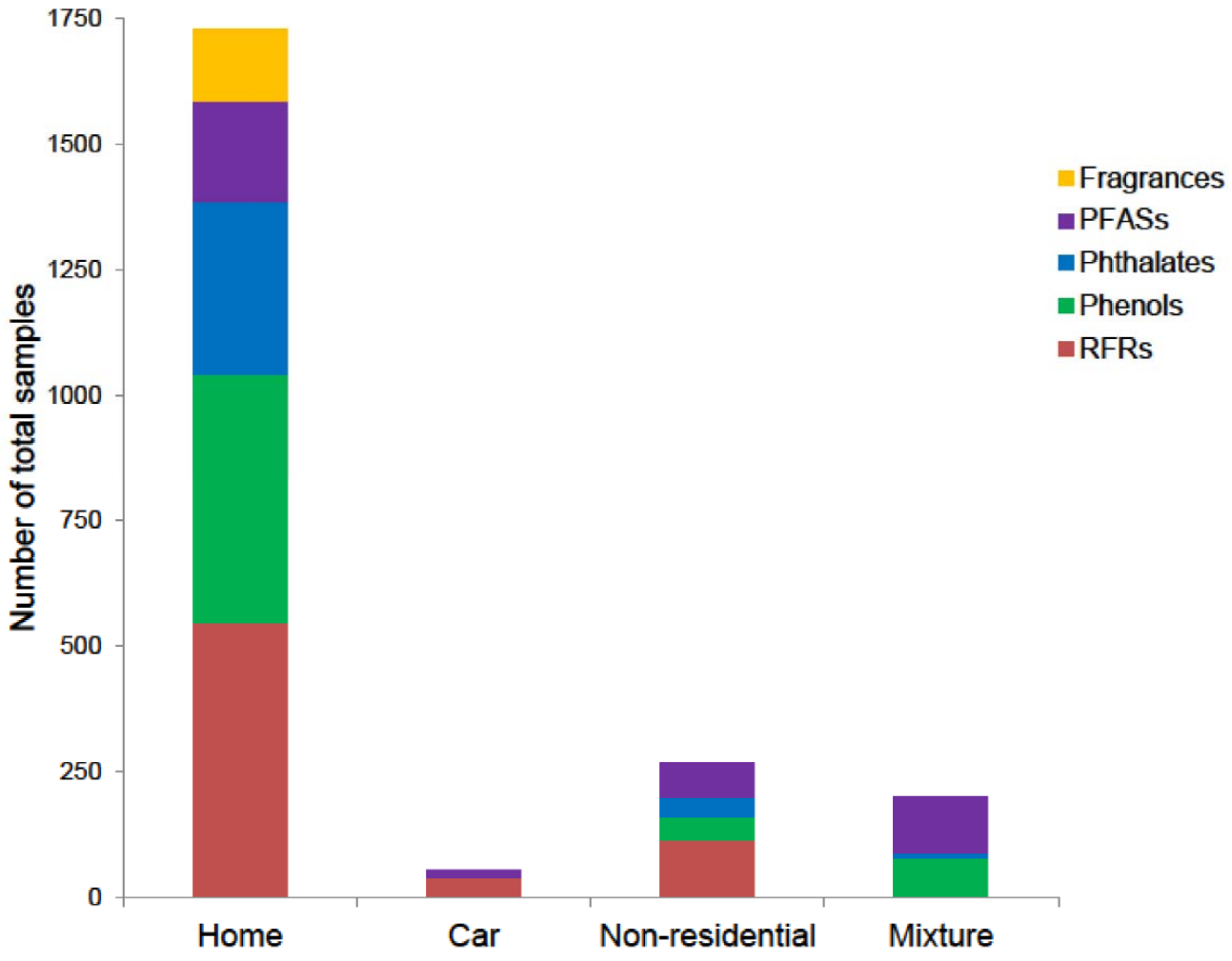
Ortho-phthalates

Phthalate alternative: adipate

Samples taken in 14 states



Samples mostly from home environments

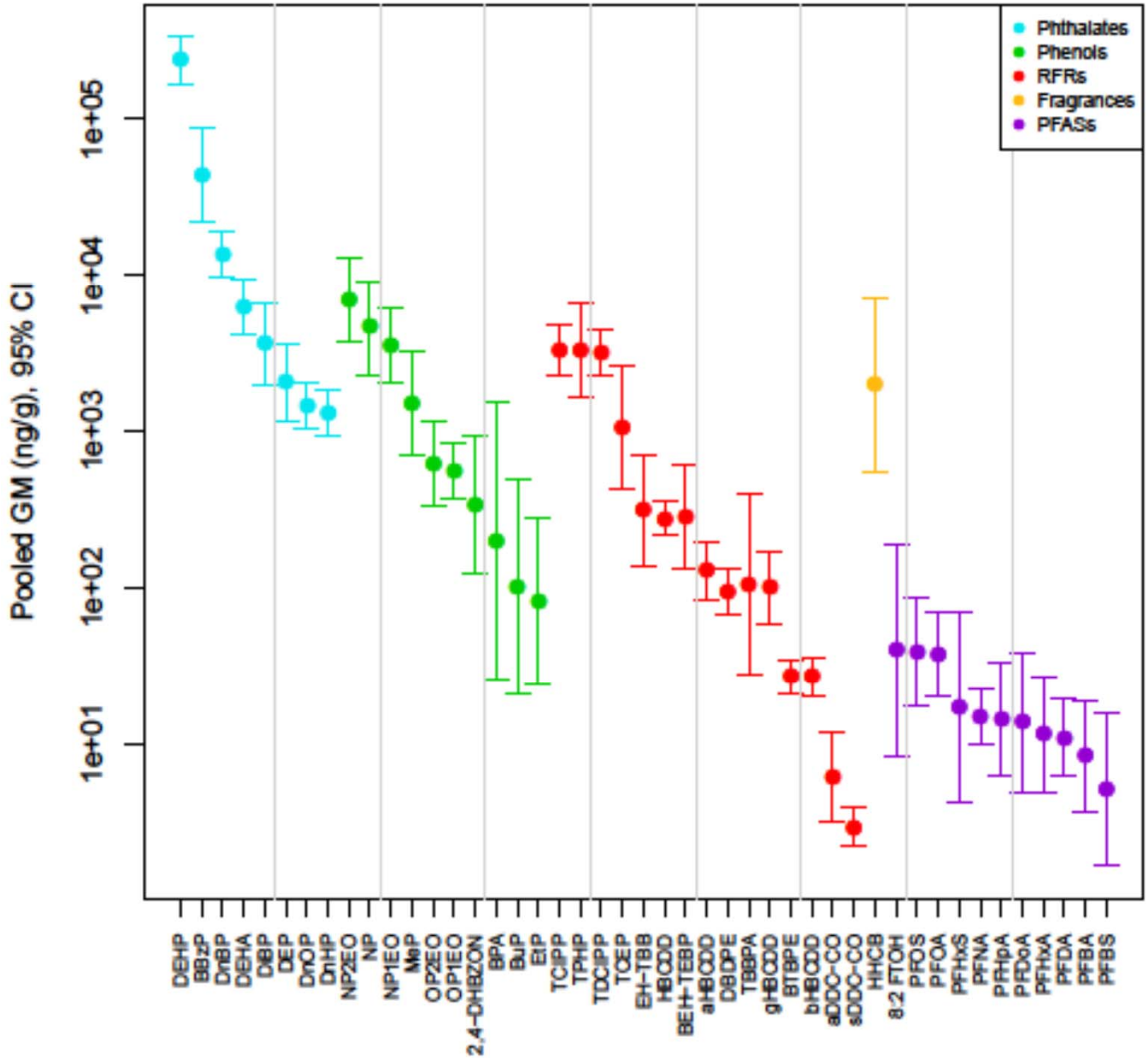


Ten chemicals consistently detected across data sets

Chemical	# datasets	Detected
DEHP	8	100%
DEHA	4	100%
HHCB	3	100%
BBzP	8	98-100%
TPHP	8	98-100%
TDCIPP	14	95-100%
DnBP	7	95-100%
DiBP	7	95-100%
HBCDD (and isomers)	10	92-100%
MeP	3	90-100%

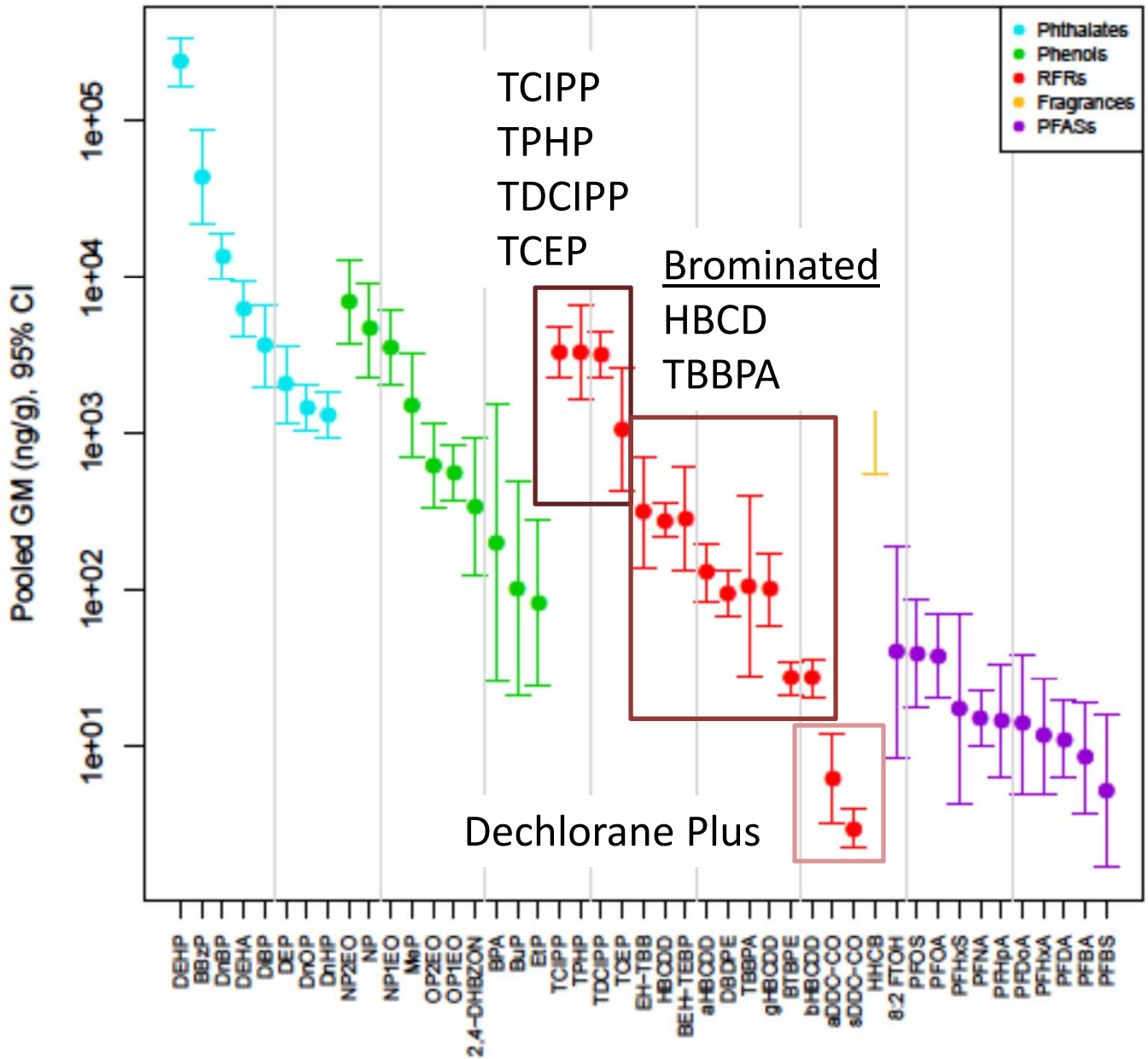
- RFRs
- Phthalates
- Fragrance
- Phenols

Average concentrations in dust



- Phthalates
- Phenols
- RFRs
- Fragrance
- PFASs

Average concentrations in dust



- Phthalates
- Phenols
- RFRs
- Fragrance
- PFASs

Flame retardant concentrations affected by **sieve size** and **type of environment**

- >150 uM sieve = higher **DBDPE** concentrations
- **TDCIPP** and **EH-TBB** concentrations higher in non-residential environments

Intake Assessment

Literature Search

↓

Descriptive Statistics

↓

Meta-Analysis

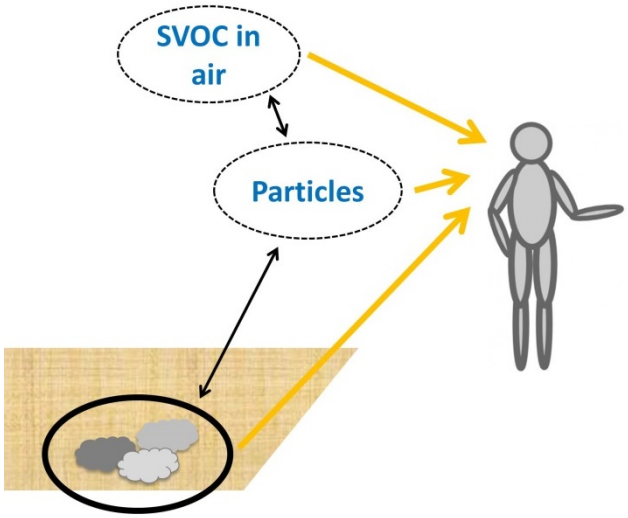
↓

Intake Assessment

↓

Hazard Identification

- Estimated total residential intake
- Adult female
- Child (3-6 years old)

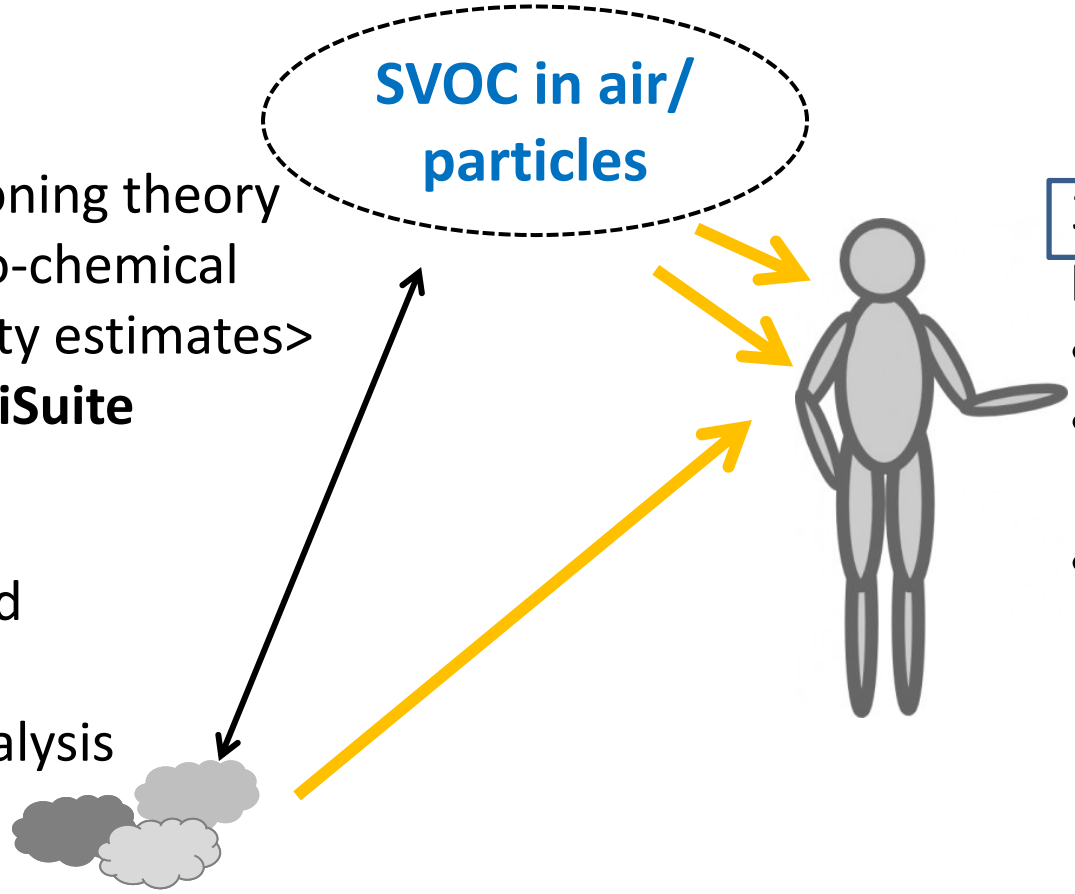


Intake Estimates: **44 chemicals**

2

- Partitioning theory
- Physico-chemical property estimates> **EPA EpiSuite**

1 Pooled GM from meta-analysis

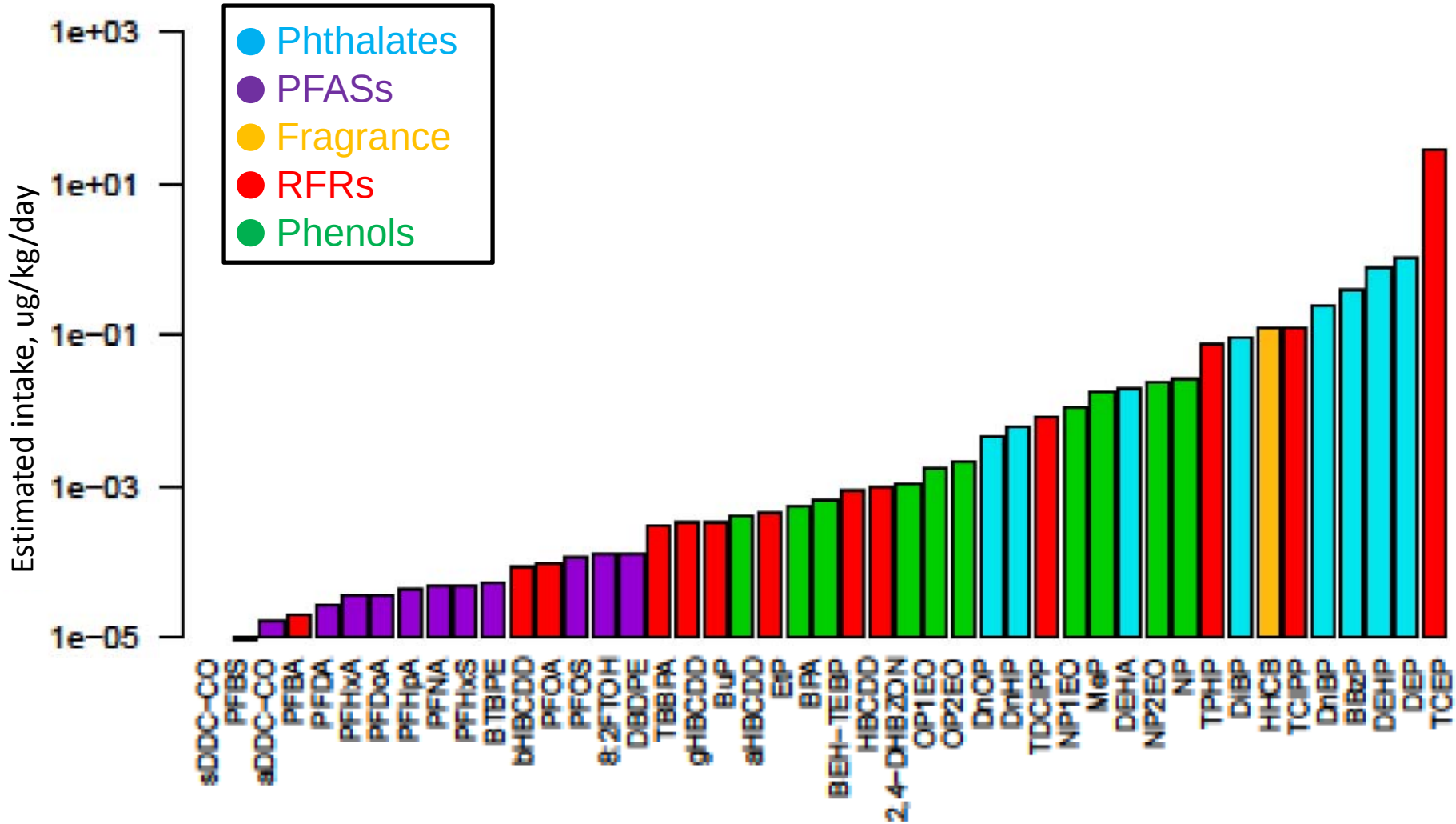


3 **EPA Exposure Factors** Handbook

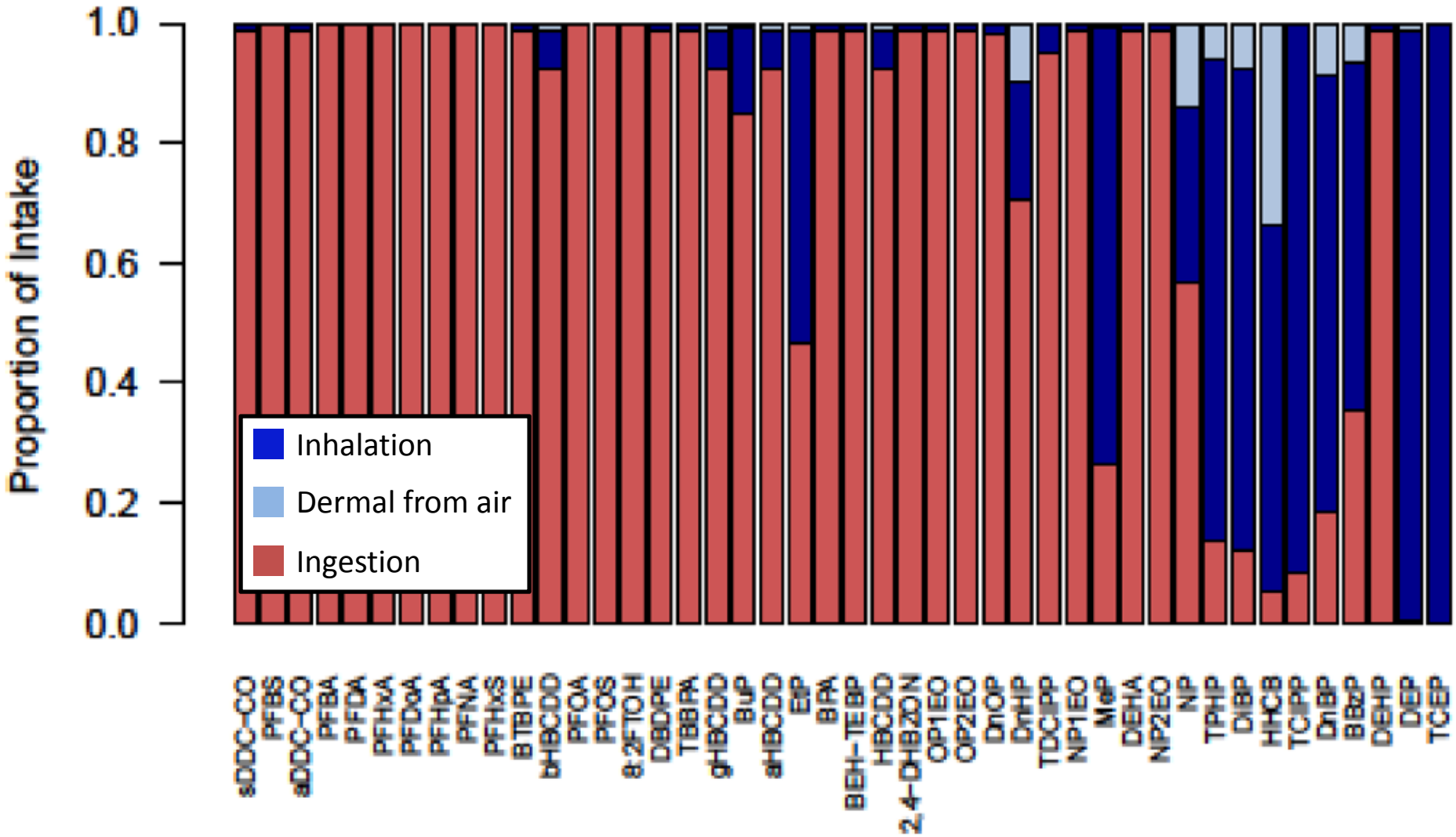
- Inhalation
- Dermal from gas phase
- Dust ingestion

***PFAS**: dust ingestion only*

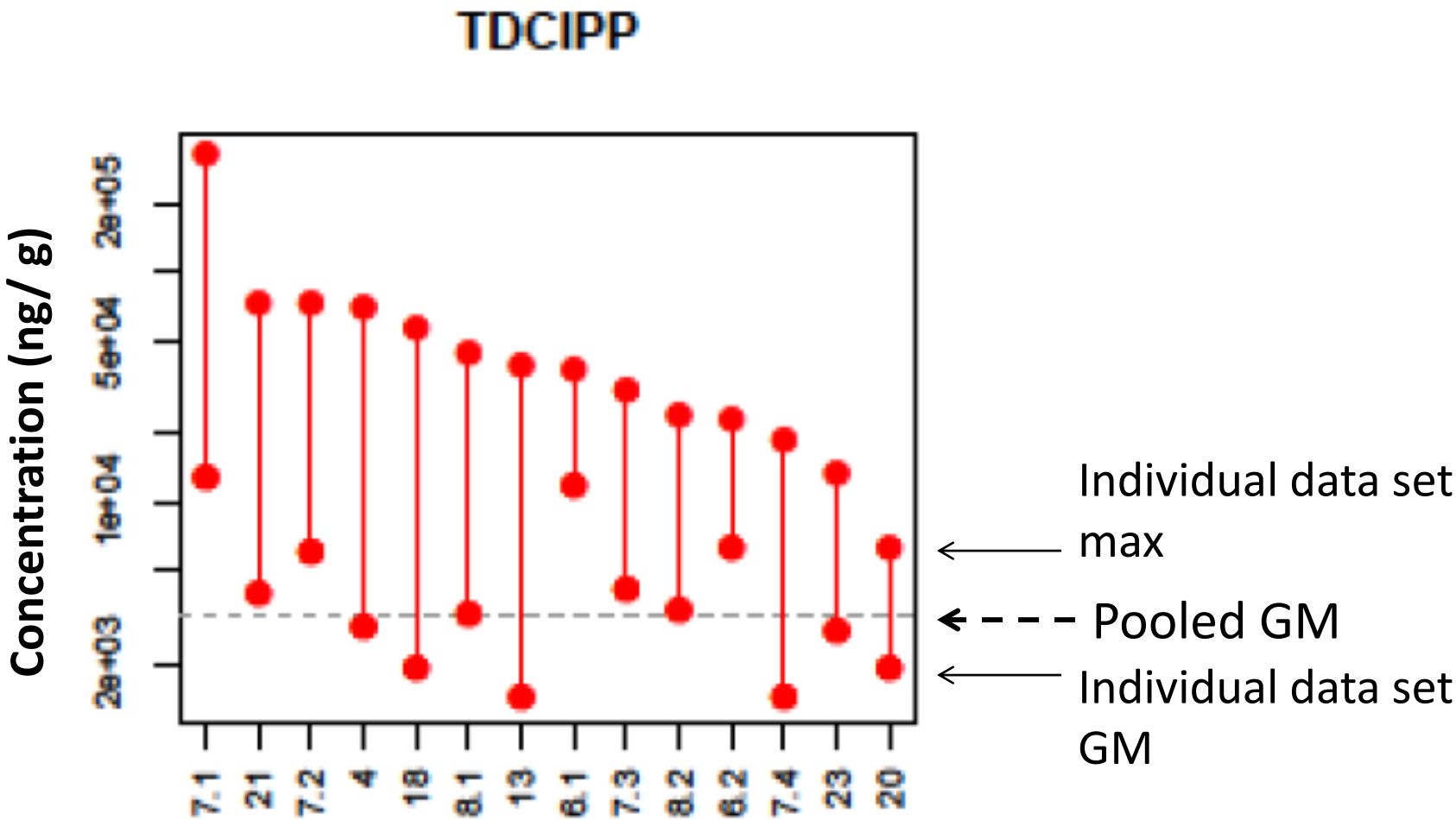
Child: Highest estimated residential intake of **flame retardants and phthalates**



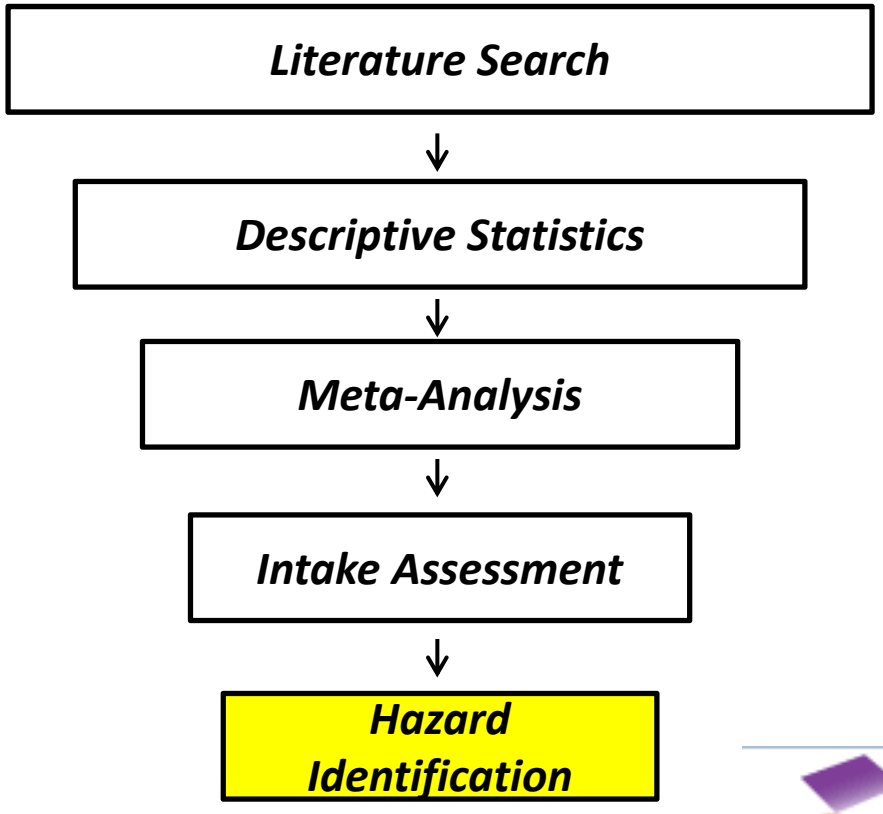
Indoor air drives higher intake estimates



Significantly **greater exposures** for some populations



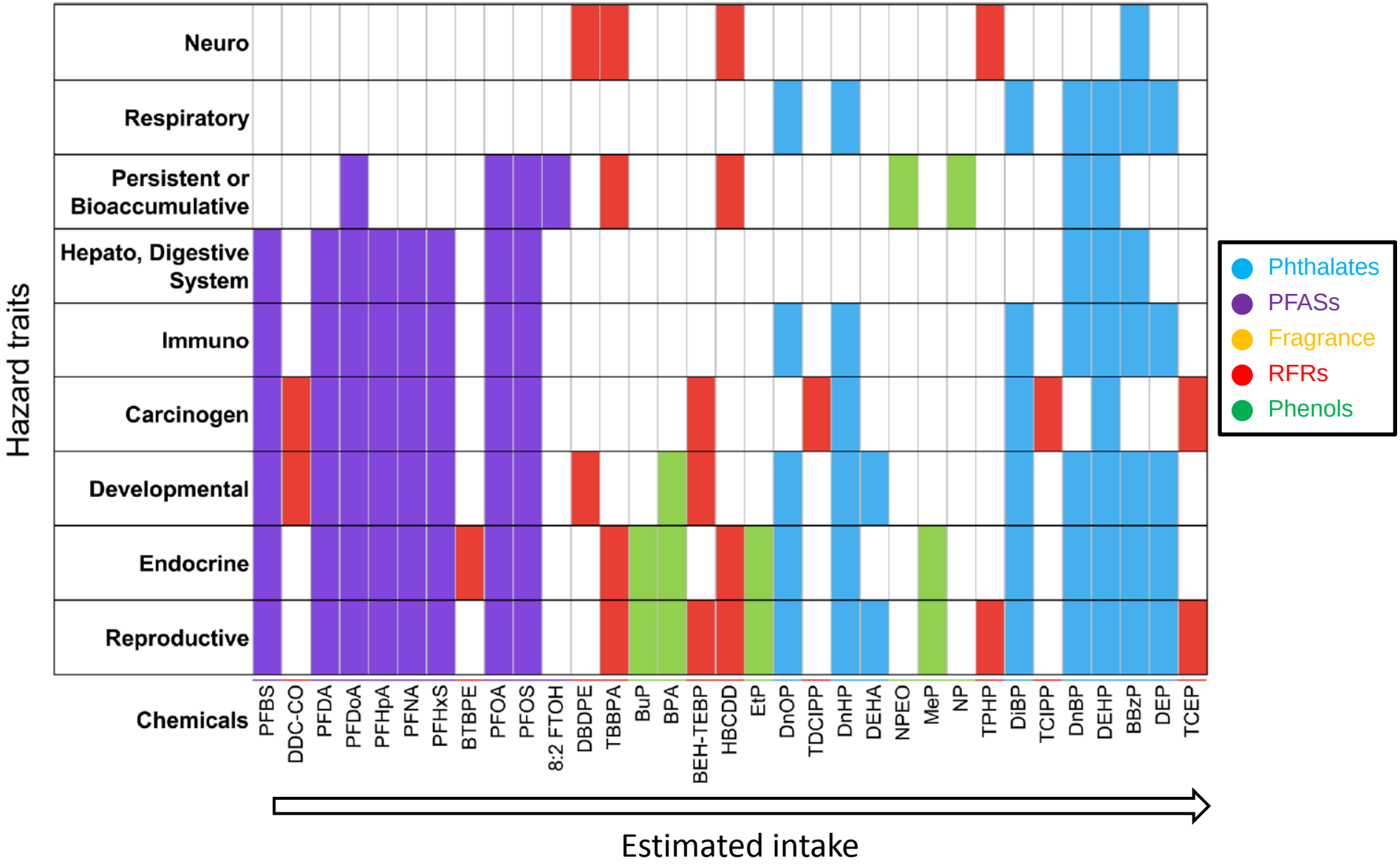
Hazard Identification: **35 chemicals**



- California Safer Consumer Products Candidate Chemical list
- Hazard traits identified by authoritative bodies

CalSAFER
SAFER CONSUMER PRODUCTS INFORMATION MANAGEMENT SYSTEM

Common hazards: **Repro, endocrine, developmental toxicity**

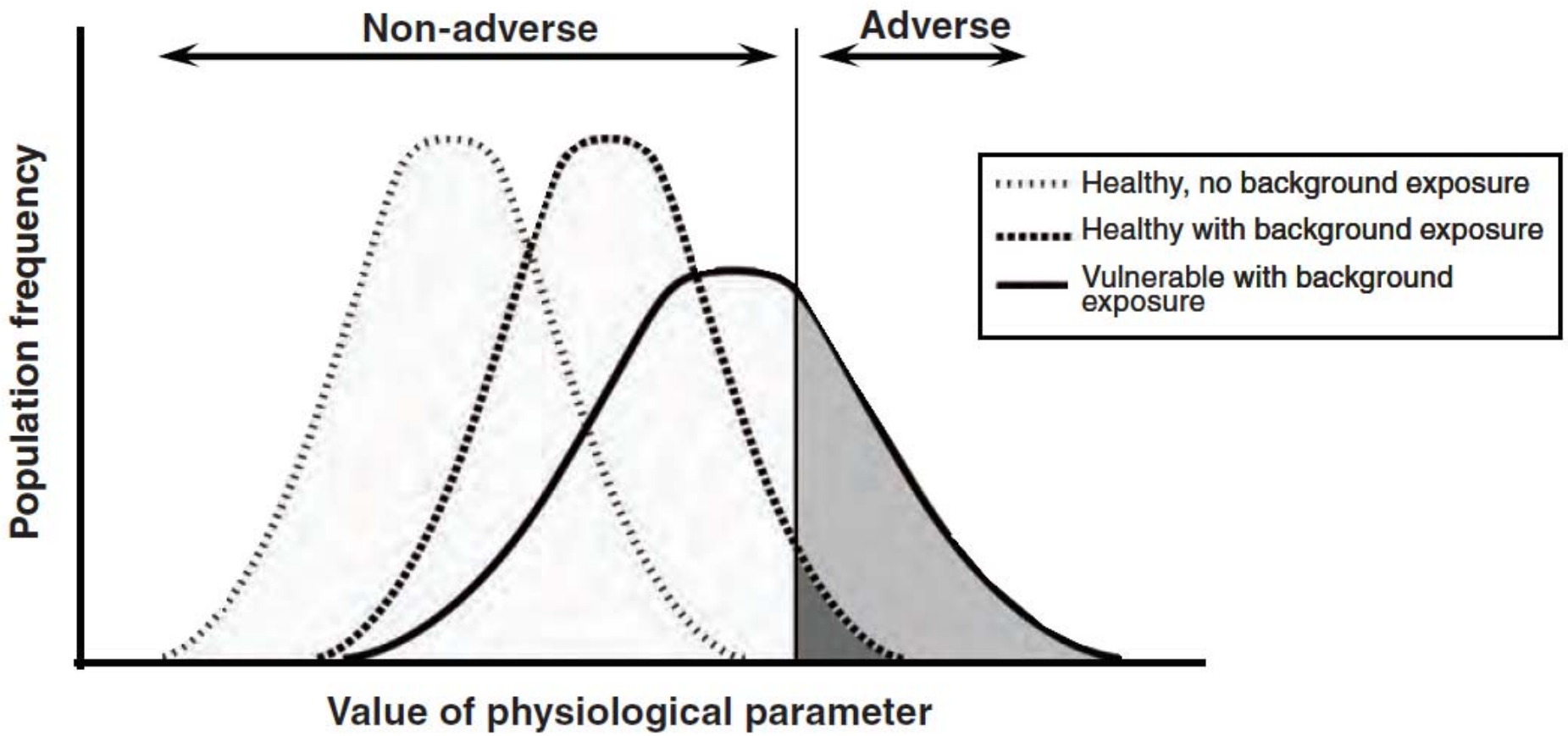


Cumulative exposure concerns

- Chemicals from the same class
  - ***Ortho*-phthalates** (Gennings 2014)
  - **Fluorinated chemicals** (Borg 2013)
  - **Brominated flame retardants** (Berger 2014)

- Mixtures of chemicals
  - Anti-androgenic (Kortenkamp 2010)
  - SVOC chemicals in dust (Fang 2015)

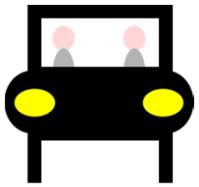
Indoor environments consistent sources of "background exposures"



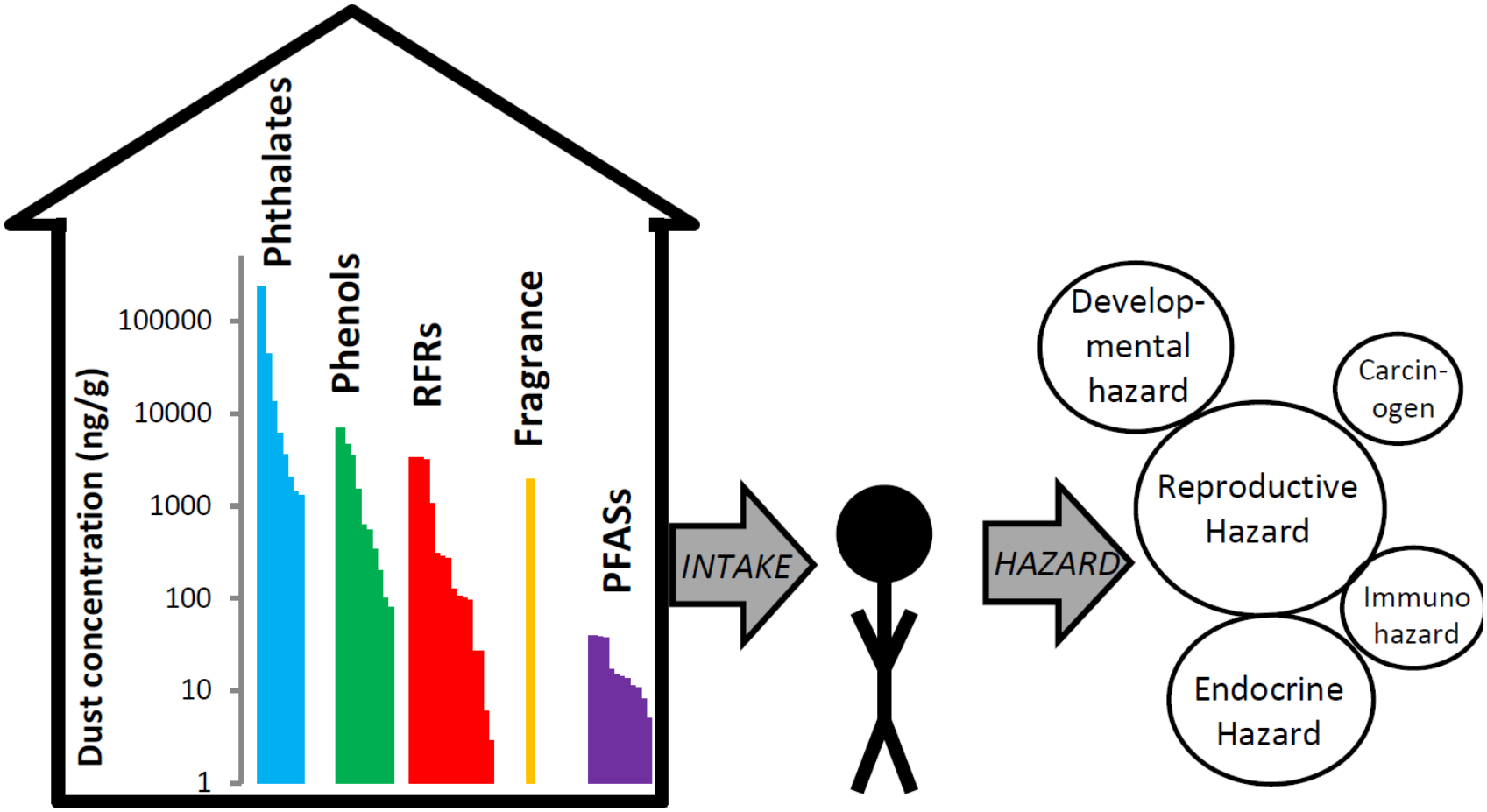
National Research Council, 2009

Recommendations for indoor dust studies

- Standard collection methodology (ASTM D5438)
- Demographic data
- Geographic diversity
- More study needed on:
  - Non-residential– cars, workplaces, etc.
  - Fragrances
  - Phenols
  - Non-targeted analysis
- Longitudinal studies



Summary


Dust concentration (ng/g)
100000
10000
1000
100
10
1
Phthalates
Phenols
RFRs
Fragrance
PFASs
INTAKE
HAZARD
Develop-
mental
hazard
Carcin-
ogen
Reproductive
Hazard
Immuno
hazard
Endocrine
Hazard

Summary

- **Phthalates**– highest dust levels, high estimated intakes, multiple hazards
- "Regrettable substitute" **phthalates**, **flame retardants**, **phenols** and **PFASs**
- Daily co-exposure to multiple chemicals in indoor environment
- Concern for cumulative exposures and impacts

Future directions

- Intervention studies
- Connections to particular products, building materials
- Safer alternatives > avoid regrettable substitutes

THANK YOU

Special thanks to:

- June-Soo Park
- Erika Houtz
- Miaomiao Wang
- Martin Snider
- Reber Brown
- Sissy Petropoulou