Biomonitoring in NHANES – Recent Advances and Future Directions

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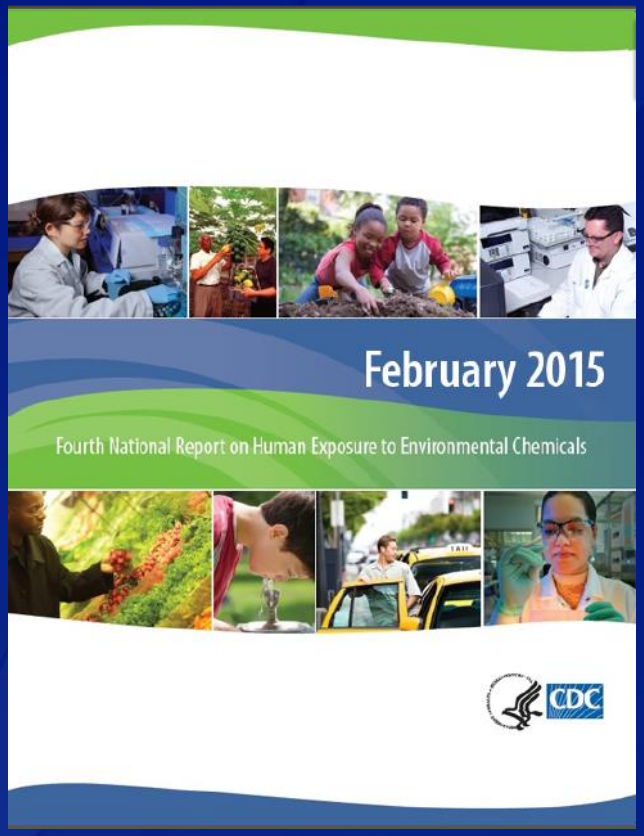
What is NHANES?

- **Annual survey (NCHS, CDC)**
  - US Congress funding
  - Clinical & nutritional data
- **Complex probability sample of civilian, noninstitutionalized US population**
  - Yearly: ~5,000 persons, ~15 counties
  - Results for 2-year cycles (e.g., 1999-2000)
- **Physical examination, collection of medical history, demographic, socioeconomic & behavioral data**
- **Also collects biological specimens**
  - Clinical chemistry tests
  - Nutritional biomarkers & environmental chemicals
  - Link exposure to other data

http://www.cdc.gov/nchs/nhanes.htm

CDC's National Reports on human exposure to environmental chemicals (1999–2012)



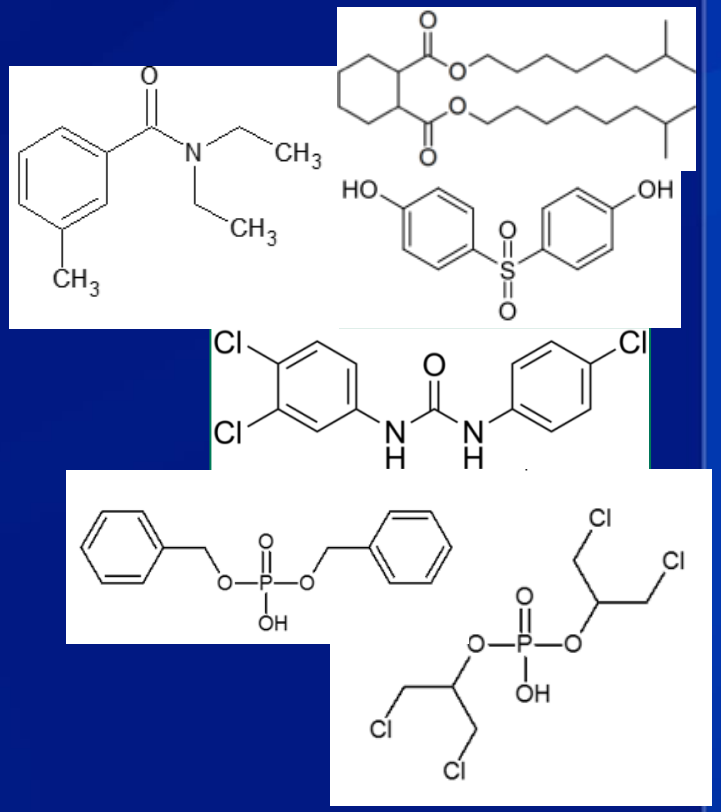
- Metals
- Cotinine
- TSNA
- Dioxins, furans & PCBs
- Organochlorine pesticides
- PBDEs
- PFASs
- Organophosphate & pyrethroid insecticides
- Other pesticides (e.g., herbicides)
- Parabens
- Phthalates & alternative plasticizers
- Phenols (e.g., PCP chemicals)
- PAHs
- Perchlorate, nitrate & thiocyanate
- VOCs

- **NHANES biomonitoring data inform public health policy**

www.cdc.gov/exposurereport

Some NHANES biomonitoring changes ahead

- **Expand portfolio of chemicals**
  - Replacement/alternative chemicals
    - DINCH
  - Other chemicals
    - DEET metabolites
- **Control cost & matrix use**
  - NHANES pools
- **Expand biomonitoring for the young**
  - Urinary data for pre-school aged children



Biomonitoring logistics

- **Limited volume of blood; urine limited by age**

Age (years)	Blood (mL)	Urine
1-2	9	No
3-5	22	Yes
6-11	38	Yes
12+	89-92	Yes

From 2015+

Metals & NPs
Nutrition markers

POPs (12+), Pb, Cd, Hg, Mn & Se (1+), cotinine (3+)
Nutrition markers

- **Randomly selected subsets of participants**
  - Average sample size ~ 2500 people/chemical for each 2-year cycle

http://www.cdc.gov/nchs/data/nhanes/survey_content_99_12.pdf

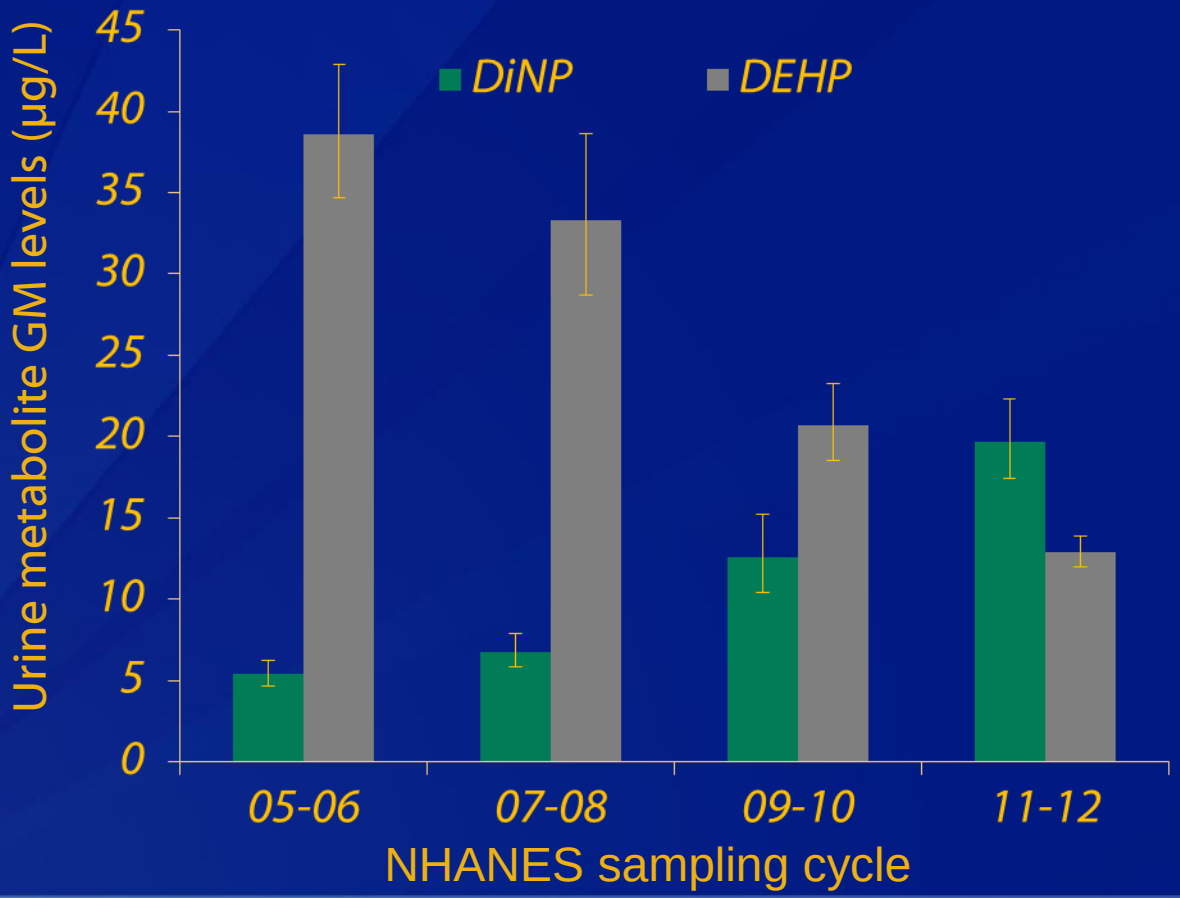
Exposure to phthalates in NHANES

Diester	Metabolite	99–00	01–02	03–04	05–––10	11–12
DEP	MEP	X	X	X	X	X
DBP	MBP	X	X	X	X	X
DiBP	MiBP		X	X	X	X
BBzP	MBzP	X	X	X	X	X
DEHP	MEHP	X	X	X	X	X
	MEHHP		X	X	X	X
	MEOHP		X	X	X	X
	MECPP			X	X	X
DiNP	MCOP				X	X
	MNP	X	X	X	X	X
DiDP	MCNP				X	X
DINCH	OH-MINCH					X

www.cdc.gov/exposurereport

Americans' exposure to phthalates is changing

- Some exposures increased: DiNP (↑265%)
- Other exposures decreased: DEHP (↓-67%)
  - Legislative actions and public scrutiny



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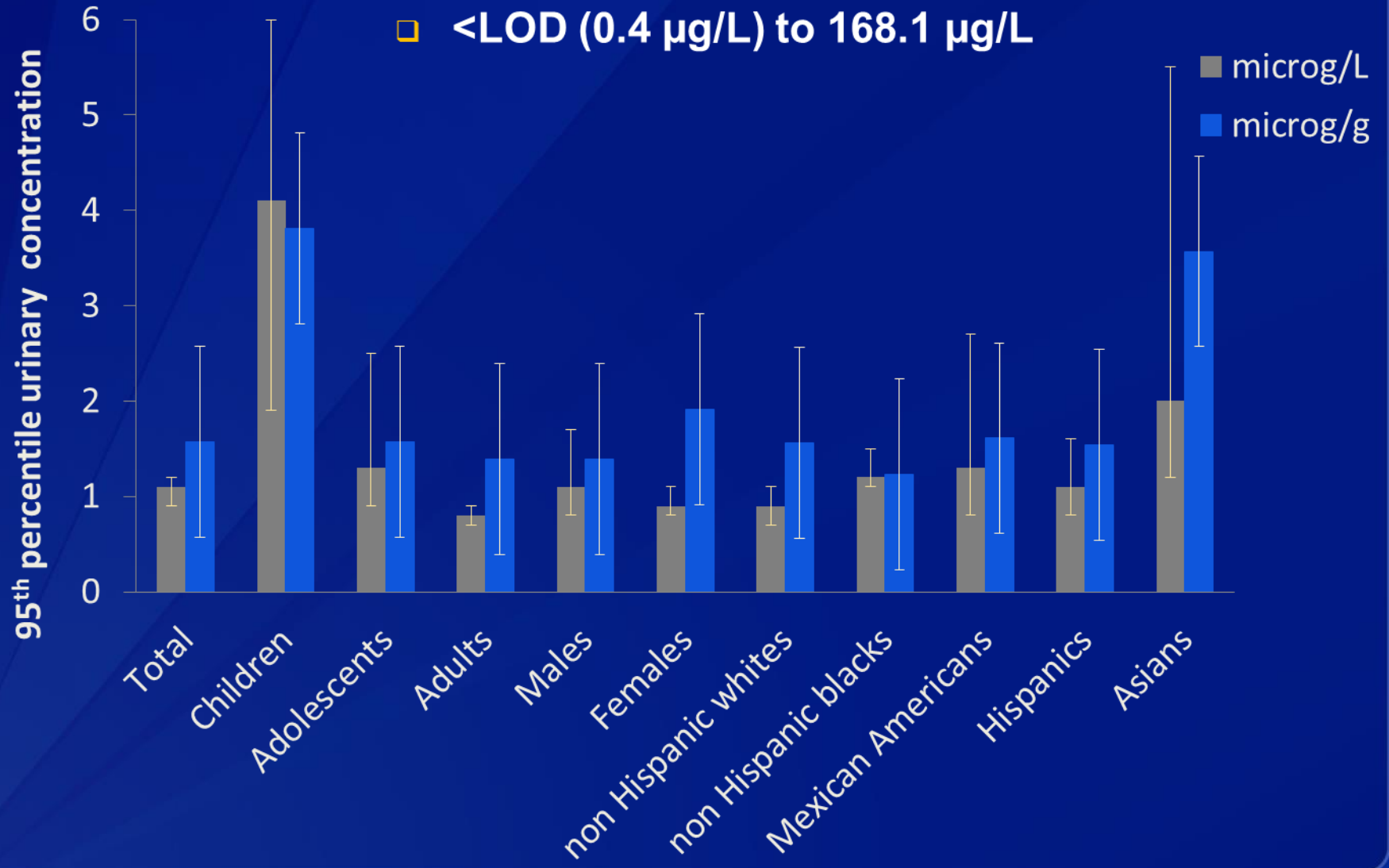
DINCH exposure: NHANES 2011–2012



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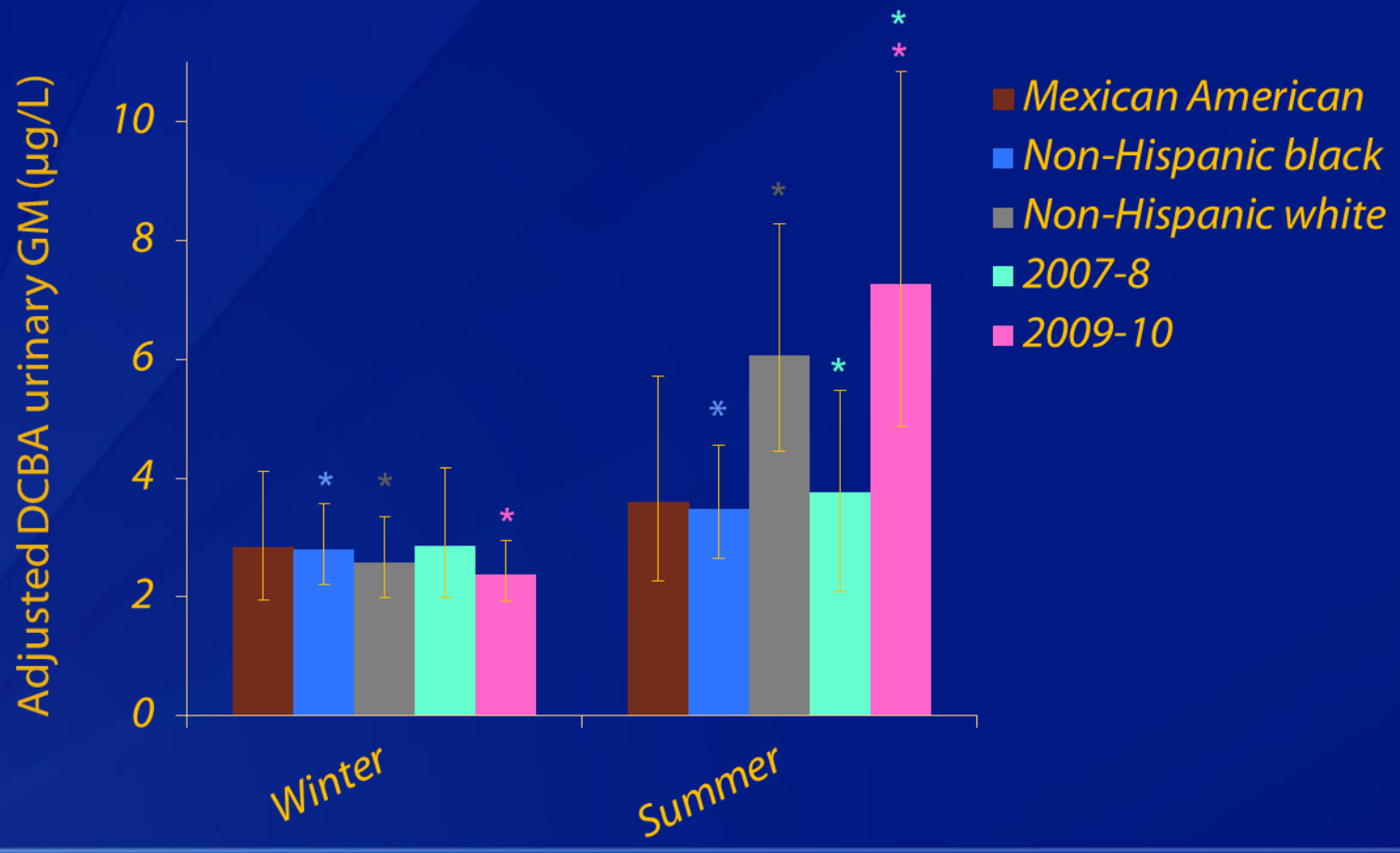
Exposure to DEET (NHANES 2007–2010)

- Eighty four percent of Americans exposed
- Higher concentrations in summer vs winter



Calafat et al. Environ Int 2016. In press

Non-Hispanic whites are among the most exposed to DEET

Independent variable		Odds ratio (95% CI)
Race by season	Mexican American: Summer vs winter (ref)	1.13 (0.26-4.87)
	Non-Hispanic black: Summer vs winter (ref)	1.67 (0.80-3.46)
	Non-Hispanic white: Summer vs winter (ref)	10.83 (3.28-35.79)
Season by race	Winter: Mexican American vs Non-Hispanic black (ref)	1.32 (0.59 -3.00)
	Summer: Mexican American vs Non-Hispanic black (ref)	0.90 (0.26 -3.07)
	Winter: Non-Hispanic white vs Non-Hispanic black (ref)	0.53 (0.19- 1.49)
	Summer: Non-Hispanic white vs Non-Hispanic black (ref)	3.45 (1.51-7.87)

Calafat et al. Environ Int 2016. In press

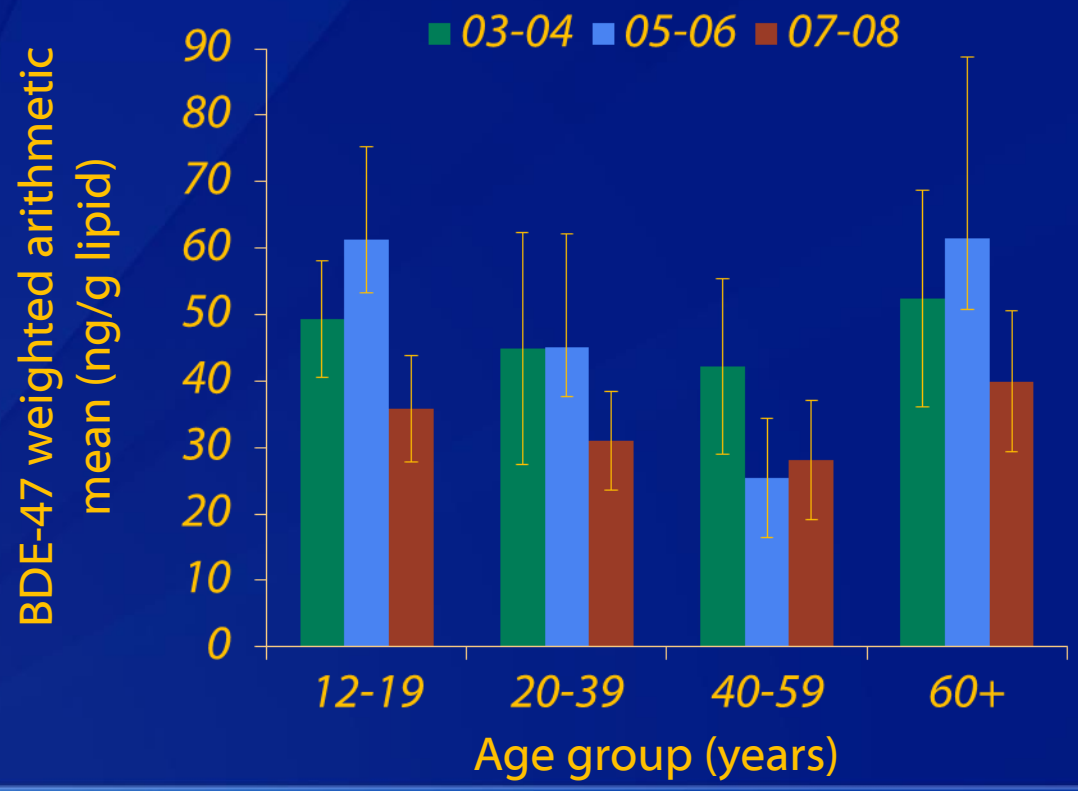
NHANES pools

- **Increase serum volume**
  - **Improve LODs (PCDD/Fs)**
- **Decrease analytical cost**
- **Provide central tendency w/o subject-specific data**
  - Multiple pools/category: 95% CI of the arithmetic mean

	2001–2	2005–6	2007–8
No. pools	78	247	264
Demographic categories	36	32	
Pools/category	2-4	5-23	
Children 3-11 years	Yes	No	
Other race(s)	No	Yes	
Subjects/pool	21-57	8	
Sample weights	No	Yes	

Exposures to PBDEs (NHANES 2003–2008)

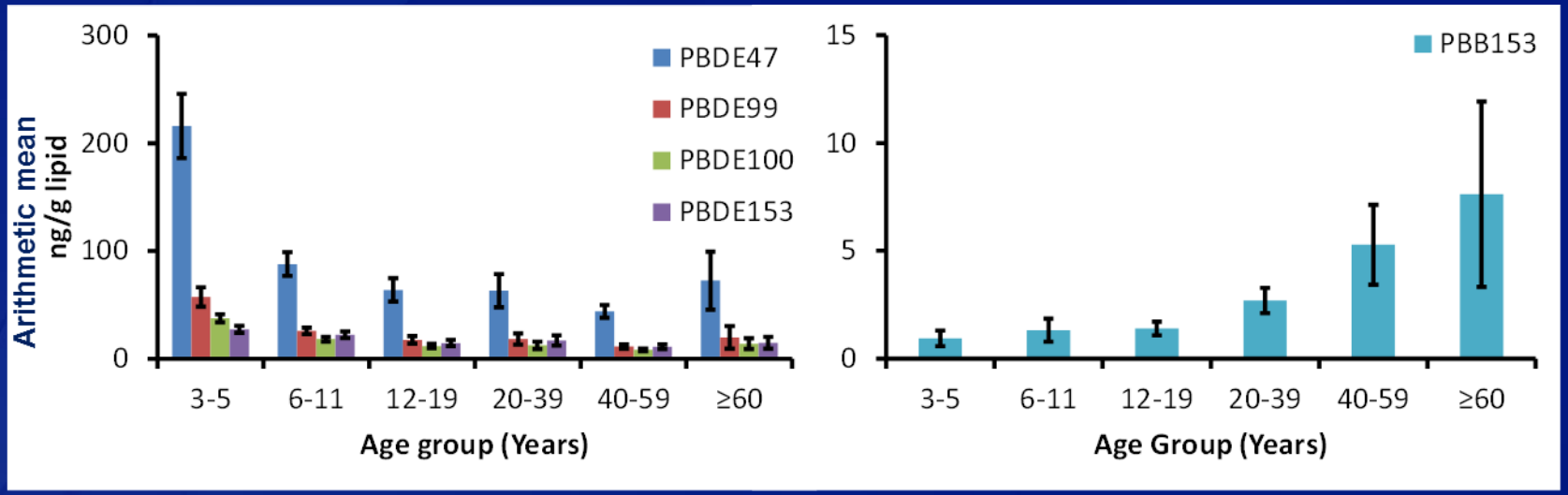
- $[PBDEs]_{2007–2008} < [PBDEs]_{2003–2004}$, but not significant
- Can't detect yet reduction in PBDE serum concentrations following discontinuation of pentaBDE
  - Furniture and other consumer articles have long lifetime



Sjodin et al. ES&T 2014

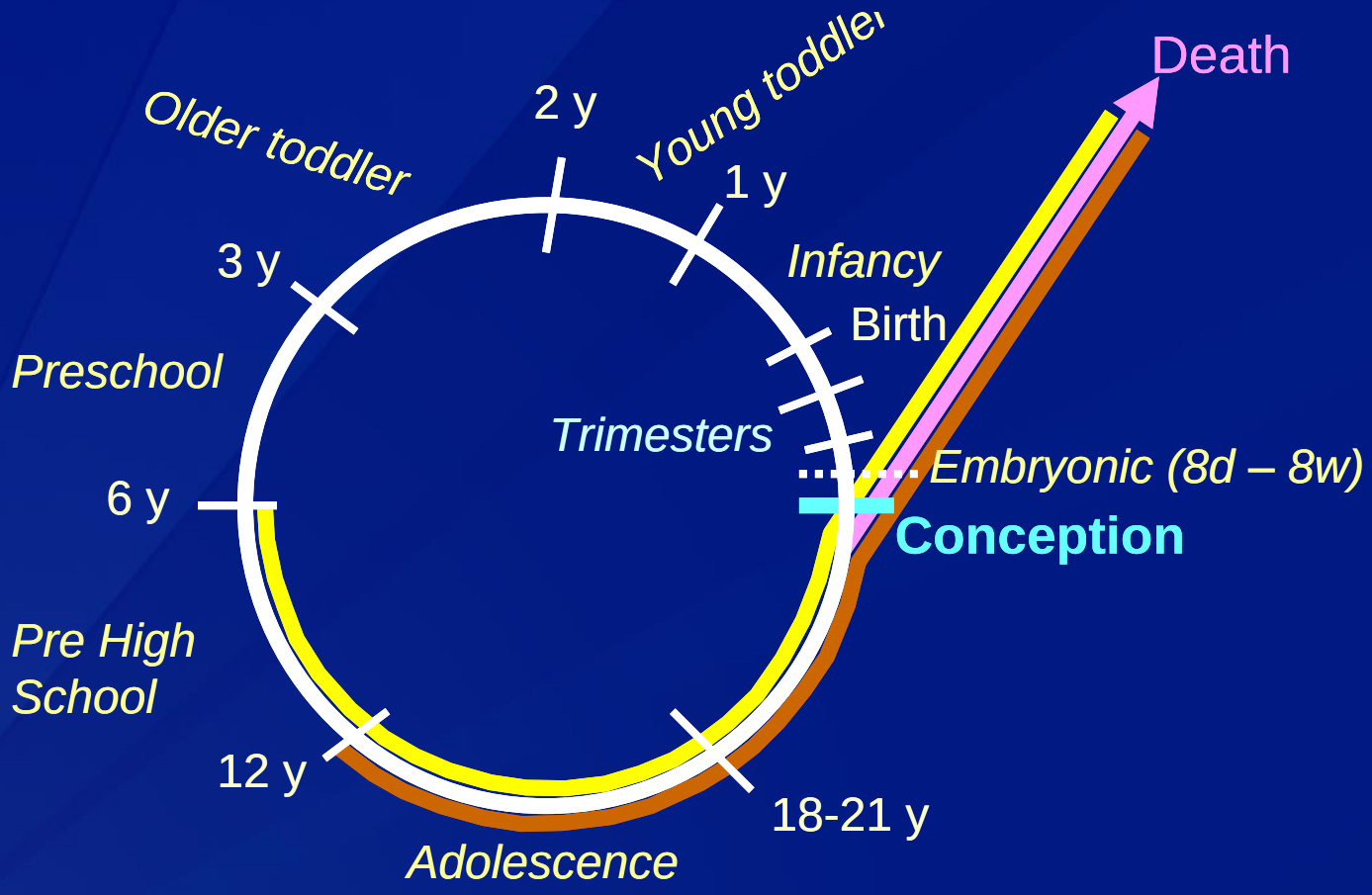
Exposure to POPs (NHANES 2001–2002)

- PBDE concentrations higher (87%-340%) in 3–5 year olds
- Traditional POPs concentrations lower in children (580%, PBB153)
- Distinct exposure sources by age (e.g., food vs dust)



Sjodin et al. ES&T Lett 2014

Importance of early-life exposures

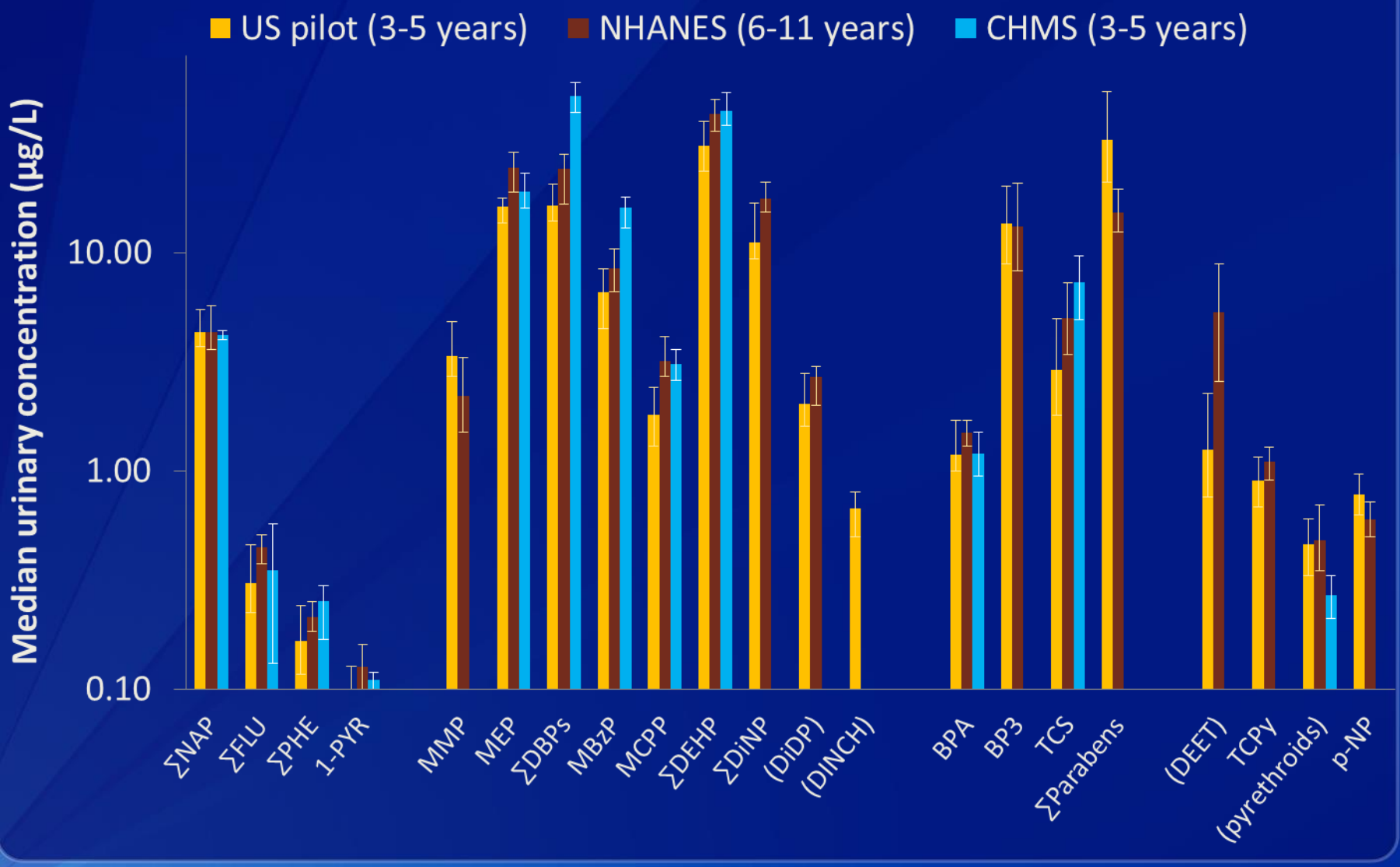


Needham et al. Neurotoxicology 2005

Non-persistent chemicals in pre-schoolers

- **Pilot conducted during 4 months**
  - NHANES 2013–2014
- **Approximately 120 children 3–5 years old**
  - Boys (~70) & girls (~50)
  - Hispanics (~80), non-Hispanic blacks (~20), others (~20)
- **Urine analyzed for 53 select biomarkers**
  - PCP chemicals
    - Phthalates & plasticizers
    - Phenols
    - Parabens
  - Pesticides
  - PAHs
- **Non-representative data**

Similar exposures among North American children



Final thoughts

- **Usefulness of NHANES to inform public health policy**
- **Continue NHANES**
  - Both legacy and replacement/alternative chemicals
    - DINCH
    - BPS, BPF
    - Contemporary flame retardants
  - Other chemicals/approaches
    - DEET metabolites
    - Triclocarban
    - Other phthalates metabolites
    - PFOA/S isomers
- **NHANES pools**
  - But also regular NHANES
- **Include urinary biomonitoring data for pre-schoolers (2015+)**

Acknowledgements

NCEH

NCHS

Our collaborators

THANK YOU!

For more information please contact Centers for Disease Control and Prevention

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