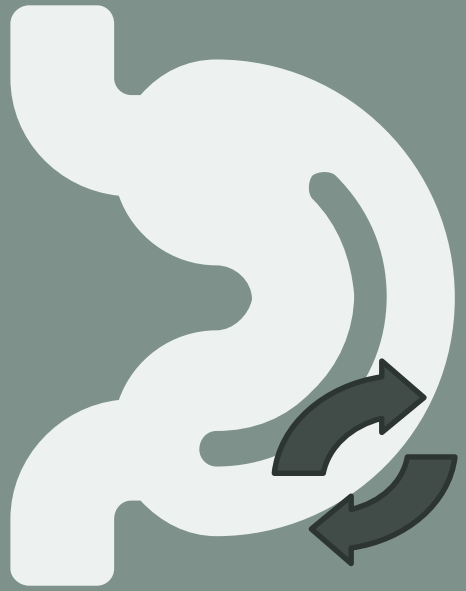
Prenatal Exposure to PFAS & Obesity in Early Childhood



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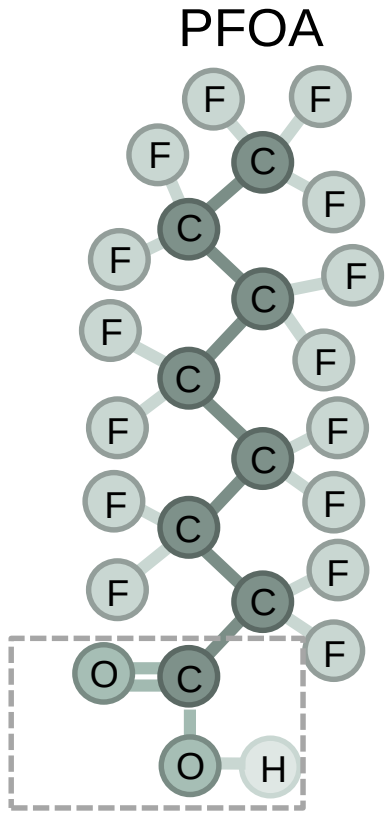
Boston University

Per- and polyfluoroalkyl Substances (PFAS)

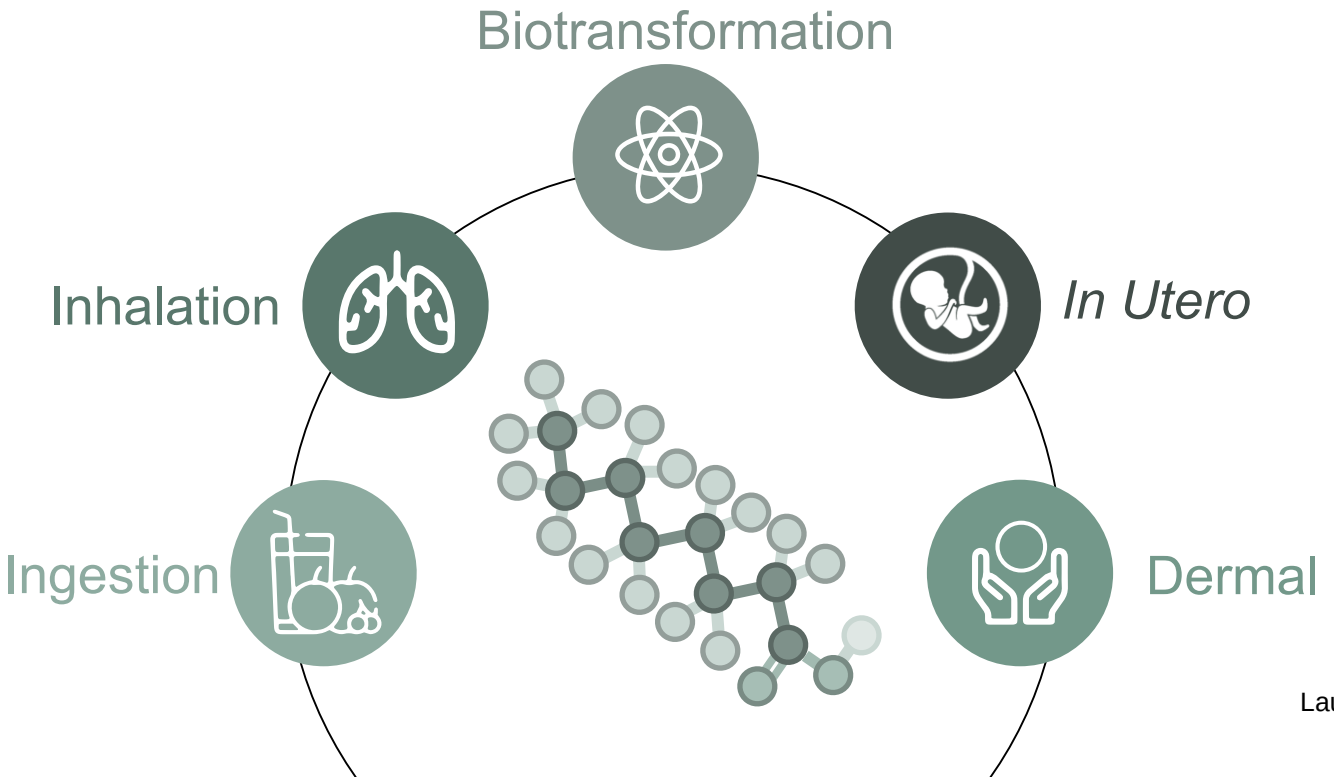
- Thousands of chemicals with hydrophobic chain with carbon-fluorine bonds and a hydrophilic functional group
- PFAS persist in all environmental media
- Some PFAS bioaccumulate and biomagnify across species
- There is on-going generational exposure to PFAS through various products



Fluorine Carbon Oxygen Hydrogen

Lau et al. 2004, ATSDR 2018, Lau et al. 2007, Harris et al. 2017

Exposure to PFAS



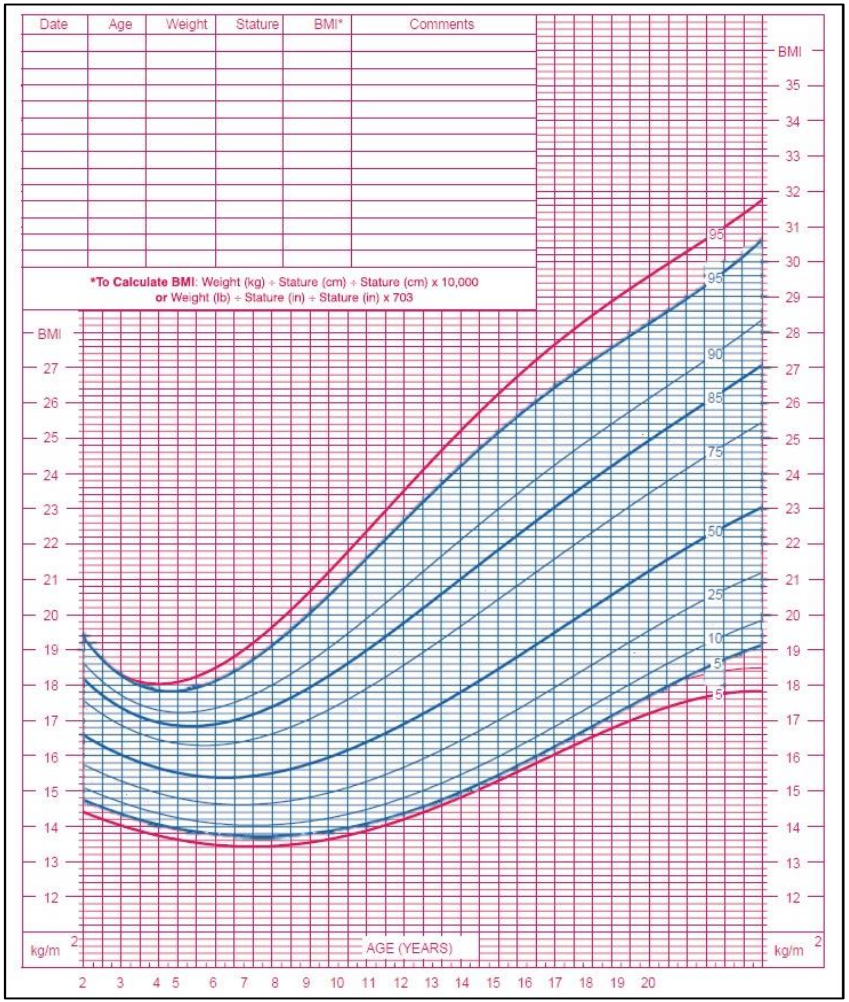
Lau et al. 2007, Sagiv et al. 2015
Poothong et al. 2020

Obesity in Children

Body mass index (BMI)

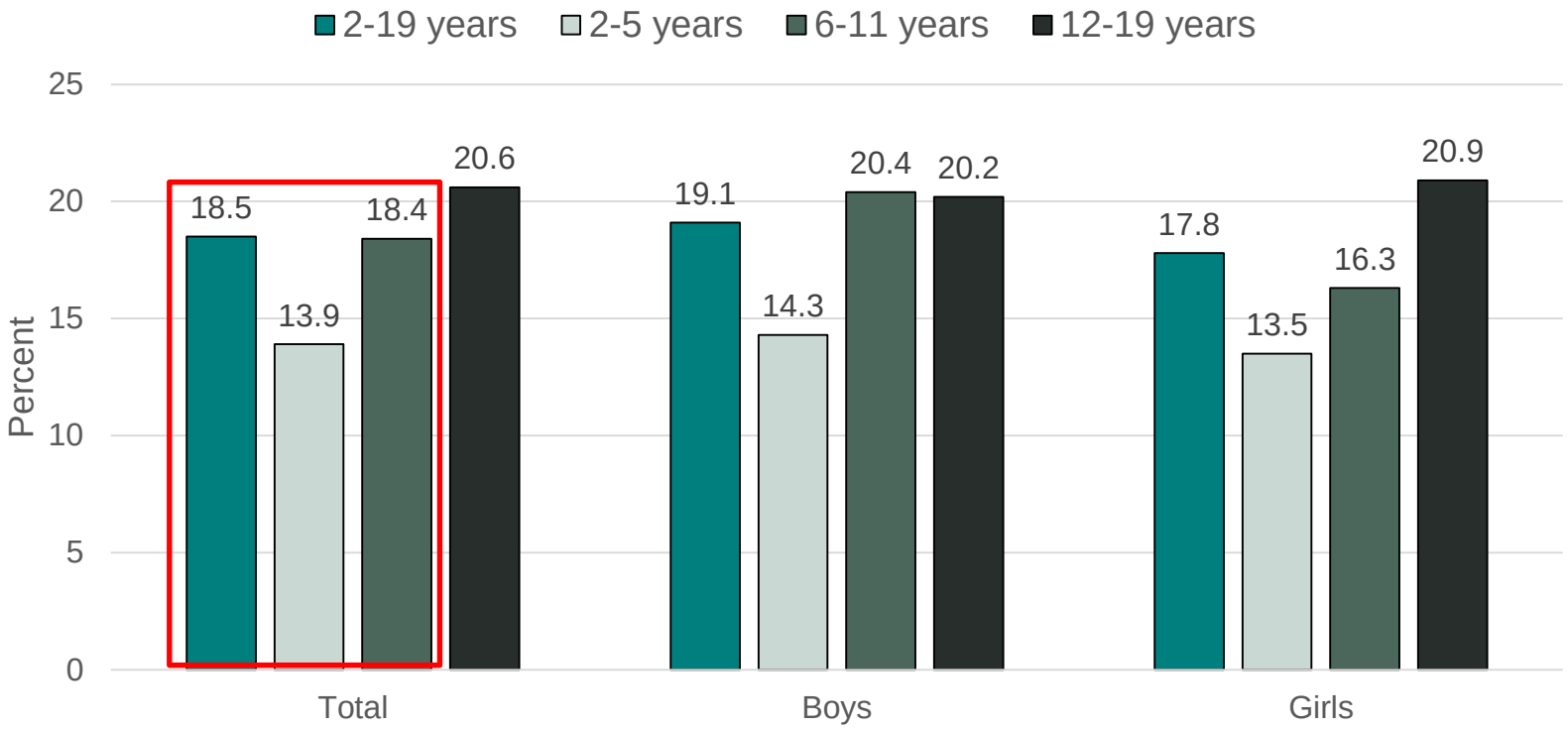
$$BMI = \frac{weight\ (kg)}{height^2\ (m^2)}$$

- *Underweight:* BMI < 5th percentile
- *Normal:* BMI 5th to <85th percentile
- *Overweight:* BMI 85th to <95th percentile
- *Obese:* BMI at or above 95th percentile



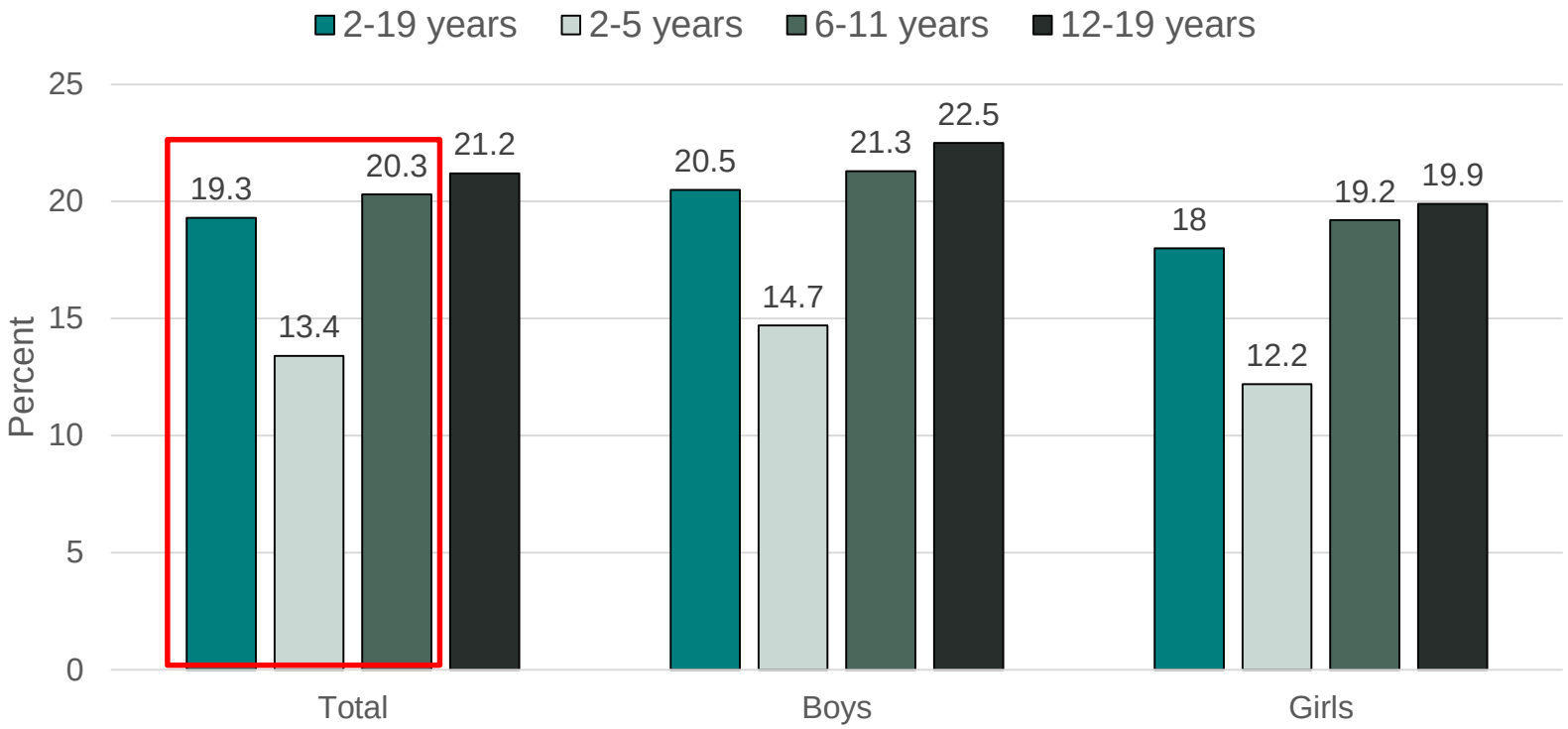
CDC 2021

Prevalence of Obesity in Children Aged 2-19 years in the United States, by Sex, 2015 - 2016



Fryar et al. 2021

Prevalence of Obesity in Children Aged 2-19 years in the United States, by Sex, 2017 - 2018



Fryar et al. 2021

Epidemiological Evidence

Prenatal PFAS and adverse metabolic function in mid-childhood

- Increased body fatness
- Increase in weight
- Increase in alanine aminotransferase levels

Prenatal PFAS and adverse metabolic function in mid-to-late childhood

- Increase in adiposity

Research Gap

- Relationship between prenatal PFAS and metabolic function in early childhood

Fleisch et al. 2017, Hartman et al. 2017, Mora et al. 2017a
Braun et al. 2016, Mora et al. 2017b

Objective

Evaluate the association between prenatal PFAS exposure and metabolic health outcomes in early childhood

Aims

- Assess the association between maternal PFAS plasma concentrations and body mass index in early childhood

- Assess the association between maternal PFAS plasma concentrations and being overweight/obese in early childhood

Study Population

Newborn Epigenetics Study (NEST)
Duke University (2005-2011)
590 women 18 years old or older, pregnant (19-42 weeks) and receiving prenatal care at Duke University

Exclusions
- Siblings
- Multiple births

Toddlers Exposure to Semi-Volatile Organic Chemicals (SVOCS) in Indoor Environments (TESIE) (2014-2016)
203 mother-child pairs

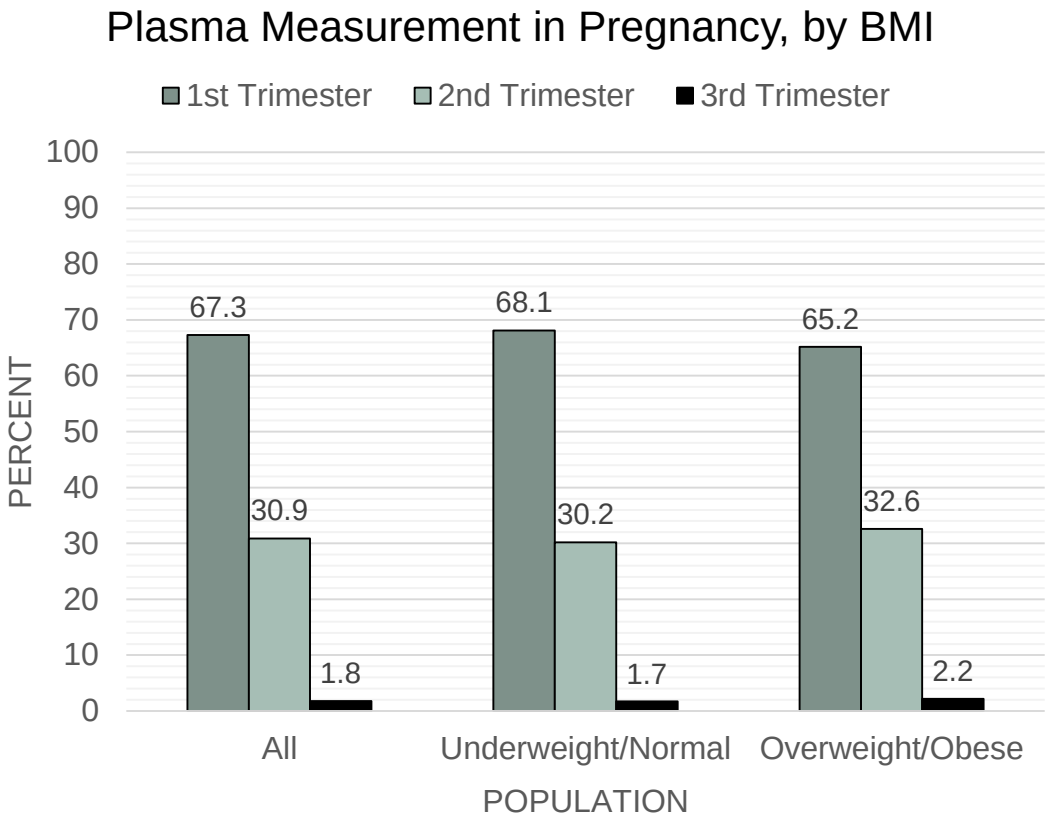
Exclusions
- Missing PFAS data
- Missing BMI data

Prenatal Exposure to Per- and Polyfluoroalkyl Substances and Obesity in Early Childhood
165 mother-child pairs

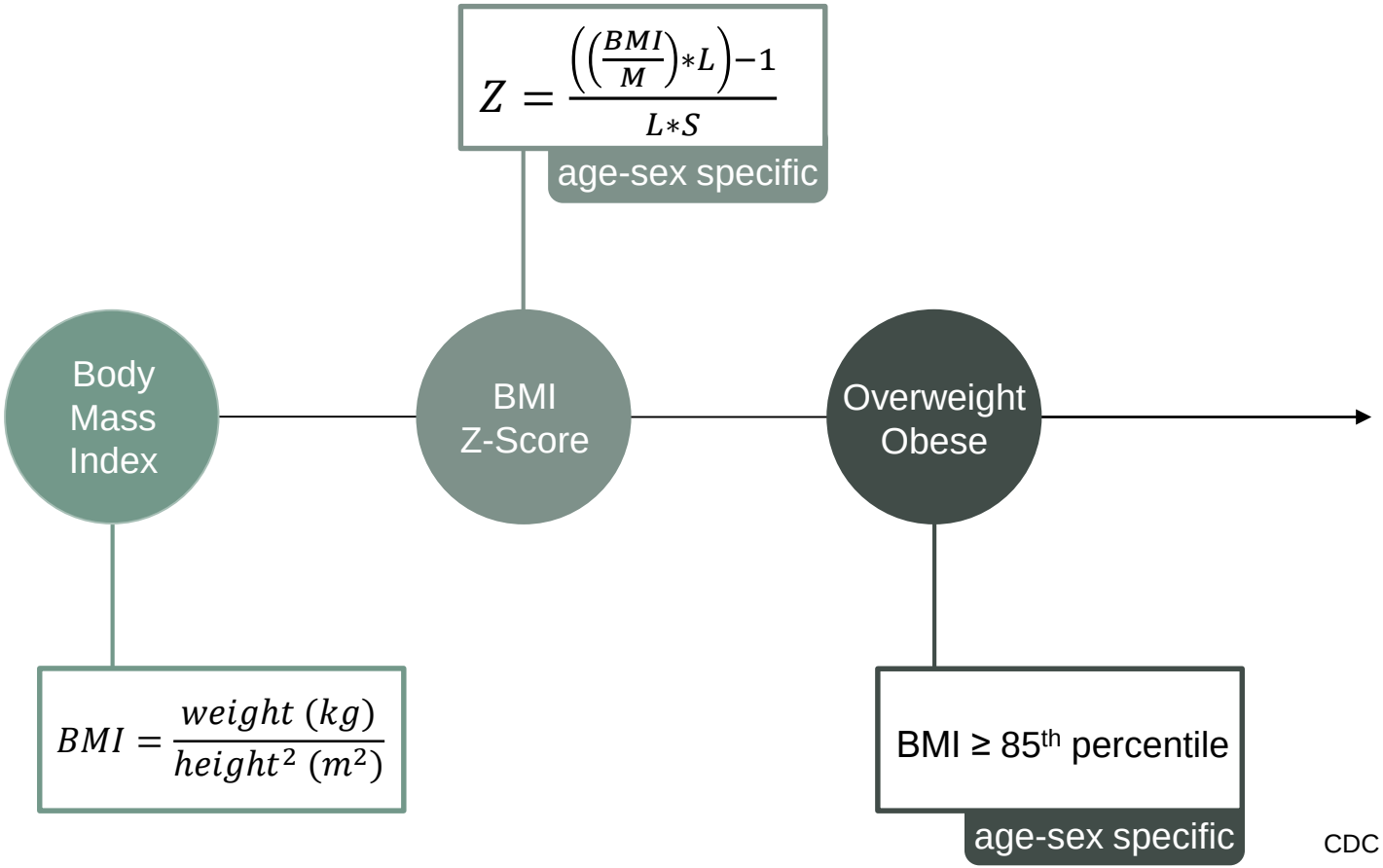
Hoyo et al. 2011, Hoffman et al. 2018

Prenatal PFAS Exposure

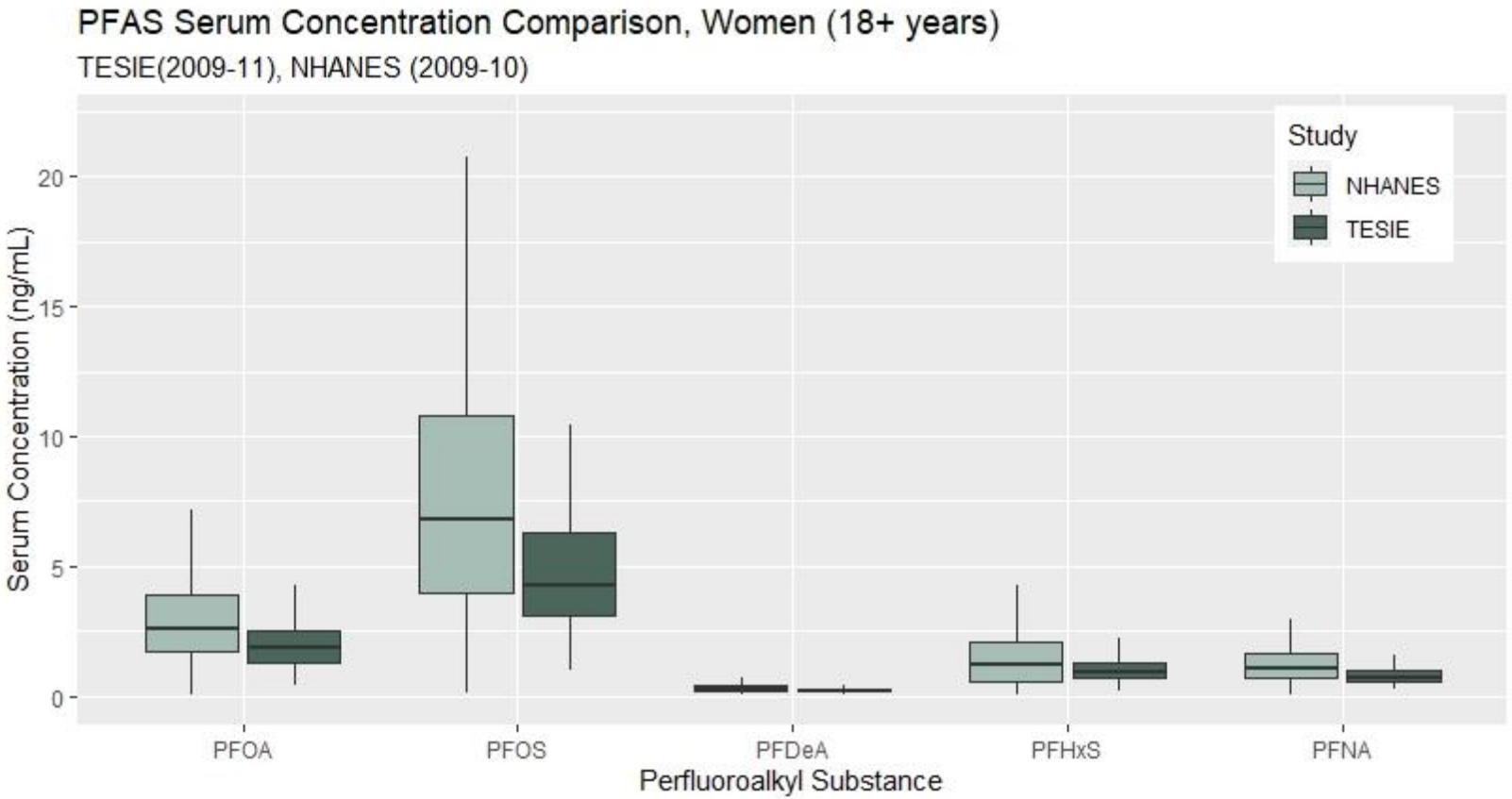
- PFAS plasma concentrations measured in pregnancy
- PFOA, PFOS, PFDeA, PFHxS & PFNA
- PFAS assessed have detection frequency of at least 95% above the limit of detection (LOD) of 0.1 ng/mL
- Values below LOD divided by $\sqrt{2}$

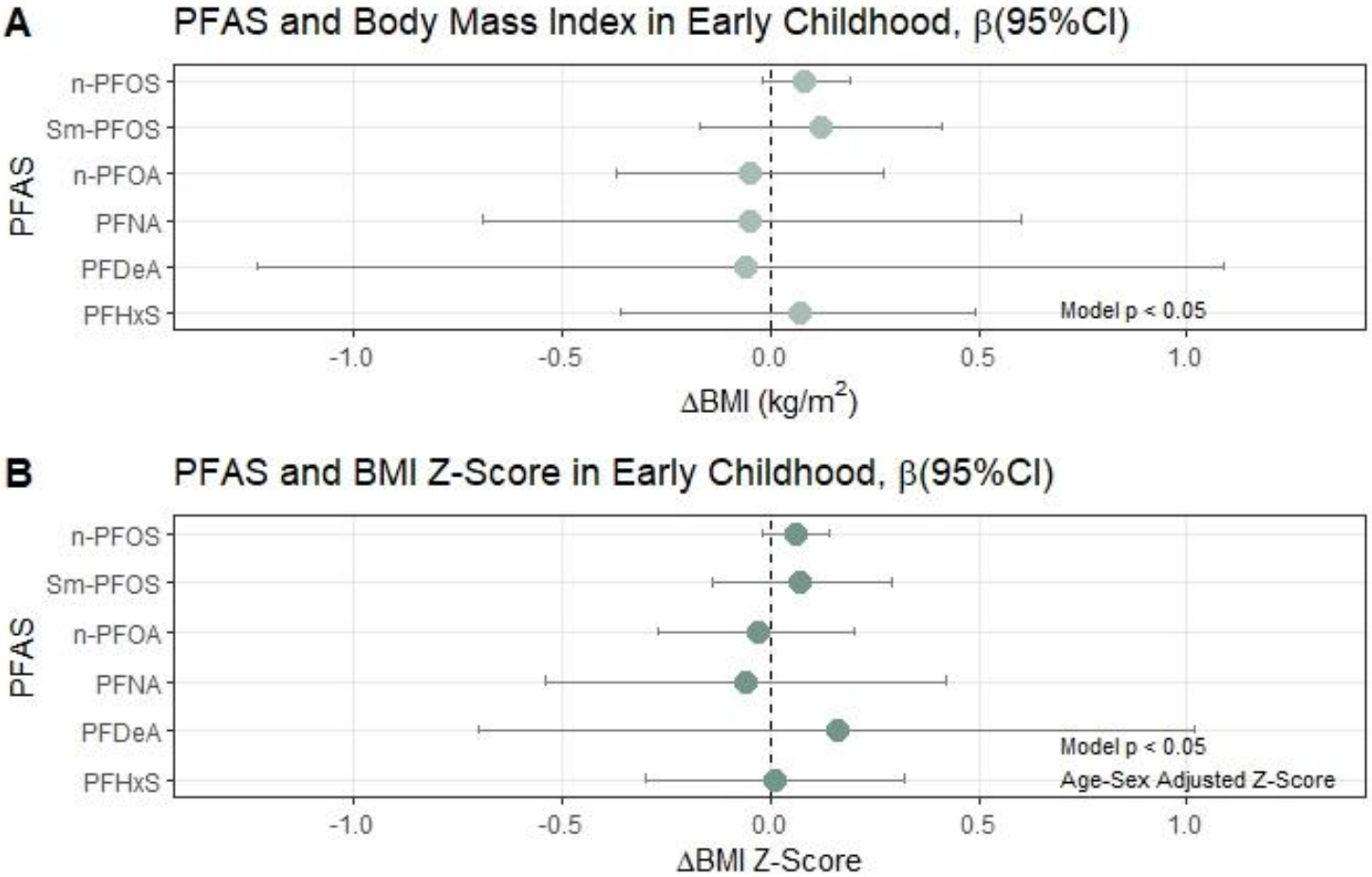


Metabolic Outcome Assessment

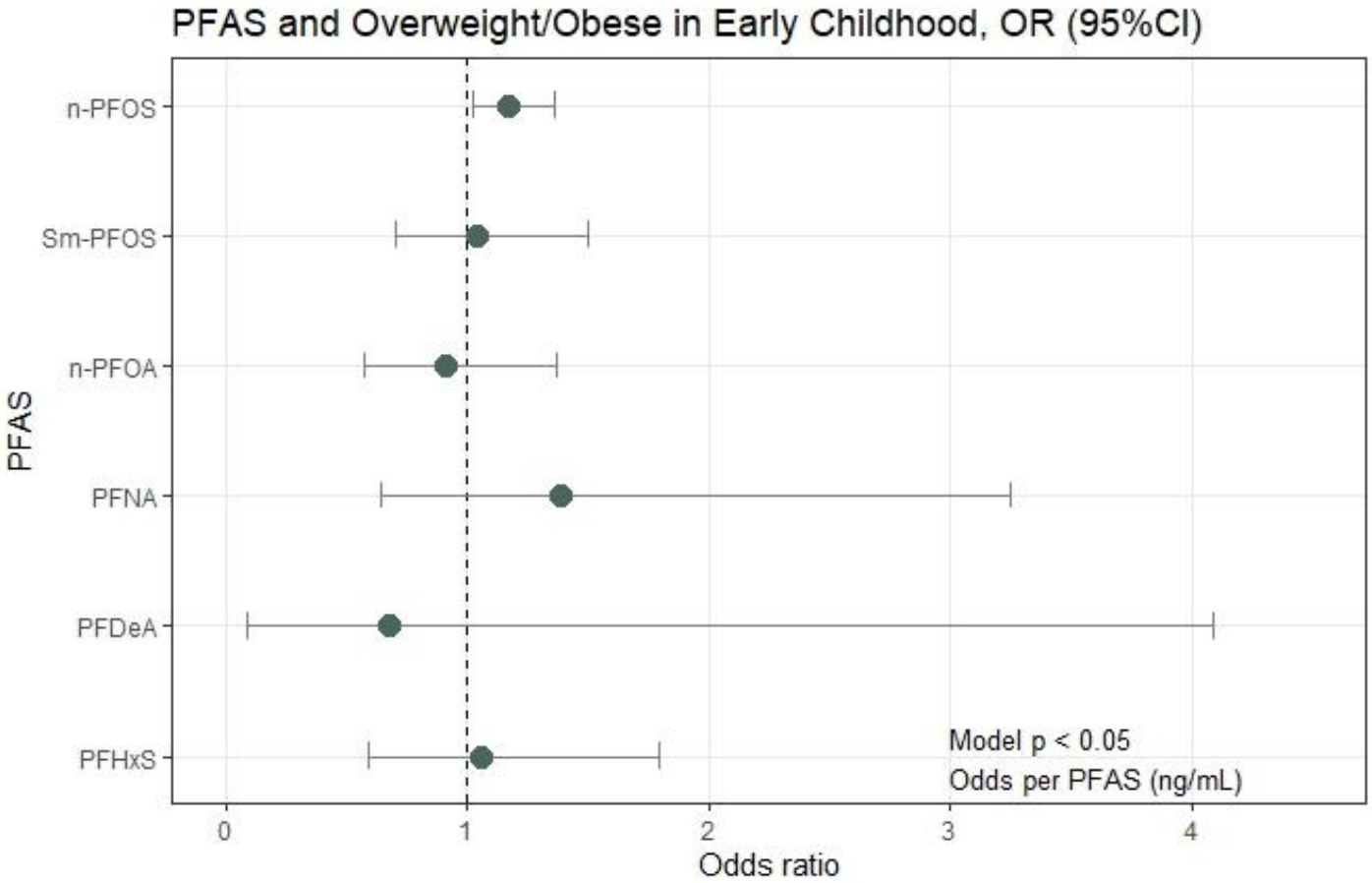


CDC 2009, CDC 2021


PFAS Serum Concentration Comparison, Women (18+ years)
TESIE(2009-11), NHANES (2009-10)
Study
NHANES
TESIE
Serum Concentration (ng/mL)
0
5
10
15
20
PFOA
PFOS
PFDeA
PFHxS
PFNA
Perfluoroalkyl Substance



All models adjusted for maternal age at delivery, race/ethnicity, education, parity, maternal BMI, gestational age at blood draw, child sex and child age



All models adjusted for maternal age at delivery, race/ethnicity, education, parity, maternal BMI, gestational age at blood draw, child sex and child age

Strengths

- Prospective cohort
- Validated biomarkers for exposure

Limitations

- Residual confounding
- Power
- Collinearity

Summary and Conclusion

Summary

- There are positive trends between prenatal exposure to PFOS and child body mass index

Conclusion

- Prenatal exposure to n-PFOS is marginally associated with an increase in body mass index and body mass index z-score

- Prenatal exposure to n-PFOS is significantly associated with an increased odds of being overweight or obese in early childhood

Acknowledgments

Thomas Webster, DSc., Boston University

BU School of Public Health

Heather Stapleton, Ph.D., Duke University

Duke | NICHOLAS SCHOOL of the ENVIRONMENT

NIH National Institute of Environmental Health Sciences
Your Environment. Your Health. T32 ES014562

References

- Lau C, Butenhoff JL, Rogers JM. The developmental toxicity of perfluoroalkyl acids and their derivatives. *Toxicol Appl Pharmacol*. 2004;198(2):231-241. doi:10.1016/j.taap.2003.11.031
- ATSDR Division of Toxicology C. Toxicological Profile for Per- and Polyfluoroalkyl Substances. 2018;(September). https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf. Accessed November 28, 2018.
- Lau C, Anitole K, Hodes C, Lai D, Pfahles-Hutchens A, Seed J. Perfluoroalkyl acids: A review of monitoring and toxicological findings. *Toxicol Sci*. 2007;99(2):366-394. doi:10.1093/toxsci/kfm128
- Harris MH, Rifas-Shiman SL, Calafat AM, et al. Predictors of Per- and Polyfluoroalkyl Substance (PFAS) Plasma Concentrations in 6-10 Year Old American Children. *Environ Sci Technol*. 2017;51(9):5193-5204. doi:10.1021/acs.est.6b05811
- Sagiv SK, Rifas-Shiman SL, Webster TF, et al. Sociodemographic and Perinatal Predictors of Early Pregnancy Per- and Polyfluoroalkyl Substance (PFAS) Concentrations. *Environ Sci Technol*. 2015;49(19):11849-11858. doi:10.1021/acs.est.5b02489
- Poothong S, Papadopoulou E, Padilla-Sánchez JA, Thomsen C, Haug LS. Multiple pathways of human exposure to poly- and perfluoroalkyl substances (PFASs): From external exposure to human blood. *Environ Int*. 2020;134:105244. doi:10.1016/j.envint.2019.105244
- Center for Disease Control and Prevention. About Child & Teen BMI | Healthy Weight, Nutrition, and Physical Activity | CDC. *Natl Cent Chronic Dis Prev Heal Promot*. 2021:1. https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html. Accessed March 16, 2022.
- Fryar CD, Carroll MD, Afful J. Prevalence of Overweight, Obesity, and Severe Obesity Among Children and Adolescents Aged 2-19 Years: United States. *Natl Cent Heal Stat*. 2021. doi:10.1001/jama.2020.14590
- Fleisch AF, Rifas-Shiman SL, Mora AM, et al. Early-life exposure to Perfluoroalkyl substances and childhood metabolic function. *Environ Health Perspect*. 2017;125(3):481-487. doi:10.1289/EHP303
- Hartman TJ, Calafat AM, Holmes AK, et al. Prenatal Exposure to Perfluoroalkyl Substances and Body Fatness in Girls. *Child Obes*. 2017;13(3):222-230. doi:10.1089/chi.2016.0126
- Mora AM, Fleisch AF, Rifas-Shiman SL, et al. Early life exposure to per- and polyfluoroalkyl substances and mid-childhood lipid and alanine aminotransferase levels. *Environ Int*. 2018;111:1-13. doi:10.1016/j.envint.2017.11.008
- Braun JM, Chen A, Romano ME, et al. Prenatal perfluoroalkyl substance exposure and child adiposity at 8 years of age: The HOME study. *Obesity*. 2016;24(1):231-237. doi:10.1002/oby.21258
- Mora AM, Oken E, Rifas-Shiman SL, et al. Prenatal exposure to Perfluoroalkyl substances and adiposity in early and mid-childhood. *Environ Health Perspect*. 2017;125(3):467-473. doi:10.1289/EHP246
- Hoyo C, Murtha AP, Schildkraut JM, et al. Folic acid supplementation before and during pregnancy in the Newborn Epigenetics STudy (NEST). 2011;11(46):1-8. doi:10.1186/1471-2458-11-46
- Hoffman K, Hammel SC, Phillips AL, et al. Biomarkers of exposure to SVOCs in children and their demographic associations: The TESIE Study. *Environ Int*. 2018;119:26-36. doi:10.1016/j.envint.2018.06.007
- Centers for Disease Control and Prevention; National Center for Health Statistics. Growth Charts - Percentile Data Files with LMS Values. https://www.cdc.gov/growthcharts/percentile_data_files.htm. Published 2009. Accessed March 16, 2022.

Extra Slides

Table 1. Maternal Covariates, TESIE (2005-2016)			
Characteristic	All	Underweight, Normal	Overweight, Obese
	(N=165)	(N=119)	(N=46)
Age at delivery, years; mean (SD)	30.2 (5.9)	30.2 (5.9)	30.2 (5.9)
Gestation, N(%)			
≥ 37 weeks	127 (76.9)	94 (78.9)	33 (71.7)
Parity			
1+	100 (60.6)	71 (59.6)	29 (63.0)
BMI at LMP			
Overweight/Obese	87 (52.7)	60 (50.4)	27 (58.7)
Race/Ethnicity			
White	75 (45.4)	55 (46.2)	20 (43.4)
Black	60 (36.4)	44 (37.0)	16 (34.8)
Hispanic	27 (16.4)	18 (15.1)	9 (19.6)
Other	3 (1.8)	2 (1.7)	1 (2.2)
Blood Draw Gestation			
1st trimester	111 (67.3)	81 (68.1)	30 (65.2)
2nd trimester	51 (30.9)	36 (30.2)	15 (32.6)
3rd trimester	3 (1.8)	2 (1.7)	1 (2.2)

Table 2. Child Covariates, TESIE (2005-2016)			
Characteristic	All	Underweight, Normal	Overweight, Obese
	(N=165)	(N=119)	(N=46)
Age, years; mean (SD)	4.43 (0.50)	4.44 (0.51)	4.41 (0.48)
Sex; N (%)			
Male	93 (56.4)	66 (55.5)	27 (58.7)
Ever Breastfed	136 (82.4)	101 (84.9)	35 (76.1)