Analyzing Chemical and Non-Chemical Stressors for Cumulative Impacts

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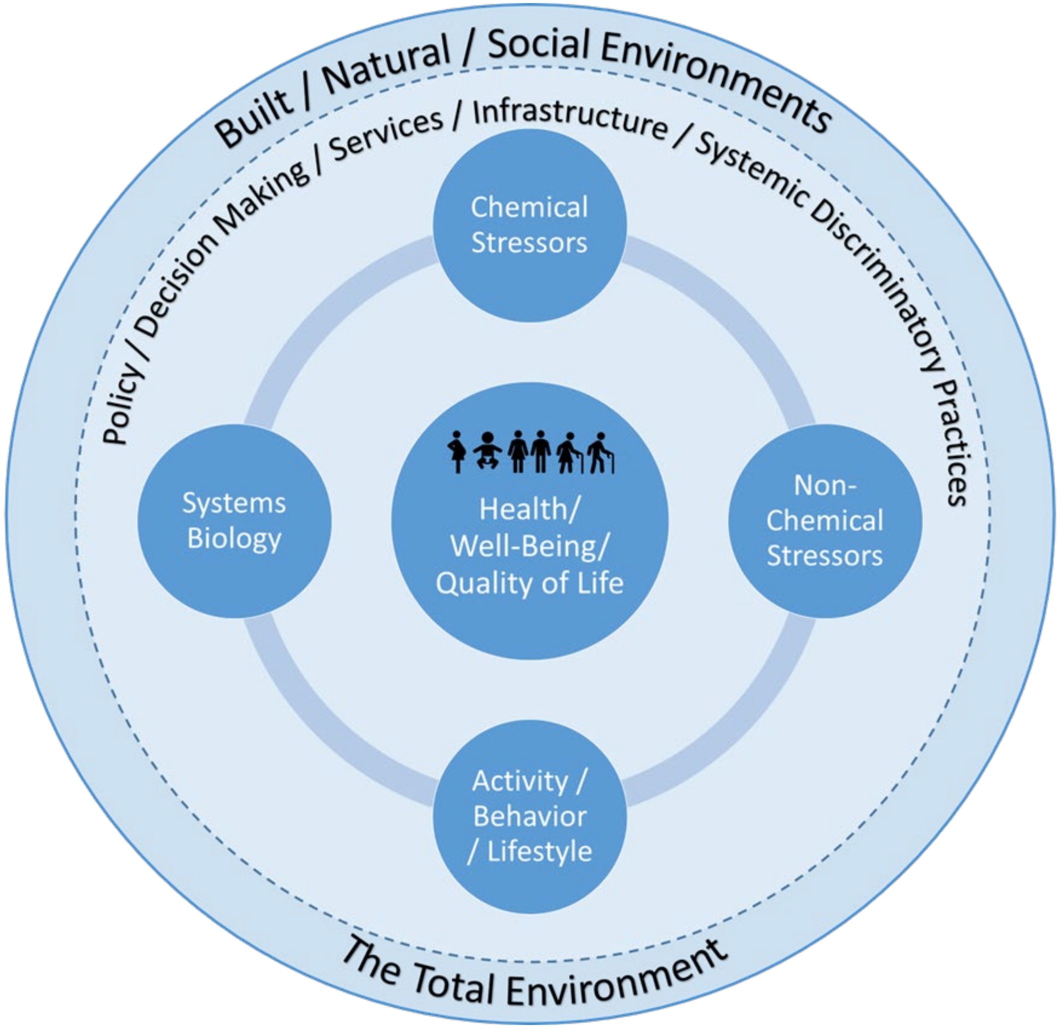
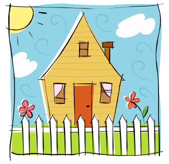
Disclaimer: The views expressed in this presentation do not necessarily reflect the views or policies of the United States Environmental Protection Agency. This presentation was prepared using National Children's Study Research Materials obtained from the NCS Vanguard Data and Sample Archive and Access System and the NICHD Data and Specimen Hub (DASH). We acknowledge NICHD DASH for providing the National Children's Study data that was used for this research.

Components of Total Environment for Children

Lifestage Specific Exposures: inhalation; dermal; ingestion (dietary/indirect); algorithms; multimedia measurements; activity/location information; laboratory-derived factors; supporting information



Home School/Daycare Community





Adapted from Tulve et al., 2016

Built Environment: land use; transportation; waste and materials management; buildings and infrastructure

Natural Environment: parks; recreation areas; walking trails; open spaces

Social Environment: family dynamics; employment; education; safety; acculturation; food; job security; neighborhood quality; school life

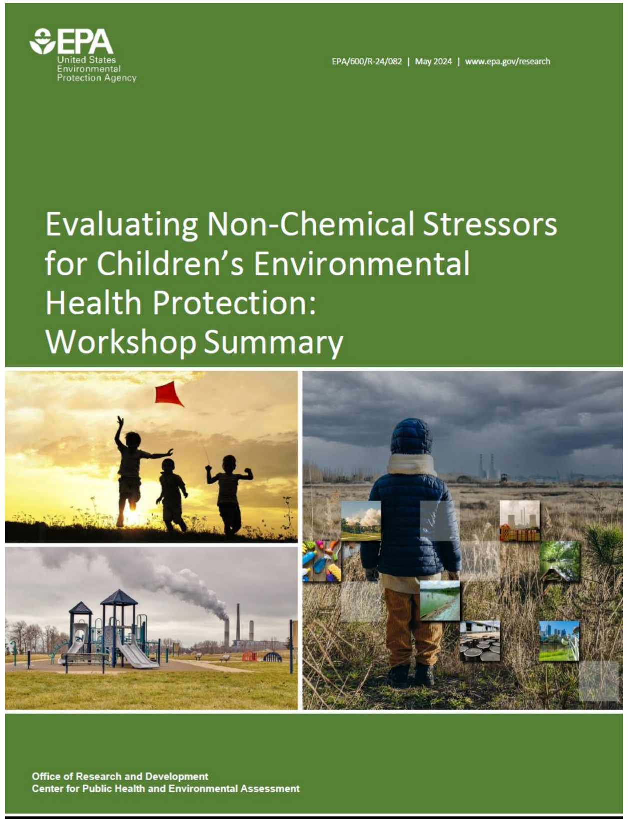
What are Cumulative Impacts?

Tulve et al., 2024

- **Cumulative Impacts:** *the totality of exposures to combinations of chemical and non-chemical stressors and their effects on health, well-being, and quality of life outcomes.*
- ***Cumulative Impact Assessment****: a process of evaluating both quantitative and qualitative data representing cumulative impacts to inform a decision.*

Non-Chemical Stressors Workshop

- Emphasis: non-chemical stressors within a chemical stressor paradigm
- Breakout group discussions:
  - Which non-chemical stressors (from the built, natural, social environments) should be the focus of research associated with chemical stressors? What is the rationale for choosing those specific non-chemical stressors?
  - What are the criteria for selecting non-chemical stressors for research within the chemical stressor paradigm?
  - Which non-chemical stressors are surrogates for other non-chemical stressors or conditions in the community environment? And how should these stressors be managed?
  - Which combination of co-occurring non-chemical stressors should be the focus of research within the chemical stressor paradigm?



Non-Chemical Stressors Workshop: Key Takeaways

- Environmental protection encompasses both chemical and non-chemical stressors
- Systems approach and integrative model(s) are essential for incorporating non-chemical stressors into the chemical stressor paradigm
- All aspects of the built, natural, and social environments should be considered when exploring how chemical and non-chemical stressors influence health, well-being, and quality of life
- Non-chemical stressors are interrelated and influence each other; important to understand these interrelationships and appropriately incorporate multiple non-chemical stressors into the chemical stressor paradigm

Non-Chemical Stressors Workshop: Key Takeaways (cont'd)

- Many non-chemical stressors co-occur; this workshop identified four of the most important as:
  - Geography
  - Neighborhood environment and characteristics
  - Housing stock
  - Racism
- Approaches and methodologies for analyzing quantitative and qualitative data and information are essential for advancing our understanding of non-chemical stressors within the chemical stressor paradigm

Case Study Example: Preliminary Analysis of Chemical and Non-Chemical Stressors Collected from Mother-Child Pairs in the National Children's Study

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U.S. Environmental Protection Agency

United States Environmental Protection Agency

Background

- Children are exposed to diverse chemical and non-chemical stressors found in their everyday community environment.
- Multiple stressors, individually and in combination, can lead to changes in health and well-being during each lifestage throughout their lifecourse.
- Many chemical and non-chemical stressors have been studied individually and linked to specific children's health outcomes.
- Only recently has the scientific community explored how both chemical and non-chemical stressors interact to affect children's health and well-being.

Objective

To examine relationships between chemical exposures, social vulnerability factors, and child birthweight for a cohort of pregnant women in the United States

Approach

- Environmental, survey, and outcome data from the National Children's Study (NCS) Vanguard Study database were obtained from the NIH Data and Specimen Hub (DASH).
- 518 NCS mother-child pairs from seven U.S. locations were included in our analysis.
- NCS survey variables were matched to PRAPARE (Protocol for Responding to and Assessing Patients' Assets, Risks, and Experiences) social determinant of health (SDoH) factors (Weir et al., 2020, https://doi.org/10.1353/hpu.2020.0075).

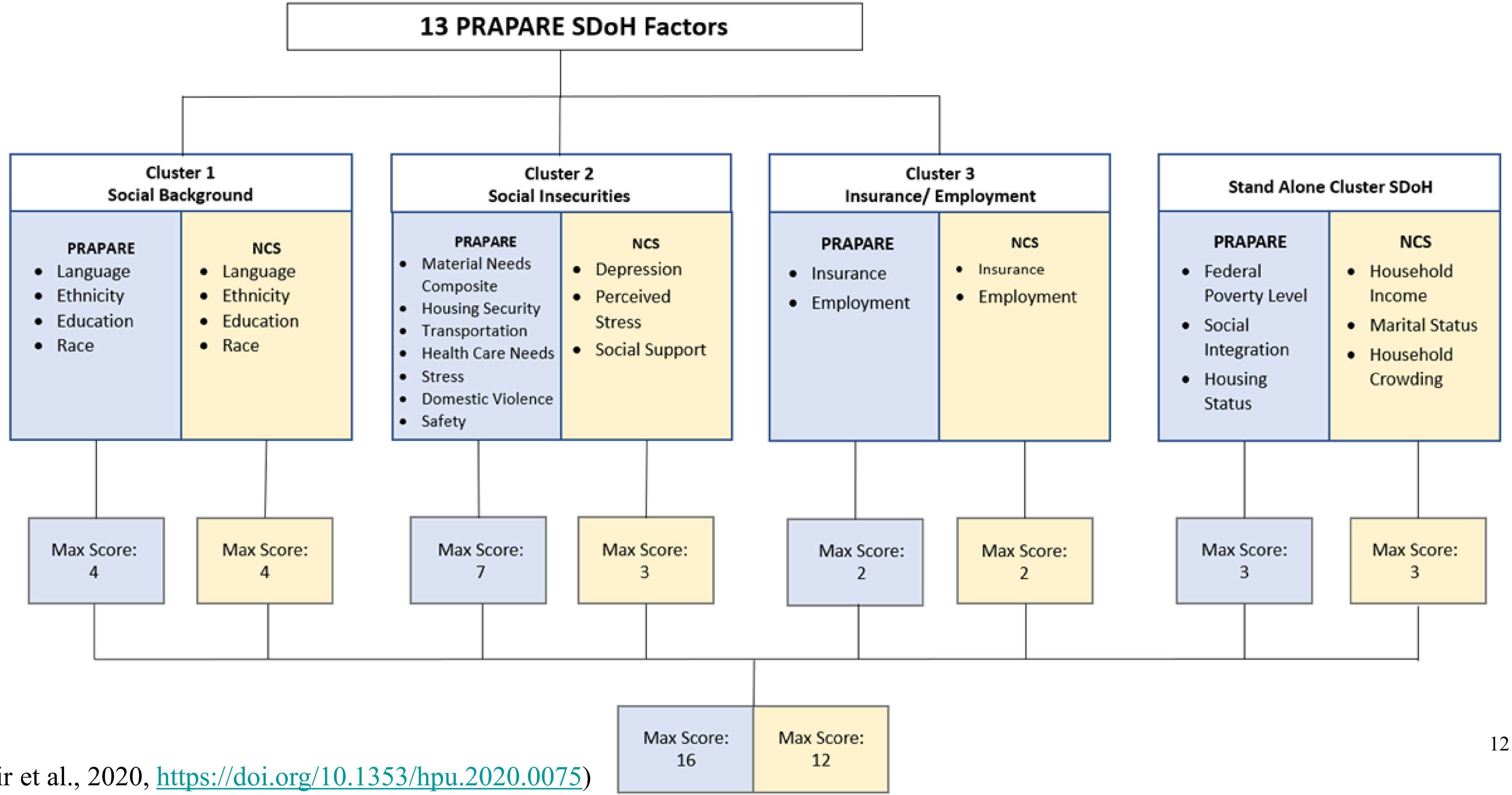
Approach (cont'd)

- SDoH were organized and scored; total scores were sorted into low (0-1), medium (2-4), and high (5-12) groupings for analysis.
- Associations between exposure measurements for selected chemicals and SDoH score groups were assessed using one-way ANOVA.
- Associations between SDoH score groups and birthweight were examined using one-way ANOVA.

Participant Demographic Characteristics

Variable	N	Variable	N
Race/Ethnicity		**Total Jobs**	
Hispanic	46	0	161
Non-Hispanic, White	357	1	291
Non-Hispanic, Other race	115	2 or more	66
Age		**Household Income**	
16-19	20	Less than $30,000	122
20-24	83	$30,000-$49,999	88
25-29	157	$50,000-$99,999	180
30-34	158	$100,000 or more	104
35-39	89	Not reported/missing	24
40-44	11	**Insurance**	
Education		Uninsured	44
Less than high school or GED	114	Insured	474
High school diploma or GED	146		
Some college but no degree	215		
College degree	43		

Mapping NCS Variables to PRAPARE SDoH Factors and Clusters



(Weir et al., 2020, https://doi.org/10.1353/hpu.2020.0075)

Summary of Associations between Selected Chemicals and SDoH Factor Scores

		All Groups Range 0-12			SDoH Factor Score Range 0-1		SDoH Factor Score Range 2-4		SDoH Factor Score Range 5-12		
Chemical Analyte	**Medium**	**N**	**GM**	**p value**	**N**	**GM**	**N**	**GM**	**N**	**GM**	**Units**
∑DEHP Metabolites	Urine	382	0.1	0.39	196	0.1	122	0.1	64	0.1	nmol/g
BPA	Urine	336	1.9	0.19	169	1.7	109	2.0	58	2.1	ng/g
Benzophenone-3	Urine	383	83.8	**0.0057**	197	107	122	82.7	64	41.1	ng/g
∑PAH Metabolites	Urine	343	7729	**<0.0001**	176	6333	112	8455	55	12171	ng/g
Hydroxypyrene	Urine	322	175	**0.0113**	163	159	104	181	55	222	ng/g
Hydroxyphenanthrene	Urine	343	324	0.6	176	324	112	313	55	349	ng/g
Naphthol	Urine	343	6240	**<0.0001**	176	4986	112	6911	55	10387	ng/g
Hydroxyfluorene	Urine	343	663	**0.0025**	176	594	112	706	55	830	ng/g
∑Dimethyls	Urine	272	87.8	0.54	147	94.4	85	82.3	40	77.2	nmol/g
∑Diethyls	Urine	185	17.1	0.56	106	15.9	57	19.7	22	18.2	nmol/g
∑DAPs	Urine	272	101	0.77	147	96.5	85	91.3	40	92.7	nmol/g
Cadmium	Blood	177	0.30	0.16	99	0.26	55	0.38	23	0.33	µg/L
Lead	Blood	251	0.47	0.0549	139	0.43	75	0.48	37	0.62	µg/dL
Lead	Wipe	514	0.43	**<0.0001**	272	0.36	165	0.43	77	0.84	ng/cm^2

∑DEHP Metabolites= MECPP, MEHHP, MEOHP, MEHP; Metabolites of Di(2-ethylhexyl) phthalate

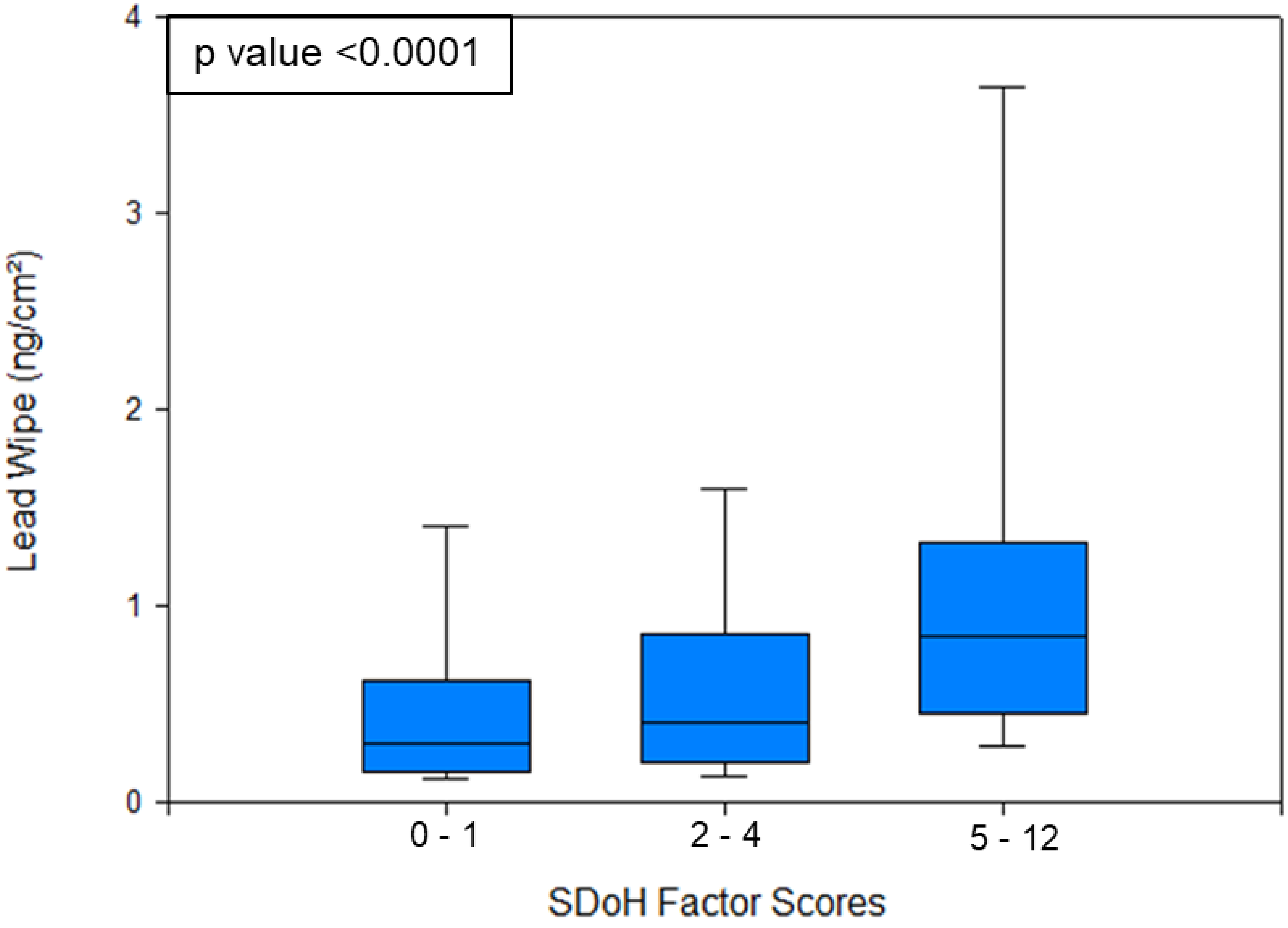
∑PAH Metabolites= 1-Hydroxypyrene, 1-Hydroxyphenanthrene, 1-Naphthol, 1-Hydroxyfluorene

∑Dimethyls= Dimethyldithiophosphate, Dimethylphosphate, Dimethylthiophosphate; Organophosphate Insectictide Metabolites

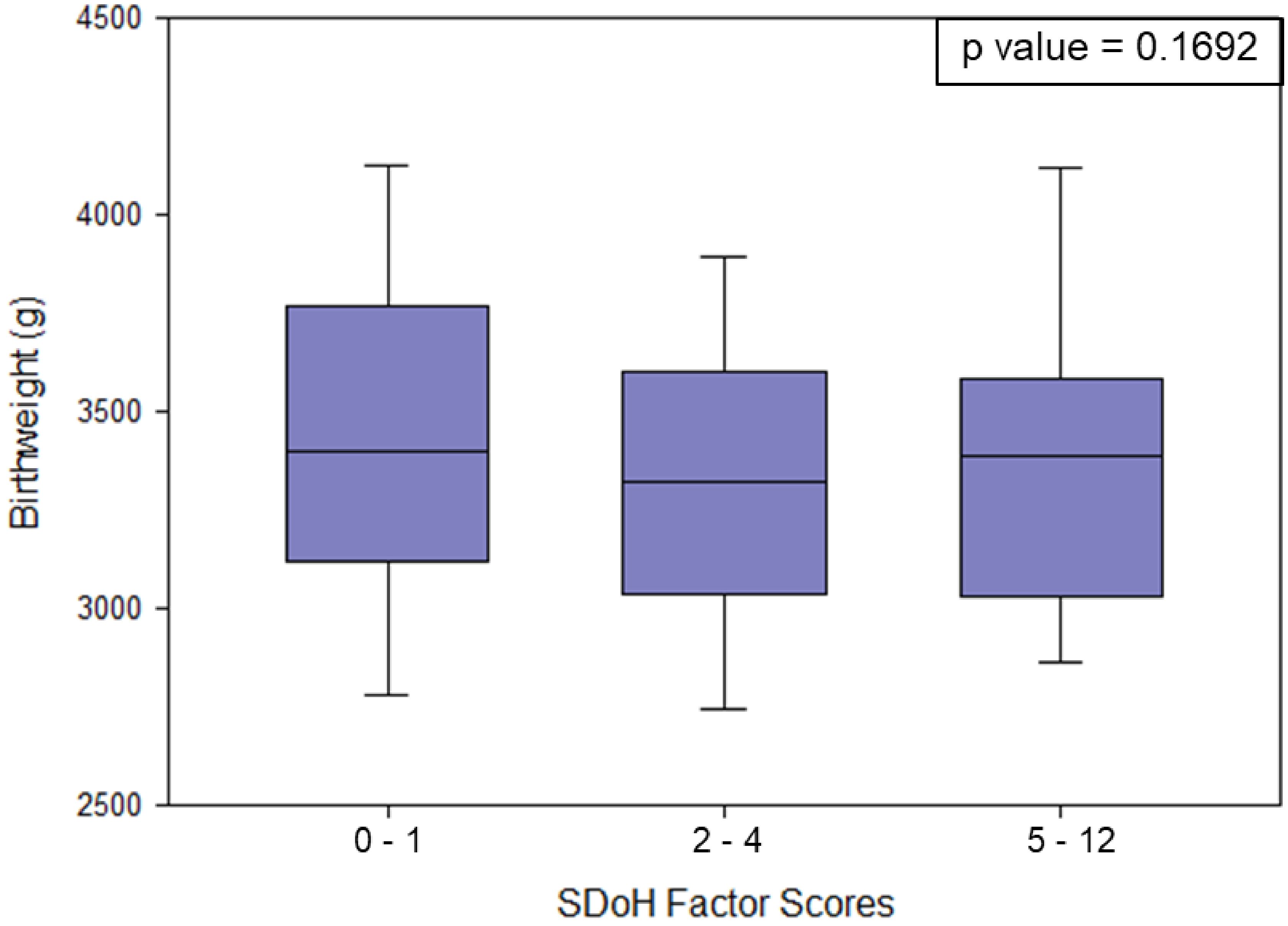
∑Diethyls= Diethyldithiophosphate, Diethylphosphate, Diethylthiophosphate; Organophosphate Insectictide Metabolites

∑DAPs= ∑Dimethyls + ∑Diethyls

Relationship between Lead Wipes and SDoH Factor Scores



Relationship between SDoH Factor Scores and Birthweight



Observations

- Approximately 15% of the pregnant NCS women had SDoH factor scores in the highest, most socially vulnerable category.
- Significantly higher exposures were observed with increasing SDoH factor scores for PAHs and Pb.
- Significantly lower exposures were observed for increasing SDoH factor scores for benzophenone-3, a consumer product chemical.
- Higher SDoH factor scores were associated with lower birthweight for this cohort of mother-child pairs.

Limitations

- Participants are not a representative U.S. population sample.
- Biomarkers were measured at only one time during pregnancy.
- Not all PRAPARE SDoH factors had exact NCS variables matches; PRAPARE cluster 2 was most affected.
- Birth weight analyses were limited by small numbers of participants with low birthweight babies (<2,500 g).

Next Steps for Case Study

- Examine additional chemicals
- Investigate other potential health outcomes such as obesity and neurocognitive development
- Investigate these relationships for SDoH clusters
- Explore potential combined/joint relationships between SDoH factor scores, biomarker data, and birthweight
- Map PRAPARE SDoH factors and score variables to Alternative Recruitment Strategy portion of the NCS study to increase study population size

Future Work

- Explore potential methods and approaches
- Data needs associated with potential methods and approaches
- Potential real-world case study exploring cumulative impacts

THANK YOU!

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