Southeast Wisconsin Interdisciplinary Study of Children's Health, Ecological Exposures, and Social Environment (SWISCHEESE)

Sheryl Magzamen on behalf of the SWISCHEESE Team

EPA ORD SHC & NCER STAR Total Environment Meeting

August 13, 2018

Colorado State University

Presentation Roadmap

I. Motivation

II. Team

III. Research Question

IV. Research Strategy

V. Lessons Learned

- Multiple exposures
- Methods for mixtures

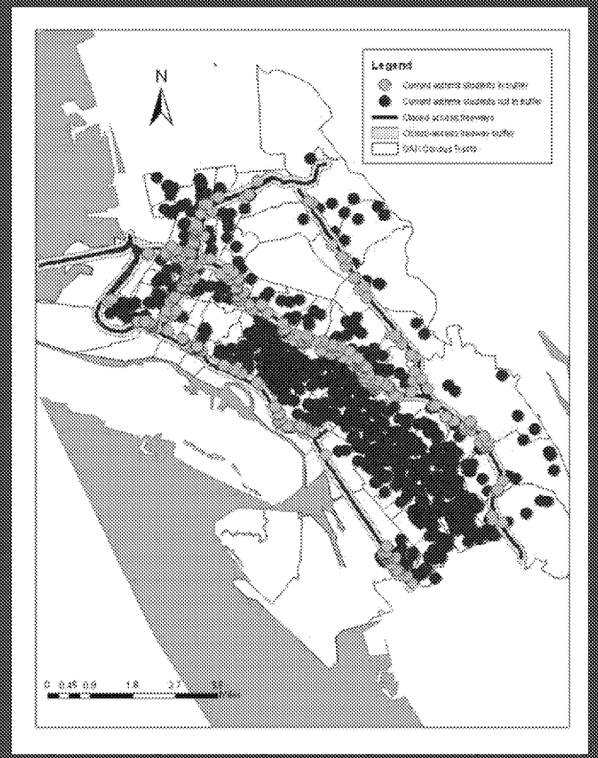
Motivation

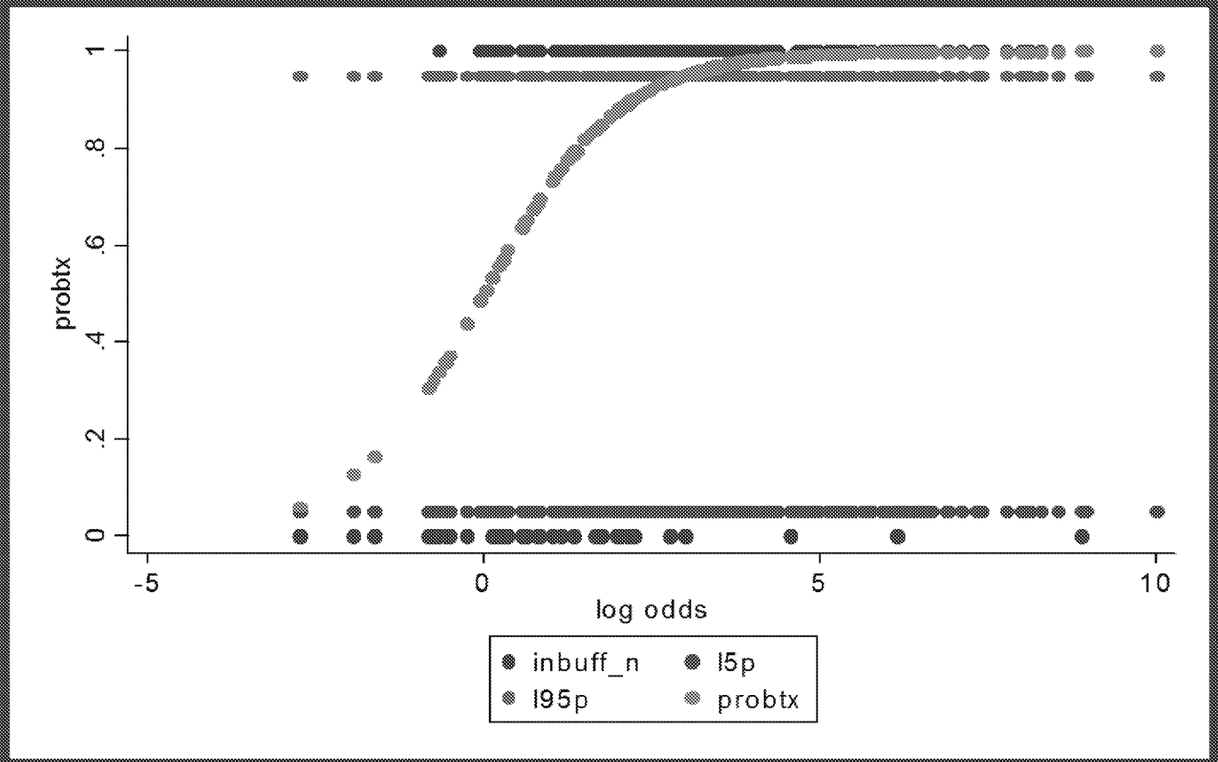
Our previous research has demonstrated that:
1) environmental exposures partially explain racial differences in outcomes;
2) social factors and environmental exposures have different magnitudes of association depending on where subjects reside on the continuum of the outcome.

[Sources: Magzamen and Tager 2009; Van Sickle, Magzamen and Mullahy 2011; Amato *et al.* 2013; Magzamen *et al.* 2013; Amato *et al.* 2015; Magzamen *et al.* 2015]

Early Thinking

Research Question: *What is the causal effect of residential proximity to closed-access freeways on emergency department visits for asthma?*





[Source: Gan and Magzamen (in preparation)]

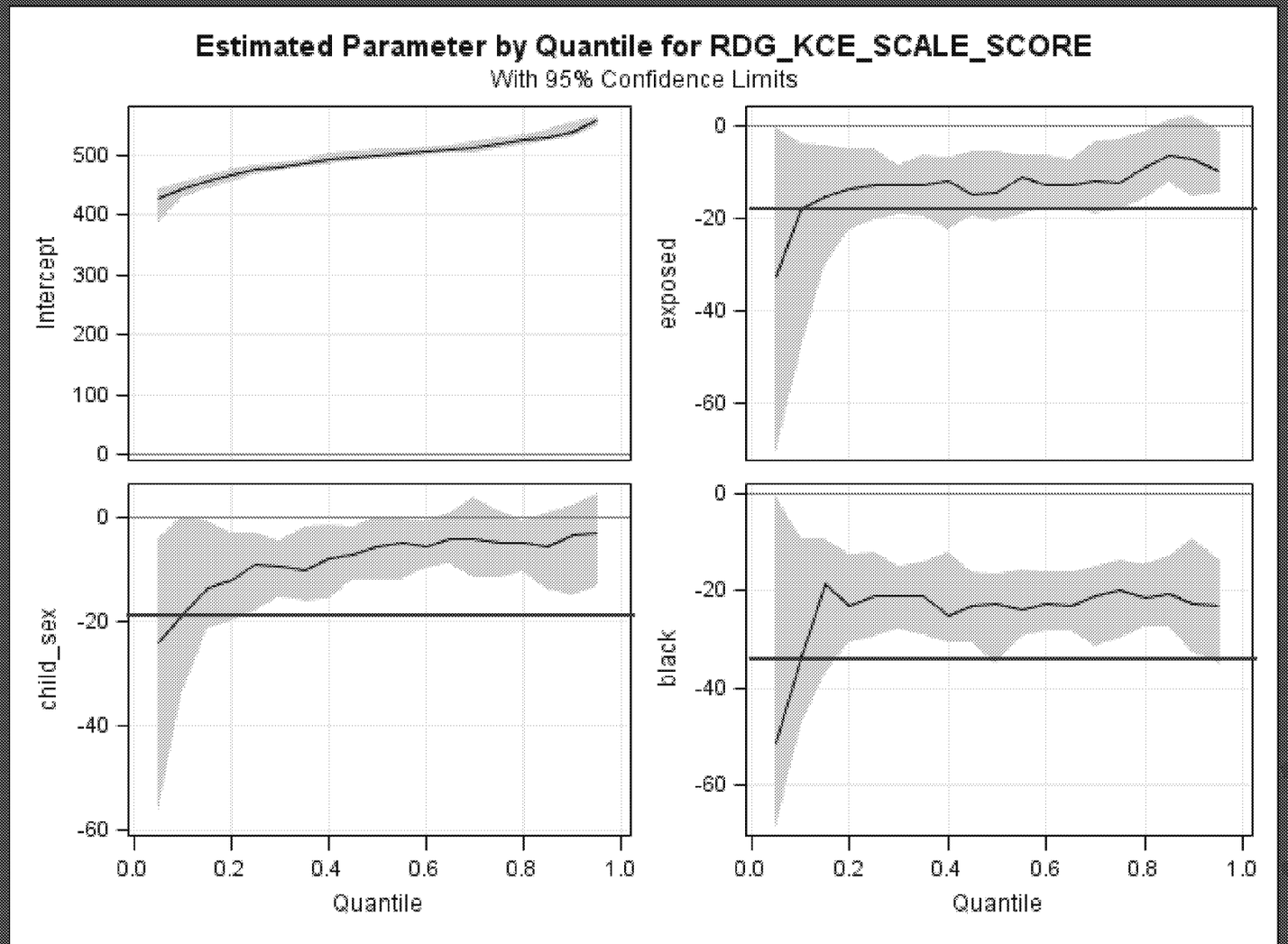
Wisconsin CLLEO Project

Research Goal: Investigate the association of moderate elevated blood lead levels (10 – 20 µg/dL) and performance on the 4th grade Wisconsin Knowledge and Concepts Exam (WKCE)

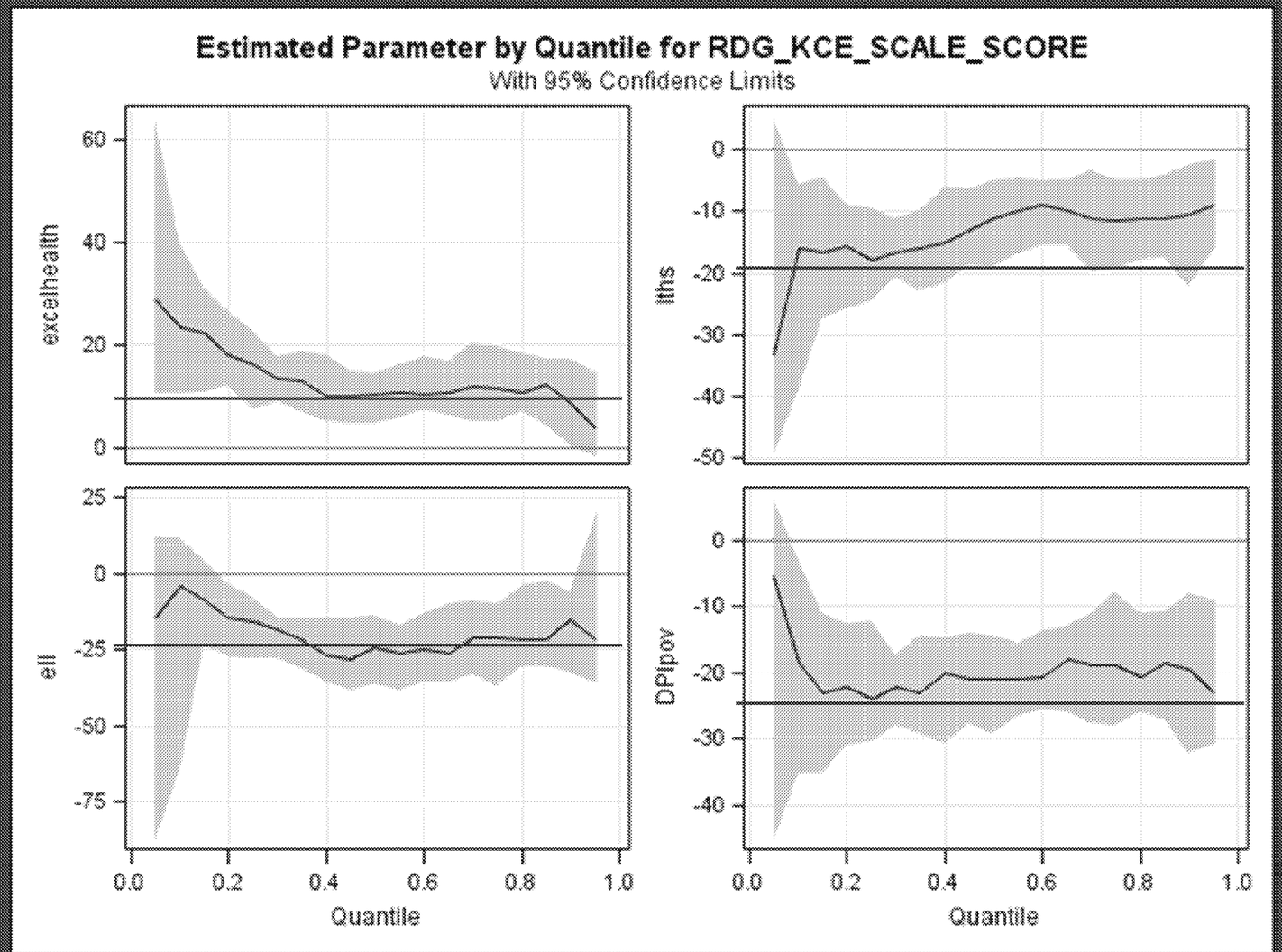
Hypothesis: Cognitive effects, as measured by scores on standardized end-of-grade exams, will be inversely related to elevated and *untreated* blood lead levels

Target Population: UW-DHS statewide study in cooperation with Wisconsin Department of Public Instruction

Results: CLLEO Reading Scores



Results: CLLEO Reading Scores

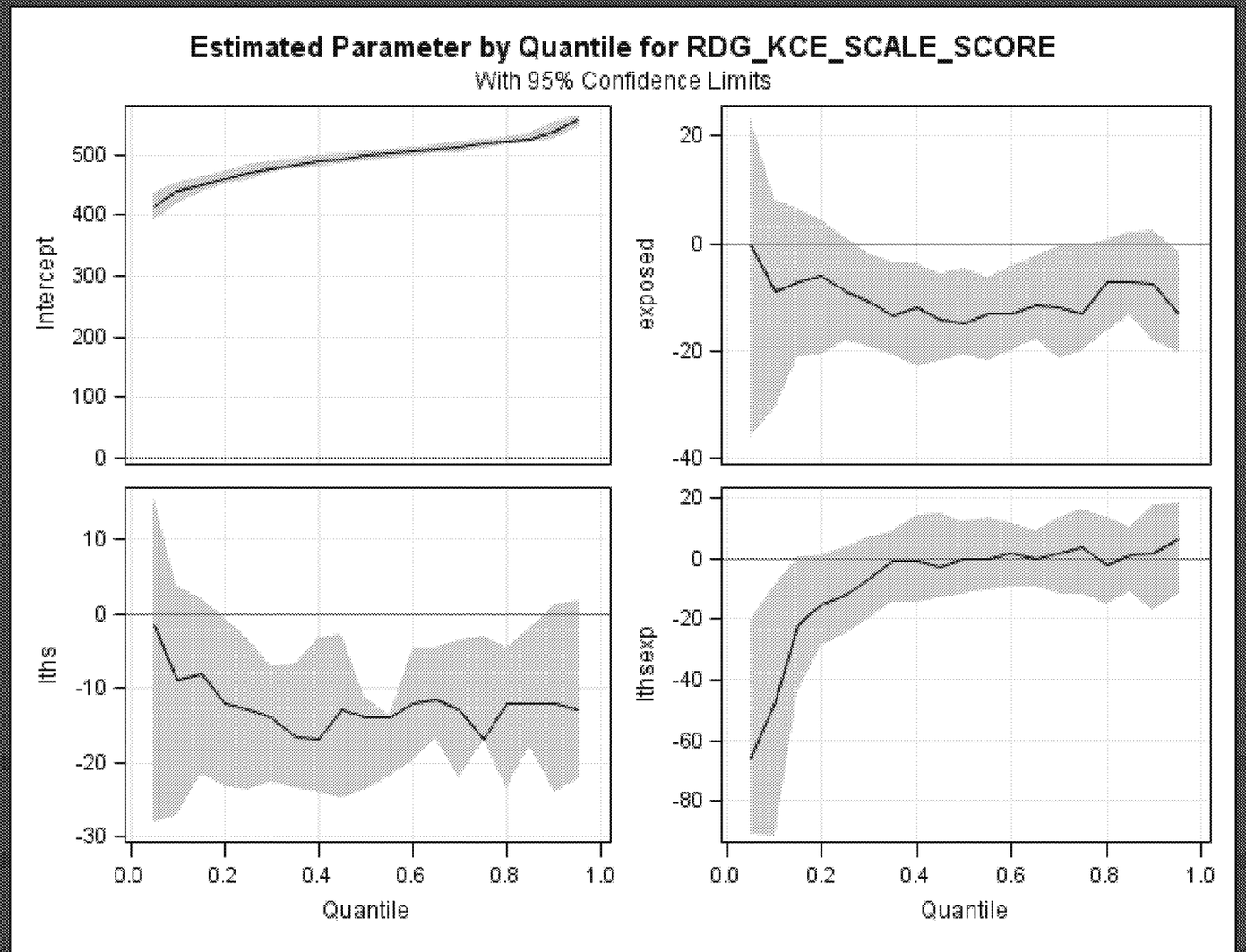


Results: CLLEO Reading Scores

Table 1. Effect estimates (95% CI) for selected quantiles, reading scores

		Quantile		
	OLS	0.1	0.5	0.9
Exposed	-13.66 (-19.94, -7.37)	-18.00 (-48.72, -3.32)	-14.50 (-20.72, -5.61)	-7.50 (-15.58, 2.07)
Males	-9.56 (-15.04, -4.08)	-19.00 (-34.46, 0.20)	-5.50 (-11.85, 0.09)	-3.50 (-15.13, 2.42)
Black	-24.57 (-31.38, -17.76)	-33.50 (-47.62, -9.27)	-22.50 (-35.37, -16.56)	-22.50 (-32.61, -9.23)
Parent < HS ed	-14.45 (-20.48, -8.42)	-16.00 (-38.97, -5.81)	-11.00 (-19.13, -4.94)	-10.50 (-22.41, -2.56)
Excellent health	15.22 (9.52, 20.93)	23.50 (10.44, 39.47)	10.50 (4.75, 14.79)	9.00 (0.36, 17.16)
ELL	-20.09 (-31.38, -8.75)	-4.50 (-64.40, 11.40)	-24.50 (-36.34, -13.88)	-15.50 (-33.00, -6.09)
Free/Reduced Lunch	-20.49 (-27.24, -13.75)	-18.50 (-35.24, -3.16)	-21.00 (-29.21, 14.34)	-19.50 (-32.19, -8.09)

Results: Interaction Terms



Results: CLLEO Reading Scores

Table 2. Effect estimates (95% CI) for interaction terms, reading scores, select quantiles

	OLS	Quantile		
		0.1	0.5	0.9
Reading				
Exposure	-9.42 (-17.40, -1.44)	-9.00 (-30.69, 7.87)	-15.00 (-2068, -4.57)	-7.50 (-18.05, 2.42)
Parent < HS Ed	-9.54 (-17.84, -1.25)	-9.00 (-27.28, 3.69)	-14.00 (-24.69, -4.87)	-12.00 (-24.21, 1.39)
Interaction	-9.91 (-21.45, 1.62)	-47.00 (-91.46, -8.51)	0.00 (-11.81, 12.11)	1.50 (-17.27, 17.16)

Research Team

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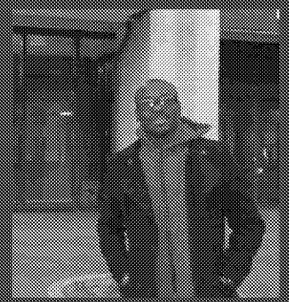

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Research Question

Our proposed research question focuses on understanding the relative and joint contributions of social and physical (built and natural) factors and chemical pollutant exposures on children's health and development for an urban, two county area in Southeast Wisconsin.

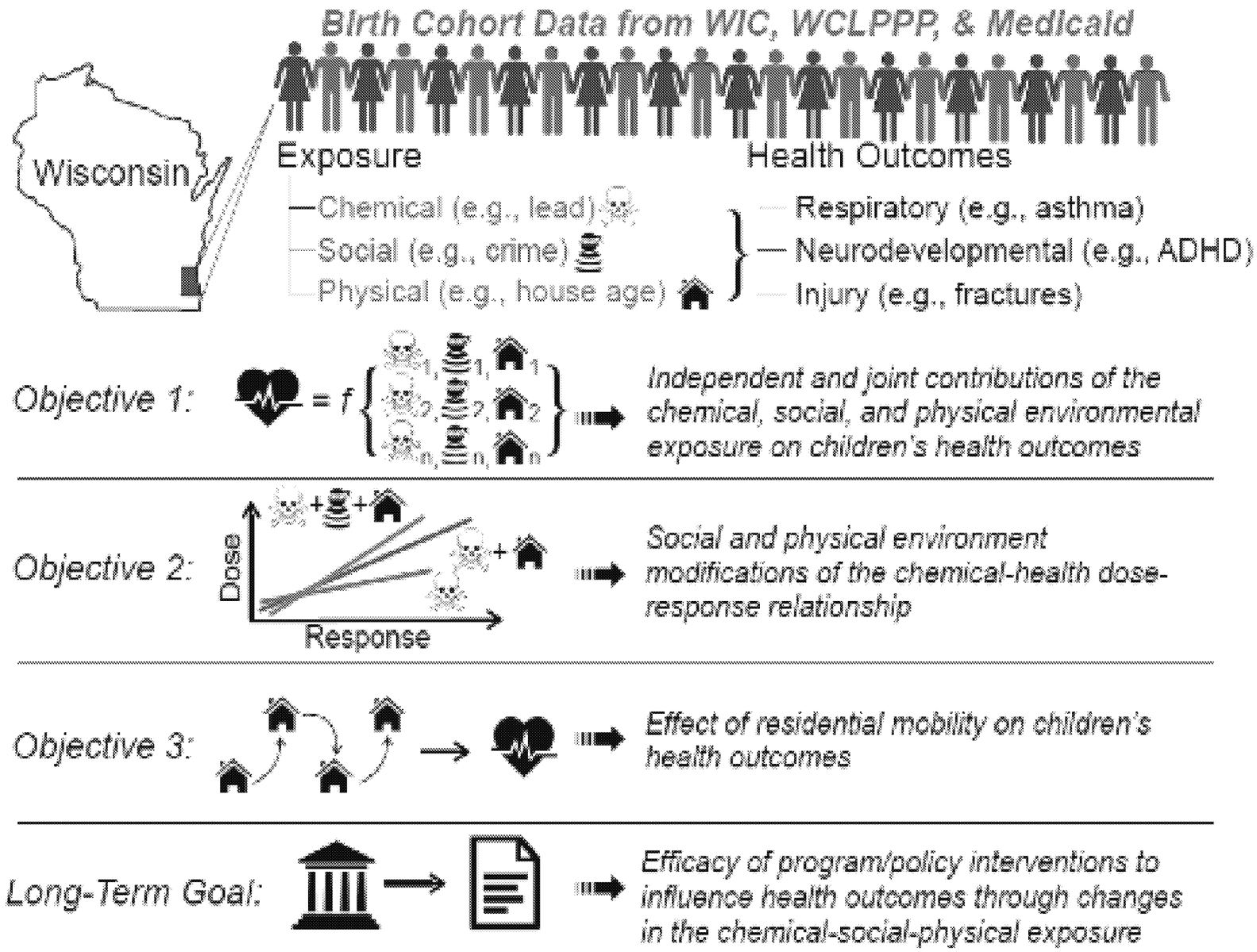


Figure 1: Proposal Schematic

SWISCHEESE

Location: Milwaukee and Racine Counties, Wisconsin

Enrollment: ~17,500

Partners: Wisconsin Department of Health Services

- Lead Program
- WIC Program
- Medicaid Program

[Photo Source: Wisconsin Daily Independent]

Study Area

"The drive into Milwaukee once offered a sweeping vista of the American industrial apocalypse."

– Colin Woodard, Politico, 2016

Table 3: 2016 Milwaukee and Racine County health indicators compared to state and national performance.

	Milwaukee	Racine	WI State Avg	National Best
Years life lost before age 75 (per 100,000 yrs)	7,900**	6,400*	6,000	5,200
% Residents reporting poor/fair health	18**	15*	15	12
% Children low birthweight	9**	8**	7	6
% Children living in poverty	32**	19*	18	13
% HS Graduates	75#	79#	88	93
% Children living in single parent HHDs	50**	36**	31	21
Violent Crimes/100,000	800#	247#	225	59
% Housing built < 1950	41#	30#	26	NA
% Unemployed	7#	6.8#	5.5	3.5
% HHDs severe housing problems	23**	15*	15	9
% Access to exercise opportunities	99#	89#	81	91

Data obtained from the 2016 County Health Rankings Index. *Indicates county data error margin excludes point estimates for Best Counties Nationally or Best Counties Nationally and Wisconsin Average (**). #Error margin not available for comparison.

[Source: countyhealthrankings.org]

Milwaukee County:

- 71st out of 72 Wisconsin counties for population health outcomes:
- 66th for length of life;
- 72nd for quality of life,
- 71st for health behaviors, including limited access to the food environment and physical inactivity;
- 71st for social and economic factors

Racine County:

- 69th for quality of life;
- 59th for health factors;
- 62nd for social and economic factors, including a higher percentage of poverty and unemployment, compared to state average.

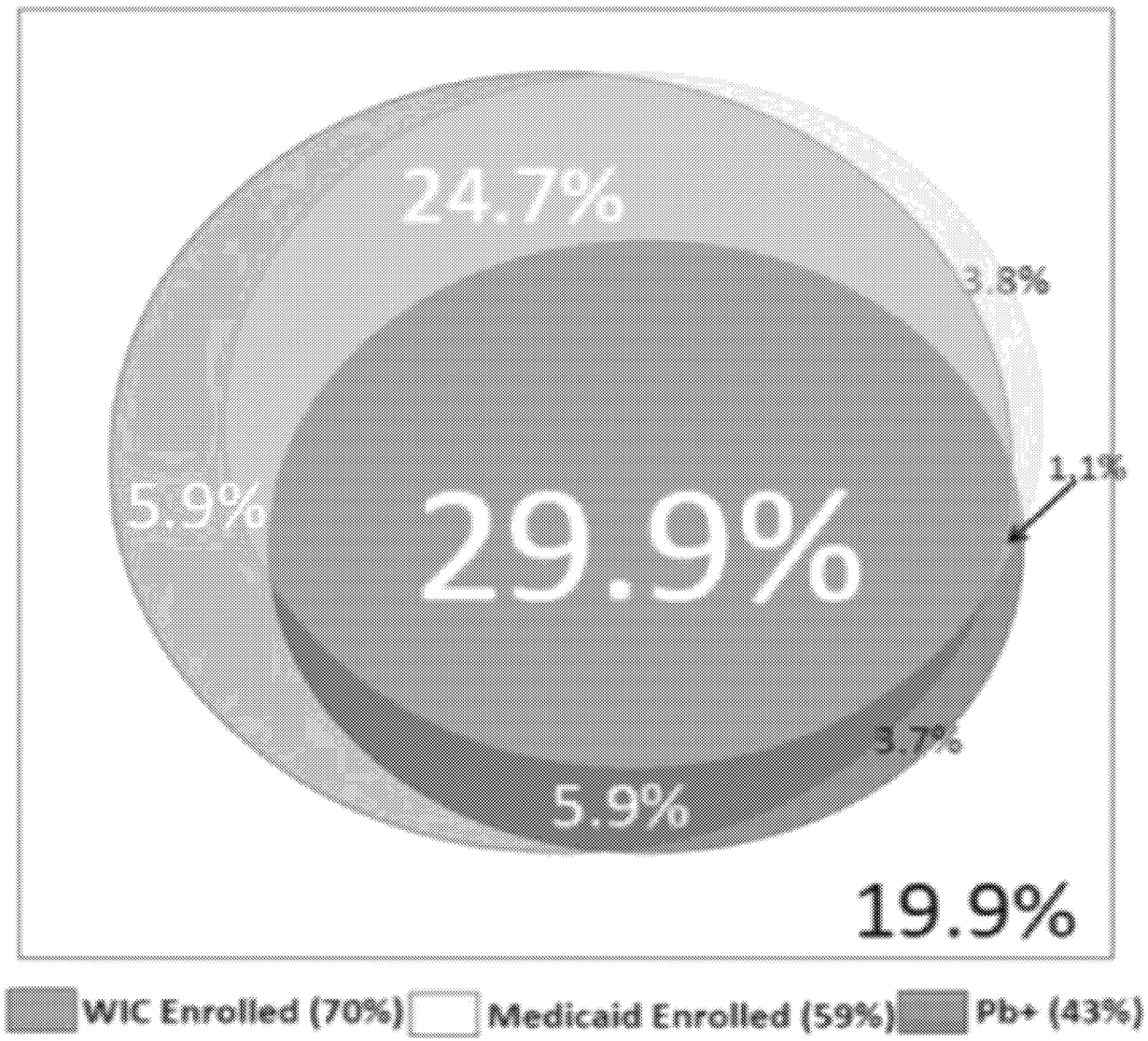


Figure 2 Overlap among WIC, Medicaid and Lead testing programs from prior SE Wisconsin study.

Study Population

2014 WIC Birth Cohort

~17,500 children

Major health indicators:

- Respiratory
- Neurocognitive
- Injury

Residential history data from WIC records (prenatal – age 5)

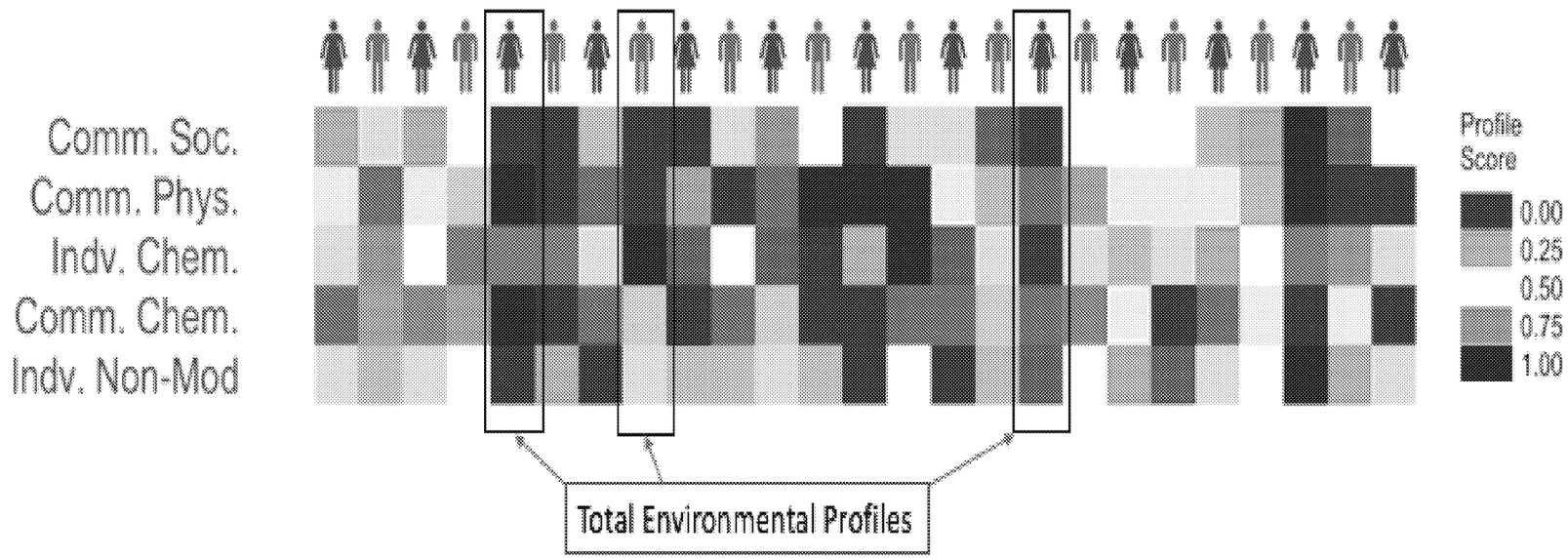


Figure 3: *Illustration of the five profiles (rows) for 25 children (columns). Red indicates a higher level of exposures (less advantageous) and blue indicates a lower level of exposures (more advantageous).*

Total Environmental Profiles

A primary task for the proposal is to develop time-resolved, individual- and community-level chemical, social, and physical environmental profiles for the birth cohort.

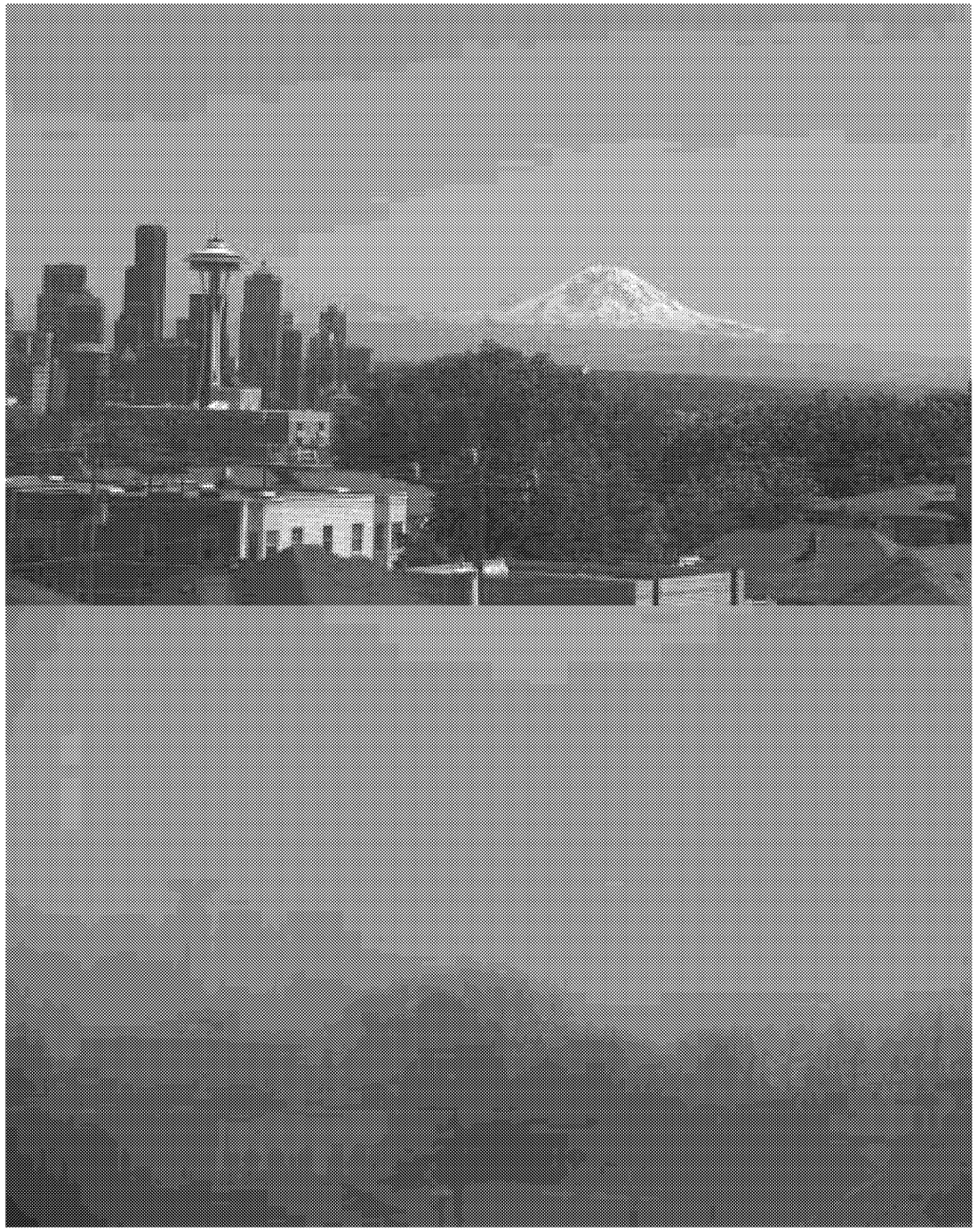
- Secondary data sources
- Possibility of augmentation with primary data

Study Objectives

Objective 1: Develop community- and individual-level profiles for social, physical, and chemical environments and determine the relative associations of these exposure profiles with respiratory, neurodevelopmental, and injury-related outcomes;

Objective 2: Evaluate the role of community-level social and physical environmental profiles on modification of the effect of chemical exposures on children's respiratory and neurodevelopmental-related outcomes for the study cohort.

Objective 3: Evaluate the role of residential mobility on respiratory, neurodevelopmental, and physical health in preschool children in Southeast Wisconsin.



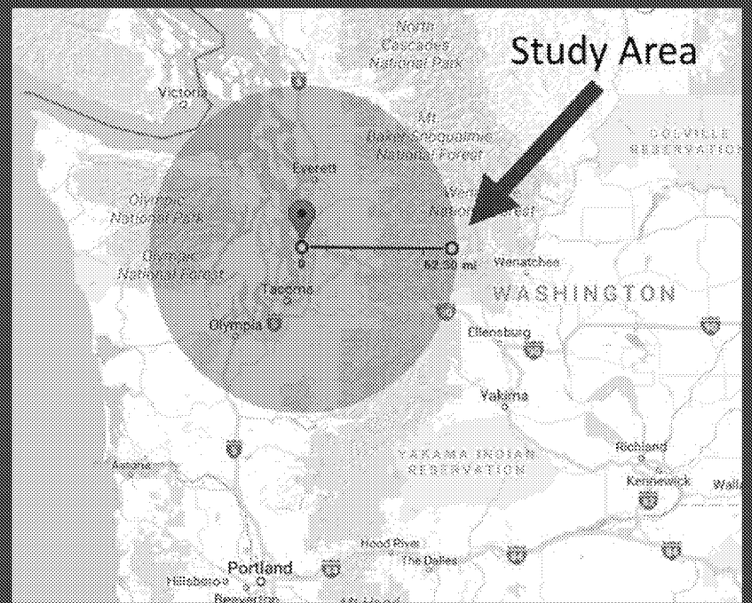
Lessons Learned

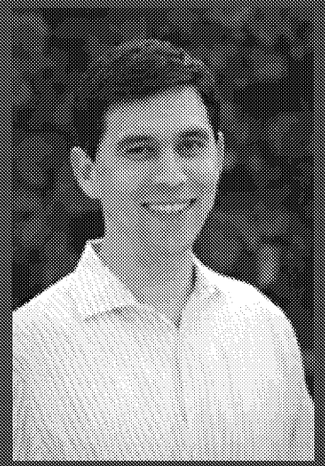
Case Study 1: Spatio-temporal Analysis of Environmental Contributions to Sub-Clinical COPD Exacerbations

Funding: VA HSR&D (PI: Fan), CSPH @CSU (PI: Magzamen)

Mixtures: COPD & Air Quality

Study area: Puget Sound, WA





Vincent Fan

Assaf Oron

Table 4. Crude and adjusted RR for daily count of SABA use ("puffs") associated with a 1 SD increase in pollutant.

Pollutant	Unadjusted RR (95% CI)	FDR	Adjusted RR (95% CI)	FDR
PM_{10}	**1.064 (1.039, 1.090)**	<0.001	**1.055 (1.029, 1.081)**	**<0.001**
$PM_{2.5}$	**1.023 (1.001, 1.046)**	0.056	1.014 (0.992, 1.038)	0.267
EC	**1.041 (1.014, 1.069)**	0.008	**1.029 (1.001, 1.057)**	**0.118**
OC	**1.036 (1.009, 1.063)**	0.016	**1.022 (0.995, 1.050)**	**0.195**
NO_2	**1.034 (1.011, 1.057)**	0.008	**1.027 (1.004, 1.050)**	**0.104**
O_3	0.980 (0.956, 1.006)	0.138	0.993 (0.967, 1.020)	0.605
AQI	1.017 (0.995, 1.04)	0.138	1.011 (0.989, 1.033)	0.364
WAQA	**1.027 (1.003, 1.051)**	0.041	1.017 (0.993, 1.042)	0.221
SVD1 ("pollution")	**1.035 (1.012, 1.059)**	0.008	**1.023 (0.999, 1.048)**	**0.118**
SVD2 ("hot-dry")	1.017 (0.989, 1.046)	0.243	1.029 (1.000, 1.060)	0.118

Adjusted models included supplemental oxygen, FEV1 % predicted, long-acting anti-cholinergic use, MRC Dyspnea Scale Score, and winter season.

[Source: Mauzemen, Oron, Locke, Fan 2013]

Results

- PM10 had strongest association with daily COPD exacerbations (as measured by use of rescue inhaler)
- Air quality summary measures significantly associated with COPD exacerbations
- AQI elevated, but not significant
- WAQA elevated, but not significant correcting for FDR
- Data-driven approaches for summary scores both significant

Lessons Learned

Case Study 2: Assessment of Joint Effects of Pesticides and Air Pollution in Pediatric Asthma

Funding: NIH/NIEHS

(PI: Magzamen)

[Source: Benka-Coker *et al.* (in preparation)]

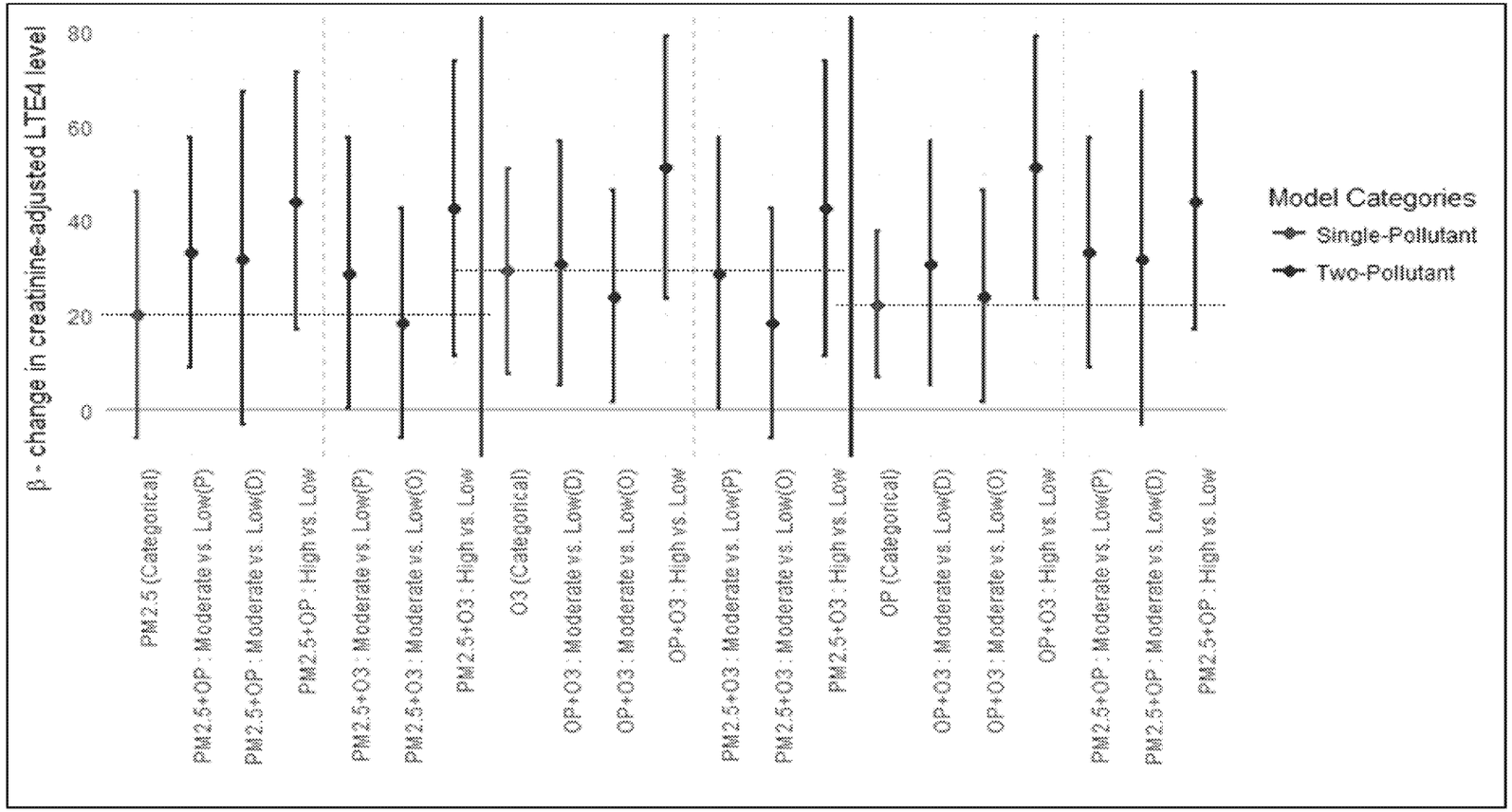
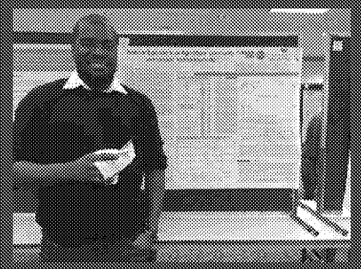
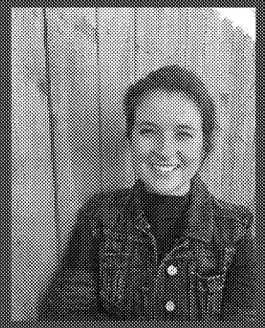


Figure 4. *Estimated effects (β change and 95% confidence intervals) on creatinine-adjusted LTE4 levels from two-pollutant models indicating specific pollutant contribution to exposure mixture categories. Letter in parenthesis indicates pollutant with highest exposure level; P: $PM_{2.5}$, O: ozone, D: total dialkylphosphate (organophosphate). Horizontal lines indicate level of effect estimates of single pollutant in comparison to multipollutants.*

Team



Wande Benka-Coker



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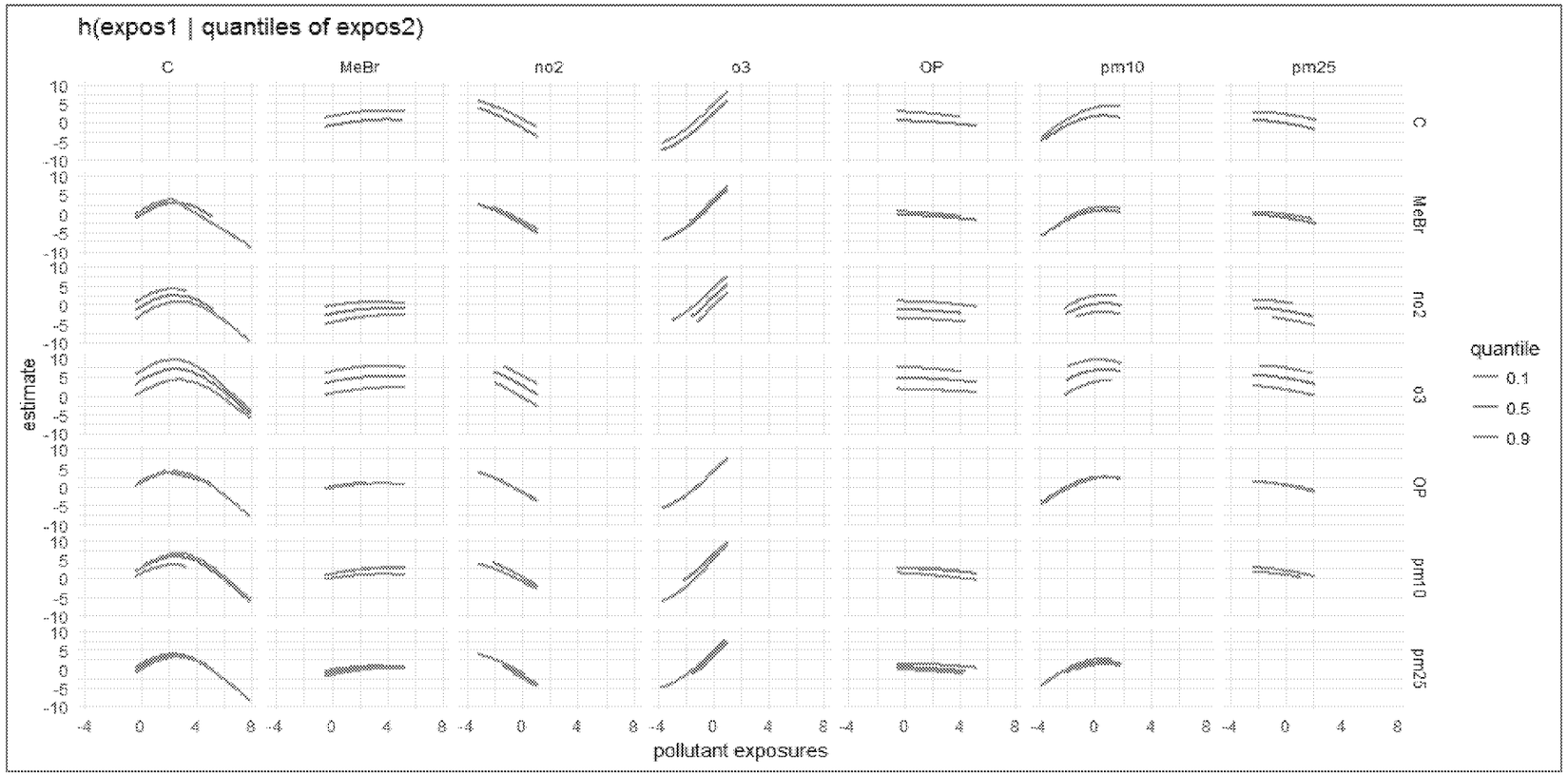

Figure 5. *Bivariate analysis looking at 2-way interaction (FEV_1%). We view the predictor-response function of a single predictor in Z for the second predictor in Z, fixed at various quantiles (0.1, 0.5, 0.9), whilst the remaining predictors fixed to a particular value.*

[Source: Benka-Coker *et al.* (in preparation)]

Bayesian Kernel Machine Regression (BKMR)

Given multiple exposures and correlated data, how do we discern the most important exposure-response association, in addition to potential interaction among pollutants?

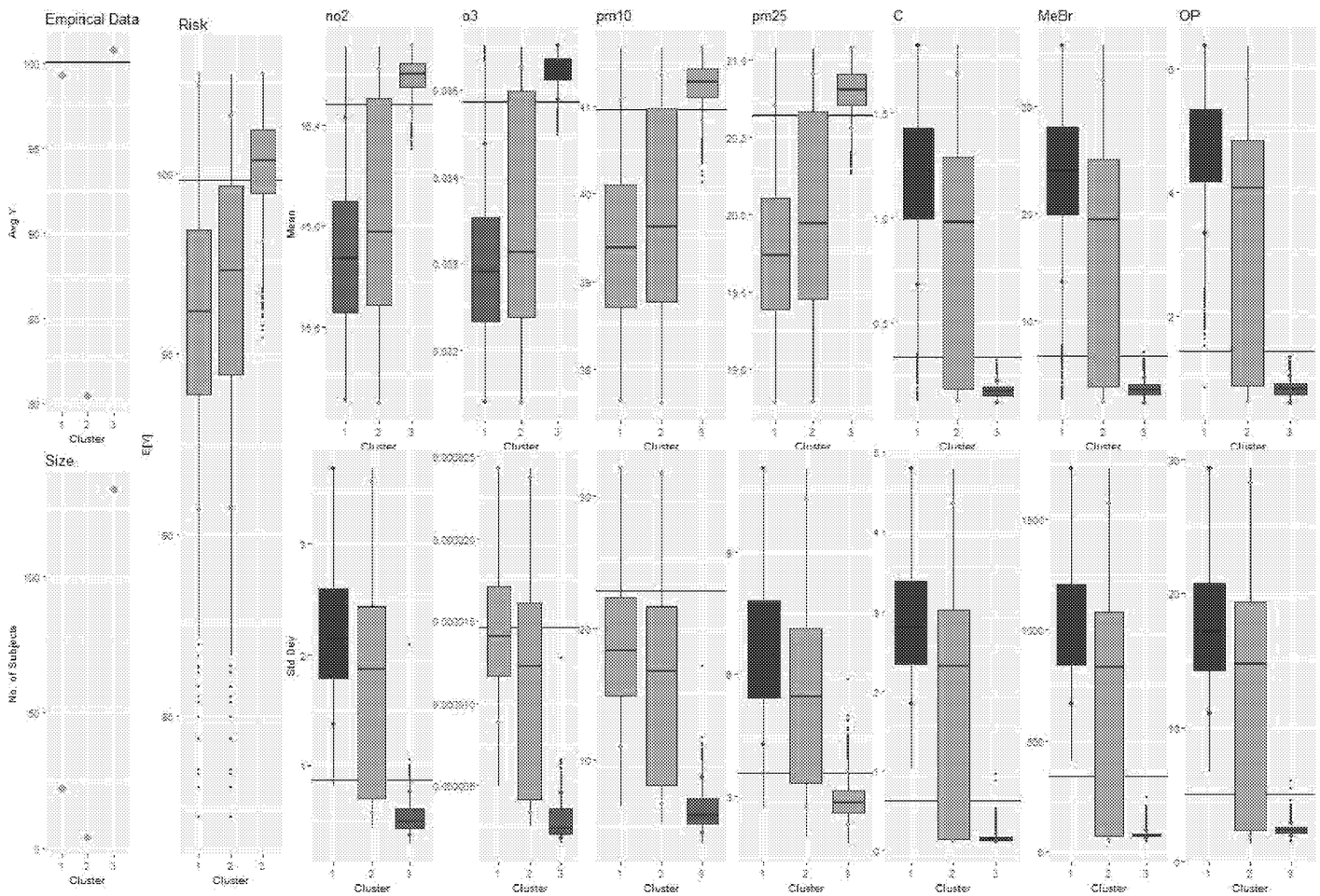

Figure 6. *Bayesian profile regression (BPR) clustering results for FACES study population by pollutant class, FEV1% predicted as outcome.*

[Source: Benka-Coker *et al.* (in preparation)]

Bayesian Profile Regression (BPR)

Does correlation among exposures allow us to classify study subjects into group to estimate joint impact on outcome of shared exposure(s)?

Summary

- Team science approach to characterize social, built and chemical environments in diverse, environmental injustice community

- Multiple methodological approaches to explore independent and joint effects of exposures on multiple children's health outcomes

- Partnership with Wisconsin DHS to promulgate Research to Practice (R2P) Model

Thank you

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