Intersectional Environmental Justice and Population Health Inequalities: A Novel Approach

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Acknowledgements

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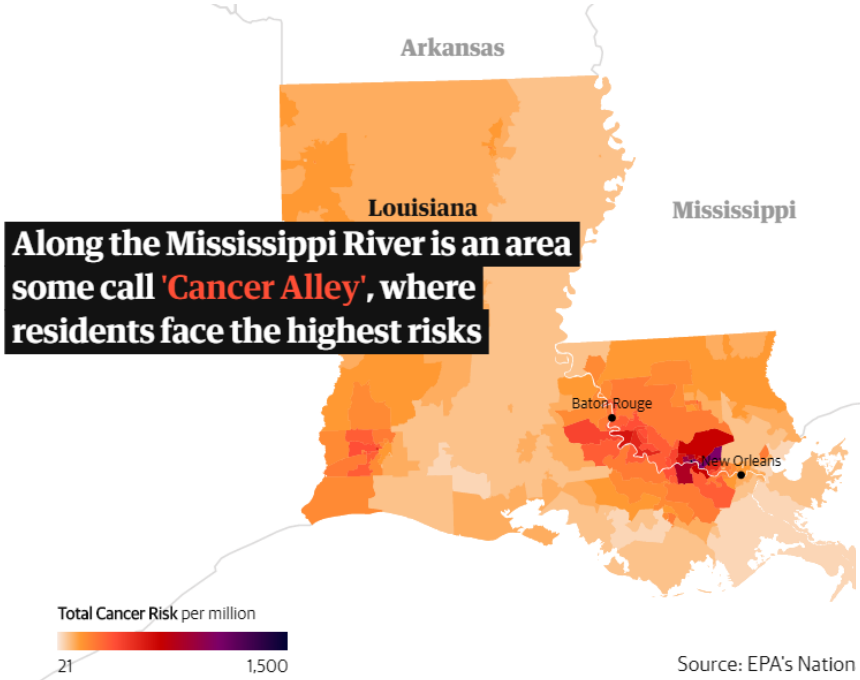


Screenshot from *"Cancer Town:* 'Almost every household has someone that has died from cancer'*"* *by* Jamiles Lartey *and* Oliver Laughland *published in The Guardian* on *06 May 2019*

CITYLAB DESIGN / TRANSPORTATION / ENVIRONMENT / EQUITY / LIFE

Why Does California's Central Valley Have Such Bad Air Pollution?

NATE BERG SEP 28, 2011

The farming communities of the Central Valley breathe some of the worst air in the nation

SHARE TWEET ...

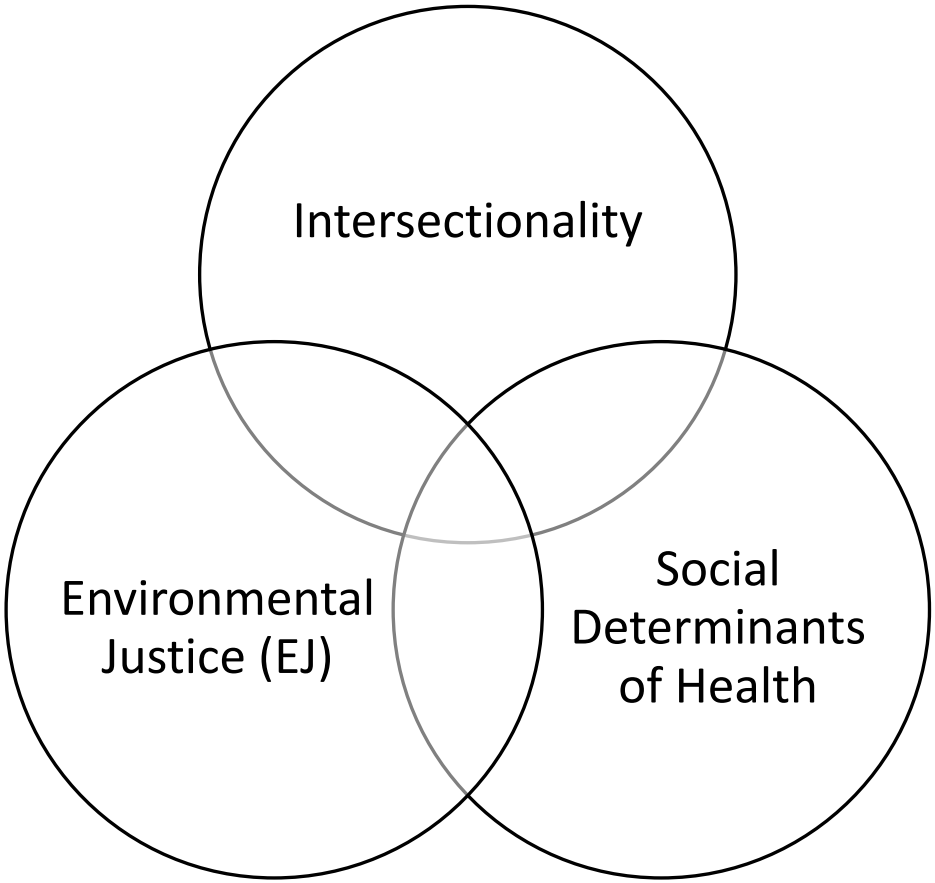
As we reported earlier this week, the World Health Organization released its latest report measuring air quality in cities all over the world. The report specifically looks at the concentration of particles measuring 10 micrometers or less – those likely to get into the blood stream and cause disease.

Of the 375 U.S. cities included in the list, only 36 of them exceed the WHO's air quality standard of 20 micrograms of particulates per cubic meter, on average. That's pretty good. But of the ten worst performing cities, five are located in California's Central Valley.

So what's going on here?

Screenshot from "Why Does California's Central Valley Have Such Bad Air Pollution?" by Nate Berg published in CityLab on 28 Sept 2011

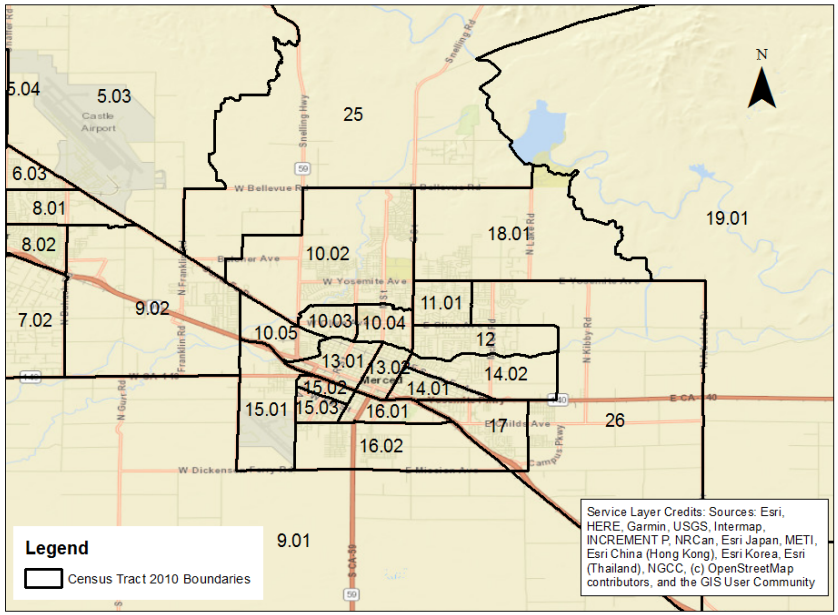
Conceptual Frameworks



Research Question

ARE THERE INTERACTION EFFECTS (OR OVERLAPPING NEIGHBORHOOD DEMOGRAPHICS) FOR ENVIRONMENTAL HEALTH RISK ACROSS CENSUS TRACTS IN THE UNITED STATES?

Unit of analysis



Unit of analysis is census tract

Using census tract as proxy of neighborhood or community

Sample=72,103 census tracts from the United States

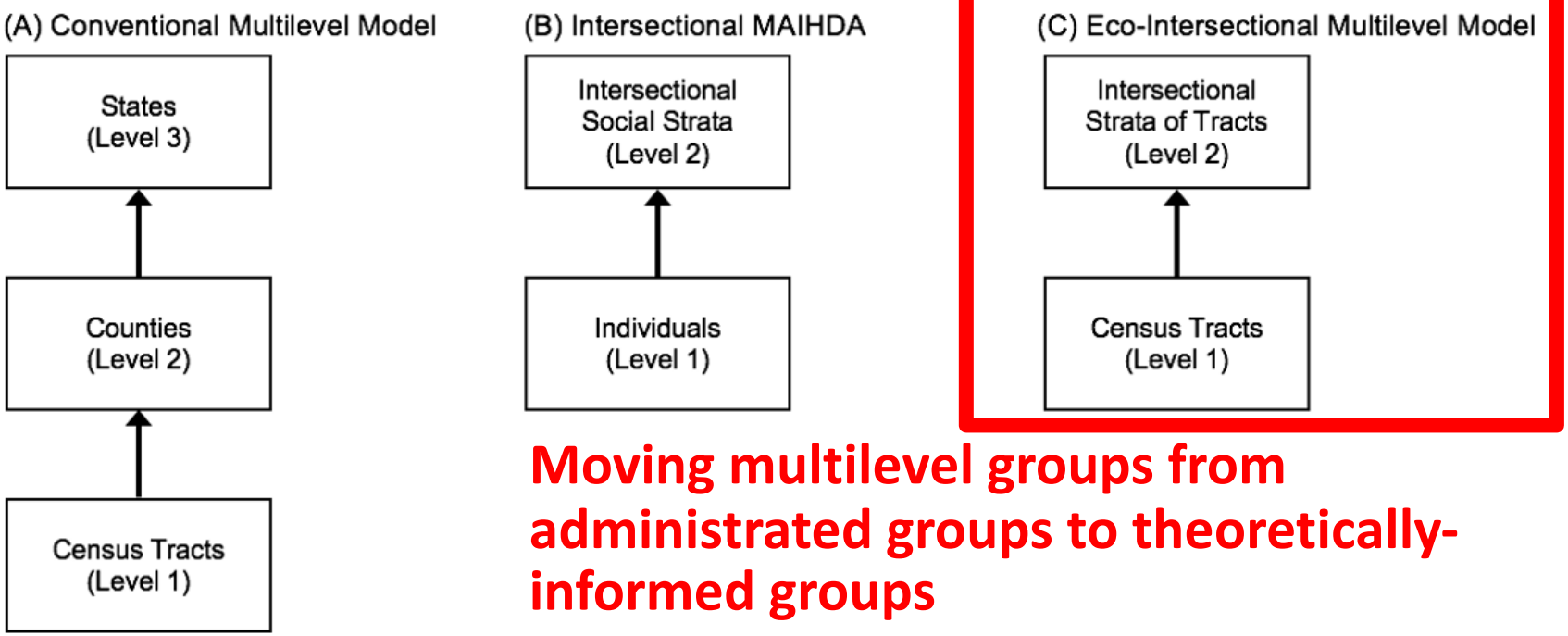
Data

Dependent Variable: 2014 annual estimated cancer risk from air toxics (EPA's National Air Toxics Assessment)

Neighborhood Demographic Data comes from U.S. Census' American Community Survey and USDA's 2013 Rural-Urban Continuum Codes .

Analytical Strategy

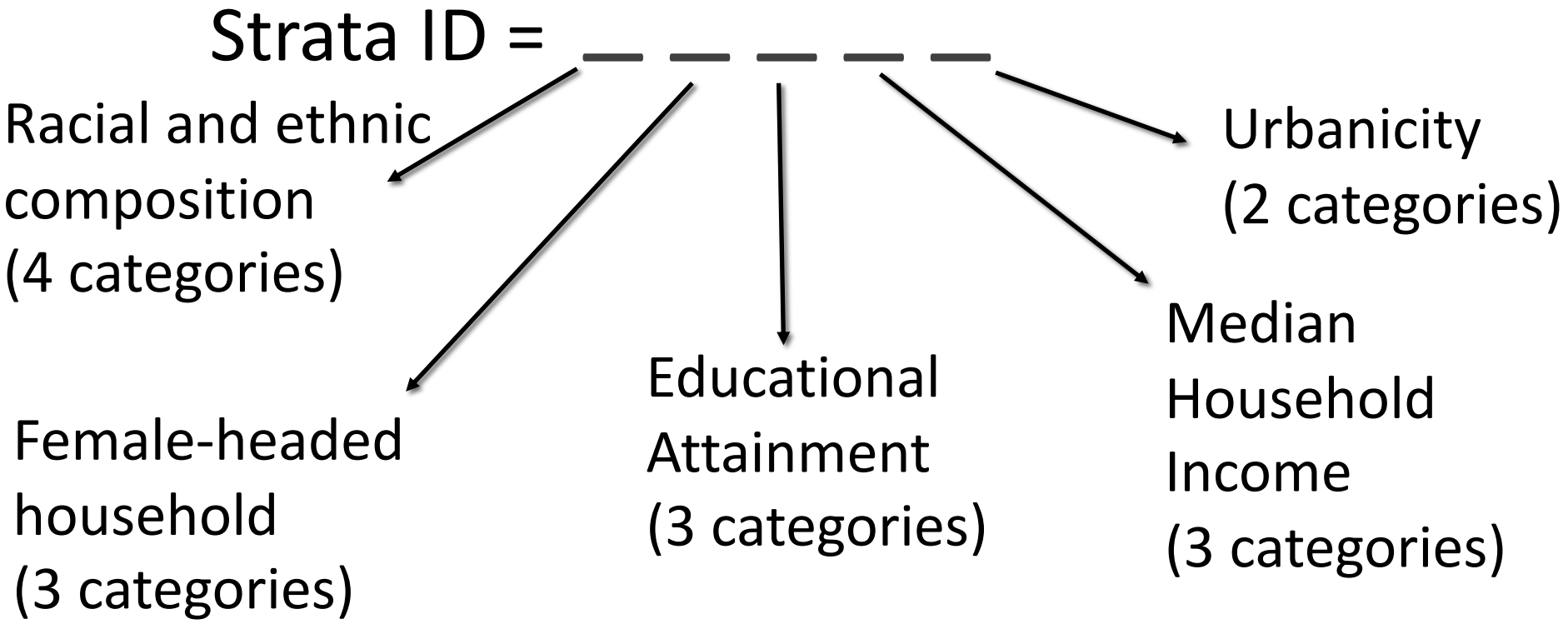
Figure 1. Comparison of multilevel model structures.



Moving multilevel groups from administrated groups to theoretically-informed groups

Notes: Arrows indicate hierarchical, nested structure of data. For instance, in conventional multilevel models, multiple census tracts (level 1) are nested within each county, and counties (level 2) are nested within each state (level 3).

Intersectional Strata of Tracts



4*3*3*3*2=216

total intersectional strata

Stratum ID	1st digit: Racial and ethnic composition		2nd digit: Female-Headed Household		3rd digit: Educational Attainment		4th digit: Income		5th digit: Urbanicity	
	1	Below the median % Black and below the median % Latinx residents	1	Lowest tercile of percent female-headed household	1	Lowest tercile of percent some college or up	1	Lowest tercile of median household income	0	Non-metro
	2	*Above* the median % Black and *below* the median % Latinx residents	2	Middle tercile of percent female-headed household	2	Middle tercile of percent some college or up	2	Middle tercile of median household income	1	Metro
	3	B*elow* the median % Black and *above* the median % Latinx residents	3	Highest tercile of percent female-headed household	3	Highest tercile of percent some college or up	3	Highest tercile of median household income		
	4	*Above* the median % Black and *above* the median % Latinx residents								

Stratum ID: 23331

2 – upper-tile % Black & % lower-tile Latinx residents

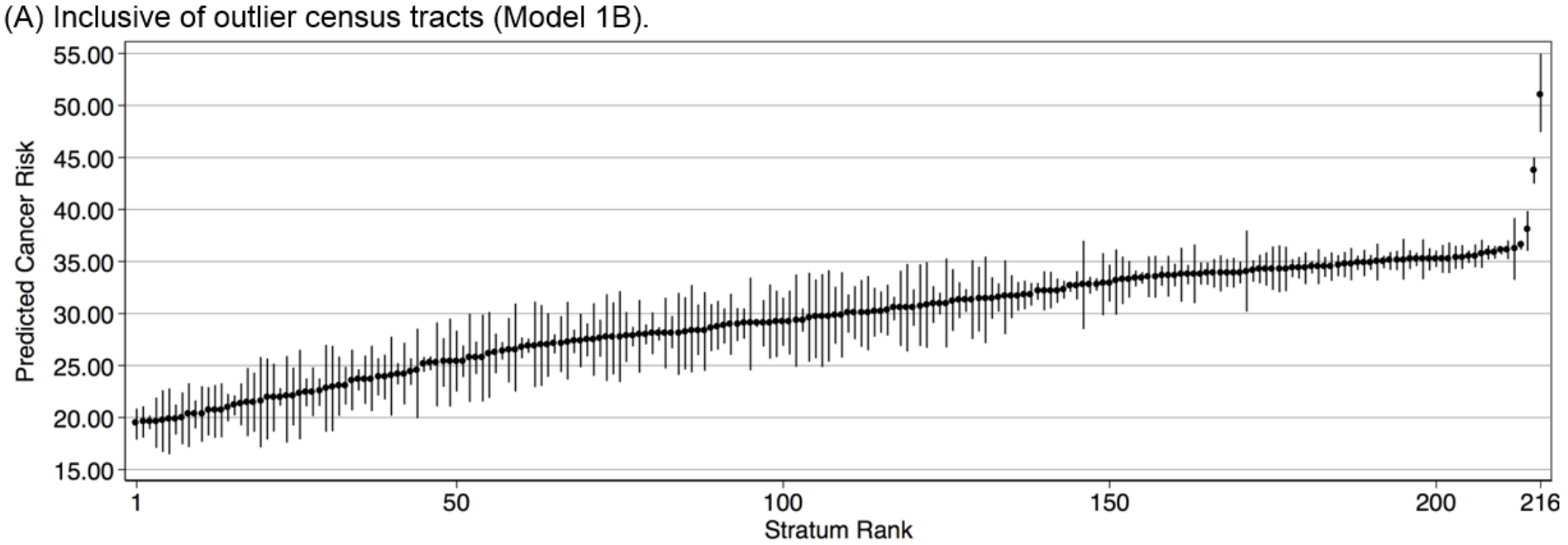
3 – upper tertile % of single female-headed household

3 – upper tertile % of % some college and up

3 – upper tertile of median household income

1 -- metro

Considerable amount of interaction effects across strata.

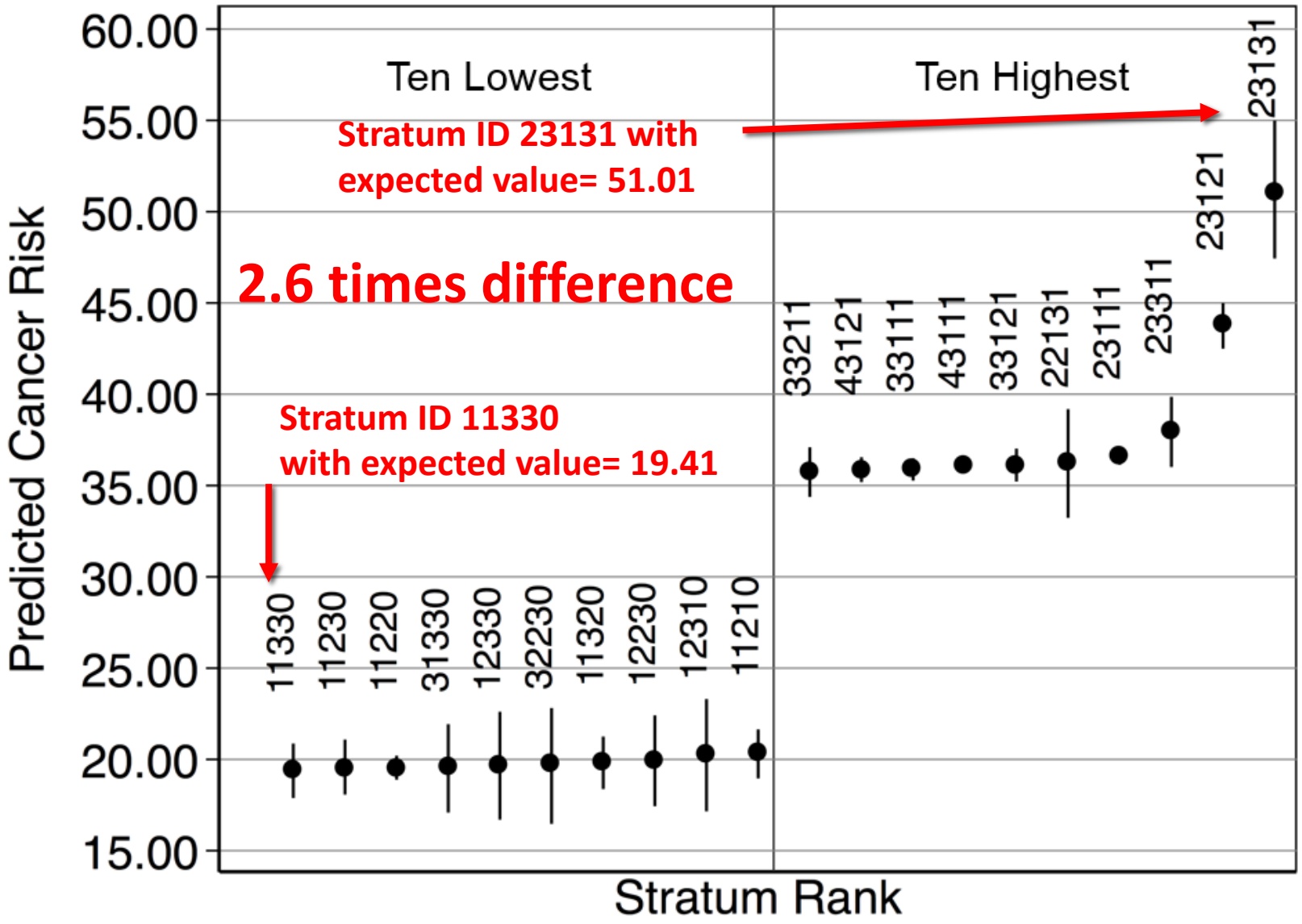


Null model VPC = 18.33%

The PCV between the null model and main effects model 85.4%.

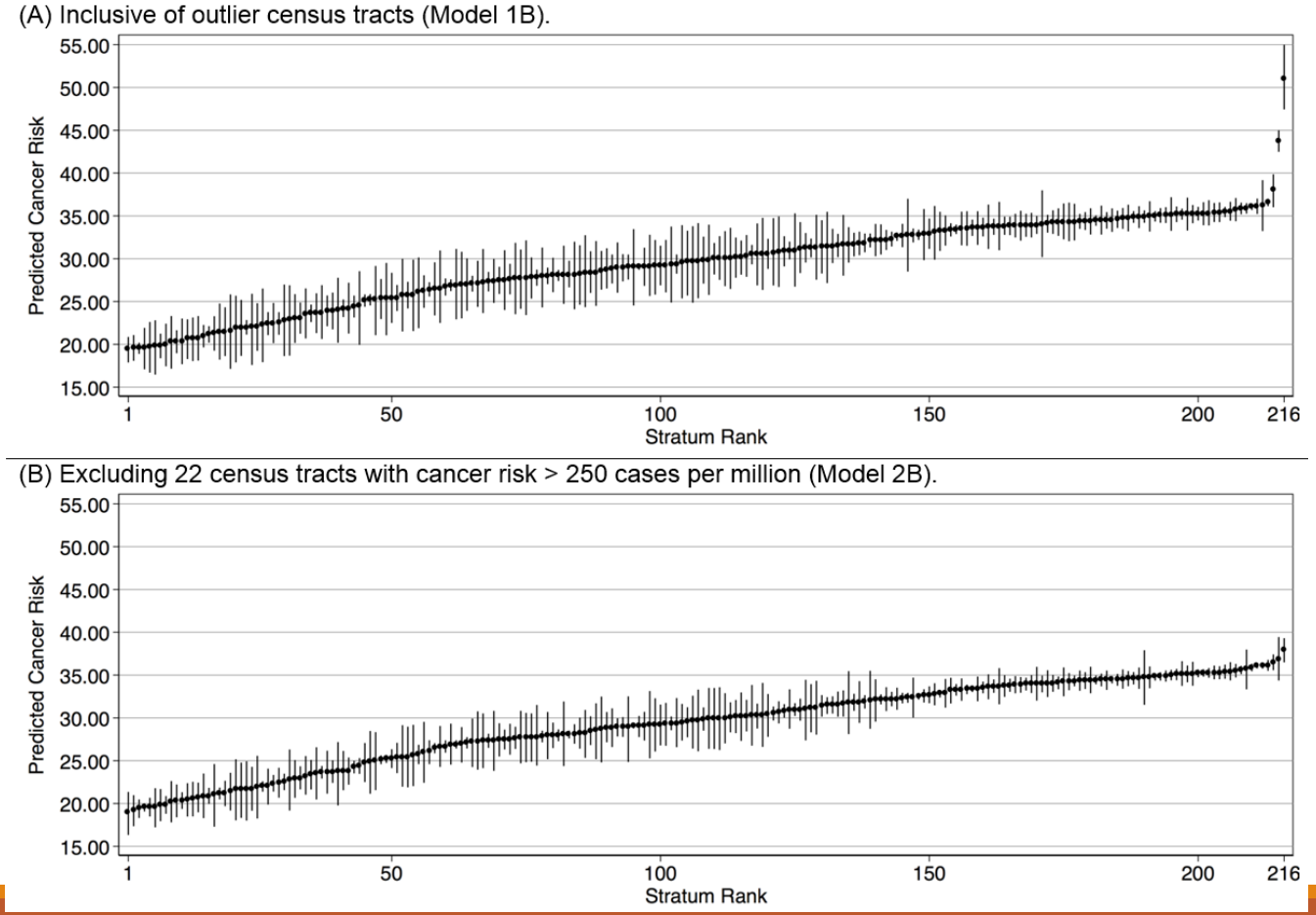
This suggests that approximately 15% of the between-stratum variance may be attributed to interaction effects

Figure 3: Up-close of high- and low-risk air pollution exposure by stratum ranking



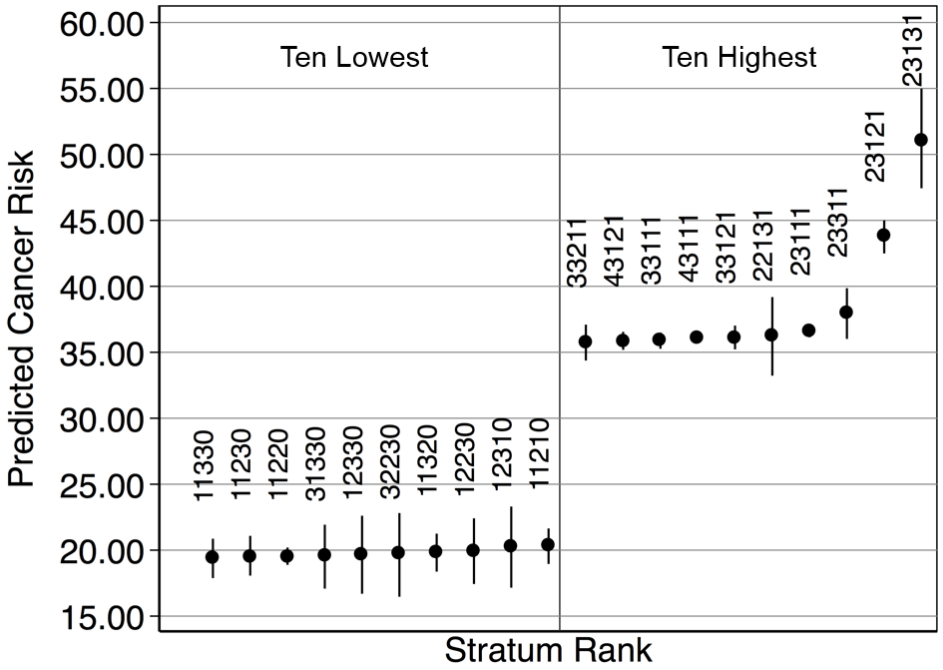
Considerable amount of interaction effects across strata.

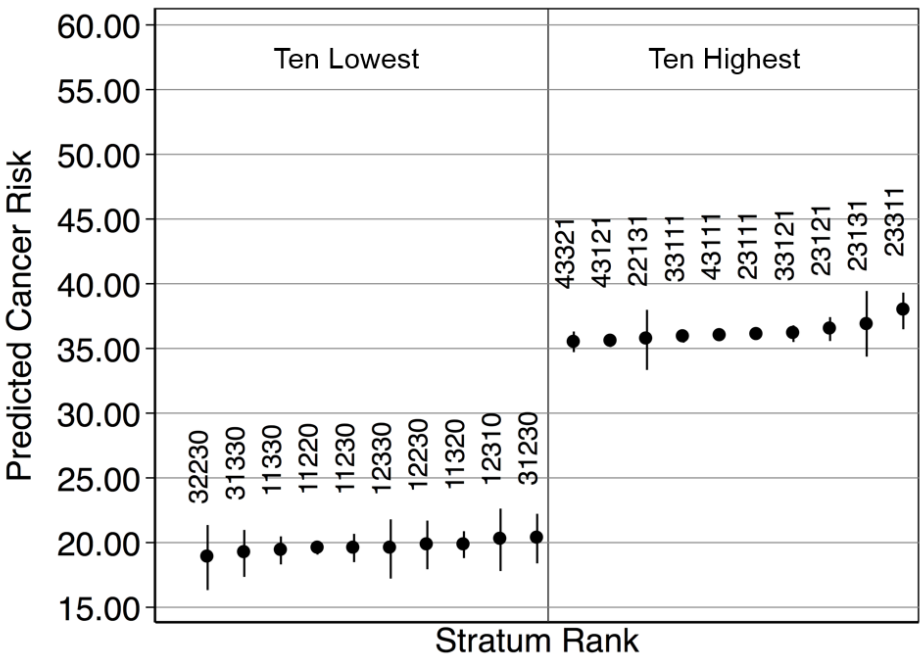
Figure 2: Expected values of total air pollution by stratum ranking



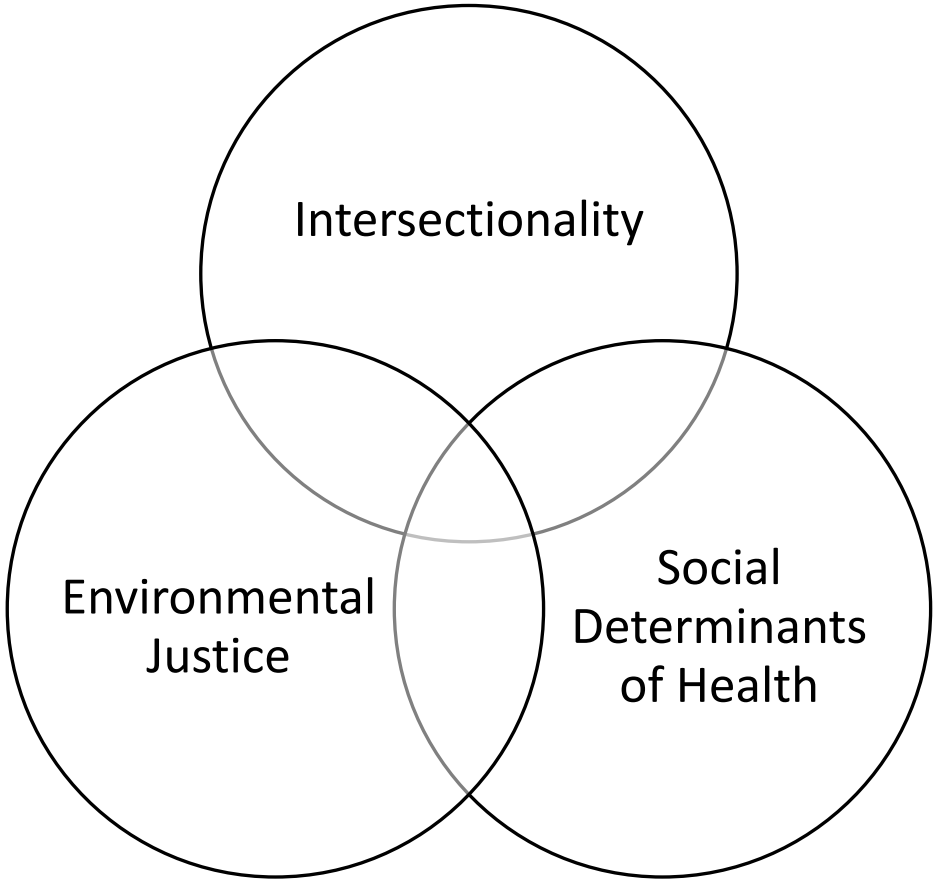
Considerable amount of interaction effects across strata.

Figure 3: Up-close of high- and low-risk air pollution exposure by stratum ranking





Conclusion



We find evidence of significant, intersectional inequalities in environmental health risk from air toxics between strata of census tracts.

Our approach reconceptualizes how environmental justice, intersectionality theory, and social determinants of health can inform each other and understand social and environmental inequalities.

Table 1. Descriptive Statistics of Census Tracts.

	Mean	SD	Min	Max	Median
Estimated Air Toxics Cancer Risk (All Tracts)	31.65	12.92	6.17	1505.12	31.00
Race/Ethnicity by Tract					
% White, not Latinx	63.22	30.16	0	100.00	72.69
% Latinx	15.65	21.16	0	100.00	6.61
% Black, not Latinx	13.38	21.93	0	100.00	3.74
% Female-Headed Households	13.64	8.71	0	87.28	11.53
% Residents with Some College or More	57.26	17.82	4.74	100.00	56.26
Median Household Income (in $1,000s)	57.23	28.49	2.50	250.00	51.00
Metro (binary)	.8338	.3723	0	1	1
% Renters	36.30	22.70	0	100	31.15
% Unemployed	9.76	6.01	0	100	8.44
% Housing units built after 1970	55.49	28.77	0	100.00	57.21
Median Housing Value (in $1,000s) (n=71,375)	219.10	173.75	10.000	100.00	162.50
% Workers in Manufacturing (n=72,102)	10.45	6.91	0	71.77	9.13
Median Age in Tract	38.75	7.62	11.50	84.30	38.80

Note: n=72,103 unless otherwise stated. Percent unemployed was calculated as the number of civilians (aged 16 years and older) in the labor force who reported being unemployed divided by the total population in the tract (aged 16 years and older) who are in the labor force. Median housing value is of owner-occupied housing units in tens of thousands of dollars. Percent of workers in manufacturing is the number of civilians (aged 16 years and older) employed in manufacturing divided by the total number of civilians (aged 16 years and older) who are employed.

Table 2. Results from Multilevel Linear Regression Models.

	Model 1A (Null)				Model 1B (Main Effects)				Model 1C (Main Effects+Controls)			
FIXED EFFECTS	Est	95% CI		P	Est	95% CI		P	Est	95% CI		P
Intercept	29.70	28.86	30.51	<0.001	21.99	20.88	23.04	<0.001	23.41	22.29	24.52	<0.001
Racialization												
Low% Black, Low% Latinx (ref)	—	—	—	—	—	—	—	—	—	—	—	—
High% Black, Low% Latinx					8.29	7.34	9.25	<0.001	7.95	6.88	9.00	<0.001
Low% Black, High% Latinx					3.30	2.33	4.22	<0.001	2.41	1.37	3.38	<0.001
High% Black, High% Latinx					6.85	5.87	7.89	<0.001	5.76	4.75	6.84	<0.001
Female Headed Household												
Low Tercile (ref)	—	—	—	—	—	—	—	—	—	—	—	—
Middle Tercile					1.02	0.10	1.85	0.014	1.13	0.25	2.03	0.006
High Tercile					2.73	1.92	3.60	<0.001	2.66	1.75	3.61	<0.001
Educational Attainment												
Low Tercile (ref)	—	—	—	—	—	—	—	—	—	—	—	—
Middle Tercile					-1.95	-2.79	-1.09	<0.001	-2.39	-3.20	-1.58	<0.001
High Tercile					-1.67	-2.59	-0.77	0.002	-3.21	-4.12	-2.27	<0.001
Median Household Income												
Low Tercile (ref)	—	—	—	—	—	—	—	—	—	—	—	—
Middle Tercile					-0.46	-1.26	0.41	0.145	-0.10	-0.88	0.77	0.401
High Tercile					-0.74	-1.60	0.16	0.069	-0.64	-1.57	0.32	0.095
Metro					6.45	5.72	7.16	<0.001	6.04	5.25	6.76	<0.001
CONTROLS												
Median Age*									-0.03	-0.05	-0.02	<0.001
Housing built after 1970 (%)*									0.03	0.02	0.03	<0.001
Median Housing Value* ‡									0.06	0.05	0.07	<0.001
Manufacturing (%)*									-0.05	-0.06	-0.03	<0.001
Renters (%)*									0.04	0.03	0.04	<0.001
Unemployment (%)*									0.01	-0.01	0.03	0.186
RANDOM EFFECTS	Est	95% CI			Est	95% CI			Est	95% CI		
Stratum Var (σ^2_{u0})	32.61	26.36	39.92		4.76	3.48	6.41		4.61	3.28	6.30	
Census Tract Var (σ^2_{e0})	145.25	143.74	146.74		145.30	143.84	146.81		144.31	142.77	145.81	
VPC (%)	18.33	15.50	21.39		3.17	2.36	4.19		3.10	2.25	4.14	
PCV (%) **					85.40				85.86			
N	72,103				72,103				71,374			

Notes: * Variable is mean-centered. ** Proportional Change in Stratum-Level Variance relative to model 1A (null model). ‡In tens of thousands. Due to missing data in ACS on median housing value (n=728) and percent manufacturing (n=1), the total number of census tracts in Model 1C was reduced to 71,374.

Table 3. Details for twenty-two "outlier" census tracts with estimated cancer risk ≥ 250 cases per million.

State	County	EPA Region	Tract #	Stratum ID	Population Size	Est Cancer Risk	Explanation for Elevated Risk *
CO	Jefferson	8	8059010902	33211	2,310	525.56	Elevated estimated risk due to ethylene oxide emissions from Terumo BCT Sterilization Services in Lakewood, CO.
IL	DuPage	5	17043845811	42321	3,838	263.44	These two census tracts are contiguous. Elevated estimated risk due to ethylene oxide emissions from the Sterigenics facility, located in Willowbrook, IL.
IL	DuPage	5	17043845902	11331	3,411	281.81	
LA	St. Charles	6	22089060100	23131	1,937	808.72	This cluster of twelve contiguous census tracts spans a section of the Mississippi River in two counties in Louisiana: St. Charles and St. John the Baptist. The area is part of the notorious "Cancer Alley." Elevated estimated risk due to chloroprene and ethylene oxide emissions. The La Place Chemical Plant operated by Denke Performance Elastomer (located in tract #22095070800) has been identified as the major source of chloroprene emissions. The Union Carbide facility and the Evonik Materials facility have been identified as the major sources of ethylene oxide emissions.
LA	St. Charles	6	22089062500	23121	2,988	273.27	
LA	St. Charles	6	22089062700	23111	4,753	284.51	
LA	St. John the Baptist	6	22095070100	22231	2,685	303.01	
LA	St. John the Baptist	6	22095070300	22221	6,258	296.31	
LA	St. John the Baptist	6	22095070400	22231	4,381	286.54	
LA	St. John the Baptist	6	22095070500	43121	6,229	329.27	
LA	St. John the Baptist	6	22095070700	23121	4,348	511.32	
LA	St. John the Baptist	6	22095070800	23121	2,537	1,505.12	
LA	St. John the Baptist	6	22095070900	23111	3,115	616.62	
LA	St. John the Baptist	6	22095071000	23111	2,840	490.28	
LA	St. John the Baptist	6	22095071100	23121	3,398	363.19	
PA	Lehigh	3	42077000101	43221	3,661	346.52	These three census tracts are contiguous. Elevated estimated risk due to ethylene oxide emissions from the B Braun Medical Inc facility, located in Allentown, PA.
PA	Lehigh	3	42077005902	42221	1,571	596.46	
PA	Lehigh	3	42077009200	31221	3,768	256.05	
TX	Harris	6	48201343100	42231	4,629	348.20	These two census tracts are contiguous and located in Houston, TX. Elevated estimated risk due to ethylene oxide emissions. East Houston is well known as the location of a variety of polluters in close proximity to fenceline neighborhoods.
TX	Harris	6	48201343200	41331	4,944	296.18	
TX	Jefferson	6	48245010902	31331	4,592	274.52	Elevated estimated risk due to ethylene oxide emissions from the Huntsman Corporation's Port Neches facility.
WV	Kanawha	3	54039013400	22211	2,222	366.66	Elevated estimated risk due to ethylene oxide emissions from the Union Carbide facility.

Notes: Estimated cancer risk is reported as cases per million persons, and assumes a lifetime (70 year) of exposure to concentrations of air toxics equivalent to those in the tract in that year.

Intersectional strata of tracts

Strata sample size of census tracts strata	Frequency of strata N	(%)
100 or more	117	54.17%
50 or more	143	66.20%
30 or more	162	75%
20 or more	169	78.24%
10 or more	185	85.65%
5 or more	194	89.84%
1 or more	216	100%

Out of 216 possible strata

Analytical Strategy: EIM modeling

$$y_{ij} = \beta\delta_j + u_{0j} + e_{0ij}$$

$$u_{0j} \sim N(0, \sigma_u^2)$$

$$e_{0ij} \sim N(0, \sigma_e^2)$$

Interactions grow linearly instead of geometrically.

Model parsimony is kept by having the estimate residual give the effect of the interaction.

MAIDHA has shown through stimulation that the model is robust to different sample sizes (Evans 2015; Evans et al 2018; Bell, Holman & Jones 2019).

Variance

Variance Partition Coefficient (VPC)

$$\text{VPC} = \frac{\sigma_u^2}{\sigma_u^2+\sigma_e^2} \times 100\%$$

Proportional Change in Variance(PCV)

$$\text{PCV} = \frac{\sigma^2_{u,\,Null\ model} - \sigma^2_{u,\,Non\ null\ model}}{\sigma^2_{u,null\ model}} \times 100\%$$