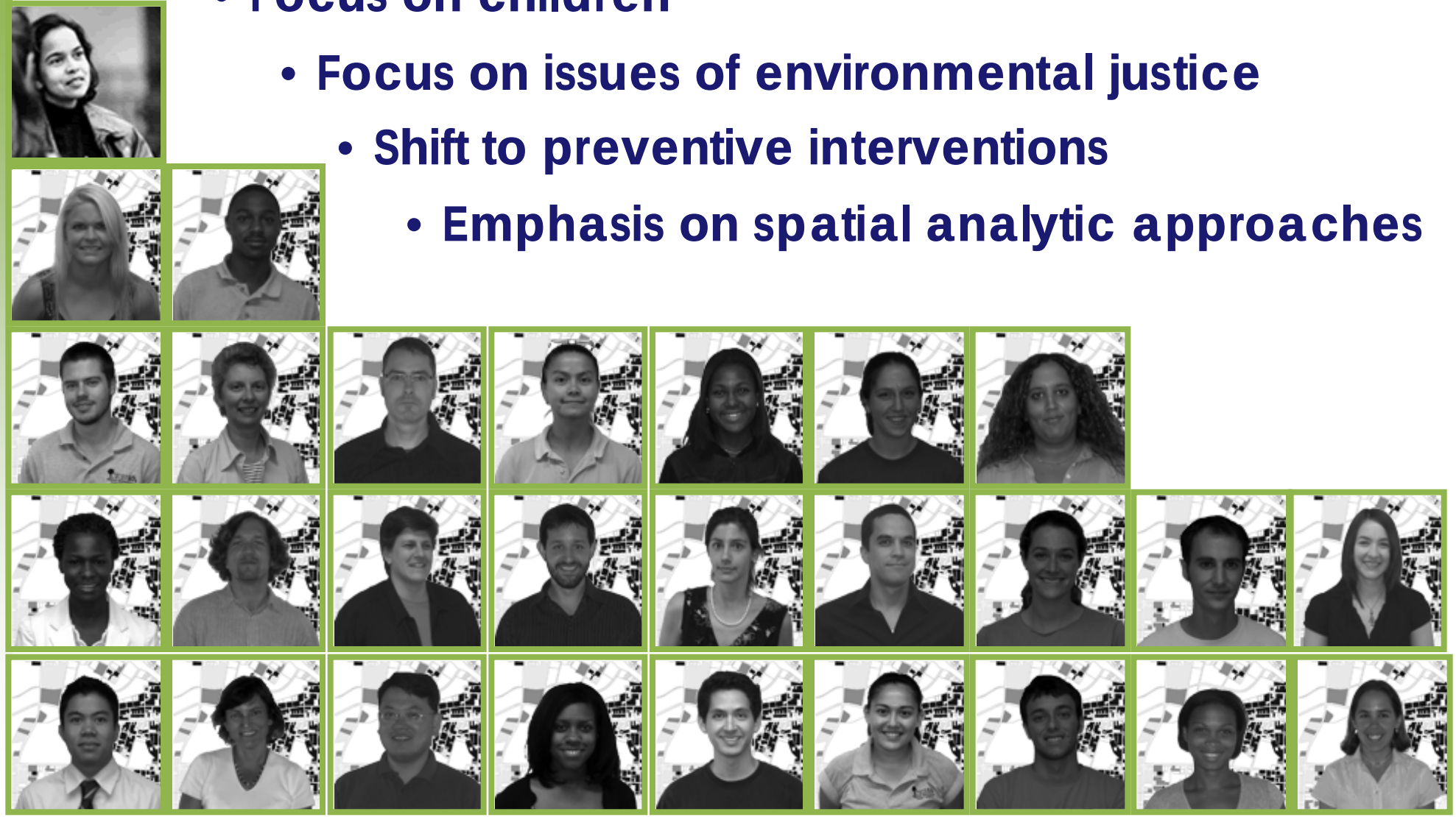
The Effects of PM_{10} and $PM_{2.5}$ on Birth Weight in North Carolina

S.C. Gray, K.V. Williams, S.E. Edwards, G.K. Swamy,
E. Tassone, A.E. Gelfand, M.L. Miranda

11/7/07

Children's Environmental Health Initiative

- Focus on children
  - Focus on issues of environmental justice
    - Shift to preventive interventions
      - Emphasis on spatial analytic approaches



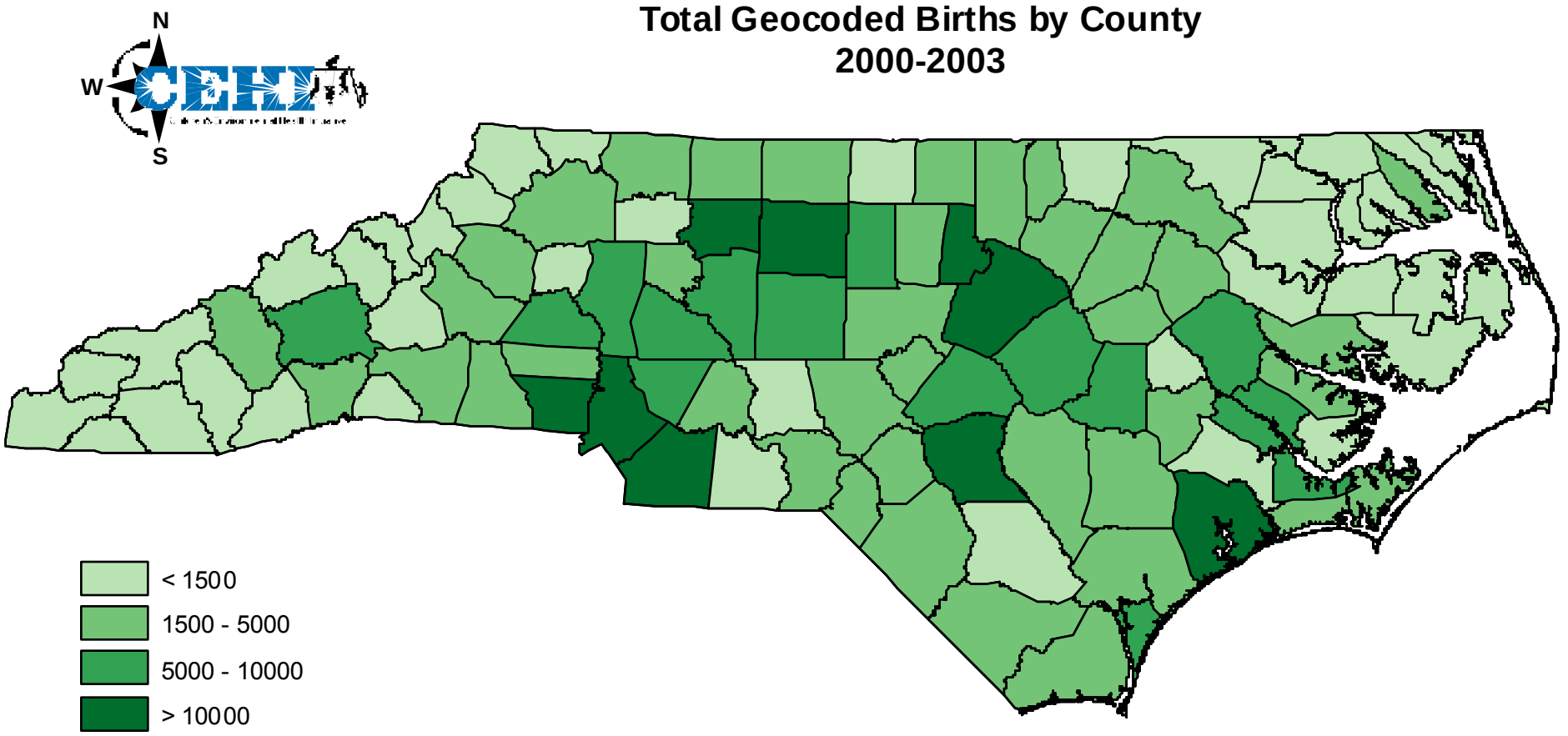
Motivation

Maternal exposure to air pollution may elevate the risk of adverse birth outcomes

- **Many of the U.S. studies focus on California or the northeastern U.S.**
- **Assesses the impact of maternal exposure to PM_{10} and $PM_{2.5}$ on BWT in North Carolina**
- **Interested in changes in BWT due to maternal air pollution exposure**

Linking Datasets

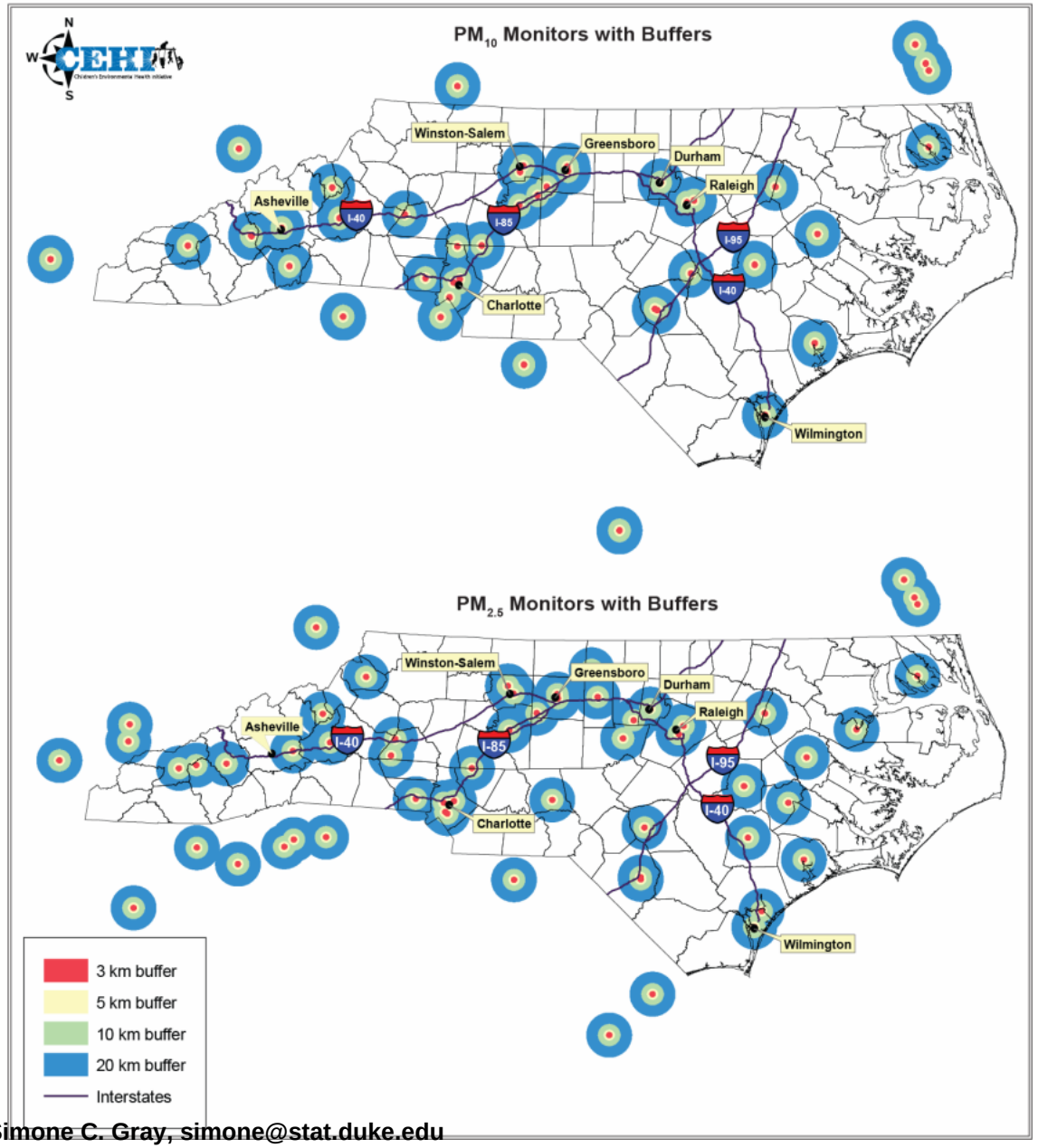
- N=386,422



Restrictions

- Singleton, non-anomalous births
- Women ages 15-44
- NHW, NHB, HISP
- No alcohol consumption
- Gestation between 33 and 42 weeks
- Within 20km of a monitor

Location of PM_{10} and $PM_{2.5}$ monitors and distance buffers



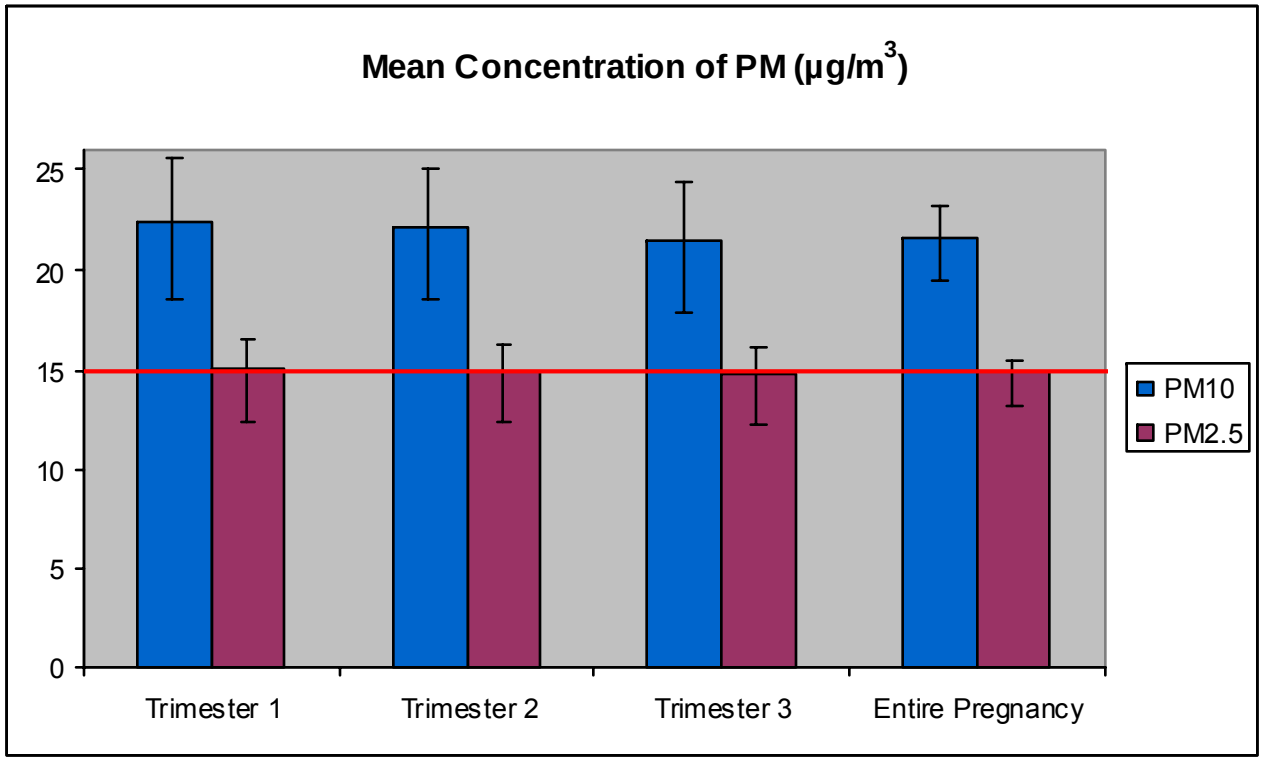
Maternal Exposure Assessment

- Daily average concentrations for PM_{10} and $PM_{2.5}$ obtained from EPA for 1999-2003
- Missing one week of data, used average of previous week and consequent week as a proxy
- Restricted to moms with at least 90% of air pollution data complete
- Trimester exposure measurements calculated by averaging weekly data for each trimester

Summary of Data

Descriptive statistics of study population (n=254780)

Variable	Mean ± SD or percentage
Birth weight (g)	3371± 527.9
Low birthweight[<2500 g (%)]	5.2
Gestational age (weeks)	38.9 ± 1.6
Male sex of infant (%)	51.00
Firstborn (%)	42.30
Maternal Tobacco use (%)	11.20
Married (%)	68.40
Maternal Race/Ethnicity (%)	
NHW	62.80
NHB	24.30
HISP	12.90
Maternal Age in years(%)	
15-19	10.50
20-24	25.50
25-29	27.00
30-34	24.60
35-39	10.50
40-44	1.80
Maternal Education (%)	
≤8 years	5.70
8-11 years	14.00
12 years	27.70
13-15 years	22.30
≥16 years	30.30



- The red line represents the annual $PM_{2.5}$ NAAQS for 2000-2003
- There is currently no annual standard for PM_{10}

Statistical Analysis

- Used multivariate linear regression modeling with BWT as the continuous outcome variable
- Controlled for gestational age, maternal race/ethnicity, education, tobacco use, marital status, infant sex and birth order
- Constructed a baseline model, with no pollution variables
- Constructed models for each pollutant using trimester exposure estimates and pregnancy long estimates

Baseline Model

Changes in birthweight in baseline model.

Variable	Change in BWT (95% CI)
Gestational age (weeks)	170.7 (169.7 to 171.7)
Male sex of infant	128.1 (124.7 to 131.5)
Firstborn	-125 (-128.7 to -121.3)
Maternal Tobacco use	-193 (-198.7 to -178.3)
Not Married	-34.1 (-38.7 to -29.5)
Maternal Race/Ethnicity	
NHW (reference)	
NHB	-178.4 (-182.9 to -173.9)
HISP	-75.3 (-81.6 to -69.0)
Maternal Age in years	
15-19	-35.3 (-42.5 to -28.1)
20-24	-27.1 (-32.0 to -22.2)
25-29 (reference)	
30-34	10.5 (5.7 to 15.3)
35-39	7.5 (1.3 to 13.7)
40-44	-31.0 (-43.8 to -18.2)
Maternal Education	
≤8 years	-47.4 (-56.2 to -38.6)
8-11 years	-35.8 (-41.7 to -29.9)
12 years (reference)	
13-15 years	23.2 (18.2 to 28.2)
≥16 years	26.3 (21.1 to 31.5)

- **Standard covariates were significant and carried the expected signs**
- **Positive correlation between BWT and gestation and male sex.**
- **Negative correlation between BWT and firstborns, tobacco use, unmarried, minority race groups, mothers with less than high school education.**

Pollutant Models: PM_{10}

	Gestation 33-42 wks		Gestation 37-42 wks	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Intercept	3503.41	0.00	3512.95	0.00
Gestation	168.20	0.00	142.39	0.00
Male	127.16	0.00	130.94	0.00
Smoker	-194.39	0.00	-196.79	0.00
Not Married	-34.41	0.00	-36.39	0.00
Edu Middle	-38.13	0.00	-41.20	0.00
Edu Somehigh	-36.53	0.00	-35.98	0.00
Edu Somecollege	21.01	0.00	19.22	0.00
Edu College	26.74	0.00	25.08	0.00
Racegroup NHB	-176.30	0.00	-177.49	0.00
Racegroup HISP	-79.77	0.00	-82.17	0.00
Age 15-19	-35.84	0.00	-42.11	0.00
Age 20-24	-28.97	0.00	-31.27	0.00
PM_{10} tri1	-0.53	0.04	-0.51	0.04
PM_{10} tri2	-0.61	0.04	-0.45	0.15
PM_{10} tri3	-0.71	0.01	-0.69	0.02

PM_{10} tri2	-0.61	0.04	-0.45	0.15
PM_{10} tri3	-0.71	0.01	-0.69	0.02

Pollutant Models: PM_{10}

	Gestation 33-42 wks		Gestation 37-42 wks	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Intercept	3502.42	0.00	3512.44	0.00
Gestation	168.16	0.00	142.35	0.00
Male	127.17	0.00	130.95	0.00
Smoker	-194.40	0.00	-196.79	0.00
Not Married	-34.40	0.00	-36.36	0.00
Edu Middle	-38.06	0.00	-41.12	0.00
Edu Somehigh	-36.50	0.00	-35.94	0.00
Edu Somecollege	21.00	0.00	19.21	0.00
Edu College	26.74	0.00	25.11	0.00
Racegroup NHB	-176.32	0.00	-177.48	0.00
Racegroup HISP	-79.78	0.00	-82.14	0.00
Age 15-19	-35.86	0.00	-42.13	0.00
Age 20-24	-28.97	0.00	-31.27	0.00
Age 30-34	5.76	0.10	5.31	0.14
Age 35-39	6.28	0.16	6.27	0.18
PM_{10} preg avg	-1.83	0.00	-1.66	0.00
Firstborn	-126.91	0.00	-119.37	0.00
PM_{10} preg avg	-1.83	0.00	-1.66	0.00

Pollutant Models: $PM_{2.5}$

	Gestation 33-42 wks		Gestation 37-42 wks	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Intercept	3472.01	0.00	3481.50	0.00
Gestation	167.32	0.00	141.47	0.00
Male	128.00	0.00	131.46	0.00
Smoker	-190.39	0.00	-192.90	0.00
Not Married	-32.53	0.00	-32.37	0.00
Edu Middle	-45.26	0.00	-48.66	0.00
Edu Somehigh	-37.81	0.00	-37.92	0.00
Edu Somecollege	21.57	0.00	20.27	0.00
Edu College	26.15	0.00	25.52	0.00
Racegroup NHB	-180.05	0.00	-181.86	0.00
Racegroup HISP	-74.80	0.00	-76.32	0.00
Age 15-19	-38.88	0.00	-45.36	0.00
$PM_{2.5}$ tri1	0.68	0.07	0.77	0.04
$PM_{2.5}$ tri2	-0.81	0.06	-0.68	0.12
$PM_{2.5}$ tri3	-0.92	0.03	-0.94	0.03

$PM_{2.5}$ tri1	0.68	0.07	0.77	0.04
$PM_{2.5}$ tri2	-0.81	0.06	-0.68	0.12
$PM_{2.5}$ tri3	-0.92	0.03	-0.94	0.03

Pollutant Models: $PM_{2.5}$

	Gestation 33-42 wks		Gestation 37-42 wks	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Intercept	3473.82	0.00	3482.64	0.00
Gestation	167.32	0.00	141.48	0.00
Male	128.03	0.00	131.49	0.00
Smoker	-190.42	0.00	-192.91	0.00
Not Married	-32.58	0.00	-32.43	0.00
Edu Middle	-45.19	0.00	-48.58	0.00
Edu Somehigh	-37.76	0.00	-37.87	0.00
Edu Somecollege	21.61	0.00	20.32	0.00
Edu College	26.17	0.00	25.54	0.00
Racegroup NHB	-180.08	0.00	-181.90	0.00
Racegroup HISP	-75.01	0.00	-76.54	0.00
Age 15-19	-38.86	0.00	-45.30	0.00
Age 20-24	-30.58	0.00	-31.52	0.00
Age 30-34	7.93	0.01	8.22	0.01
$PM_{2.5}$ preg avg	**-1.15**	**0.06**	**-0.91**	**0.15**
Age 40-44	-27.89	0.00	21.30	0.01
Firstborn	-124.67	0.00	-116.95	0.00
$PM_{2.5}$ preg avg	-1.15	0.06	-0.91	0.15

Pollutant Models: $PM_{2.5}$

	Gestation 33-42 wks		Gestation 37-42 wks	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Intercept	3463.69	0.00	3471.36	0.00
Gestation	167.31	0.00	141.47	0.00
Male	128.03	0.00	131.51	0.00
Smoker	-107.70	0.00	-98.86	0.00
Not Married	-32.57	0.00	-32.41	0.00
Edu Middle	-45.26	0.00	-48.65	0.00
Edu Somehigh	-37.64	0.00	-37.74	0.00
Edu Somecollege	21.59	0.00	20.30	0.00
Edu College	26.14	0.00	25.51	0.00
Racegroup NHB	-180.13	0.00	-181.96	0.00
Racegroup HISP	-75.14	0.00	-76.69	0.00
Age 15-19	-38.82	0.00	-45.26	0.00
Age 20-24	-30.54	0.00	-31.47	0.00
Age 30-34	7.94	0.01	8.24	0.01
Age 35-39	6.27	0.11	7.62	0.06
$PM_{2.5}$ preg avg	-0.44	0.50	-0.12	0.86
$PM_{2.5}$ preg avg*Smoker	-5.80	0.00	-6.60	0.00

NAAQS in NC

- Average annual $PM_{2.5}$ levels are less than the standard of 15 $\mu g/m^3$
- PM_{10} levels are less than half the previous NAAQS of 50 $\mu g/m^3$
- Even with NC's relatively low measures, we still see an association between maternal exposure to both PM_{10} and $PM_{2.5}$ and BWT
- The health risk of air pollution exposure on pregnant women is an important public health issue

Future Work

- PM is one of 6 criteria pollutants regulated by the EPA
- Also interested in the effects of other air pollutants on birth outcomes
- Use spatial modeling for assessing air pollution exposure

Acknowledgements

- National Institutes of Health
- US Environmental Protection Agency
- Duke University and Medical Center
- Office of Research Support

http://www.nicholas.duke.edu/cehi/