Perinatal Outcomes and Unconventional Natural Gas Development in Southwest Pennsylvania

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Outline

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Motivation for Study

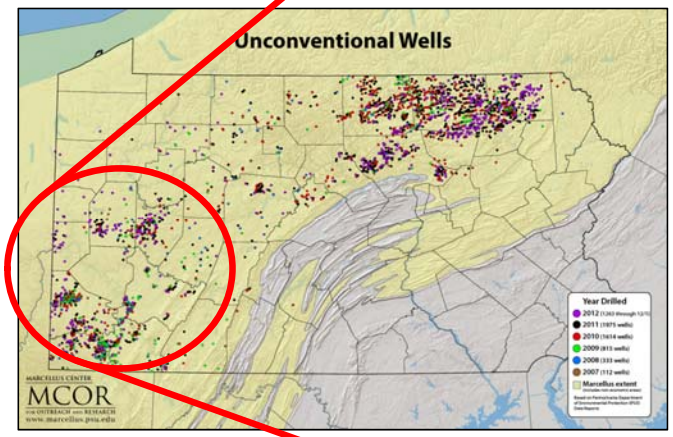
Unconventional gas development (UGD) has the potential to increase both air and water pollution and associated health effects.

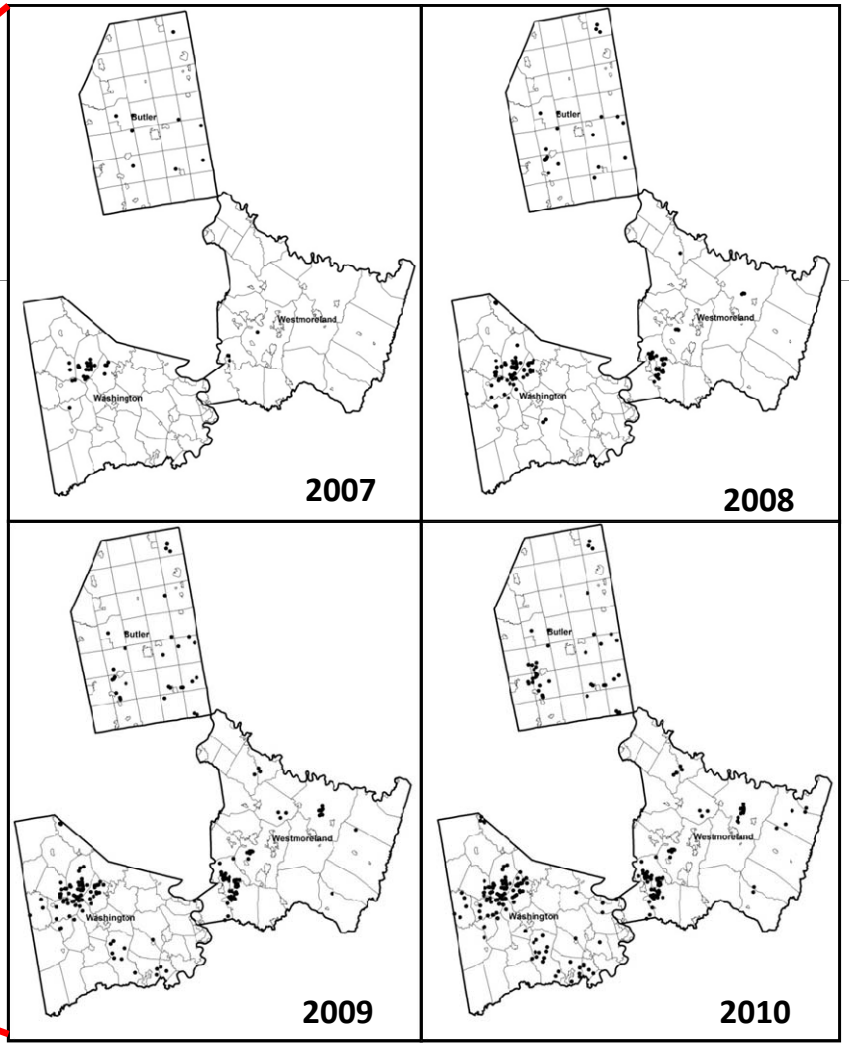
To date, few studies have sought to link UGD with human health effects.

Infant health is of particular interest:

- Vulnerable population
- Pollutants linked to poor infant health outcomes:
  - Benzene and diesel exhaust (NO_x, SO_2, particulate matter, polycyclic aromatic hydrocarbons) → low birth weight and preterm birth
  - Endocrine disruptors
- Health across the lifespan!

Growth of UGD in SW Pennsylvania





Objective

- To assess the impact of UGD on infant health in southwestern Pennsylvania using well density as a surrogate for exposure

- **Hypothesis:** The risk for adverse birth outcomes will be greater for those infants born to mothers living in more densely drilled areas.

Approach

- Study sample included 15,451 singleton live births in Butler, Washington, and Westmoreland counties from 2007-2010 (Pennsylvania Department of Health)
- Natural gas well data obtained from the Pennsylvania Department of Environmental Protection's (PADEP) Oil & Gas Reports
- Used a geographic information system (GIS) to investigate the spatial relationship between UGD and birth outcomes

Approach

- Using the methods of McKenzie et al. (2014), we calculated an inverse distance weighted (IDW) well count for each mother living within 10-miles of UGD:

$$\textit{IDW well count} = \sum_{i=1}^{n} \frac{1}{d_i}$$

IDW well count: inverse distance weighted count of active, unconventional natural gas wells within a 10-mile radius of maternal residence in the birth year

n: the number of existing unconventional wells

d_i: the distance of the ith individual well from the mother's residence

Approach

- Categorized mothers into groups of low, medium, and high exposure
- Compared to the least exposed (Group 1, the “referent”)

Group 1: IDW Well Count >0 but <0.87
Group 2: IDW Well Count ≥0.87 but <2.60
Group 3: IDW Well Count ≥2.60 but <6.00
Group 4: IDW Well Count ≥6.00

Approach

- Outcomes of interest:
  - Continuous birth weight (g)
  - Small for gestational age (SGA): Birth weight is within 10^{th} percentile for a given gestational age
  - Premature: Age of gestation <37 weeks
- Models accounted for child's sex, gestational age (linear birth weight model), and maternal risk factors
  - age, race, education, pre-pregnancy weight, smoking during pregnancy, gestational diabetes, WIC (Women, Infants and Children) assistance, prenatal visits, parity (first child, second child, etc.)

Results

Table 1. Maternal and child demographics.

Factor	Total N=15,451	Referent (First Quartile)[a] N=3,604	Second Quartile[a] N=3,905	Third Quartile[a] N=3,791	Fourth Quartile[a] N=4,151
Mother's age (years)[b]	28.6 ± 5.8	28.8 ± 5.8	28.7 ± 5.8	28.6 ± 5.7	28.3 ± 5.8
Mother's Education (% high school graduate/GED)[b]	22.7%	22.1%	22.5%	22.6%	23.6%
Pre-Pregnancy Weight (lbs)[b]	153.8 ± 39.1	152.6 ± 38.2	152.9 ± 38.2	155.2 ± 40.2	154.7 ± 39.9
Race (% African American)[b]	3.0%	2.6%	2.0%	3.4%	4.1%
WIC (% assistance)[b]	32.1%	29.6%	31.0%	33.6%	34.1%
Prenatal care (% at least one visit)	99.5%	99.5%	99.5%	99.5%	99.3%
Presence of gestational diabetes	4.1%	4.7%	3.7%	4.3%	3.9%
Cigarette smoking during pregnancy[b]	20.0%	19.6%	18.8%	19.9%	21.7%
Birth parity (first)	42.7%	42.8%	41.7%	42.2%	44.1%
Percent female	48.5%	48.7%	48.3%	48.6%	48.5%
Gestational age (weeks)[b]	38.7 ± 1.9	38.6 ± 1.9	38.8 ± 1.8	38.7 ± 1.9	38.7 ± 1.9
Birth weight (g)[b]	3345.8 ± 549.2	3343.9 ± 543.9	3370.4 ± 540.5	3345.4 ± 553.5	3323.1 ± 558.2
Small for gestational age[b]	5.5%	4.8%	5.2%	5.6%	6.5%
Premature[b]	7.7%	8.0%	6.7%	8.4%	7.9%

[a]Referent (First quartile), <0.87 wells per mile; Second quartile, 0.87 to 2.59 wells per mile; Third quartile, 2.60 to 5.99 wells per mile; Fourth quartile, ≥6.00 wells per mile

[b]Difference between quartiles is significant (p-value <0.05)

Table 2. Multivariate linear regression of birth weight and proximity.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance (P)
	B	Standard Error	Beta		
Constant	-3711.86	93.06	-39.88		<0.01
Mother's Age	-2.95	0.77	-0.03	-3.82	<0.01
Mother's Education	17.88	2.72	0.05	6.58	<0.01
Pre-Pregnancy Weight	2.01	0.09	0.15	23.37	<0.01
Gestational Age	172.64	1.97	0.56	87.51	<0.01
Female	-133.90	6.63	-0.12	-20.19	<0.01
Prenatal Care	127.07	51.53	0.02	2.47	0.01
Smoking During Pregnancy	-184.69	9.07	-0.14	-20.37	<0.01
Gestational Diabetes	33.57	16.82	0.01	2.00	0.05
WIC	-27.44	8.62	-0.02	-3.18	<0.01
Race	-146.22	19.88	-0.05	-7.36	<0.01
Birth parity	65.89	4.01	0.12	16.41	<0.01
Low[a]	10.55	9.52	0.01	1.11	0.27
Medium[a]	-0.48	9.59	0.00	-0.05	0.96
High[a]	-21.83	9.39	-0.02	-2.32	0.02
[a]Low, Second quartile to referent; Medium, Third quartile to referent; High, Fourth quartile to referent					

Figure 1. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) for small for gestational age.

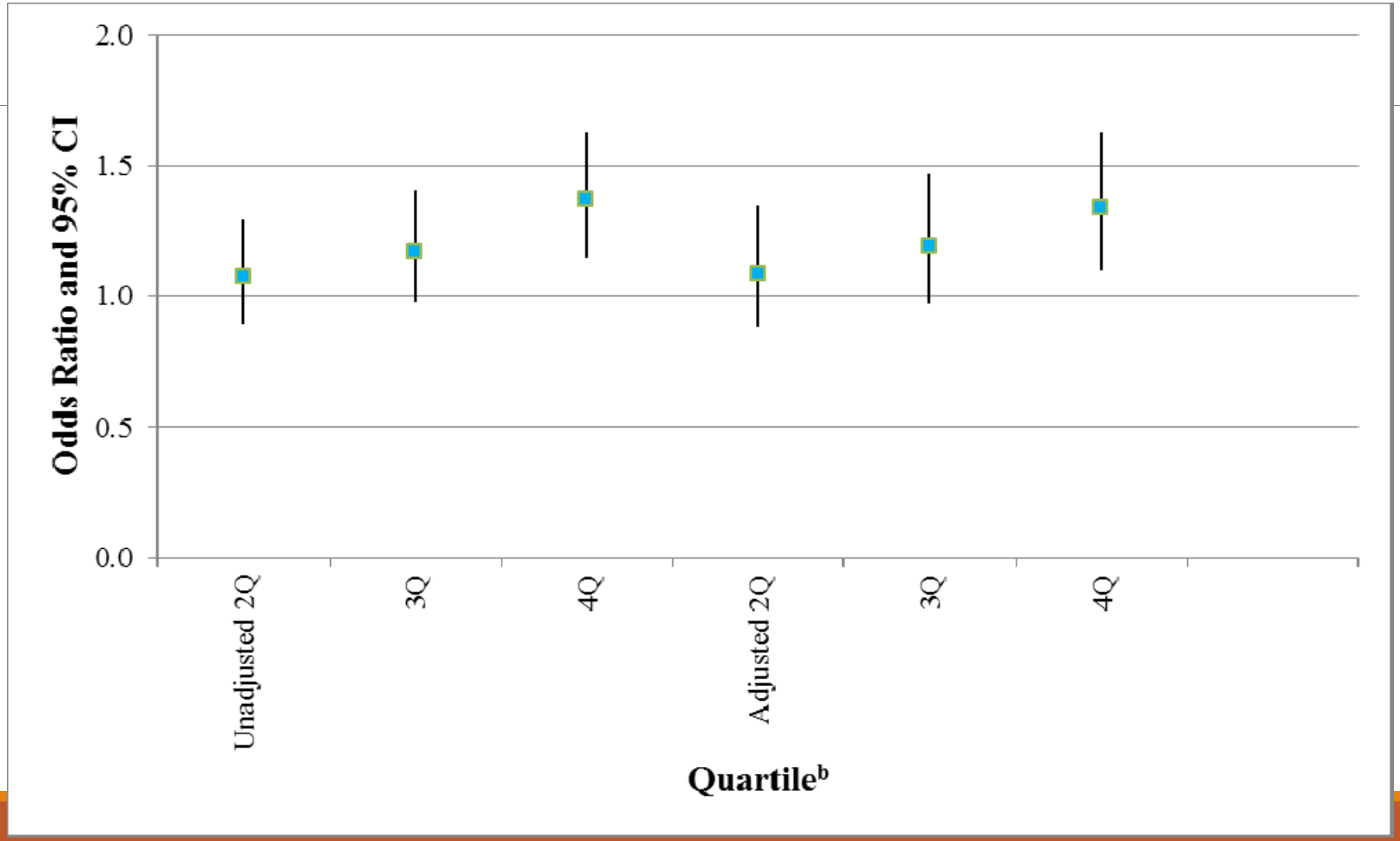
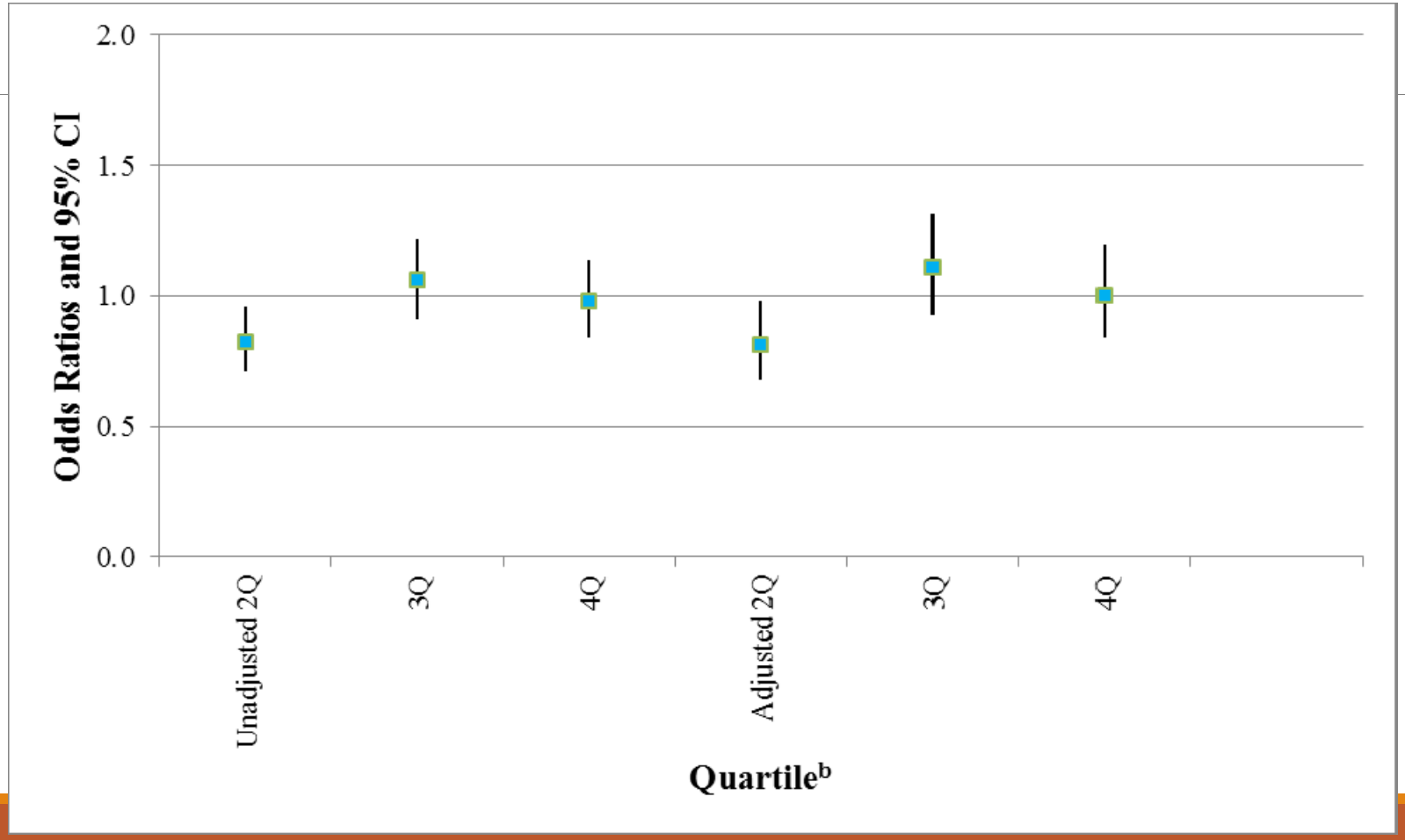


Figure 2. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) for prematurity.



Conclusions

- To recap, we found that ↓ birth weights and ↑ risk for SGA were associated with ↑ well density.

- These associations remained when 1) continuous IDW well count was used and 2) only 2010, the year with the most UGD activity in our study period, was considered.

Future Directions

- Individual exposure assessments and environmental sampling
- Analysis of blood samples from about 150 pregnant women who underwent routine prenatal testing (SW Pennsylvania)
  - Metals (arsenic, cadmium, mercury, and lead) and benzene oxide adducts
  - Elevated concentrations of these biomarkers and residential proximity to UGD

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