

Reproductive outcomes at changing PFAS exposures in Minnesota

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Background

- Production and disposal of PFAS at multiple locations in Minneapolis East Metro Area beginning in 1950s
- High levels of PFOA (0.07 to 0.70 µg/L) and PFOS (ND to 1.04 µg/L) detected in Oakdale municipal wells in 2005
- Almost all 27,000 Oakdale residents served by municipal water
- Granular activated charcoal (GAC) filtration installed for municipal supply in 2006
- PFAS detected in other surrounding communities but less consistent exposure, no large-scale intervention

- All singleton birth records in all zip codes in Washington County 2002 to 2011 (MDH)
 - Birth weight
 - Gestational age
 - Sex
- Individual-level maternal characteristics (MDH)
 - Age
 - Residence zip code
 - Marital status
 - Educational attainment
 - [Drug use and Medical risk factors]
- Zip code-level characteristics (ACS)
 - Income
 - Racial/ethnic composition



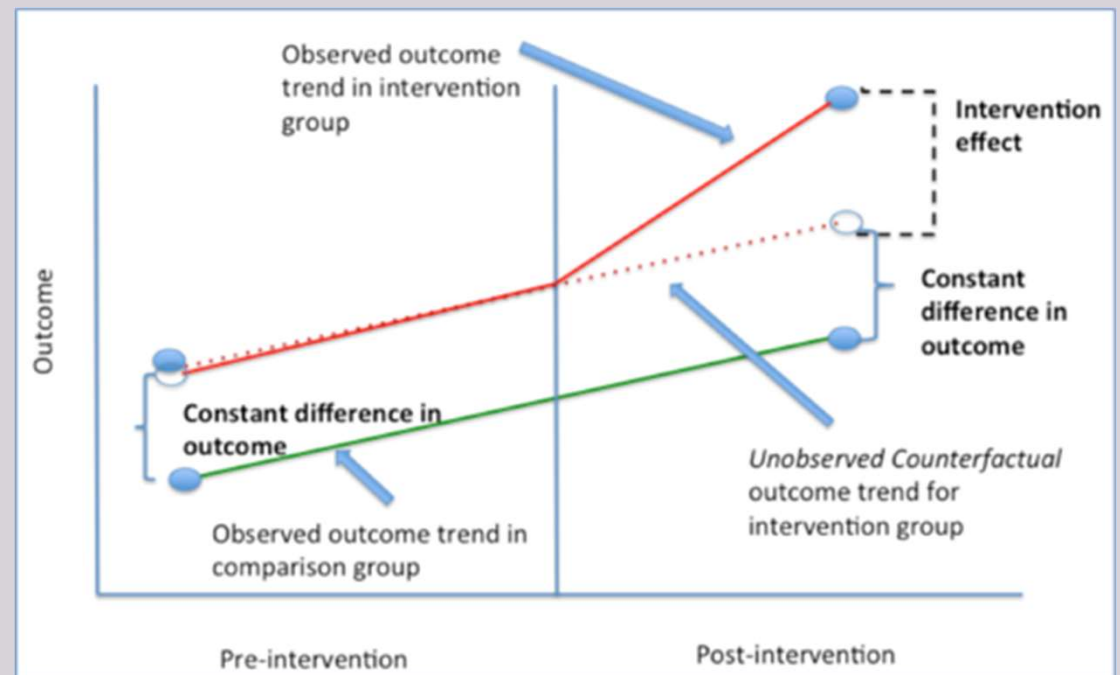
Data Sources

Summary of Selected Characteristics

Variable	Oakdale 2002-2006	Oakdale 2007-2011	Other Affected 2002-2006	Other Affected 2007-2011	Control Zip Codes 2002-2006	Control Zip Codes 2007-2011
Number of Births	1,685	1,715	9,017	8,600	13,811	14,237
Maternal Characteristics						
Age						
Mean (SD)	28.5 (5.7)	28.1 (5.5)	30.0 (5.5)	29.8 (5.4)	28.6 (5.8)	28.5 (5.7)
Marital Status						
% Married	70.5%	63.2%	82.7%	78.6%	70.9%	65.6%
Educational Attainment						
% No HS Diploma	5.7%	6.2%	3.7%	3.4%	7.3%	7.8%
% College Degree	38.7%	35.9%	53.6%	56.0%	38.9%	40.6%
Newborn Characteristics						
Sex						
% Female	47.4%	50.3%	48.5%	48.2%	48.8%	49.3%
Birth Weight (grams)						
Mean (SD)	3,390 (573)	3,360 (542)	3,445 (545)	3,409 (538)	3,419 (551)	3,392 (538)
% < 2,500g	5.7%	4.7%	3.8%	4.2%	4.3%	4.4%
% < 1,500g	1.0%	0.7%	0.7%	0.7%	0.8%	0.7%
Gestational Age (weeks)						
Mean (SD)	38.8 (2.0)	39.0 (1.8)	38.9 (1.7)	38.9 (1.9)	38.9 (1.9)	38.9 (1.8)
% < 37 Weeks	7.2%	5.9%	6.3%	6.4%	6.4%	6.3%
% < 32 Weeks	1.1%	0.8%	0.7%	0.9%	0.8%	0.7%
Zip Code Characteristics						
Household Income (\$)						
Median	73,588	70,040	99,082	96,002	77,474	74,027

Identification Strategy

- Compare outcomes in affected communities, and changes in outcomes in Oakdale, to control communities without known PFAS contamination of drinking water supplies
 - Implicitly controls for fixed differences in community characteristics
 - Implicitly controls for changes over time common to all communities



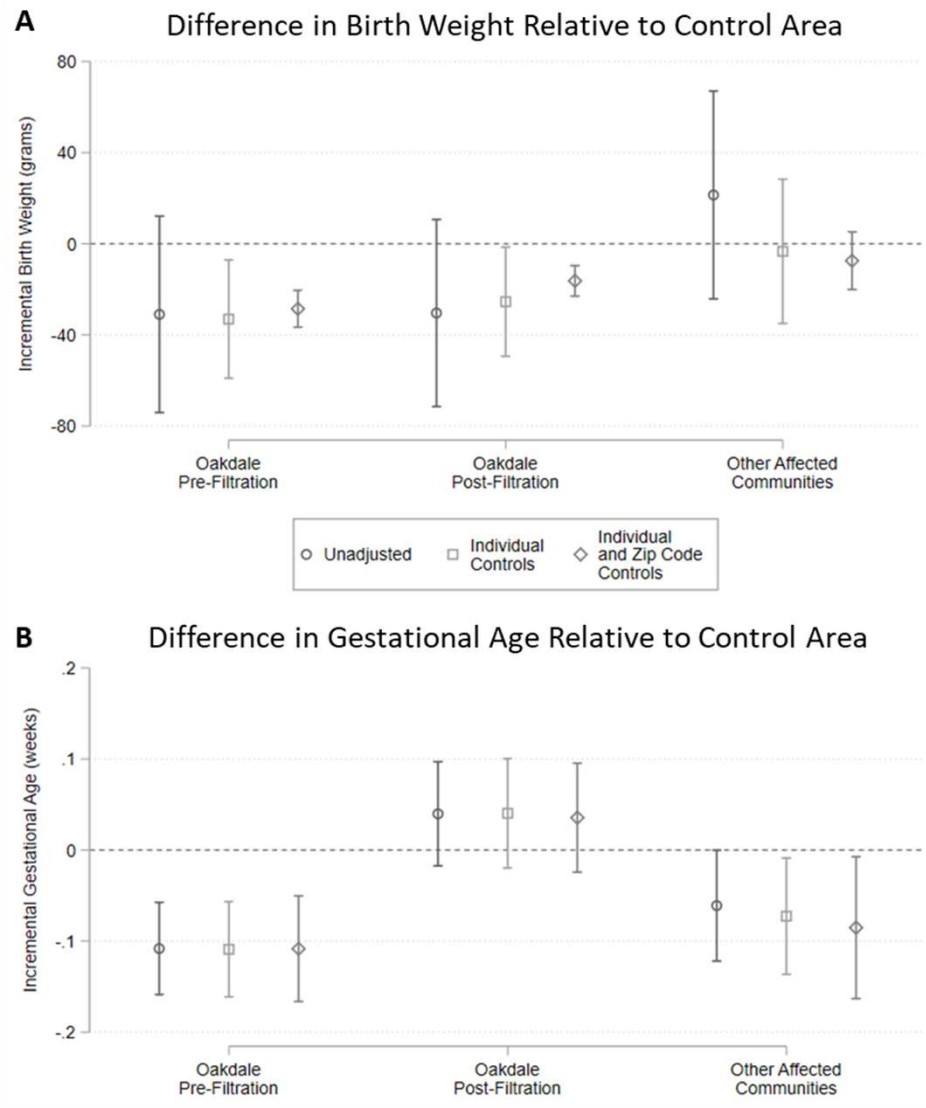
Credit: Columbia Public Health, Columbia University,
<https://www.publichealth.columbia.edu/research/population-health-methods/difference-difference-estimation>

Estimating Equations

Individual level regressions with explicit controls for maternal characteristics and additional zip code level controls:

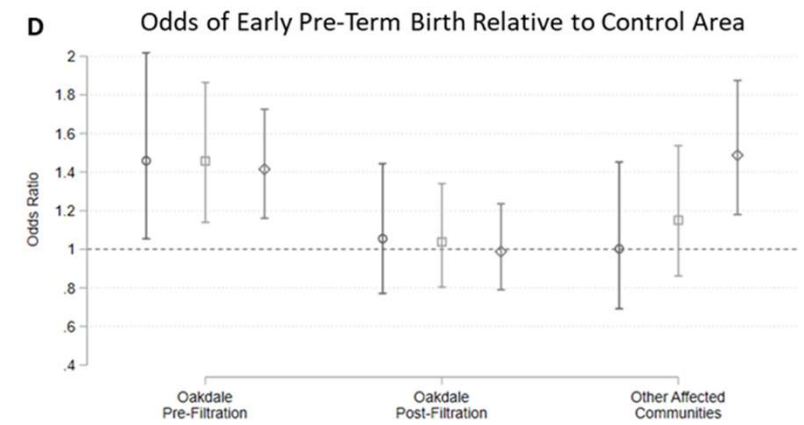
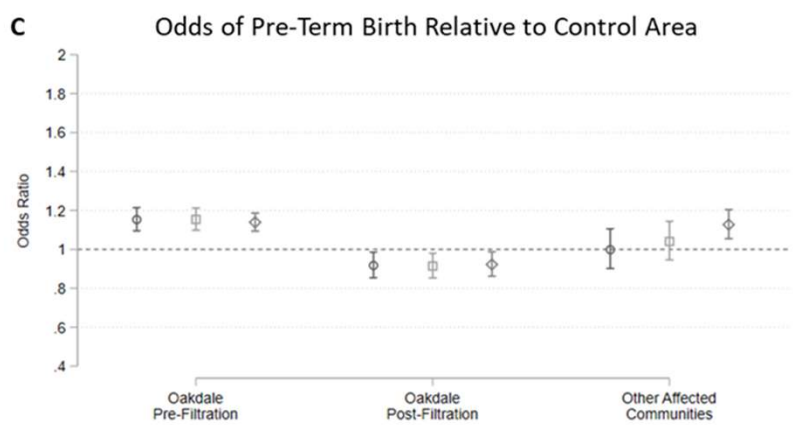
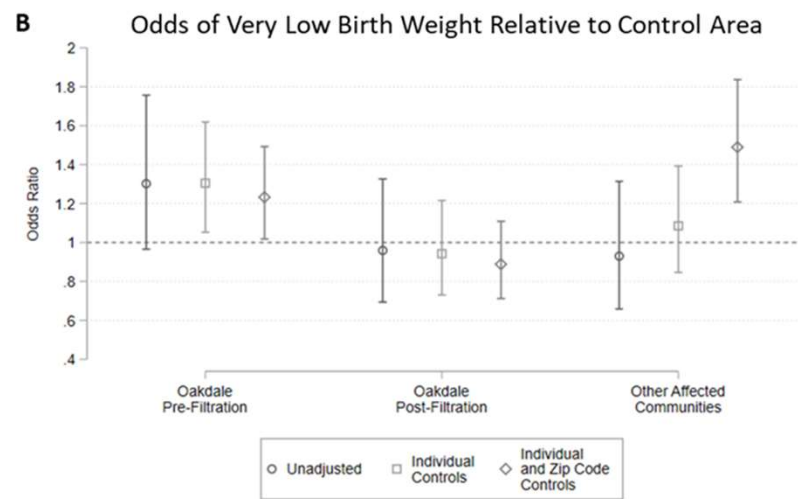
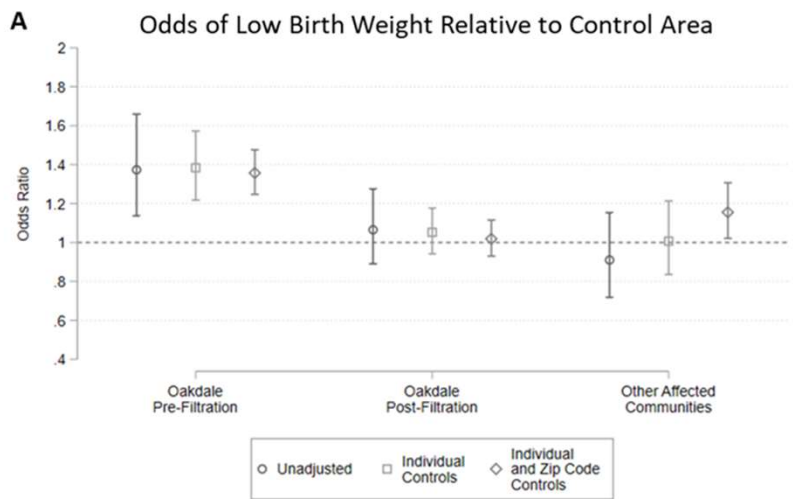
Birth Outcome

$$= f(\alpha + \beta_1 \text{Oakdale}_{2002-200} + \beta_2 \text{Oakdale}_{2007-201} + \beta_3 \text{Other Affected} \\ + \beta_4 \text{Maternal Characteristics} + \beta_4 \text{Zip Code Characteristics} \\ + \gamma \text{Birth Years} + \theta \text{Birth Months} + \epsilon)$$

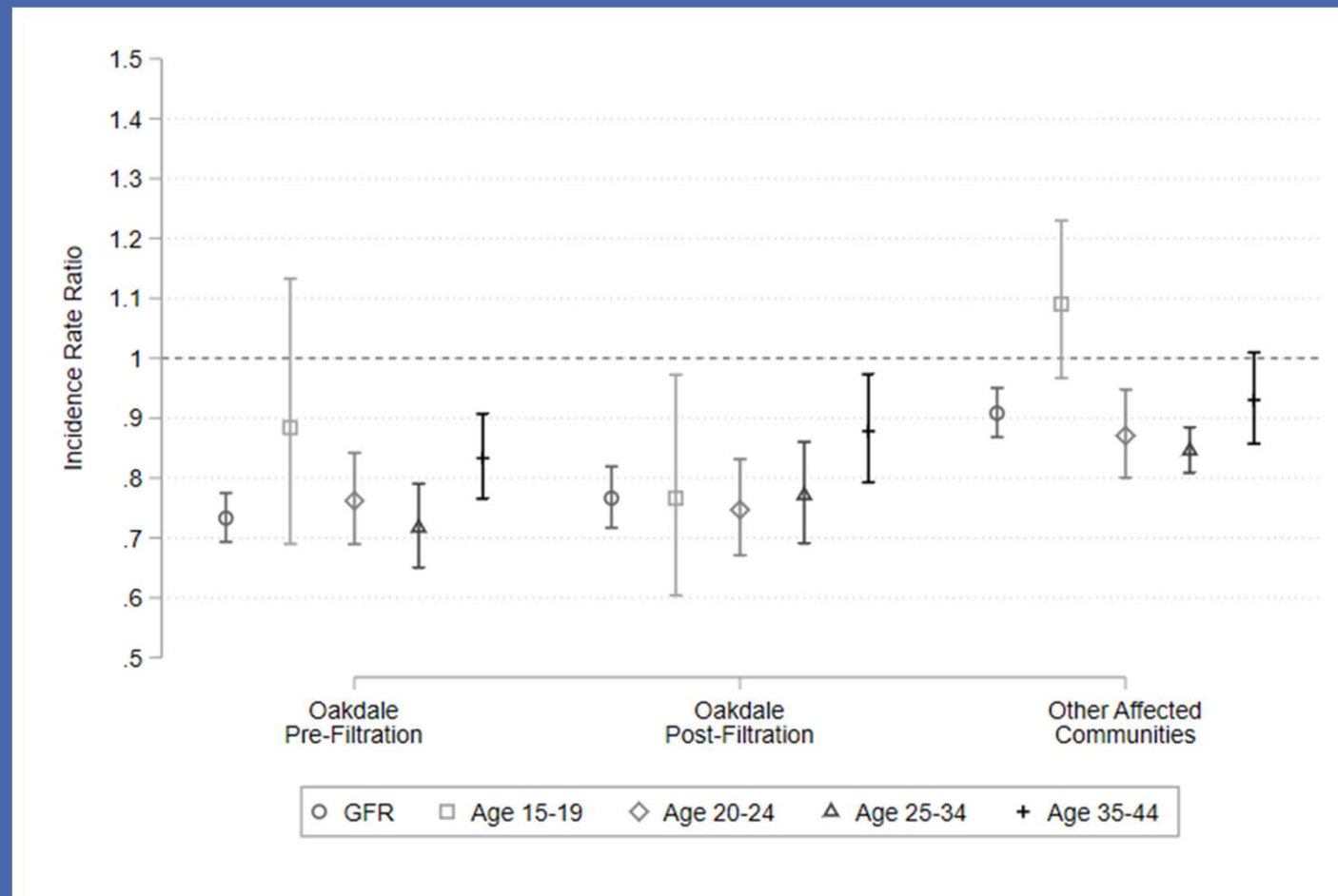


Reducing PFAS exposure had a small impact on birth weight and gestational age

Reducing PFAS exposure substantially and significantly reduced the odds of adverse birth outcomes in Oakdale



Reducing PFAS exposure appears to have had a positive effect on the general fertility rate in Oakdale but the response is slower



Conclusions

- Reduced exposure to PFAS in drinking water was associated with slightly higher birth weight and gestational age on average
- PFAS filtration significantly reduced the odds of low birth weight and preterm birth in Oakdale relative to other communities
- Response in general fertility rate was slower but appears to be positive
- Caveats and limitations:
 - Exposures in Oakdale and other affected communities not known
 - Cannot disentangle effects of PFOA, PFOS and other PFAS
 - Cannot rule out confounding factors, despite “quasi-experimental” study design
- Continued need for follow-up and monitoring of outcomes; additional studies of PFAS interventions