IMPACT OF WILDFIRE SMOKE ON ADVERSE PREGNANCY OUTCOMES IN COLORADO, 2007-2015

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BACKGROUND

- Air pollutants, including particulate matter (PM), have been associated with acute and/or chronic adverse pregnancy outcomes including:
  - Low birth weight
  - Fetal malformations
  - Fetal death
- Exposure to wildfire smoke (Particulate Matter 2.5 ($PM_{2.5}$)) during pregnancy was found to be associated with low birth weight and other adverse health outcomes including:
  - Respiratory disease
  - Cardiovascular disease
  - All-cause mortality

BACKGROUND

- Increase in wildfires in the Western US and Western Canada in recent decades

  - As the region continues to warm due to greenhouse gas emissions, wildfires will continue to increase and air quality will continue to worsen

- Colorado is susceptible to increased wildfires

  - Experience high smoke levels due to wildfires throughout the Western US

- Smoke-exposure is expected to continue to increase

- Important to understand the association between pollutants that are released from fires and birth outcomes

  - The impact of smoke exposure on birth outcomes has not previously been studied across multiple fire seasons

BACKGROUND

- Gap in the literature at the time to look at the association between exposure to smoke and birth outcomes

  - Only one prior study that looked at only birth weight and the study only looked at one-year exposure and treated the exposure as a dichotomous outcome instead of estimating an exposure concentration

- **Study Aim:** Characterize the association between wildfire smoke $PM_{2.5}$ exposure and birth outcomes by trimester

METHODS

- **Population**
  - Birth outcome and individuals-level covariate data were extracted from the Colorado Vital Records Registry
    - 589,992 birth records, with 535,895 meeting the inclusion criteria
      - Singleton births between the years of 2007 and 2015 in Colorado
      - Estimated gestational age between 30 and 42 weeks

METHODS

- **Exposure**

- **Wildfire smoke PM$_{2.5}$**
  - Estimated using a previously published method which incorporates ground-based monitors and remote sensing data

- Concentrations were matched to ZIP codes

- **Ambient temperature, PM$_{10}$, and ozone**

METHODS

- **Primary Outcomes:**
- Pre-term birth
  - Births with estimated gestational age of 37 weeks or less
- Birth weight
- **Secondary Outcomes:**
- Gestational diabetes
- Gestational hypertension
- Neonatal intensive care unit admission
- Assisted ventilation following delivery
- Low birth weight
  - Infants weighting less than 2500g
- Small for gestational age
  - Births with weight below the 10th percentile for gestational age

METHODS

- **Covariates:**
- Mother's education
- Graduated index
- Birth year
- Birth calendar month
- Alcohol consumption during pregnancy
- Smoking during pregnancy
- Income
- Asthma
- Number of prenatal visits
- Race/ethnicity
- Maternal age

STATISTICAL ANALYSIS

- Descriptive statistics to characterize the cohort overall and by pre-term outcome

  - Means and standard deviations for continuous variables

  - Frequency and percentages for categorical variables

- Pre-term outcome

  - Logistic regression models were used

  - Separate strata for each residential ZIP code

- Continuous birth weight

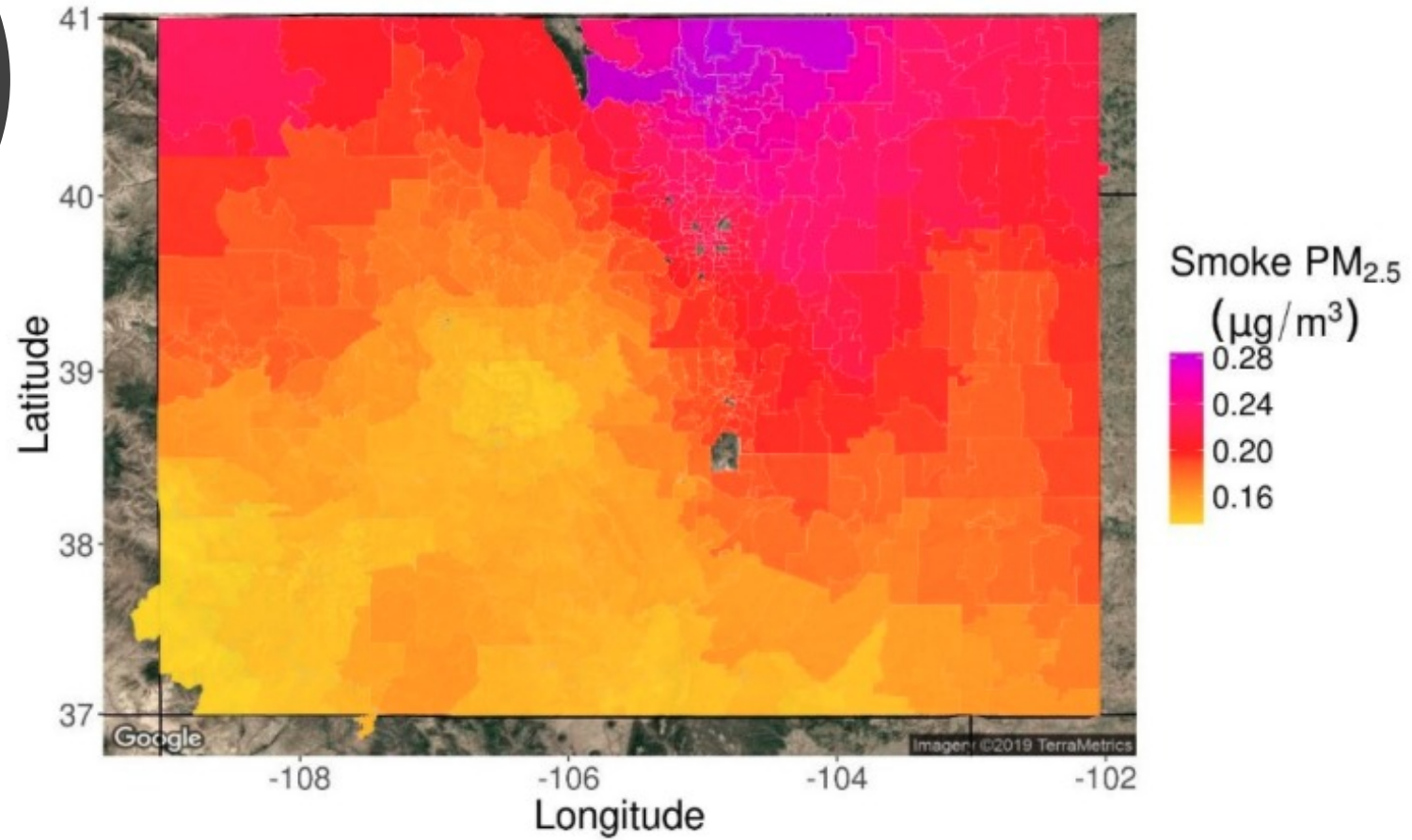 - Mixed effects models with a random intercept by ZIP code

STATISTICAL ANALYSIS

- Secondary outcomes:

  - Logistic models

- Sensitivity analyses:

  - Using different data processing (different buffer)

  - Different confounder choices

RESULTS
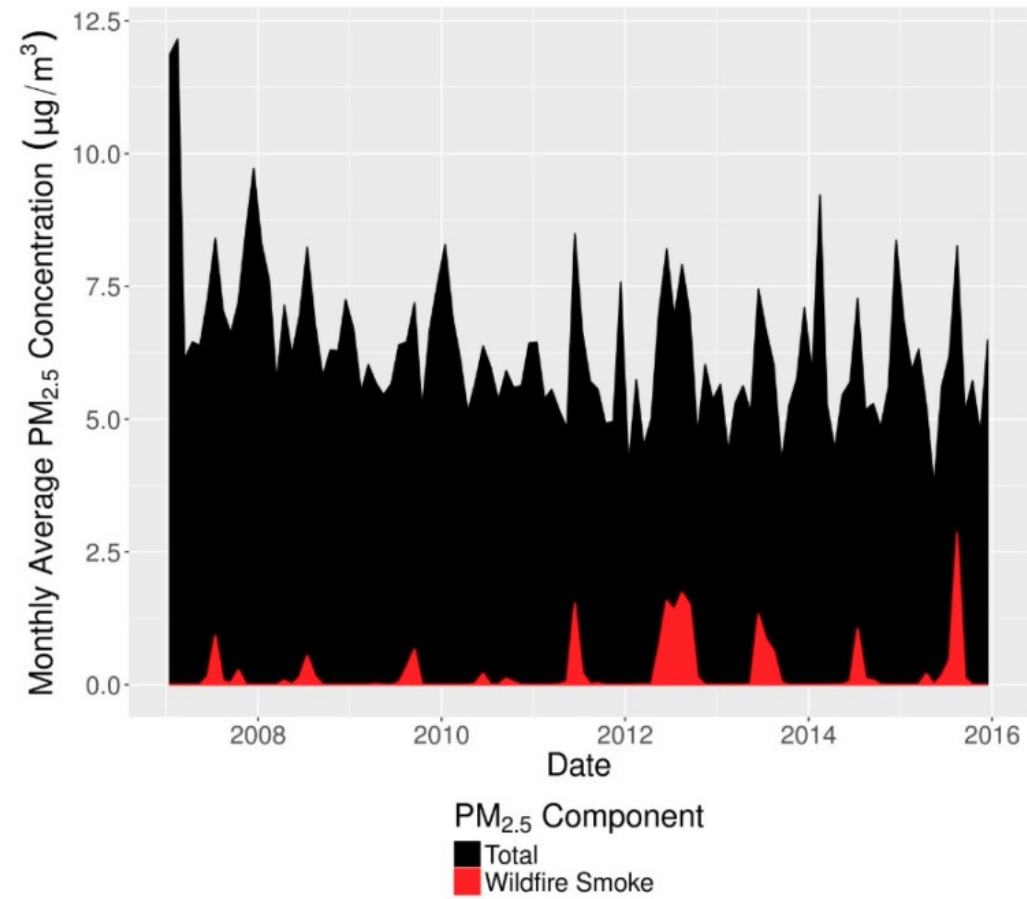
RESULTS

Crude and adjusted associations between wildfire smoke PM$_{2.5}$ (µg/m³) exposure and preterm births.

	Crude Model		Adjusted Model *	
	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
First Trimester	0.972 (0.950, 0.995)	0.019	1.024 (0.986, 1.065)	0.22
Second Trimester	1.058 (1.034, 1.082)	<0.0001	1.132 (1.088, 1.178)	<0.0001
Third Trimester	0.949 (0.930, 0.969)	<0.0001	1.013 (0.978, 1.050)	0.47
Mean Over All Trimesters	0.992 (0.980, 1.004)	0.19	1.055 (1.033, 1.078)	<0.0001
Full Gestation	0.972 (0.938, 1.006)	0.11	1.076 (1.016, 1.139)	0.013

*Model adjusted for: Ozone, non-wildfire PM2.5, PM10, temperature deviation, month, year, mother's race/ethnicity, mother's education and income, mother's age, smoking during pregnancy, drinking during pregnancy, maternal asthma, and gindex

Crude and adjusted associations between wildfire smoke PM$_{2.5}$ exposure (µg/m³) and birth weight (g).

	Crude Model		Adjusted Model *	
	Estimate (95%CI)	p-Value	Estimate (95% CI)	p-Value
First Trimester	2.9 (−1.1, 6.9)	0.16	−5.7 (−11.1, −0.4)	0.036
Second Trimester	11.7 (−15.7, −7.8)	<0.0001	3.0 (−2.7, 8.6)	0.3
Third Trimester	4.2 (0.8, 7.7)	0.017	−3.4 (−8.3, 1.6)	0.19
Mean Over All Trimesters	−1.5 (−3.6, 0.5)	0.14	−2.0 (−5.0, 0.9)	0.18
Full Gestation	−4.8 (−10.8, 1.1)	0.11	−2.0 (−9.9, 5.9)	0.61

*Models adjusted for: Ozone, non-wildfire PM2.5, PM10, temperature deviation, month, year, mother's race/ethnicity, mother's education, income, mother's age, smoking during pregnancy, drinking during pregnancy, maternal asthma, gindex, and gestational age.

SECONDARY ENDPOINTS

- Significant positive association between exposure to wildfire smoke and gestational diabetes during the first trimester and over the entire pregnancy

- Significant positive association between exposure to wildfire smoke and gestational hypertension during the first trimester, second trimester, and over the entire pregnancy

- Associations with NICU admission and assisted ventilation were contrary to expectation. Negatively associated

STRENGTHS AND LIMITATIONS

STRENGTHS

- Large sample size

- Numerous gestational outcomes

- Multiple years of data

- Numerous variables to adjust for

LIMITATIONS

- Self-reported variables

- Ambient exposure might not accurately reflect personal exposure

- Few pregnant women were exposed to significant wildfire smoke for extended periods of time

- Did not have specific birth dates, but only month and year of birth

CONCLUSION

- Wildfire smoke PM2.5 exposure in the second trimester was positively associated with pre-term birth

- Wildfire smoke PM2.5 exposure was associated with gestational diabetes and hypertension

- Future direction: determine if results vary by race/ethnicity or socioeconomic status. If lifestyle variables such as alcohol use or smoking modify the associations observed

CONCLUSION

- Important to develop interventions aimed at reducing pregnant women's exposure to wildfire smoke to reduce adverse birth outcomes

- Public health recommendations:
  - Pregnant women who are exposed to high levels of wildfire smoke wear a dust mask outdoors
  - Limit time outdoors
  - Build an indoor air filter in their house

- As climate change is expected to increase and the intensity of wildfires in the Western US is expected to intensify, it is important to consider targeting pregnant women when developing wildfire smoke exposure reduction strategies