



# Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births

Kathy Tran, PhD

UC Berkeley

Generation Chemical Webinar, CHE

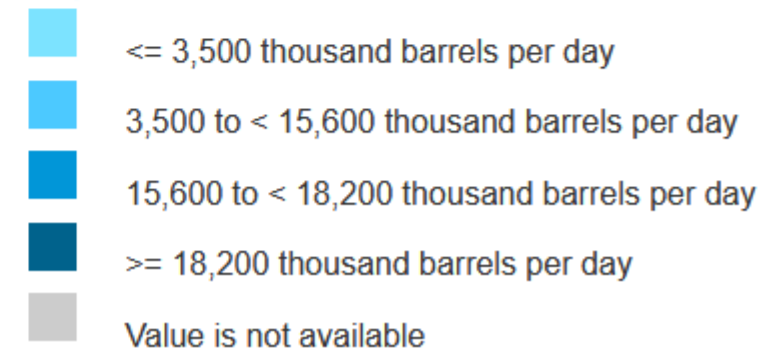
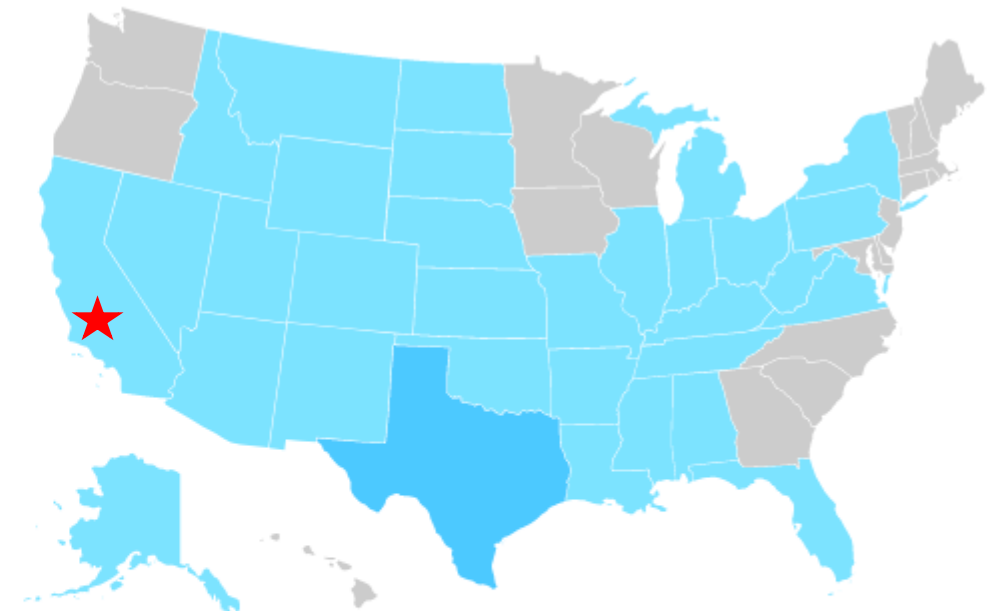
Feb 25, 2021

# CA Production: 7th Top US Crude Oil Producer (2020)

Rankings: Crude Oil Production, July 2020  
(thousand barrels per day)

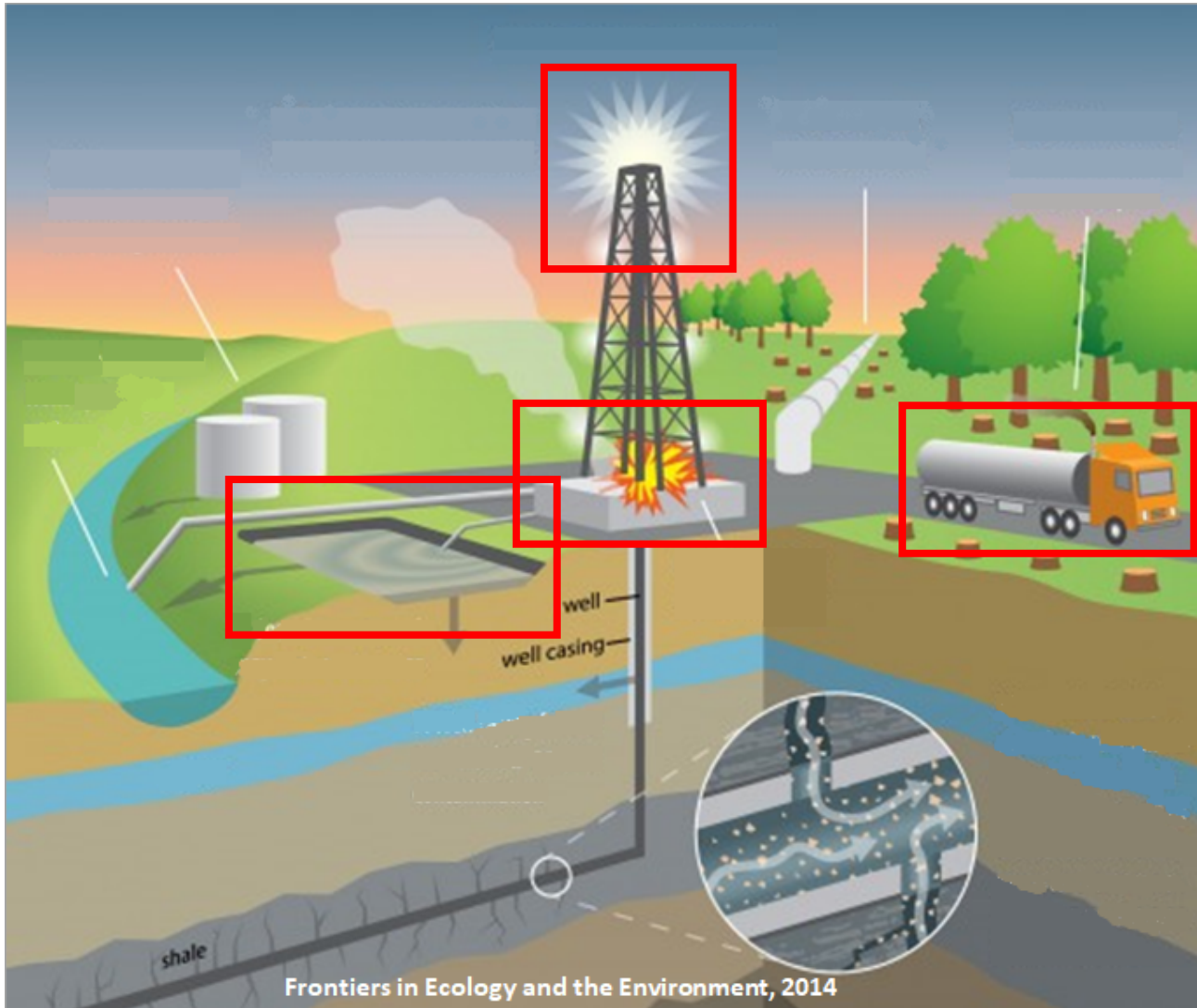
 [Download Table Data as CSV](#)

Rank	State	Crude Oil Production (thousand barrels per day)
1	Texas	4,735
2	North Dakota	1,029
3	New Mexico	988
4	Oklahoma	482
5	Colorado	450
6	Alaska	444
★ 7	California	388
8	Wyoming	237
9	Louisiana	101



Source: US Energy Information Administration, 2018

# Routes of Exposure



- Potential direct health impacts
  - Air pollution
    - e.g. particulate matter
  - Water pollution
    - e.g. benzene
- Potential indirect health impacts
  - Noise
    - e.g. equipment
  - Excessive lighting



# Prior Research on Perinatal Health Impacts

Birth Outcome	# Studies that evaluated outcome	# Studies that found significant increased risk
Preterm birth	5	3
Small-for-gestational age	4	2
Low birth weight	2	1
Decreased birth weight	5	2

Note: Location (PA, CO, TX), control groups, exposure definition, regression models, and covariates in adjusted models vary by study



## Study Design: Retrospective cohort study

**Question:** What is the relationship between prenatal exposure to oil+gas development (OGD) and birth outcomes in CA?

- Do associations differ by urban/rural community type?

**Hypothesis:** Prenatal exposure to OGD increases risk or likelihood of adverse birth outcomes

**Statistical analysis:** Linear/logistic regression modeling

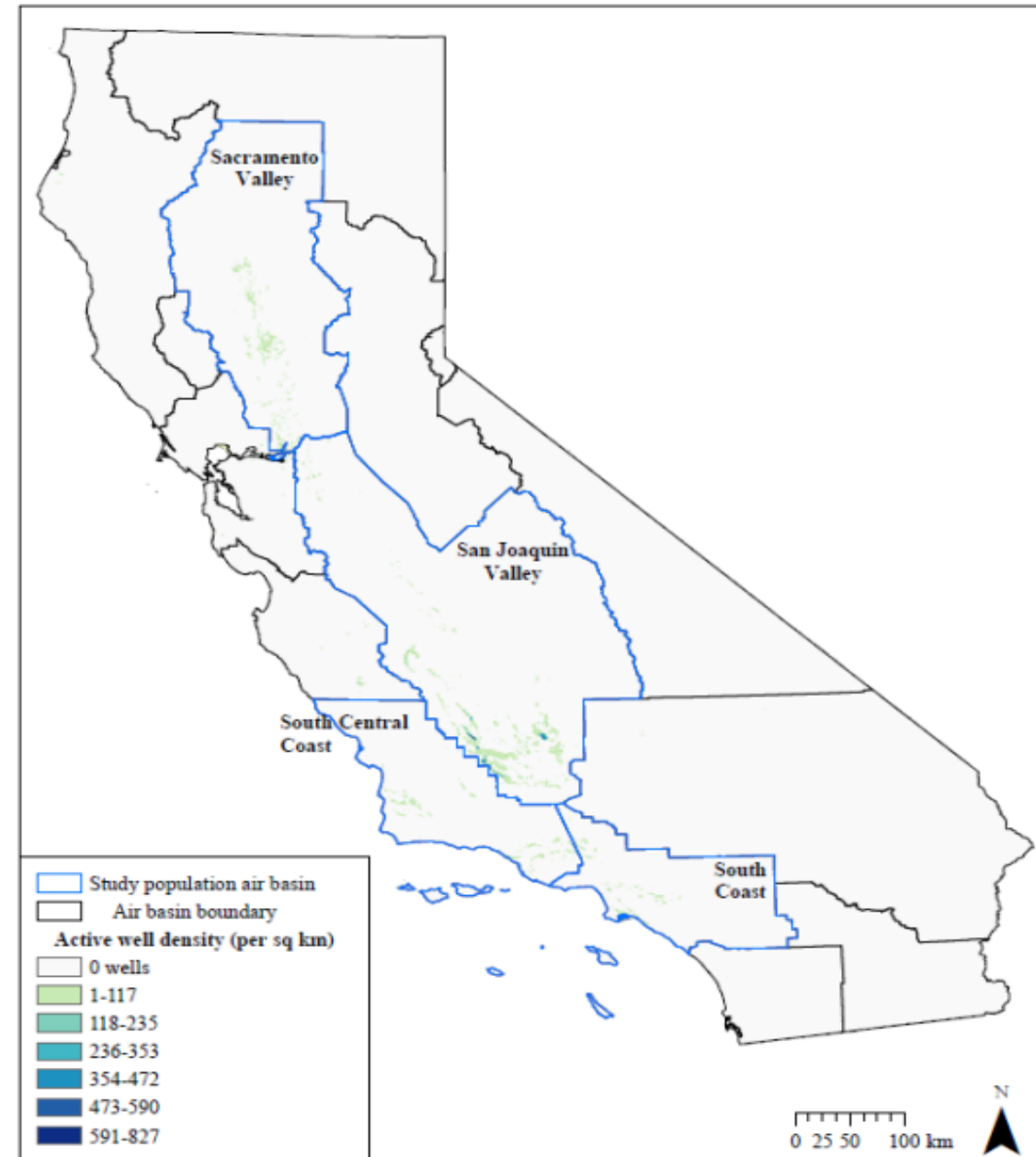
# Data Sources

- Birth records: CA Dept. Public Health birth records
- Well records: CA Dept. of Conservation
- Covariates
  - Individual: birth records
  - Area-level
    - US Census
    - Center for Air, Climate, and Energy Solutions (CACES)
    - CA Air Resources Board



# Study population

- Birth years: 2006-2015
- Exposure period: 2005-2015
- Study population (N=2.9M births)
  - 4 air basins:
    - Sacramento Valley
    - San Joaquin Valley
    - South Central Coast
    - Southern California
  - Births with at least 1 well within 10 km (~6 miles) of maternal residence



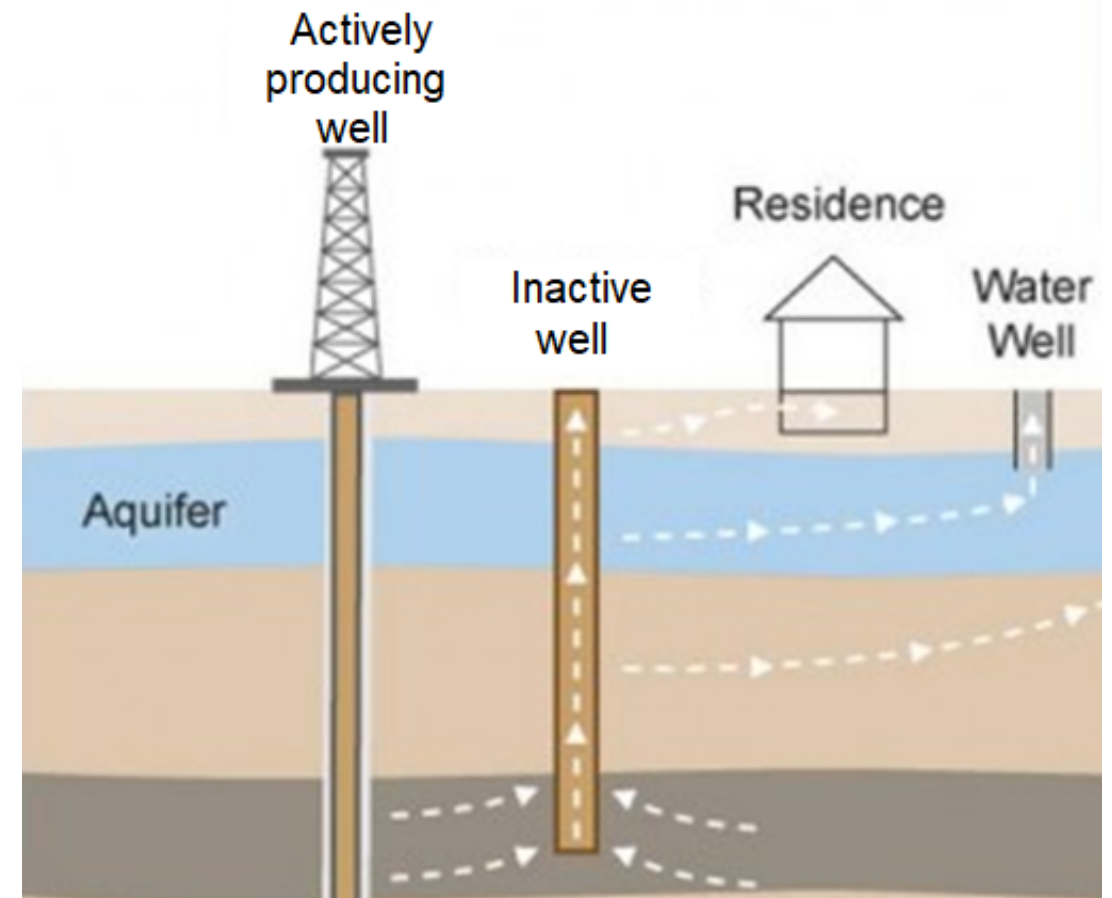


# Birth Outcomes

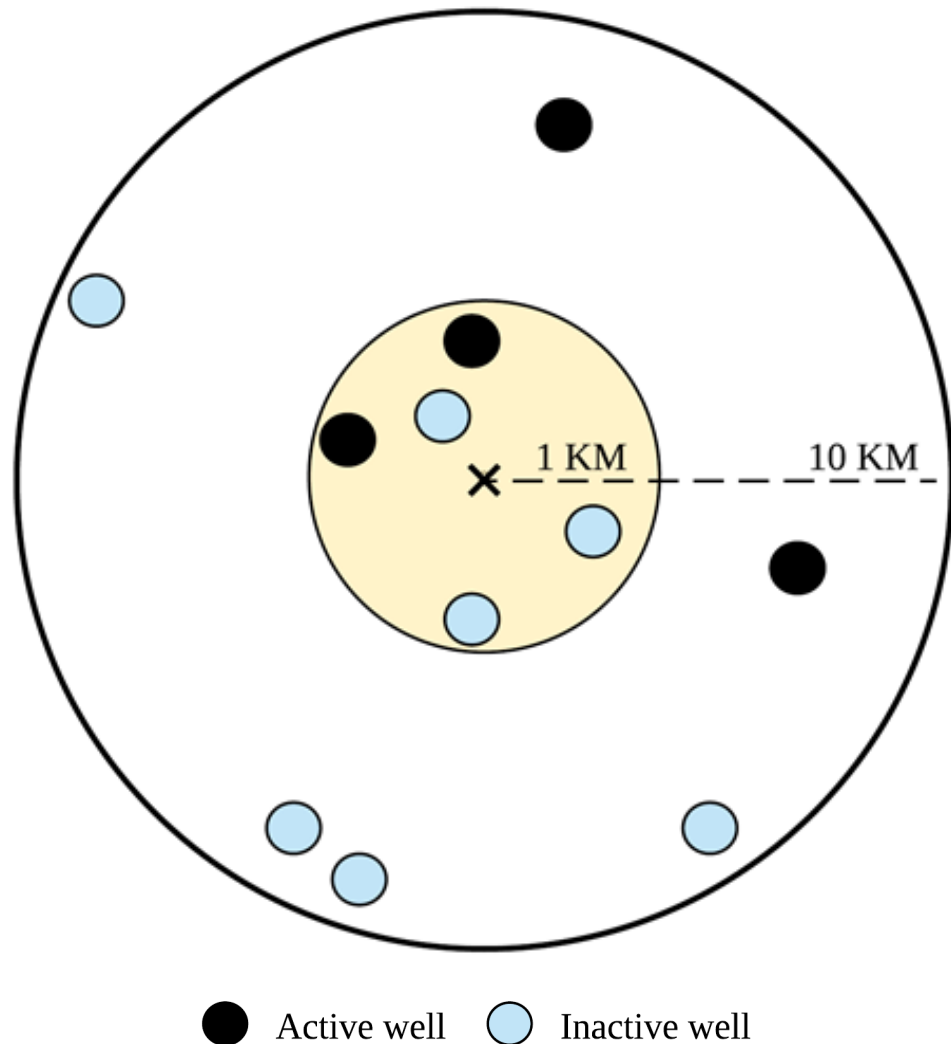
Outcome	Definition
Low birth weight (LBW)	Birth weight <2500 grams
Preterm birth (PTB)	<37 weeks of gestation
Small-for-gestational age (SGA)	Birth weight less than the US sex-specific 10th percentile of weight for each week of gestation
Term birth weight (g)	Birth weight in grams, born after 37 weeks

# Exposure to Two Well Types

- 1) Active well production volume (total)
- 2) Inactive well count



# Defining Exposure



Total study population

Births **within 10 km** of **at least one** active or inactive well **during pregnancy**

Exposed

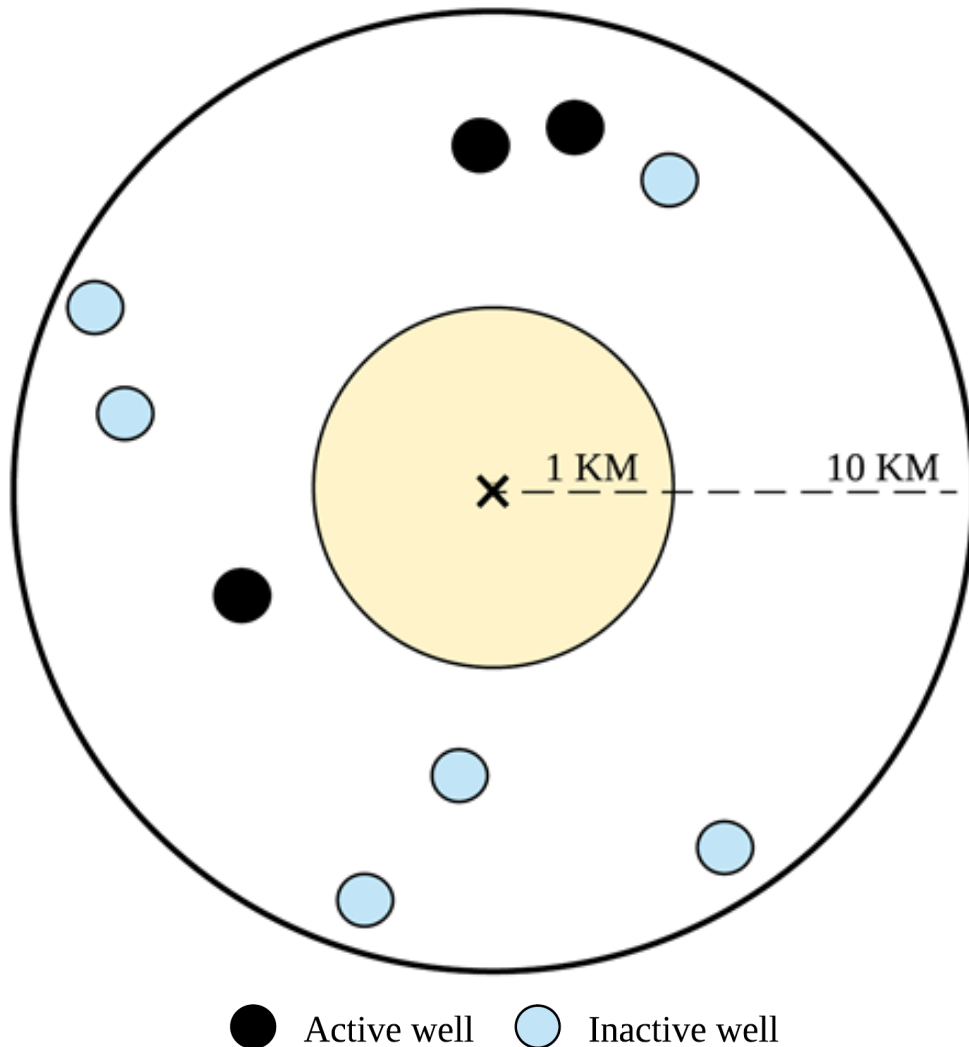
Births with active/inactive well(s) **within 1 km**

Unexposed

Births **without any wells within 1 km**



# Defining Exposure



Total study population

Births **within 10 km** of **at least one** active or inactive well **during pregnancy**

Exposed

Births with active/inactive well(s) **within 1 km**

Unexposed

Births **without any wells within 1 km**

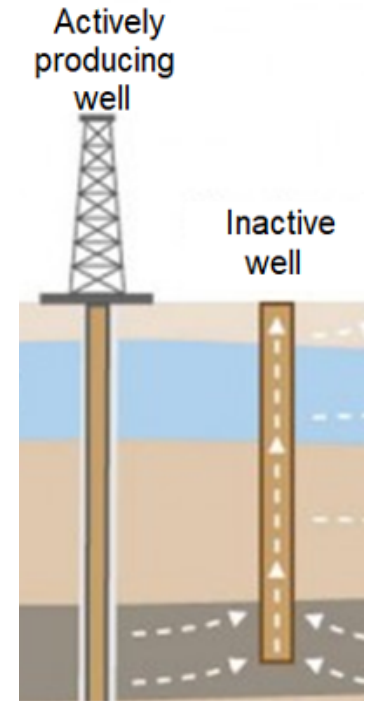
# Exposure Metrics

## Production Volume

- Total production volume of oil and gas wells within 1 km
  - Unit: barrels of oil equivalent (BOE)
- Categories:
  - Reference: No production volume
  - Moderate: 1-100 BOE/day
  - High: 100+ BOE/day

## Inactive Wells

- Total count within 1 km
- Categories:
  - Reference: No inactive wells
  - Low: 1 inactive well
  - Moderate: 2-5 inactive wells
  - High: 6+ inactive wells

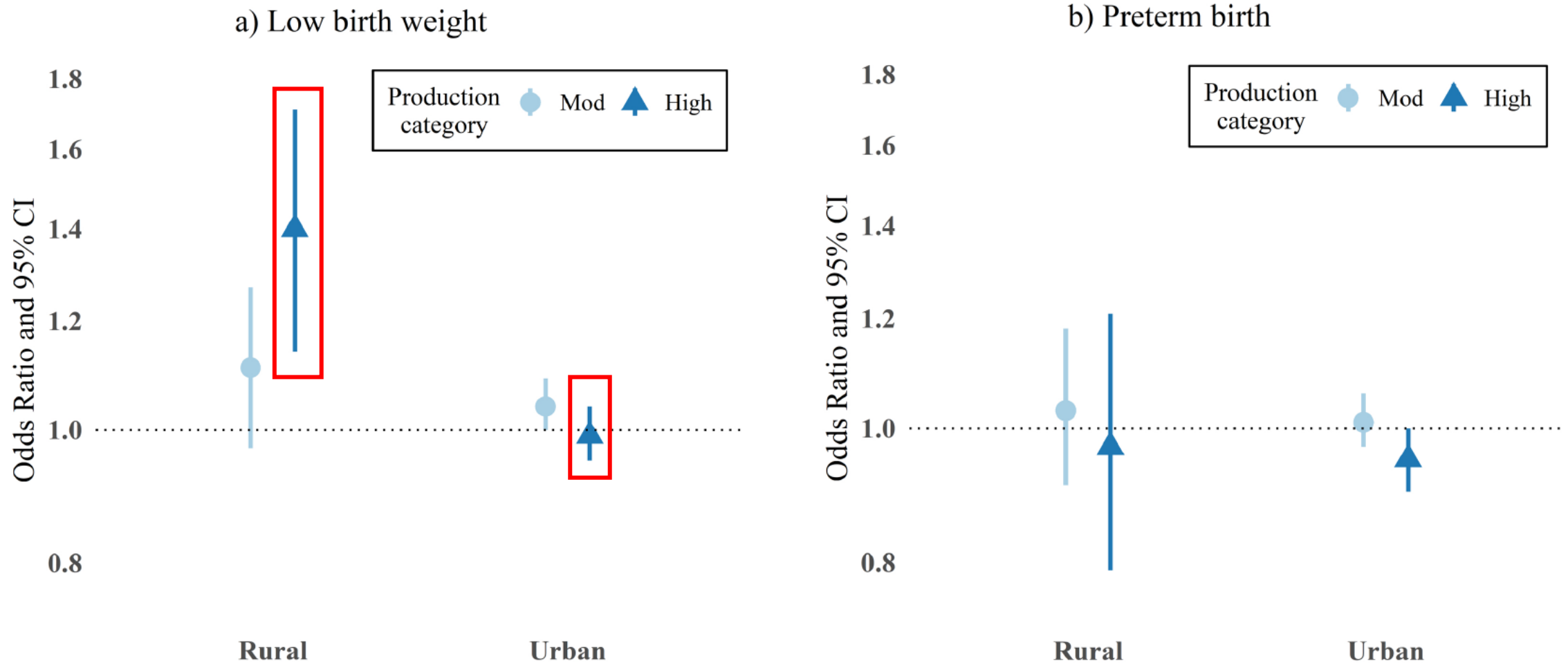


# Statistical Approach: Multivariable Regression

- Regression models
  - Logistic (binary): LBW, PTB, SGA
  - Linear (continuous): term birth weight
  - Accounted for clustering within census tracts
- Adjusted for individual and area-level covariates
  - Child: gender, birth month and year
  - Mother: age, race-ethnicity, education, metric for adequacy for prenatal care, parity
  - Area-level: air basin, urban/rural status, NO<sub>2</sub> concentration, metric for income inequality

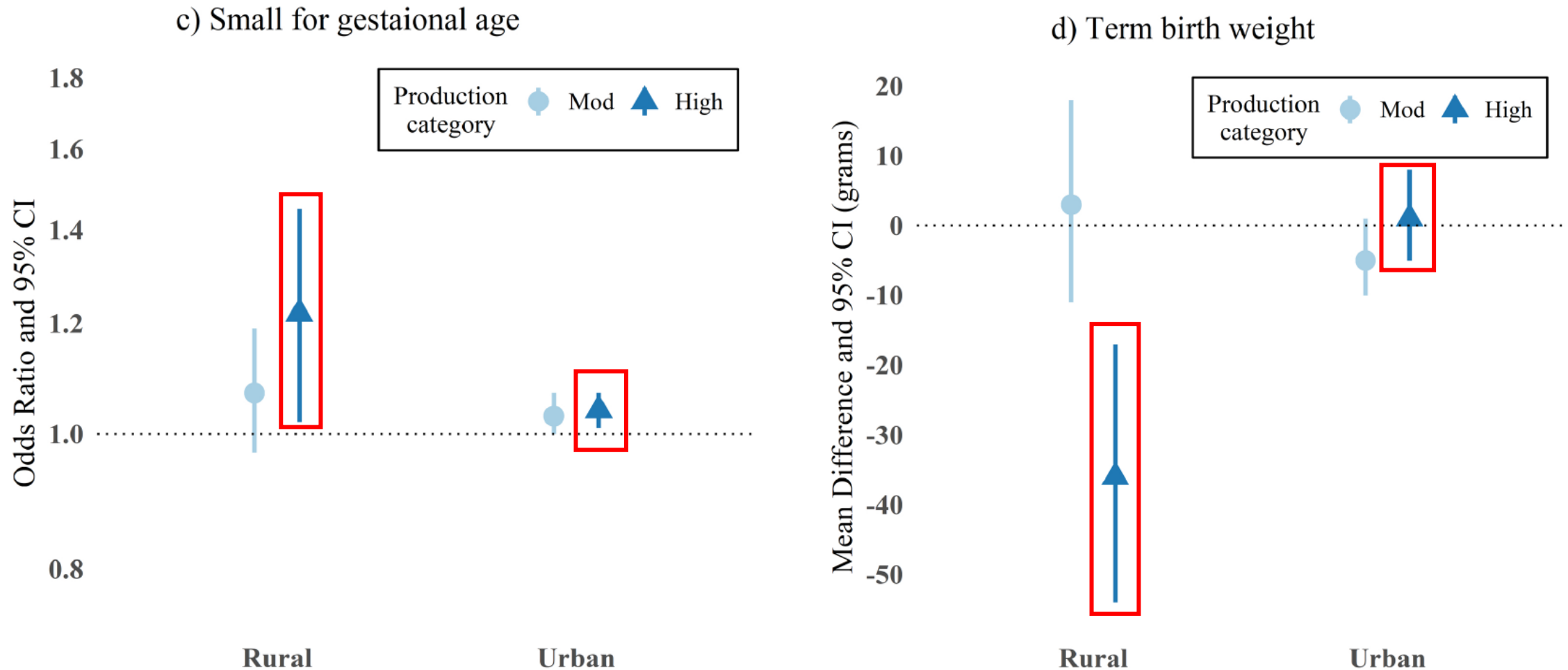


# Results: Exposure to Active Well Production Volume



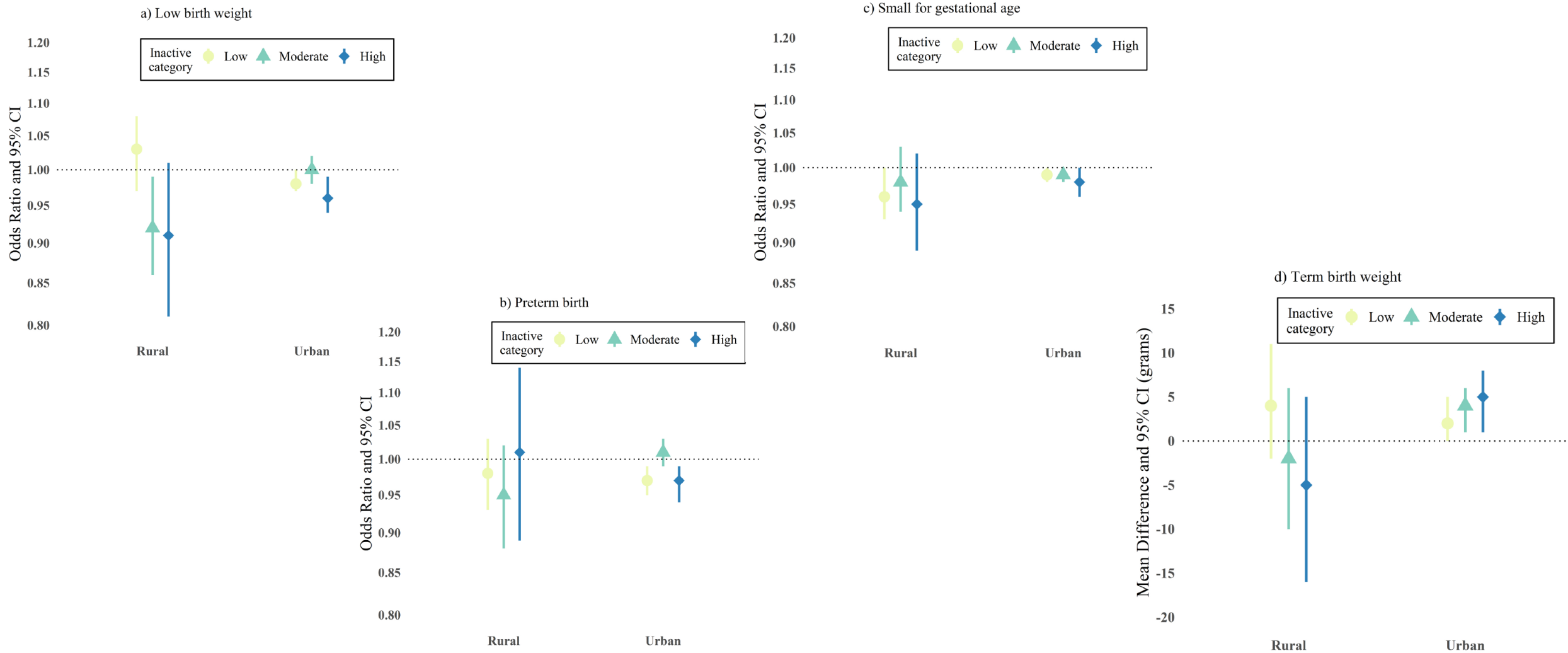
Note: Models adjusted for inactive well count + covariates

# Results: Exposure to Active Well Production Volume



Note: Models adjusted for inactive well count + covariates

# Results: Exposure to Inactive Wells



Note: Models adjusted for production volume + covariates

# Results Summary

- Higher production volume from active wells is associated with
  - Increased odds of LBW and SGA
  - Decreased term birth weight
- Highly productive wells in rural areas may pose greatest risk
- Robust results: sensitivity analyses other sources of pollution or maternal risk factors did not change effect estimates

# Interpretation

- Why **active production**?
  - Off-gassing of pollutants at wellheads
  - Excessive noise from equipment during production
- Why **rural**?
  - Differences in source contribution and exposure patterns
    - Unique signal to OGD may be more difficult to parse
    - Observed modest effect for SGA in urban areas

# Limitations + Strengths

## Limitations

- Exposure pathways remain unclear
- Unmeasured individual/area-level confounding
  - e.g. Other sources of pollution
- Exposure misclassification
  - Maternal residential/occupational mobility

## Strengths

- One of two studies in CA
- Unique exposure metrics
  - Inactive wells
  - Active production volume
- Evaluation of effects by urban/rural communities

# Public Health Implications



Research informs regulatory decision-making

- Increase air and water monitoring efforts in and around wells
- Update setback distances
- Consider sensitive populations in regulations
- Consider production volume in other analyses





# EHP paper

Tran KV, Casey JA, Cushing LJ, Morello-Frosch R. Residential proximity to oil and gas development and birth outcomes in California: a retrospective cohort study. *Environmental Health Perspectives*. 2020 Jun 03;128(6):067001-13.

Vol. 128, No. 6 | Research


## Residential Proximity to Oil and Gas Development and Birth Outcomes in California: A Retrospective Cohort Study of 2006–2015 Births


Kathy V. Tran  Joan A. Casey, Lara J. Cushing, and Rachel Morello-Frosch 

Published: 3 June 2020 | CID: 067001 | <https://doi.org/10.1289/EHP5842> | Cited by: 1

 Sections  PDF

 Supplemental Materials  Tools  Share

 Open Access

-  [Figures](#)
-  [References](#)
-  [Related](#)
-  [Details](#)

### Cited By

Cushing L, Vavra-Musser K, Chau K, Franklin M and Johnston J (2020) Flaring from Unconventional Oil and Gas Development and Birth Outcomes in the Eagle Ford Shale in South Texas, *Environmental Health Perspectives*, 128:7, Online publication date: 1-Jul-2020.

### Recommended

UC Berkeley Public Health

Rachel Morello-Frosch

Joan Casey

Lara Cushing

Funding Sources

California Air Resources Board Research Grant (#18RDo18)

NSF SAGE-IGERT (#1144885)

PSE for Energy Health

Seth Shonkoff

CA Air Resources Board

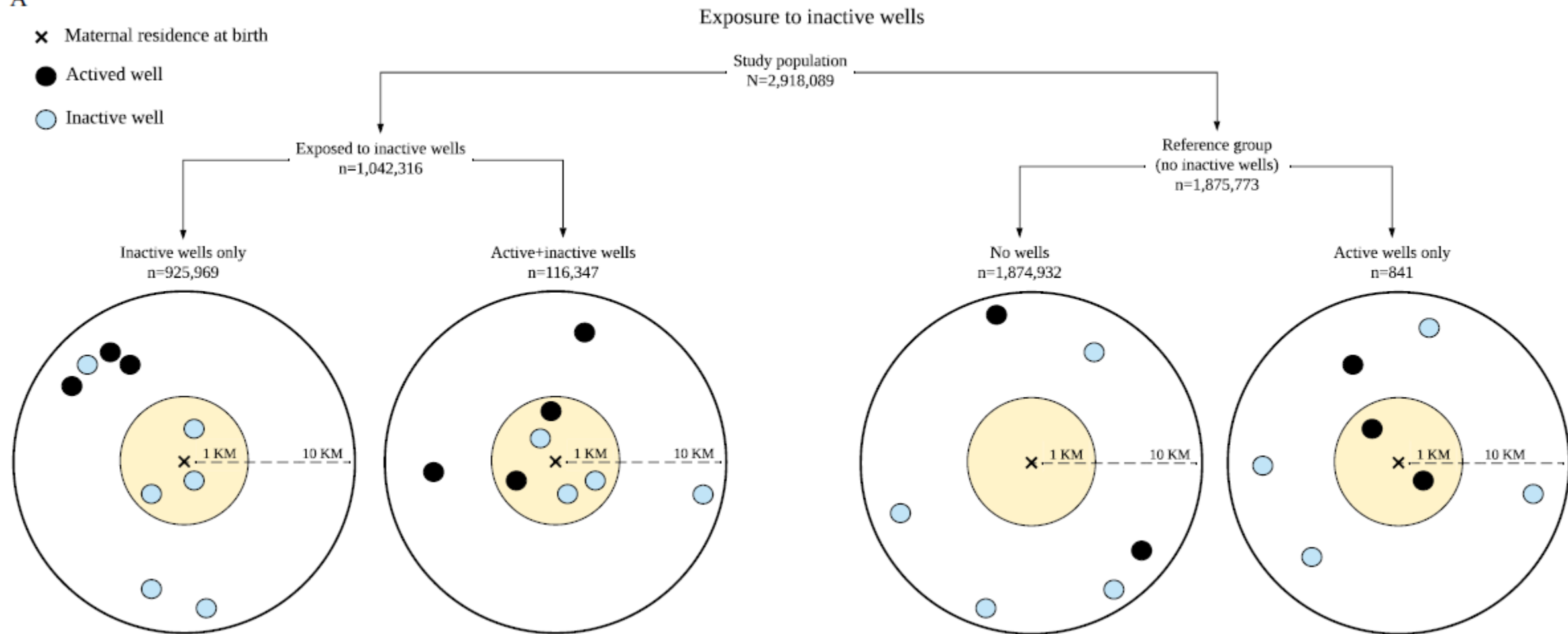
Cynthia Garcia

Alvaro Alvarado

**Thank you!**

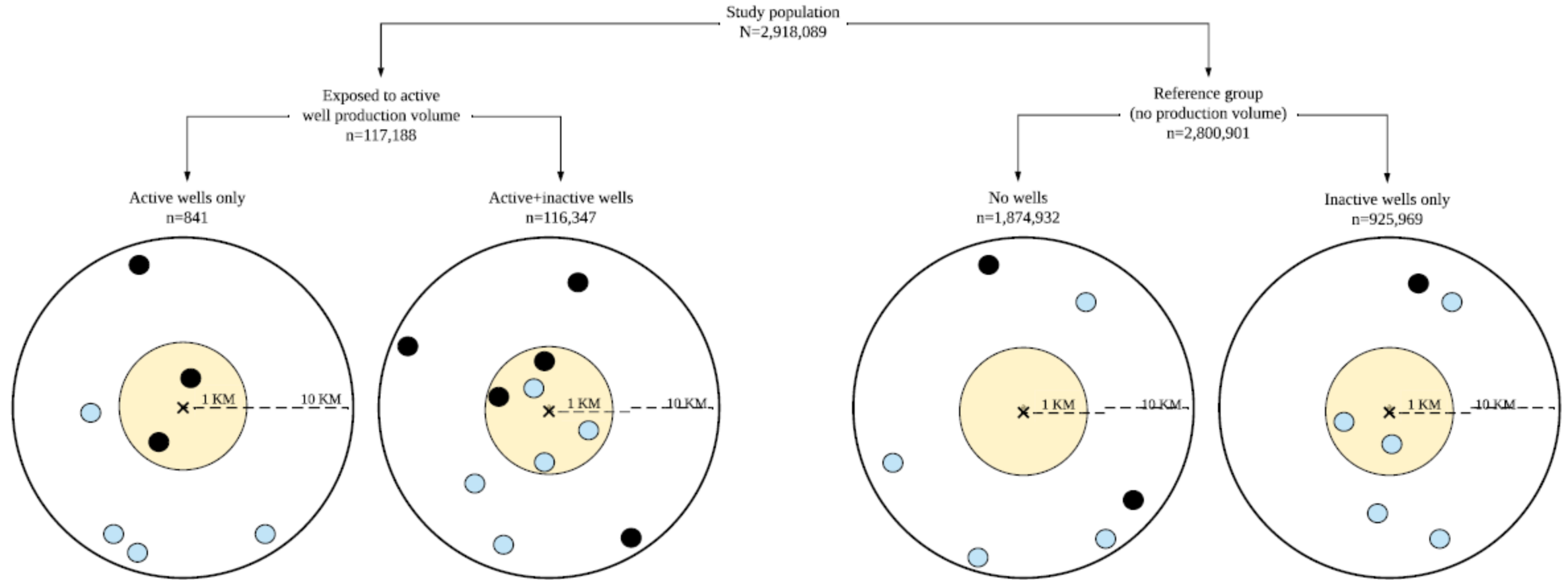
# Backup slides

A



B

Exposure to production volume from active wells



# Estimates: LBW + Exposure to production volume

Prod volume categories	No BOE (ref)		1-100 BOE/day				GT 100 BOE/day			
	n	Cases (%)	<i>n</i>	Cases (%)	aOR (95% CI)	EM p-value	n	Cases (%)	aOR (95% CI)	EM p-value
Rural <sup>a</sup>										
Entire pregnancy	318,488	14,451 (5)	8,957	400 (4)	1.11 (0.97, 1.27)	0.81	1,689	94 (6)	1.40 (1.14, 1.71)	0.01
Trimester 1	318,629	14,457 (5)	8,809	394 (4)	1.12 (0.98, 1.28)	0.67	1,696	94 (6)	1.39 (1.11, 1.75)	0.002
Trimester 2	318,675	14,461 (5)	8,258	367 (4)	1.10 (0.96, 1.26)	1.00	2,201	117 (5)	1.35 (1.13, 1.61)	0.002
Trimester 3	317,913	13,684 (4)	8,790	359 (4)	1.07 (0.93, 1.23)	1.00	1,420	77 (5)	1.38 (1.11, 1.72)	0.01
Urban <sup>a</sup>										
Entire pregnancy	2,482,413	127,533 (5)	59,685	3,161 (5)	1.04 (1.00, 1.09)	--	46,857	2,461 (5)	0.99 (0.95, 1.04)	--
Trimester 1	2,483,224	127,576 (5)	58,967	3,119 (5)	1.04 (0.99, 1.09)	--	46,764	2,460 (5)	1.00 (0.95, 1.04)	--
Trimester 2	2,483,156	127,566 (5)	55,448	2,950 (5)	1.05 (1.00, 1.10)	--	50,351	2,639 (5)	0.99 (0.95, 1.04)	--
Trimester 3	2,475,357	120,289 (5)	64,045	3,298 (5)	1.06 (1.02, 1.11)	--	40,776	1,929 (5)	0.93 (0.88, 0.98)	--

Note: aOR, adjusted odds ratio; CI, confidence interval; BOE, barrel of oil equivalents of oil and gas; GT, greater than; EM, effect modification.

<sup>a</sup>Logistic regression models adjusted for inactive well count; child's sex, birth month and birth year; maternal education, age, race/ethnicity, Kotelchuck prenatal care index, parity; air basin, NO<sub>2</sub> concentration, and ICE for income.

# Estimates: PTB + Exposure to production volume

Prod volume categories	No BOE (ref)		1-100 BOE/day				GT 100 BOE/day			
	n	Cases (%)	<i>n</i>	Cases (%)	aOR (95% CI)	EM p-value	n	Cases (%)	aOR (95% CI)	EM p-value
Rural <sup>a</sup>										
Entire pregnancy	318,488	20,845 (7)	8,957	618 (7)	1.03 (0.91, 1.18)	1.00	1,689	99 (6)	0.97 (0.78, 1.21)	1.00
Trimester 1	318,629	20,857 (7)	8,809	604 (7)	1.02 (0.90, 1.16)	1.00	1,696	101 (6)	1.00 (0.80, 1.24)	1.00
Trimester 2	318,675	20,850 (7)	8,258	582 (7)	1.06 (0.94, 1.21)	1.00	2,201	130 (6)	0.98 (0.82, 1.18)	1.00
Trimester 3	317,913	19,899 (6)	8,790	575 (7)	1.03 (0.90, 1.17)	1.00	1,420	77 (5)	0.92 (0.71, 1.19)	0.84
Urban <sup>a</sup>										
Entire pregnancy	2,482,413	170,691 (7)	59,685	4,120 (7)	1.01 (0.97, 1.06)	--	46,857	3,087 (7)	0.95 (0.90, 1.00)	--
Trimester 1	2,483,224	170,735 (7)	58,967	4,088 (7)	1.01 (0.97, 1.06)	--	46,764	3,075 (7)	0.95 (0.91, 1.00)	--
Trimester 2	2,483,156	170,728 (7)	55,448	3,868 (7)	1.02 (0.98, 1.07)	--	50,351	3,302 (7)	0.95 (0.90, 1.00)	--
Trimester 3	2,475,357	162,385 (7)	64,045	4,436 (7)	1.06 (1.02, 1.11)	--	40,776	2,300 (6)	0.82 (0.77, 0.88)	--

Note: aOR, adjusted odds ratio; CI, confidence interval; BOE, barrel of oil equivalents of oil and gas; GT, greater than; EM, effect modification.

<sup>a</sup>Logistic regression models adjusted for inactive well count; child's sex, birth month and birth year; maternal education, age, race/ethnicity, Kotelchuck prenatal care index, parity; air basin, NO<sub>2</sub> concentration, and ICE for income.



# Estimates: SGA + Exposure to production volume

Prod volume categories	No BOE (ref)		1-100 BOE/day				GT 100 BOE/day			
	n	Cases (%)	<i>n</i>	Cases (%)	aOR (95% CI)	EM p-value	n	Cases (%)	aOR (95% CI)	EM p-value
<b>Rural<sup>a</sup></b>										
Entire pregnancy	318,488	33,034 (10)	8,957	966 (11)	1.07 (0.97, 1.19)	0.99	1,689	211 (13)	1.22 (1.02, 1.45)	0.14
Trimester 1	318,629	33,056 (10)	8,809	937 (11)	1.05 (0.95, 1.16)	1.00	1,696	218 (13)	1.25 (1.04, 1.50)	0.07
Trimester 2	318,675	33,058 (10)	8,258	889 (11)	1.07 (0.96, 1.19)	1.00	2,201	264 (12)	1.17 (1.02, 1.35)	0.20
Trimester 3	317,913	33,038 (10)	8,790	948 (11)	1.08 (0.97, 1.19)	0.90	1,420	183 (13)	1.24 (1.02, 1.50)	0.14
<b>Urban<sup>a</sup></b>										
Entire pregnancy	2,482,413	290,654 (12)	59,685	7,339 (12)	1.03 (1.00, 1.07)	--	46,857	5,739 (12)	1.04 (1.01, 1.07)	--
Trimester 1	2,483,224	290,768 (12)	58,967	7,246 (12)	1.03 (1.00, 1.07)	--	46,764	5,718 (12)	1.04 (1.00, 1.07)	--
Trimester 2	2,483,156	290,748 (12)	55,448	6,834 (12)	1.03 (1.00, 1.07)	--	50,351	6,150 (12)	1.04 (1.00, 1.07)	--
Trimester 3	2,475,357	290,367 (12)	64,045	7,858 (12)	1.03 (1.00, 1.07)	--	40,776	5,030 (12)	1.04 (1.01, 1.08)	--

Note: aOR, adjusted odds ratio; CI, confidence interval; BOE, barrel of oil equivalents of oil and gas; GT, greater than; EM, effect modification.

<sup>a</sup>Logistic regression models adjusted for inactive well count; child's sex, birth month and birth year; maternal education, age, race/ethnicity, Kotelchuck prenatal care index, parity; air basin, NO<sub>2</sub> concentration, and ICE for income.

# Estimates: Term BW + Exposure to production volume

Prod volume categories	No BOE (ref)		1-100 BOE/day		GT 100 BOE/day		
	n	n	aDiff (95% CI)	EM p-value	n	aDiff (95% CI)	EM p-value
Rural <sup>a</sup>							
Entire pregnancy	297,643	8,339	3 (-11, 18)	0.62	1,590	-36 (-54, -17)	0.001
Trimester 1	297,772	8,205	4 (-10, 18)	0.47	1,595	-39 (-59, -19)	0.0003
Trimester 2	297,825	7,676	3 (-12, 18)	0.71	2,071	-27 (-45, -8)	0.01
Trimester 3	298,014	8,215	4 (-11, 20)	0.41	1,343	-30 (-48, -12)	0.001
Urban <sup>a</sup>							
Entire pregnancy	2,311,722	55,565	-5 (-10, 1)	--	43,770	1 (-5, 8)	--
Trimester 1	2,312,489	54,879	-5 (-11, 1)	--	43,689	2 (-4, 9)	--
Trimester 2	2,312,428	51,580	-5 (-11, 1)	--	47,049	2 (-4, 8)	--
Trimester 3	2,312,972	59,609	-6 (-12, 0)	--	38,476	5 (-2, 12)	--

Note: aDiff, adjusted mean difference (grams); CI, confidence interval; BOE, barrel of oil equivalents of oil and gas; GT, greater than; EM, effect modification.

<sup>a</sup>Linear regression models adjusted for inactive well count; child's gestational age, sex, birth month and birth year; maternal education, age, race/ethnicity, Kotelchuck prenatal care index, parity; air basin, NO<sub>2</sub> concentration, and ICE for income.