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Ambient Temperature and Birth Outcomes

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Background

- Pregnant women are sensitive to environmental exposures
- Environmental exposures are important determinants of pregnancy outcomes and child health
- Preterm birth
  - Leading cause of neonatal death and child death
  - Associated with higher risk of childhood morbidity
- Birthweight
  - Marker of fetal growth
  - Predictive of morbidity and mortality through the life course

Background

- Ambient temperature might increase risk of PTB and affect fetal growth
  - Smaller studies
  - Heterogeneous results
- Objectives:
  - To evaluate the association between days of extreme heat or cold and risk of preterm birth
  - To evaluate the association between temperature throughout pregnancy and markers of fetal growth

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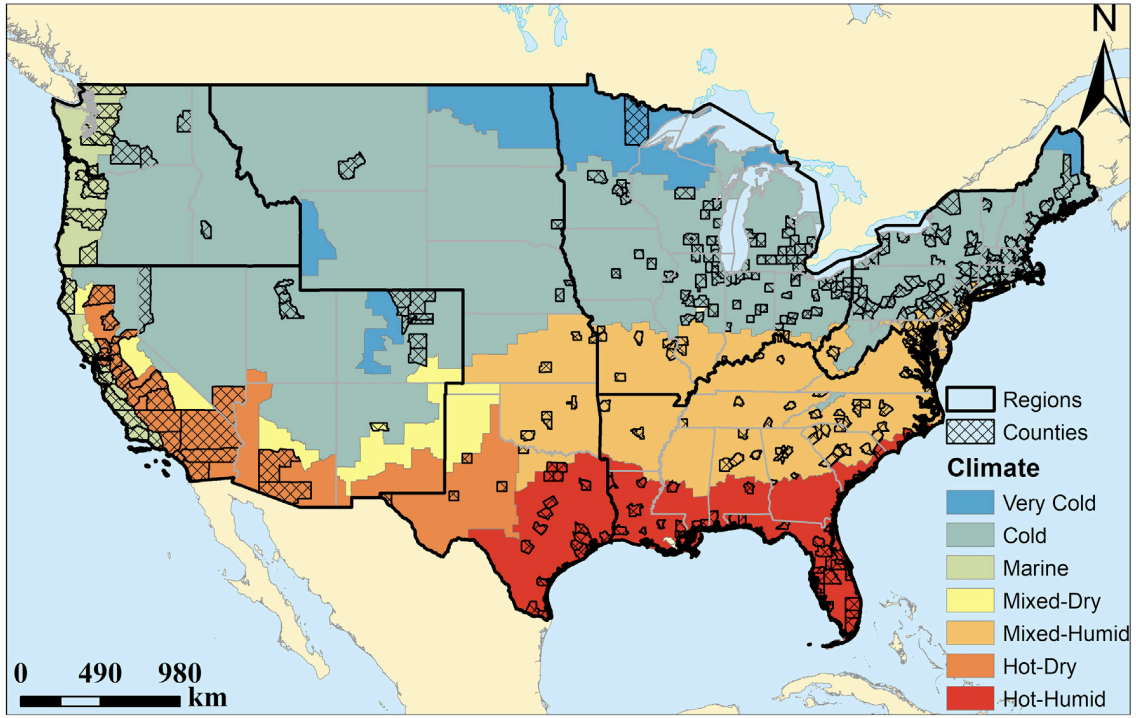
Methods

- National dataset of US births
  - 1989-2002
  - 403 counties in contiguous US with >100,000 residents
  - ~32 million singleton births
  - Defined preterm birth as delivery <37 weeks of gestation
  - Defined term SGA as <10th percentile of term birthweight
  - Term birthweight and birthweight z-score



Sun et al. *Environ Int.* 2019

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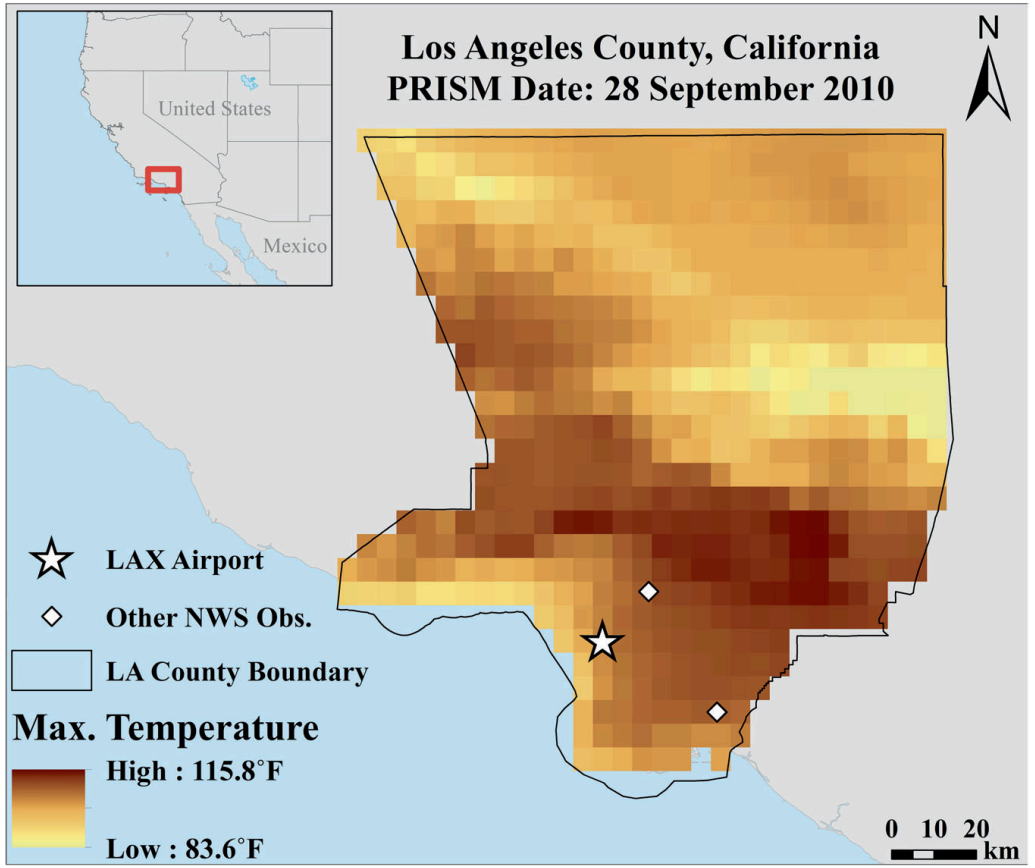
Methods

- Temperature
  - Daily data from PRISM (4km)
  - Calculated population weighted average daily mean temperature
- Analysis
  - PTB: Distributed lag nonlinear models
  - SGA: logistic regression, adjusting for age, race, marital status, education, smoking, alcohol, parity, chronic hypertension, time trends
  - Birthweight: linear regression with adjustment for same factors



Spangler et al. *JESEE.* 2018

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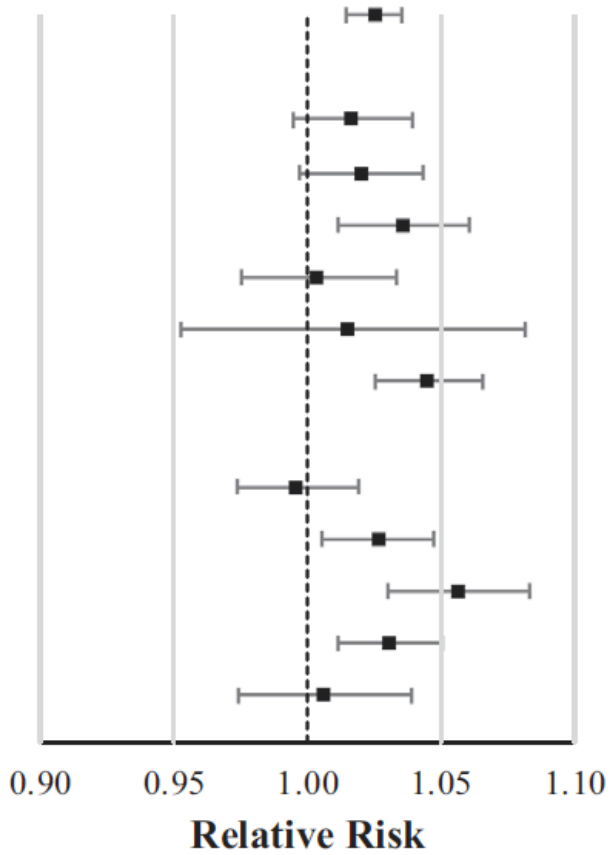
Mean Temperature and Risk of Preterm Birth

Subgroup	No. of Counties	Relative Risk (95% CI)	*P* Value for Heterogeneity	Extreme Heat (95th vs. 50th)
Overall	403	1.025 (1.015, 1.036)		
Geographic Region			0.001	
Northeast	110	1.017 (0.995, 1.040)		
Southeast	94	1.020 (0.997, 1.044)		
Midwest	99	1.036 (1.012, 1.061)		
Great Plains	35	1.004 (0.976, 1.034)		
Northwest	17	1.015 (0.953, 1.082)		
Southwest	48	1.046 (1.026, 1.066)		
Climate Zone			<0.001	
Hot-Humid	58	0.997 (0.974, 1.019)		
Mixed-Humid	113	1.026 (1.006, 1.048)		
Hot-Dry/Mixed-Dry	26	1.057 (1.030, 1.083)		
Cold/Very Cold	181	1.031 (1.012, 1.051)		
Marine	25	1.006 (0.975, 1.039)		



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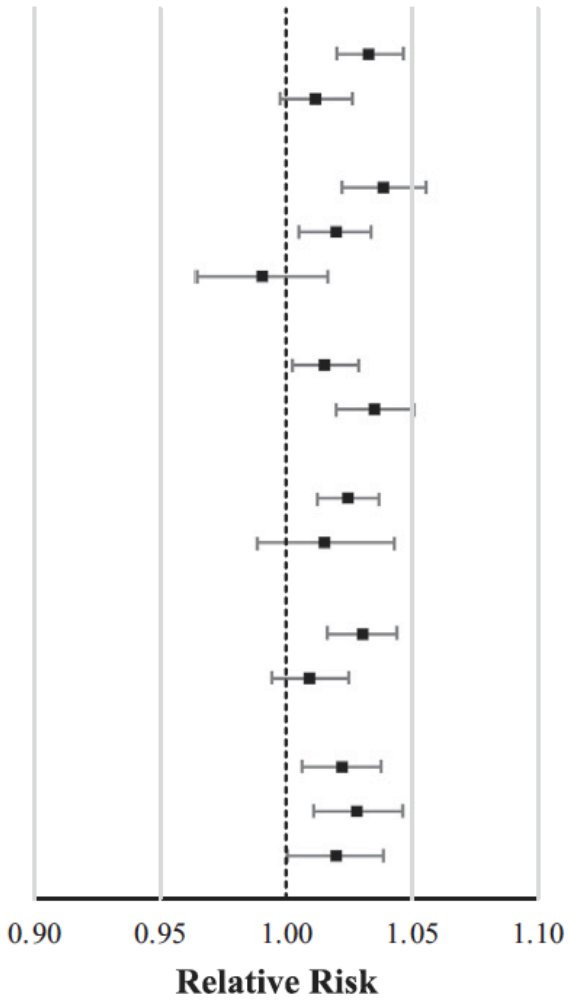
Mean Temperature and Risk of Preterm Birth

Subgroup	Relative Risk (95% CI)	*P* Value for Heterogeneity
Infant sex		0.133
Male	1.033 (1.020, 1.047)	
Female	1.012 (0.998, 1.026)	
Maternal age, years		0.010
<25	1.039 (1.022, 1.055)	
25-34	1.019 (1.005, 1.034)	
≥ 35	0.990 (0.965, 1.017)	
Marital status		0.170
Married	1.016 (1.002, 1.029)	
Unmarried	1.035 (1.020, 1.051)	
Maternal race		0.702
White	1.025 (1.012, 1.037)	
Non-white	1.015 (0.989, 1.043)	
Maternal education, years		0.140
<9	1.030 (1.016, 1.044)	
9-17	1.009 (0.994, 1.025)	
Parity		0.577
0	1.022 (1.006, 1.038)	
1	1.028 (1.011, 1.046)	
≥ 2	1.019 (1.000, 1.039)	



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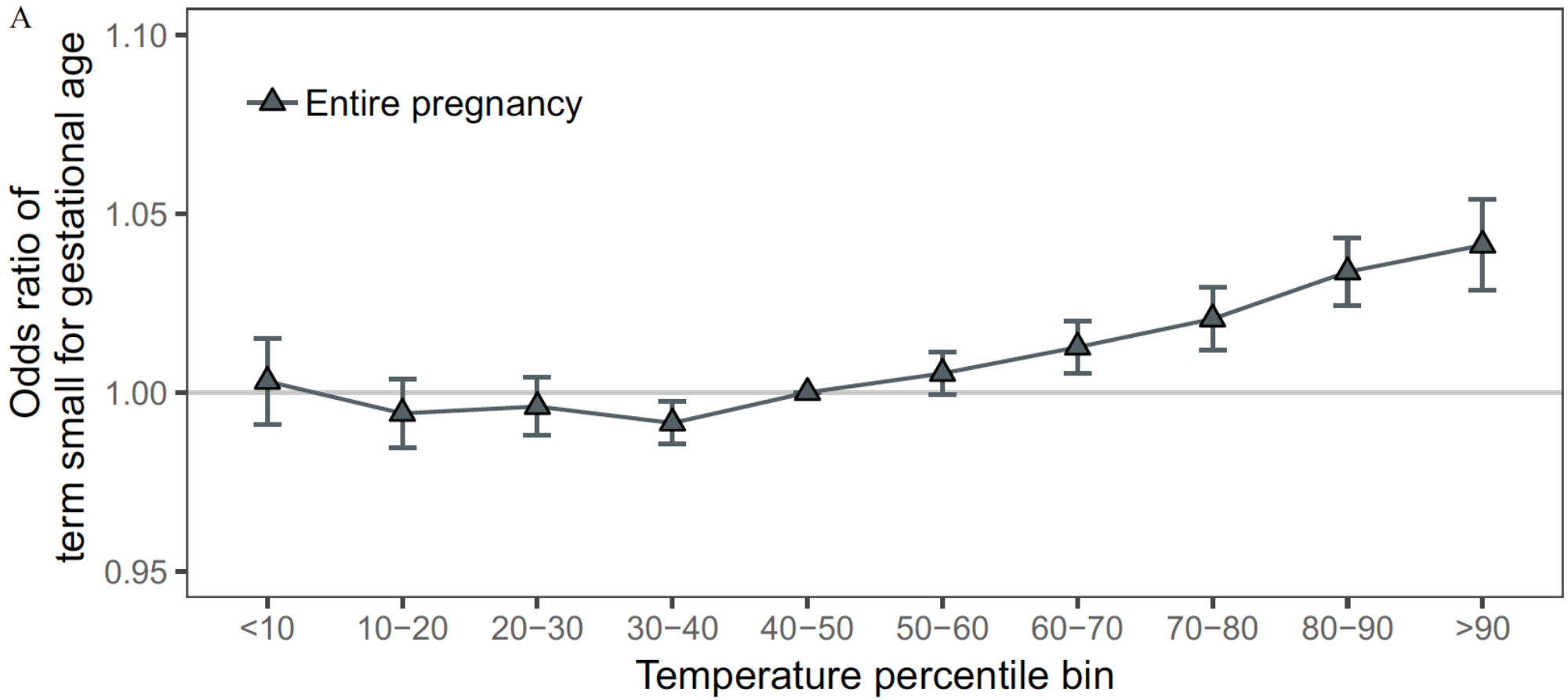
Mean Temperature and Risk of Preterm Birth

Table 2
Fraction and number of preterm births attributable to extreme heat.

Subgroup	Fraction of preterm births % (empirical CI)	Number of preterm births per million pregnancies No. (empirical CI)
All US	0.17 (0.14, 0.19)	154 (127, 173)
Geographic region		
Northeast	0.13 (0.08, 0.17)	116 (73, 153)
Southeast	0.17 (0.13, 0.20)	181 (141, 219)
Midwest	0.19 (0.13, 0.23)	176 (122, 220)
Great Plains	0.14 (0.05, 0.21)	140 (50, 216)
Northwest	0.12 (0.01, 0.22)	90 (10, 160)
Southwest	0.20 (0.12, 0.26)	174 (108, 222)
Climate zone		
Hot-Humid	0.14 (0.09, 0.19)	151 (93, 206)
Mixed-Humid	0.14 (0.10, 0.18)	145 (99, 185)
Hot-Dry/Mixed-Dry	0.21 (0.13, 0.29)	194 (113, 262)
Cold/Very Cold	0.18 (0.14, 0.22)	158 (122, 189)
Marine	0.09 (0.01, 0.16)	69 (7, 122)

Sun et al. *Environ Int.* 2019

Mean Temperature and Risk of SGA



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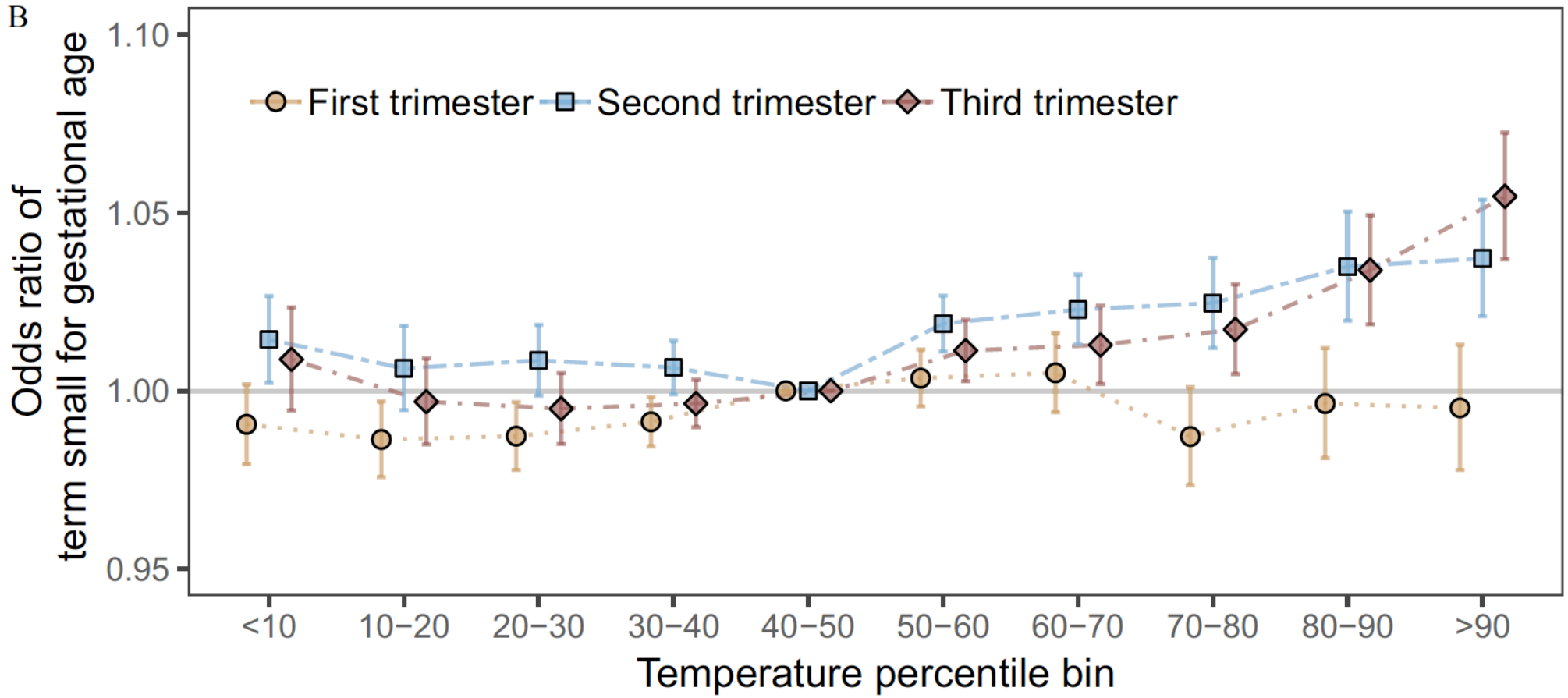
Mean Temperature and Risk of SGA



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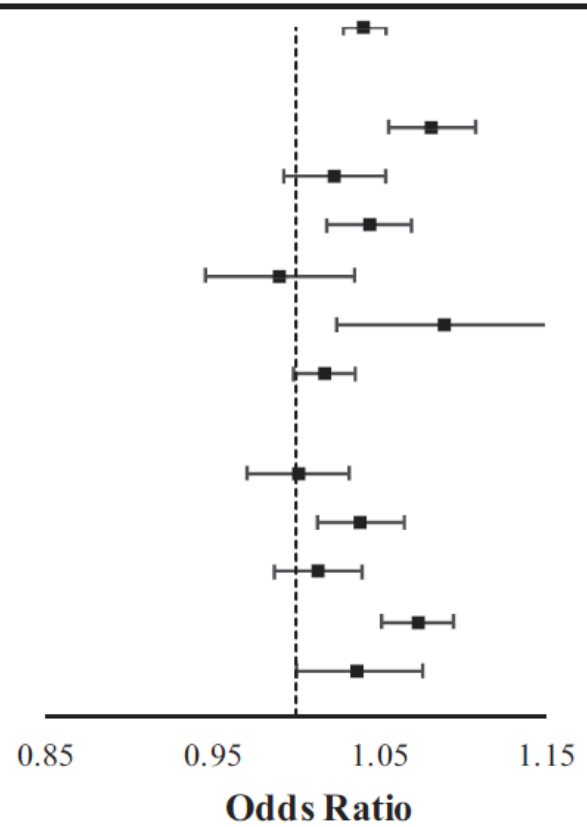
Mean Temperature and Risk of SGA

Subgroup	No. of Counties	Odds Ratio (95% CI)	*P* Value for Heterogeneity
Overall	403	1.041 (1.029, 1.054)	
Geographic Region			<0.001
Northeast	110	1.081 (1.056, 1.108)	
Southeast	94	1.023 (0.993, 1.054)	
Midwest	99	1.044 (1.019, 1.069)	
Great Plains	35	0.989 (0.946, 1.035)	
Northwest	17	1.088 (1.024, 1.155)	
Southwest	48	1.017 (0.999, 1.036)	
Climate Zone			<0.001
Hot-Humid	58	1.001 (0.971, 1.032)	
Mixed-Humid	113	1.039 (1.013, 1.065)	
Hot-Dry/Mixed-Dry	26	1.013 (0.987, 1.040)	
Cold/Very Cold	181	1.073 (1.051, 1.094)	
Marine	25	1.037 (1.000, 1.076)	



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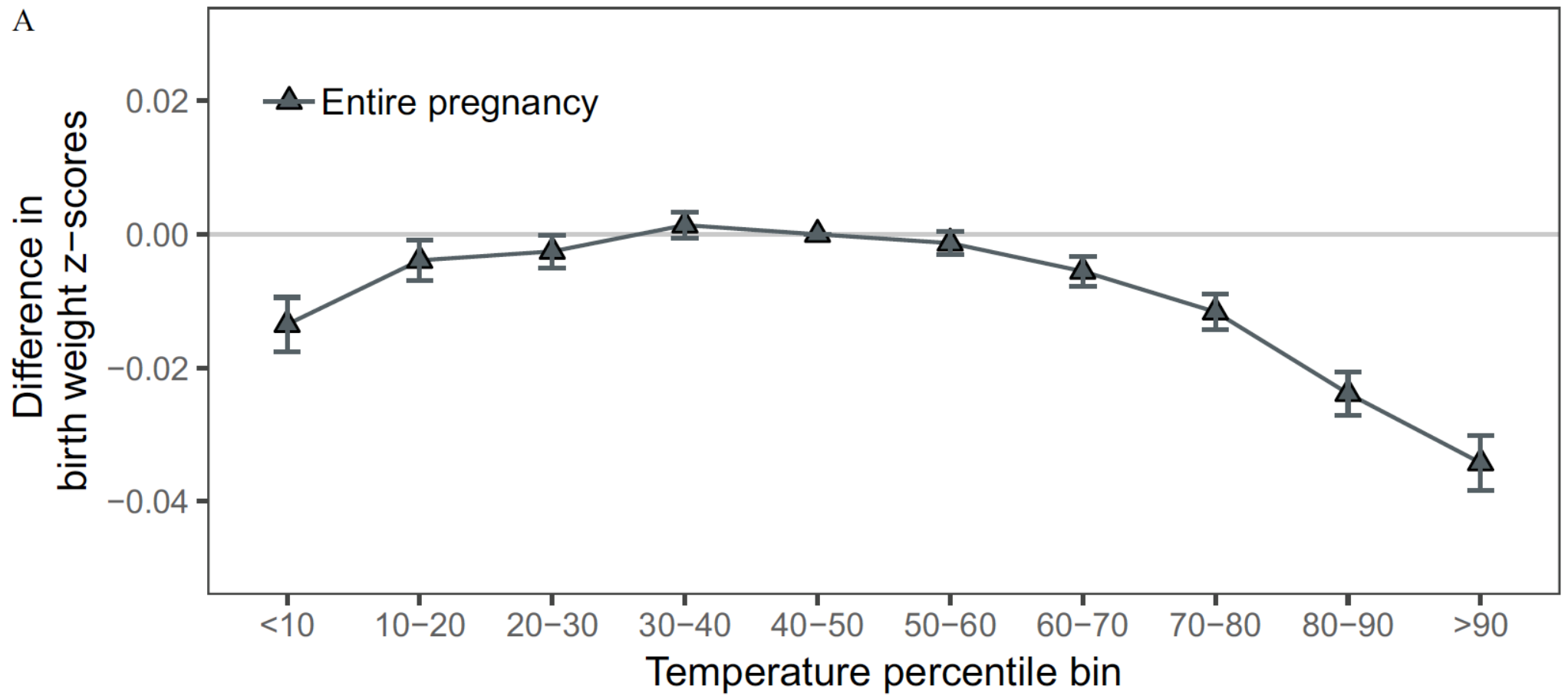
Mean Temperature and Birth Weight



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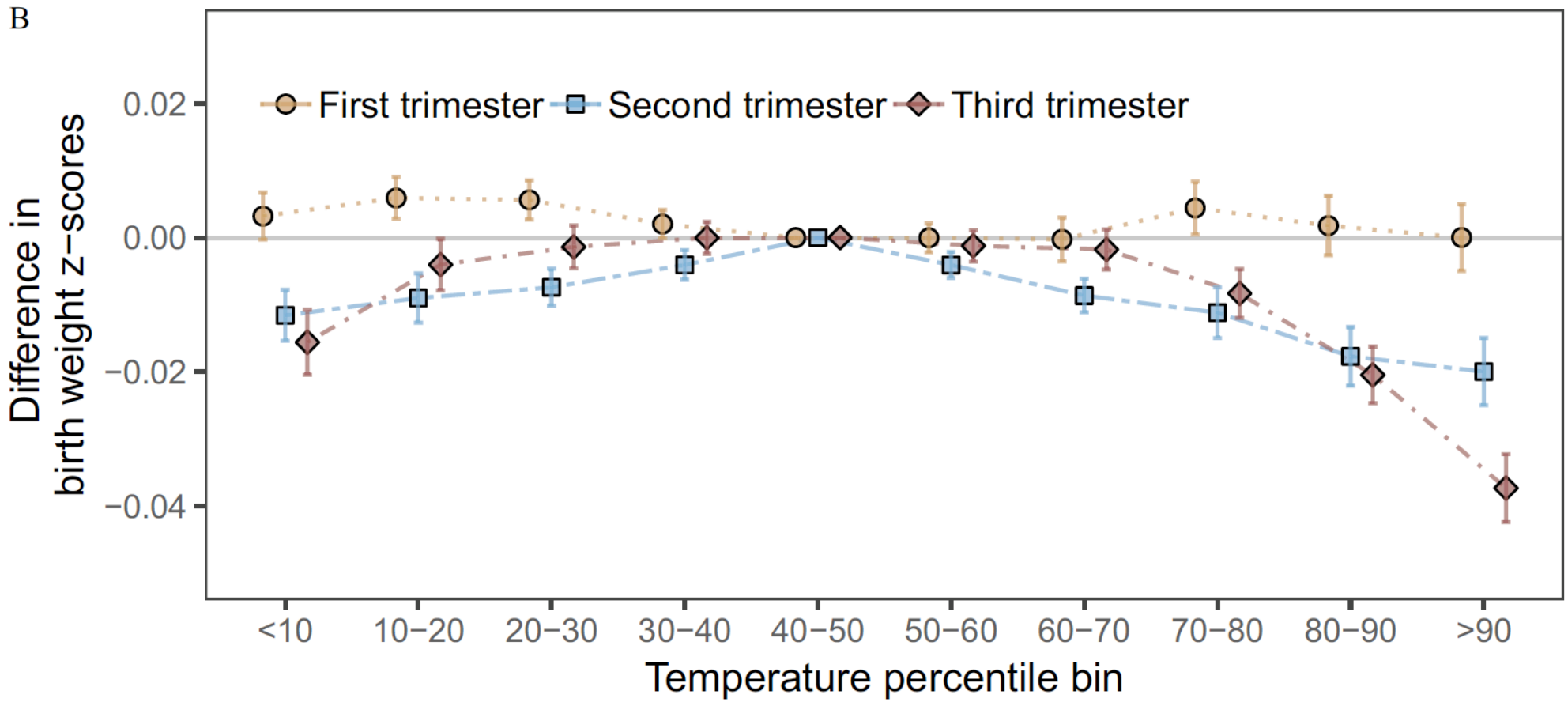
Mean Temperature and Birth Weight



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Mean Temperature and Birth Weight

Table 3. Difference in birth weight *z*-score (95% CI) and standardized birth weight (g) (95% CI) associated with warmer-than-average and colder-than-average temperatures during the entire pregnancy among 29,597,735 singleton term births in 403 U.S. counties between 1989 and 2002.

Temperature (percentile)	Unadjusted model[a]	Main model[b]	Main model + $PM_{2.5}$
Birth weight *z*-score			
>90th	–0.031 (–0.034, –0.029)	–0.034 (–0.038, –0.030)	–0.034 (–0.038, –0.029)
80th–90th	–0.024 (–0.026, –0.022)	–0.024 (–0.027, –0.021)	–0.024 (–0.027, –0.020)
10th–20th	0.004 (0.002, 0.006)	–0.004 (–0.007, –0.001)	–0.004 (–0.007, –0.001)
<10th	–0.002 (–0.004, 0.000)	–0.014 (–0.018, –0.009)	–0.014 (–0.018, –0.010)
Birth weight (g)			
>90th	–14 (–15, –13)	–15 (–17, –13)	–15 (–17, –13)
80th–90th	–11 (–12, –10)	–11 (–12, –9)	–11 (–12, –9)
10th–20th	2 (1,3)	–2 (–3, 0)	–2 (–3, 0)
<10th	–1 (–2, 0)	–6 (–8, –4)	–6 (–8, –4)

Note: Difference in birth weight was standardized to the difference in absolute birth weight (in grams) in infants at 40 completed weeks of gestation. The difference in birth weight for temperature percentiles were relative to temperatures ranging from the 40th to 50th percentile of each county temperature distribution. CI, confidence interval; $PM_{2.5}$, particulate matter with aerodynamic diameter less than 2.5 μm.

[a]Unadjusted model included only the indicator variable of temperature deciles.

[b]Main model included parity, maternal age, race, marital status, years of education, smoking or drinking during pregnancy, chronic hypertension, and year and month of conception.

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Summary

- Days of extreme heat (but not extreme cold) are associated with higher risk of preterm birth
- Pregnancies during warmer periods are associated with higher risk of being born small for gestational age and lower birth weight
- Pregnancies during colder periods may be associated with slightly lower birthweights

Limitations and Strengths

- Limitations
  - Data limited to more populous counties and only through 2002
  - Lacking fine spatial resolution
  - No information on personal exposures or time-activity patterns
  - Date of birth is imputed from date of LMP and gestational age
- Strengths
  - Very large sample size with information on key individual risk factors
  - Geographic representation across the contiguous US

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