CHILD HEALTH TASK FORCE

Adapting Health Systems to Protect Children from the Impact of Climate Change

A discussion series

Monday, February 13

Photo: MCSP, 2018, Anjiro, Madagascar

Adapting Health Systems to Protect Children from the Impact of Climate Change

Re-imagining the Package of Care for Children Subgroup
February 13, 2022

Co-Chairs:
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Series Objectives

- Raise awareness of the child health-specific health and climate change intersections
- Build capacity of Task Force members to inform climate adaptations to health plans and programs through sharing programmatic learnings
- Build consensus on ways forward and monitoring

Series Overview

Session 3: The Impact of Climate Change on Newborn Health Outcomes: A Focus on Congenital Heart Defects (February13, 2022)

- February 7-14 marks the annual Congenital Heart Disease Awareness Week
- Review extreme heat and its contributions to congenital heart disease (CHD)

Previous sessions:

Session 1: Framed the series (November 10, 2022)

- Shared an overview of the Healthy Environments for Healthy Children (HEHC) Framework
- Shared highlights from UNICEF heatwaves report
- Reviewed effects on health effects of heatwaves/heat stress on children
- Presented an example an intervention addressing health

Session 2: Children's Climate Risk Index (CCRI) (December 13, 2022)

- Review HEHC
- Provide an overview of the CCRI methodology and its potential application

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Healthy Environments for Healthy Children

Swathi Manchikanti I Climate Adaptation for Health Lead, Healthy Environments for Healthy Children UNICEF HQ, New York

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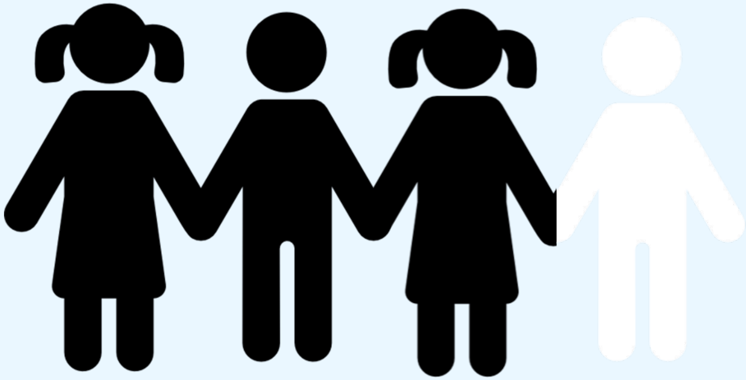
Child survival, health and well-being is under threat

Over 1 in 4 children under the age of 5 are dying from environmental risks

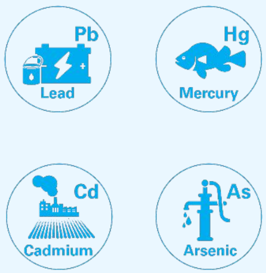


Healthy Environments for Healthy Children

Focusing on adapting primary healthcare response to five categories of environmental hazards

Climate Change

Toxic Metals



Toxic Chemicals

- Highly hazardous pesticides
- Benzene
- Excess Fluoride
- Additional chemicals in consumer products
- Dioxins and dioxin-like substances (incl. PCBs)

Hazardous Waste

- Landfills and household waste
- E-waste
- Medical waste
- Conflict related contamination

Environmental Risks

- Air Pollution
- Mould and mycotoxins
- Noise
- Radiation

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Healthy Environments for Healthy Children Framework

1	Pollution and health
2	**Climate adaptation for health**
3	Climate-resilient and environmentally sustainable healthcare facilities

- Strengthen climate-resilience and environmental sustainability in healthcare facilities
- **Develop responsive primary health care**
- Embed environmental health in school programmes
- Promote climate and environmental action with children, adolescents and young people
- Mobilize collective action

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Presenters:

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School of Public Health, University at Albany
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Dr. Shabnam Peyvandi
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Chief Specialist Scientist
Environment and Health Research Unit
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Extreme Ambient Heat Exposure and Congenital Heart Diseases

Shao Lin, MD, MPH, PhD, Wangjian Zhang, MD, PhD

Professor, Department of Environmental Health Sciences, School of Public Health, University at Albany, State University of New York, US

Co-authors: Ziqiang Lin, Yanqiu Ou, Aida Soim, Srishti Shrestha, Yi Lu, Scott Sheridan, Thomas J. Luben, Edward Fitzgerald, Erin Bell, Gary M. Shaw, Jennita Reefhuis, Peter H. Langlois, Paul Romitti, Marcia L. Feldkamp, Sadia Malik, Cristian Pantea, Seema Nayak, Syni-An Hwang, Marilyn Browne, the National Birth Defects Prevention Study (NIH ES021359 and CDC U01EH000396)

Maternal Ambient Heat Exposure during Early Pregnancy in Summer and Spring and Congenital Heart Defects – a Large US Population-based, Case-Control Study

Lin S, Lin Z*, Ou Y*, Soim A*, Shrestha S, Lu Y*, Sheridan S, Luben TJ, Fitzgerald E, Bell E, Shaw GM, Reefhuis J, Langlois PH, Romitti P, Feldkamp ML, Malik S, Pantea C, Nayak S, Hwang SA, Browne M, and the National Birth Defects Prevention Study (2018). Maternal Ambient Heat Exposure during Early Pregnancy in Summer and Spring and Congenital Heart Defects – a Large US Population-based, Case-Control Study. Environ Int. 118:211-221.

Association between Extreme Heat Events (EHE) in Summer and Spring during Pregnancy (Weeks 3-8) and CHD Phenotypes, National Birth Defects Prevention Study 1997-2007

	Adjusted ORs* for **EHE95 Summer**			Adjusted ORs* for **EHE95 Spring**		
	Having EHE95† or not	EHE95 frequency‡	EHE95 duration§	Having EHE95† or not	EHE95 frequency‡	EHE95 duration§
All CHD defects	1.09(0.93,1.29)	1.06(0.93,1.21)	1.02(0.96,1.08)	1.08(0.88,1.32)	1.03(0.86,1.24)	1.03(0.95,1.11)
Conotruncal defects	1.03(0.76,1.40)	0.96(0.76,1.22)	0.99(0.89,1.11)	1.39(0.46,4.23)	1.16(0.31,4.16)	1.12(1.14,8.94)
South (AR,TX)	0.74(0.44,1.23)	0.93(0.60,1.44)	0.87(0.72,1.06)	**1.78(1.10,2.90)**	**1.72(1.10,2.69)**	**1.23(1.00,1.51)**
Southeast(NC,GA)	1.14(0.72,1.80)	1.01(0.73,1.40)	1.03(0.86,1.22)	0.71(0.41,1.24)	0.74(0.46,1.19)	0.90(072,1.11)
Northeast(NY)	1.39(0.75,2.59)	1.11(0.70,1.75)	1.14(0.91,1.43)	1.51(0.79,2.89)	1.10(0.66,1.84)	1.12(0.89,1.41)
Southwest(UT)	0.60(0.26,1.40)	0.53(0.28,1.00)	0.87(0.64,1.17)	1.97(0.74,5.22)	1.11(0.55,2.25)	**1.34(1.00,1.81)**
West(CA)	1.14(0.64,2.02)	0.92(0.58,1.47)	0.99(0.83,1.17)	1.27(0.76,2.12)	1.12(0.73,1.71)	1.08(0.90,1.29)
Midwest (IA)	1.38(0.72,2.66)	1.36(0.7,2.34)	1.08(0.84,1.40)	1.33(0.65,2.72)	1.25(0.67,2.34)	1.08(0.79,1.48)
Left outflow tract defects	1.02(0.73,1.44)	1.00(0.76,1.32)	1.01(0.89,1.14)	0.84(2.91,2.41)	0.91(0.27,3.07)	0.97(0.14,6.91)
South (AR,TX)	0.89(0.52,1.51)	0.89(0.55,1.43)	0.95(0.78,1.15)	1.34(0.77,2.34)	1.39(0.84,2.31)	1.09(0.86,1.39)
Southeast(NC,GA)	1.08(0.59,1.97)	0.95(0.60,1.49)	1.01(0.80,1.27)	0.65(0.32,1.35)	0.62(0.32,1.20)	0.81(0.60,1.10)
Northeast(NY)	1.02(0.49,2.13)	1.24(0.74,2.0)	1.13(0.86,1.49)	0.42(0.15,1.22)	0.64(0.28,1.46)	0.83(0.57,1.20)
Southwest(UT)	2.00(0.96,4.19)	**1.53(1.00,2.35)**	1.24(0.98,1.58)	1.28(0.71,2.30)	1.16(0.75,1.79)	1.09(0.90,1.33)
West(CA)	0.80(0.41,1.58)	0.80(0.45,1.42)	0.89(0.72,1.10)	1.15(0.65,2.06)	1.12(0.70,1.79)	0.97(0.78,1.20)
Midwest (IA)	0.89(0.47,1.67)	0.79(0.44,1.40)	0.95(0.74,1.22)	1.36(0.73,2.53)	1.18(0.68,2.07)	1.15(0.88,1.49)
Right outflow tract defects	0.92(0.63,1.36)	0.94(0.70,1.25)	0.98(0.85,1.12)	1.11(0.45,2.77)	1.08(0.35,3.31)	1.02(0.16,6.65)
South (AR,TX)	0.83(0.49,1.40)	0.90(0.57,1.44)	0.96(0.79,1.16)	1.27(0.72,2.27)	1.43(0.87,2.35)	1.08(0.85,1.38)
Southeast(NC,GA)	0.87(0.48,1.55)	0.82(0.52,1.27)	0.92(0.73,1.16)	0.69(0.33,1.45)	0.78(0.42,1.45)	0.88(0.66,1.18)
Northeast(NY)	1.06(0.48,2.31)	0.93(0.52,1.70)	1.06(0.79,1.43)	1.20(0.46,3.11)	1.03(0.49,2.17)	1.12(0.80,1.57)
Southwest(UT)	0.60(0.27,1.37)	0.84(0.48,1.47)	0.87(0.65,1.16)	1.29(0.58,2.88)	1.11(0.61,2.02)	1.10(0.85,1.42)
West(CA)	1.89(0.71,5.07)	1.41(0.70,2.86)	1.15(0.87,1.50)	1.62(0.71,3.67)	1.44(0.76,2.73)	1.11(0.84,1.48)
Midwest (IA)	0.88(0.43,1.80)	0.95(0.51,1.77)	0.94(0.71,1.23)	0.79(0.37,1.69)	0.93(0.48,1.81)	0.89(0.64,1.25)
Septal defects	1.08(0.80,1.44)	1.06(0.81,1.37)	1.00(0.90,1.12)	0.95(0.26,3.48)	0.90(0.21,3.80)	0.98(0.10,9.42)
South (AR,TX)	1.03(0.75,1.41)	1.05(0.79,1.38)	1.00(0.89,1.12)	1.08(0.77,1.51)	1.11(0.82,1.52)	1.03(0.90,1.19)
Southeast(NC,GA)	1.13(0.76,1.69)	1.04(0.78,1.39)	1.02(0.87,1.20)	0.79(0.51,1.23)	0.77(0.52,1.14)	0.90(0.76,1.08)
Northeast(NY)	0.67(0.36,1.24)	0.69(0.43,1.13)	0.78(0.60,1.01)	1.72(0.89,3.34)	1.34(0.81,2.21)	**1.30(1.05,1.62)**
Southwest(UT)	1.07(0.50,2.28)	0.97(0.60,1.59)	1.09(0.84,1.41)	0.72(0.40,1.29)	0.72(0.45,1.16)	0.93(0.77,1.13)
West(CA)	1.37(0.71,2.66)	1.01(0.60,1.71)	1.05(0.86,1.27)	0.92(0.51,1.65)	0.85(0.51,1.40)	0.92(0.74,1.15)
Midwest (IA)	1.35(0.77,2.39)	**1.71(1.09,2.69)**	1.09(0.88,1.36)	0.72(0.40,1.30)	0.78(0.46,1.34)	0.85(0.65,1.11)

*Adjusted for age, race, education, dew point and all numbers in bold indicated statistically significant with $P < 0.05$

†EHE95: at least two consecutive days with daily Tmax above 95th percentile of the Tmax distribution for the season and the year

‡EHE95 Frequency: number of EHE95.

§EHE95 Duration: longest consecutive days of EHE95.

Adjusted Odds Ratio* between Extreme Heat Events in Summer and Spring during Pregnancy Critical Period (Weeks 3-8) and Ventricular Septal Defects and Atrial Septal Defects, National Birth Defects Prevention Study, 1997-2007

	Adjusted ORs* for **EHE95 Summer**			Adjusted ORs* for **EHE95 Spring**		
	Having EHE95† or not	EHE95 frequency‡	EHE95 duration§	Having EHE95† or not	EHE95 frequency‡	EHE95 duration§
Ventricular septal defects	1.18(0.81,1.72)	1.14(0.83,1.57)	1.04(0.90,1.19)	1.06(0.41,2.74)	0.97(0.32,2.93)	1.03(0.15,6.70)
South (AR,TX)	1.38(0.81,2.35)	1.34(0.84,2.12)	1.12(0.94,1.35)	**1.64(1.00,2.71)**	**1.67(1.07,2.62)**	**1.24(1.01,1.52)**
Southeast(NC,GA)	1.30(0.77,2.18)	1.12(0.78,1.60)	1.05(0.86,1.29)	0.76(0.41,1.39)	0.75(0.44,1.27)	0.91(0.71,1.16)
Northeast(NY)	0.78(0.34,1.79)	0.81(0.42,1.55)	0.80(0.56,1.14)	**2.28(1.00,5.21)**	1.58(0.86,2.88)	**1.44(1.11,1.88)**
Southwest(UT)	1.27(0.38,4.23)	1.07(0.50,2.26)	1.13(0.76,1.69)	0.63(0.24,1.64)	0.67(0.30,1.49)	0.92(0.67,1.25)
West(CA)	1.01(0.40,2.54)	0.81(0.38,1.74)	1.04(0.79,1.37)	0.91(0.33,2.47)	0.77(0.32,1.86)	0.91(0.63,1.31)
Midwest (IA)	1.19(0.58,2.42)	1.70(0.96,3.00)	1.02(0.77,1.36)	0.98(0.49,1.98)	1.07(0.58,1.99)	0.97(0.71,1.32)
Atrial septal defects	1.32(0.88,1.99)	1.20(0.90,1.62)	1.07(0.93,1.24)	1.15(0.33,4.04)	0.92(0.30,2.90)	1.03(0.16,6.75)
South (AR,TX)	0.97(0.68,1.40)	1.00(0.73,1.38)	0.97(0.85,1.11)	0.87(0.58,1.31)	0.89(0.61,1.30)	0.95(0.80,1.12)
Southeast(NC,GA)	1.19(0.64,2.21)	1.09(0.71,1.68)	1.08(0.86,1.37)	0.83(0.45,1.52)	0.81(0.47,1.38)	0.91(0.71,1.16)
Northeast(NY)	2.79(0.69,11.31)	1.70(0.67,4.30)	1.24(0.79,1.95)	4.15(0.73,23.71)	1.88(0.55,6.47)	**1.87(1.11,3.16)**
Southwest(UT)	0.90(0.36,2.24)	0.84(0.46,1.55)	1.06(0.77,1.45)	0.83(0.42,1.65)	0.80(0.46,1.38)	0.97(0.77,1.21)
West(CA)	1.72(0.69,4.29)	1.16(0.60,2.27)	1.04(0.81,1.34)	0.94(0.47,1.87)	0.89(0.49,1.61)	0.93(0.72,1.21)
Midwest (IA)	1.72(0.73,4.06)	1.84(0.91,3.68)	1.22(0.88,1.70)	0.40(0.14,1.14)	0.41(0.15,1.11)	0.67(0.42,1.08)

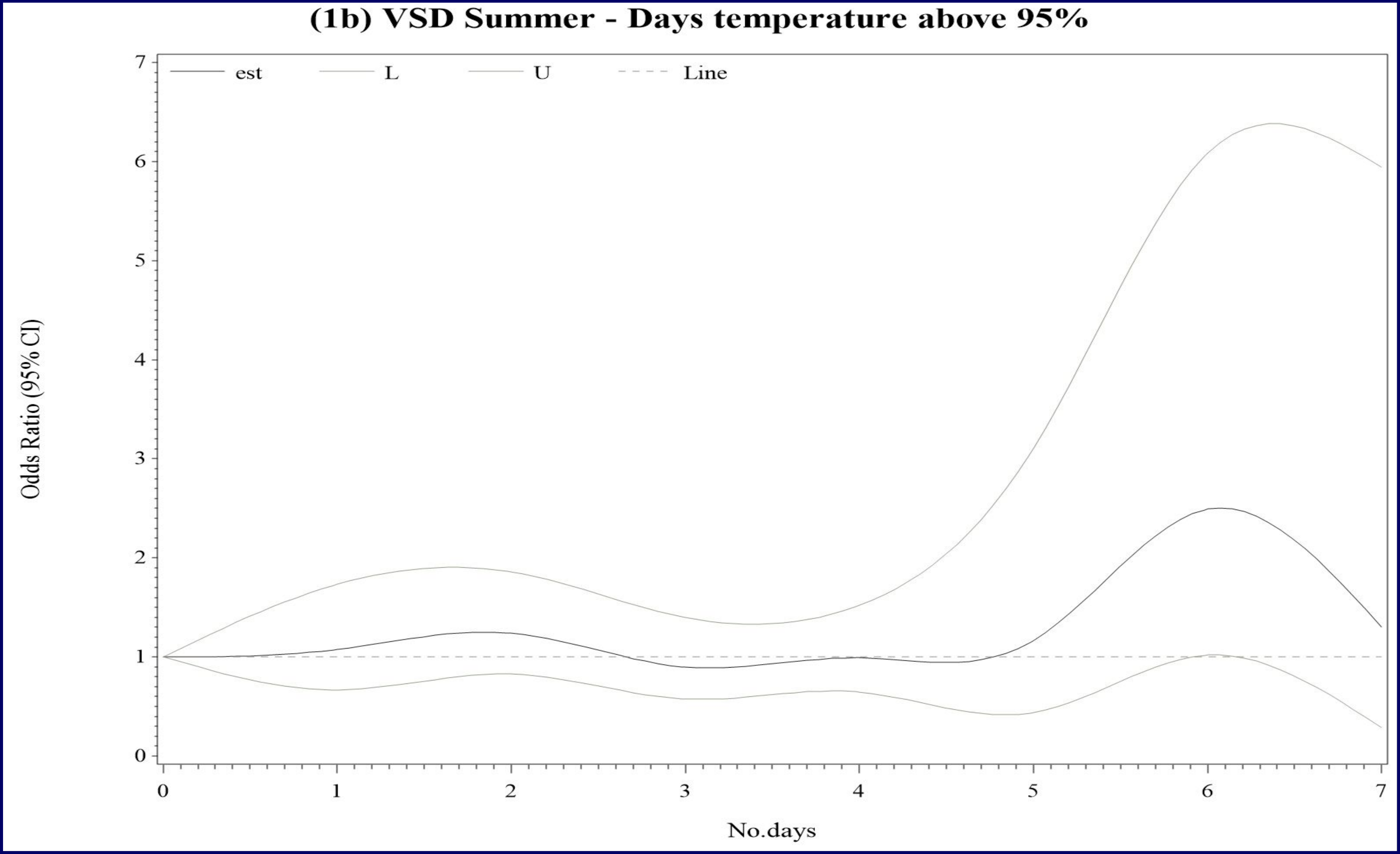
*Adjusted for age, race, education, dewpoint and all numbers in bold indicated statistically significant with $P < 0.05$

†EHE95: at least two consecutive days with daily Tmax above 95th percentile of the Tmax distribution for the season and the year

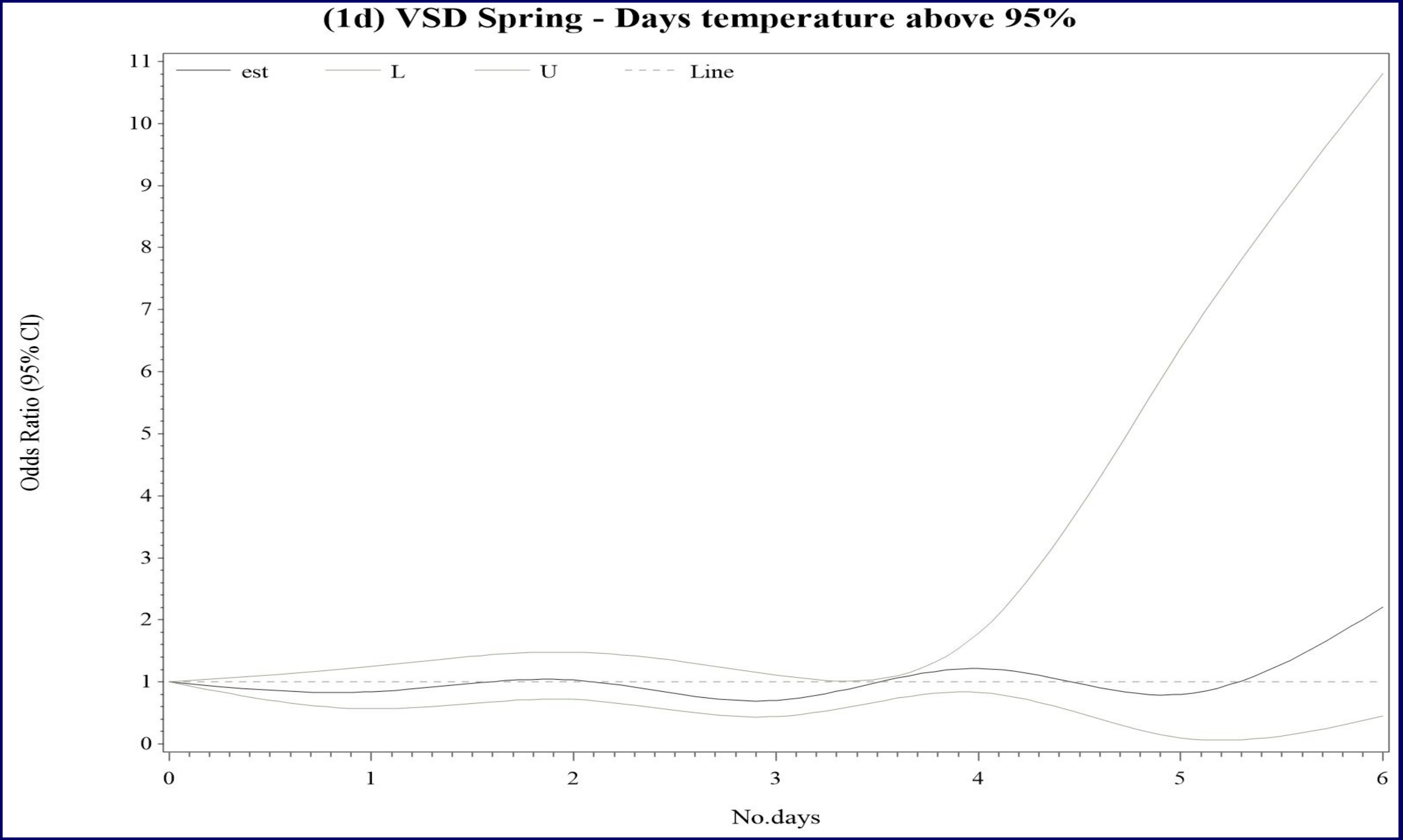
‡EHE95 Frequency: number of EHE95.

§EHE95 Duration: longest consecutive days of EHE95.

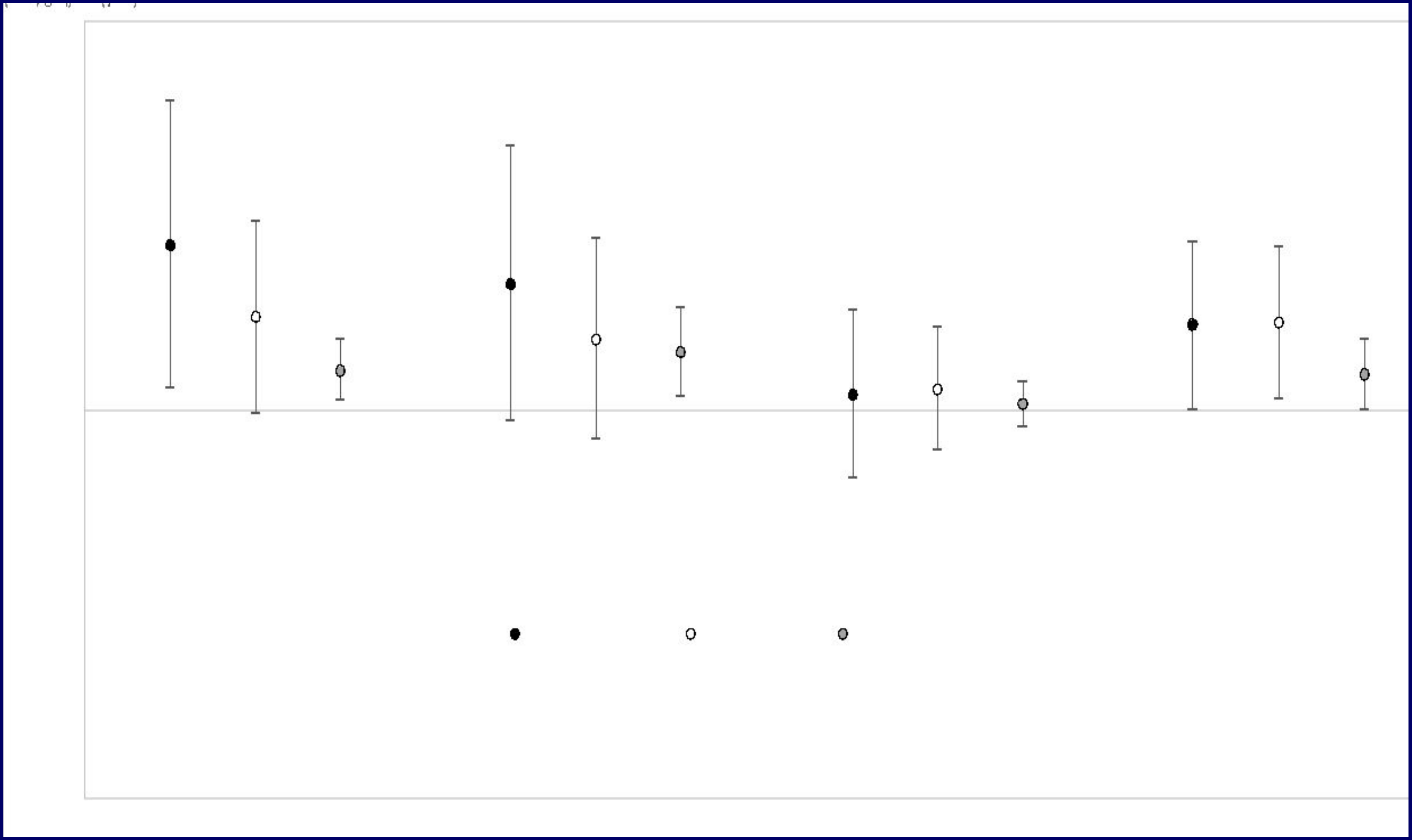
Adjusted Odds Ratio* Estimates of the Association between Total Days of EHE95 during Pregnancy Critical Period (weeks 3-8) in summer (June - August) and Ventricular septal defect, NBDPS 1997-2007. (Number of days with daily Tmax above 95th percentiles, cumulative but not necessarily consecutive, during the 6-week critical period)



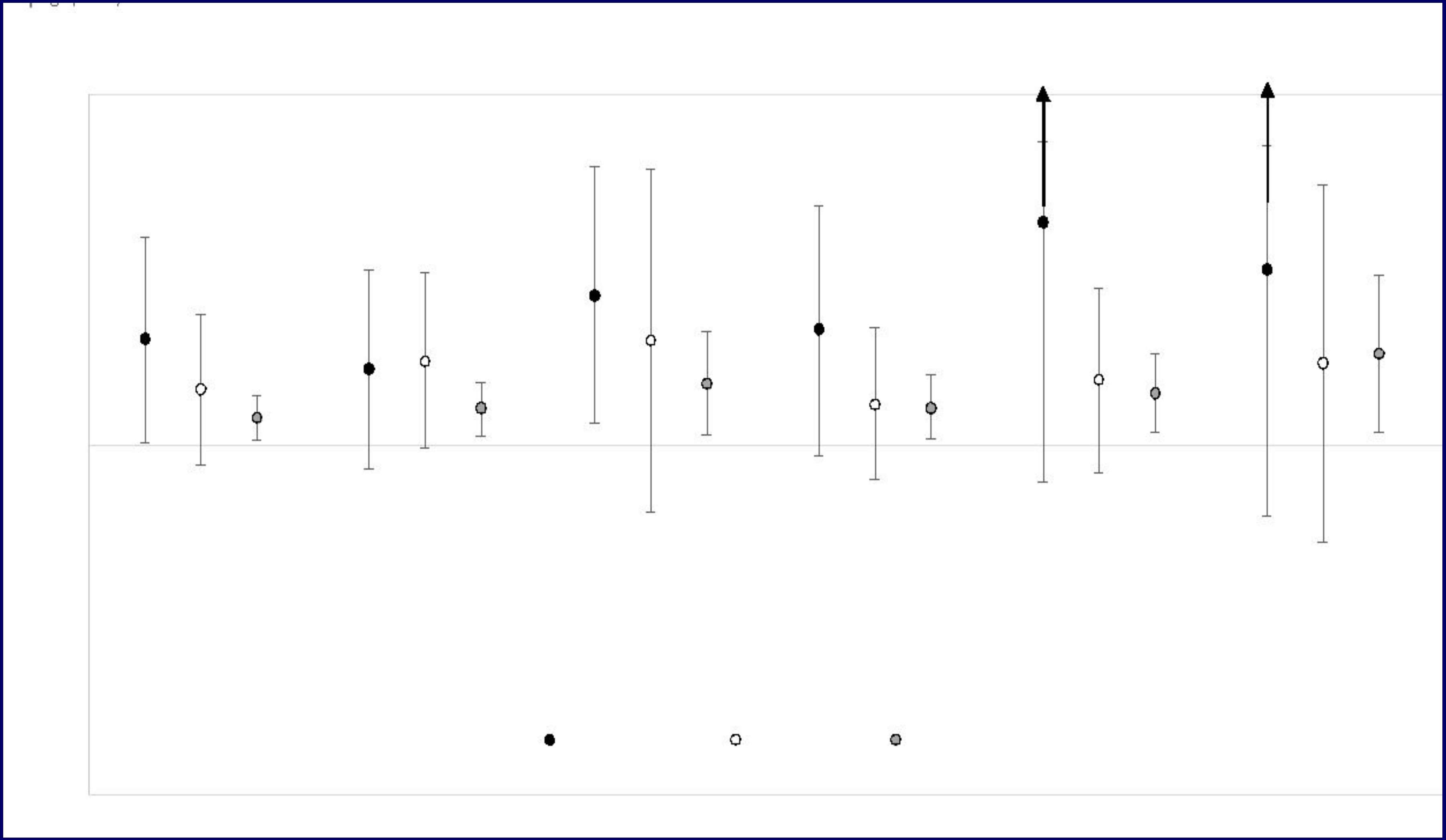
Adjusted Odds Ratio* Estimates of the Association between Total Days of EHE95 during Pregnancy Critical Period (weeks 3-8) in spring (March - May) and Ventricular septal defect, NBDPS 1997-2007 (Number of days with daily Tmax above 95th percentiles (cumulative but not necessarily consecutive) during the 6-week critical period)



Odds ratios and 95% confidence intervals for ventricular septal defects (VSD) and exposure to extreme heat events (EHEs) in the Northeast and South during the spring. (Daily maximum temperature (Tmax) was used to define EHE indicators as: 1) at least two consecutive days with daily Tmax > 95th percentile of the Tmax distribution for the season and the year (EHE95); or 2) at least three consecutive days with daily Tmax >90th percentile of the Tmax distribution for the season and the year (EHE90))



Odds ratios and 95% confidence intervals for septal defects, ventricular septal defects (VSD) and atrial septal defects (ASD) and exposure to extreme heat events (EHEs) in the Northeast during the spring. (Daily maximum temperature (Tmax) was used to define EHE indicators as: 1) at least two consecutive days with daily Tmax > 95th percentile of the Tmax distribution for the season and the year (EHE95); or 2) at least three consecutive days with daily Tmax > 90th percentile of the Tmax distribution for the season and the year (EHE90) **)**



Findings Summary

- We observed no significant relationship between maternal heat exposure and total CHDs in most regions during summer.
- We found that 3-11 days of heat exposure during summer and spring was significantly associated with ventricular septal defects (VSDs) in eight states of US.
- Extreme heat in spring were significantly associated with conotruncal defects and VSDs in the South.
- Most heat indicators in spring were significantly associated with increased septal defects (both VSDs and atrial septal defects (ASDs)) in the Northeast.

Projected Changes in Maternal Heat Exposure During Early Pregnancy and the Associated Congenital Heart Defect Burden in the United States

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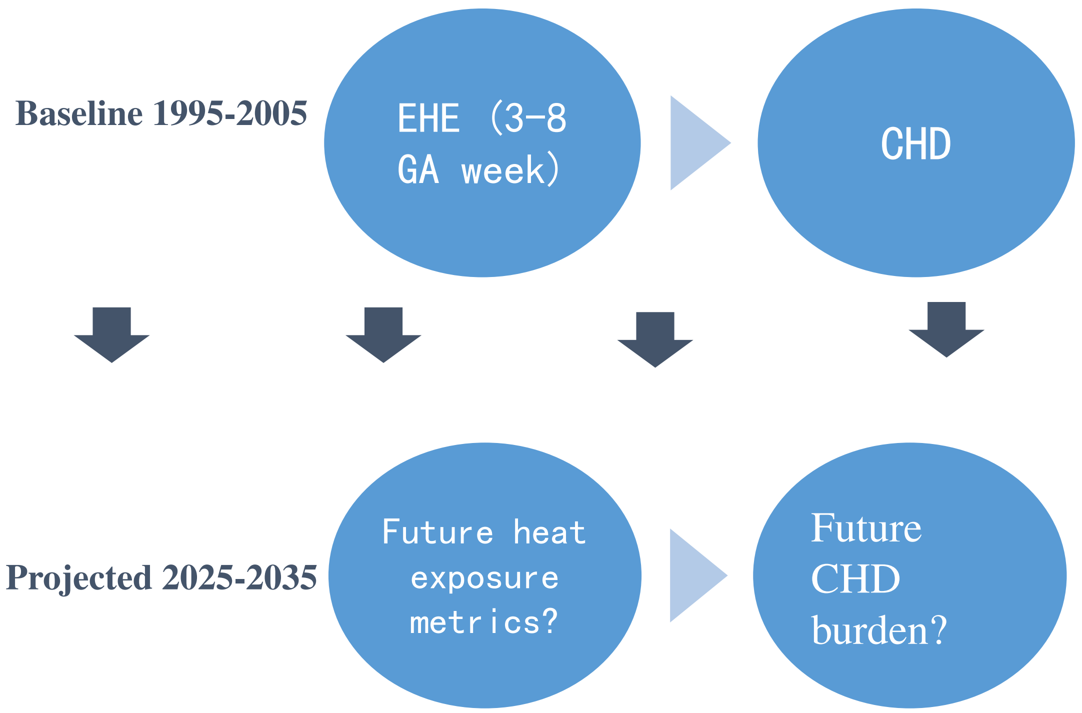
American Heart Association.



Methodology and Procedures

- Obtaining baseline (1995-2005) conditions, such as the odds ratio (OR) of CHDs and populations at risk;
- Simulating the potential changes in ambient temperature and subsequent maternal heat exposure in a future projection period (2025-2035);
- Predicting changes in CHDs burden between two periods.

Strengths of this procedure:

1) Prior work used global model; but ours are dynamic downscaling model which improve the spatial and temporal resolution;
2) Represent the nationwide scenarios in the future;
3) Multiple criterion to define heat exposure which is more comprehensive and check for consistency.

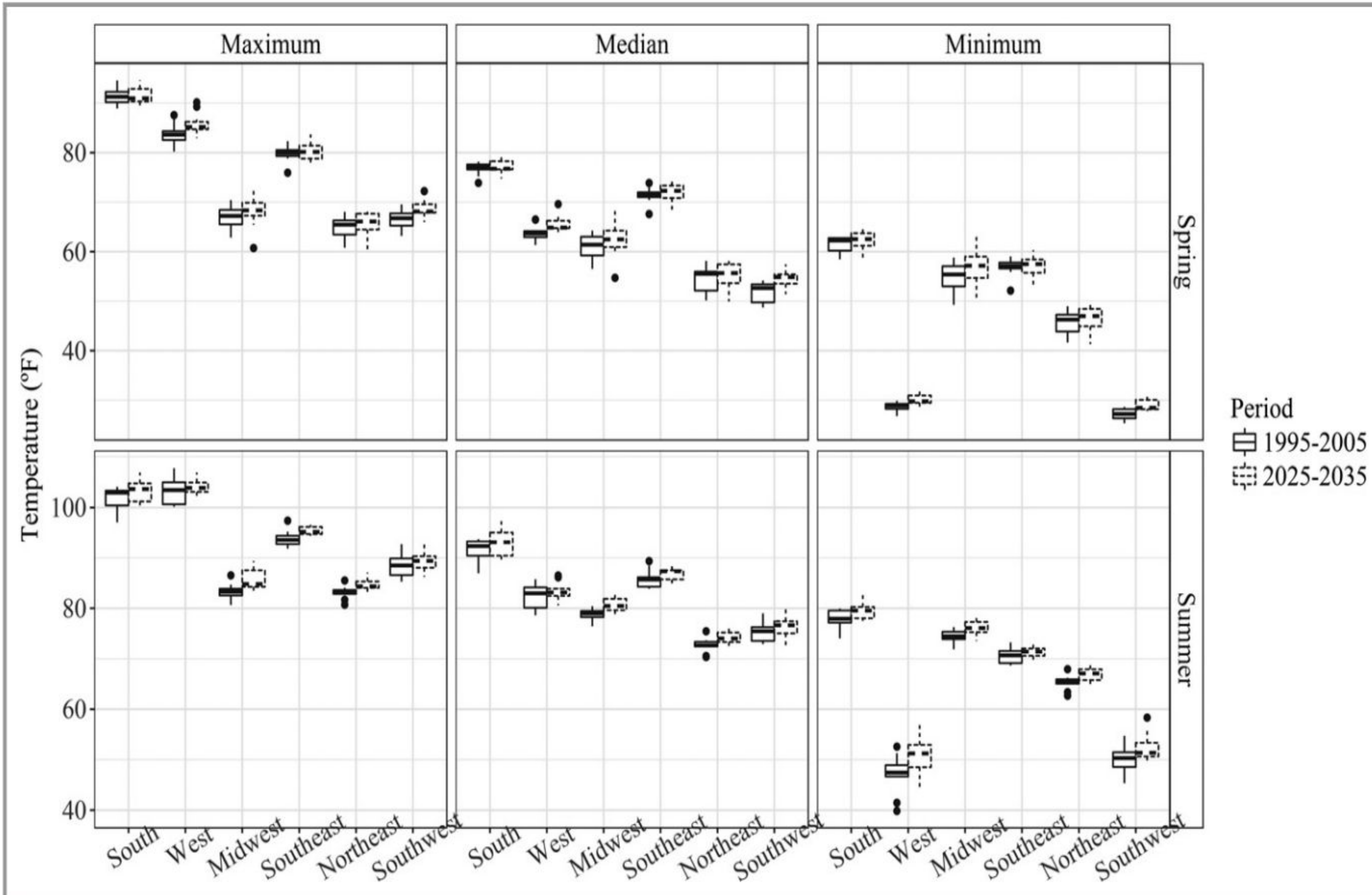


Figure 1. Comparing temperature range (°F) between the baseline (1995–2005) and the projection (2025–2035) periods by season and geographic region.

Table 1. Projected Increase in Maternal Heat Exposure During Early Pregnancy by Different Metrics and Region (2025–2035 Versus 1995–2005) in the United States in Summer (per Pregnancy)

		EHE 90						EHE 95					
		EHD Counts		EHE Frequency		EHE Duration		EHD Counts		EHE Frequency		EHE Duration	
Regions	Maximum Temperature Criterion*	Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI
South (AR/TX)	Maximum	1.08	0.57–1.58	0.19	0.11–0.26	1.05	0.72–1.37	0.71	0.36–1.06	0.06	−0.02–0.14	0.34	0.12–0.57
	Median	2.15	1.57–2.74	0.26	0.17–0.35	1.29	0.88–1.67	1.58	1.19–1.99	0.23	0.15–0.31	1.17	0.88–1.44
	Minimum	2.90	2.38–3.41	0.35	0.26–0.44	1.19	0.94–1.47	1.61	1.28–1.94	0.33	0.25–0.41	0.63	0.44–0.83
West (CA)	Maximum	−0.14	−0.58–0.29	−0.04	−0.12–0.04	0.08	−0.21–0.35	−0.29	−0.62–0.02	−0.16	−0.24–−0.08	−0.17	−0.39–0.02
	Median	−0.10	−0.58–0.32	−0.16	−0.24–−0.08	0.31	0.02–0.58	0.01	−0.29–0.28	−0.17	−0.25–−0.10	0.23	0.01–0.42
	Minimum	1.43	0.94–1.91	0.21	0.13–0.28	1.00	0.67–1.31	1.13	0.77–1.47	0.16	0.08–0.23	0.83	0.58–1.07
Midwest (IA)	Maximum	4.27	3.75–4.80	0.74	0.65–0.83	2.66	2.43–2.93	3.50	3.11–3.93	0.85	0.74–0.96	1.86	1.68–2.05
	Median	3.42	2.99–3.88	0.52	0.44–0.60	1.73	1.49–1.97	2.95	2.59–3.34	0.66	0.56–0.76	1.80	1.63–2.00
	Minimum	2.09	1.68–2.50	0.20	0.12–0.28	0.97	0.74–1.19	1.96	1.64–2.25	0.49	0.40–0.57	1.05	0.91–1.20
Southeast (NC/GA)	Maximum	2.45	1.96–2.95	0.17	0.09–0.24	1.19	0.91–1.50	0.67	0.36–1.00	0.19	0.12–0.26	0.49	0.30–0.68
	Median	1.20	0.73–1.69	0.20	0.12–0.29	0.05	−0.22–0.35	0.46	0.20–0.75	0.22	0.14–0.31	0.13	−0.01–0.28
	Minimum	0.84	0.44–1.25	0.05	−0.02–0.11	−0.56	−0.79–−0.34	−0.16	−0.42–0.12	0.10	0.03–0.17	−0.27	−0.45–−0.10
Northeast (NY)	Maximum	2.01	1.62–2.41	0.18	0.10–0.26	0.85	0.66–1.04	1.28	1.00–1.57	0.51	0.43–0.59	0.82	0.69–0.96
	Median	2.66	2.27–3.07	0.43	0.34–0.51	1.21	1.01–1.41	1.76	1.42–2.06	0.56	0.47–0.65	0.80	0.65–0.96
	Minimum	2.29	1.93–2.69	0.67	0.58–0.75	1.32	1.17–1.50	0.86	0.62–1.11	0.06	−0.02–0.15	0.24	0.11–0.36
Southwest (UT)	Maximum	0.86	0.35–1.36	0.21	0.12–0.30	0.30	−0.02–0.59	0.19	−0.16–0.52	0.03	−0.06–0.11	−0.03	−0.28–0.19
	Median	2.06	1.57–2.55	0.18	0.10–0.25	0.97	0.64–1.30	1.29	0.92–1.63	0.36	0.27–0.45	0.29	0.06–0.49
	Minimum	1.76	1.26–2.24	0.20	0.12–0.28	0.62	0.27–0.96	1.44	1.08–1.77	0.31	0.23–0.40	0.77	0.54–0.99

EHD indicates excessively hot day; EHE, extreme heat event.

*Maximum, median, or minimum grid-cell daily maximum temperature $T_{max\text{-}cell}$ was used to represent the regional daily maximum temperature, $T_{max\text{-}region}$.

Table 2. Projected Increase in Maternal Heat Exposure During Early Pregnancy by Different Metrics and Region (2025–2035 Versus 1995–2005) in the United States in Spring (per Pregnancy)

Regions	Maximum Temperature Criterion*	EHE 90						EHE 95					
		EHD Counts		EHE Frequency		EHE Duration		EHD Counts		EHE Frequency		EHE Duration	
		Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI	Increase	95% CI
South (AR/TX)	Maximum	1.35	0.85–1.85	0.14	0.06–0.21	1.37	1.08–1.66	1.12	0.79–1.48	0.21	0.12–0.30	0.60	0.41–0.78
	Median	1.96	1.48–2.45	0.25	0.18–0.33	1.26	0.95–1.59	1.90	1.56–2.27	0.24	0.18–0.32	1.18	0.94–1.43
	Minimum	1.21	0.79–1.61	0.07	0.00–0.14	0.62	0.41–0.84	0.80	0.55–1.07	0.11	0.05–0.17	0.37	0.20–0.55
West (CA)	Maximum	0.62	0.19–1.05	−0.03	−0.11–0.04	0.46	0.17–0.73	0.47	0.14–0.80	0.10	0.03–0.17	0.27	0.05–0.49
	Median	0.63	0.18–1.06	0.05	−0.04–0.13	0.27	0.01–0.51	0.15	−0.11–0.42	−0.01	−0.07–0.06	0.25	0.05–0.44
	Minimum	1.82	1.38–2.24	0.30	0.23–0.37	0.96	0.68–1.24	0.54	0.25–0.82	0.03	−0.03–0.09	0.28	0.08–0.48
Midwest (IA)	Maximum	1.53	1.06–1.98	0.28	0.19–0.37	1.14	0.92–1.34	1.41	1.10–1.72	0.38	0.28–0.47	0.83	0.65–0.98
	Median	0.95	0.48–1.36	0.26	0.18–0.33	0.49	0.25–0.71	1.30	0.95–1.61	0.24	0.15–0.33	0.79	0.61–0.95
	Minimum	1.27	0.78–1.68	0.17	0.09–0.24	0.34	0.09–0.57	1.09	0.78–1.37	0.10	0.01–0.18	0.68	0.51–0.85
Southeast (NC/GA)	Maximum	1.18	0.69–1.66	0.15	0.08–0.23	0.51	0.21–0.80	0.60	0.31–0.88	0.17	0.11–0.24	0.30	0.12–0.48
	Median	0.84	0.41–1.27	0.12	0.05–0.18	0.57	0.32–0.84	0.32	0.08–0.56	0.19	0.12–0.26	0.09	−0.04–0.22
	Minimum	0.57	0.23–0.93	0.08	0.03–0.13	0.13	−0.07–0.32	0.24	0.02–0.45	0.24	0.18–0.31	0.21	0.07–0.34
Northeast (NY)	Maximum	1.41	0.99–1.80	0.14	0.06–0.20	0.91	0.71–1.11	0.82	0.56–1.07	0.24	0.16–0.32	0.49	0.34–0.62
	Median	1.29	0.87–1.67	0.10	0.02–0.18	0.43	0.23–0.62	0.74	0.48–0.99	0.18	0.09–0.25	0.44	0.30–0.58
	Minimum	0.51	0.12–0.88	0.06	−0.01–0.12	0.28	0.09–0.46	0.01	−0.20–0.23	−0.12	−0.19–−0.05	−0.05	−0.18–0.07
Southwest (UT)	Maximum	1.37	0.88–1.83	0.33	0.25–0.42	0.46	0.17–0.75	0.41	0.09–0.71	0.10	0.02–0.17	−0.06	−0.28–0.15
	Median	2.18	1.68–2.67	0.27	0.20–0.34	1.07	0.75–1.37	1.16	0.82–1.46	0.40	0.32–0.48	0.24	0.02–0.44
	Minimum	2.46	1.92–2.93	0.35	0.27–0.42	1.07	0.73–1.39	1.53	1.20–1.84	0.42	0.34–0.49	0.76	0.53–0.97

EHD indicates excessively hot day; EHE, extreme heat event.

*Maximum, median, or minimum grid-cell daily maximum temperature $T_{max\text{-}cell}$ was used to represent the regional daily maximum temperature, $T_{max\text{-}region}$.

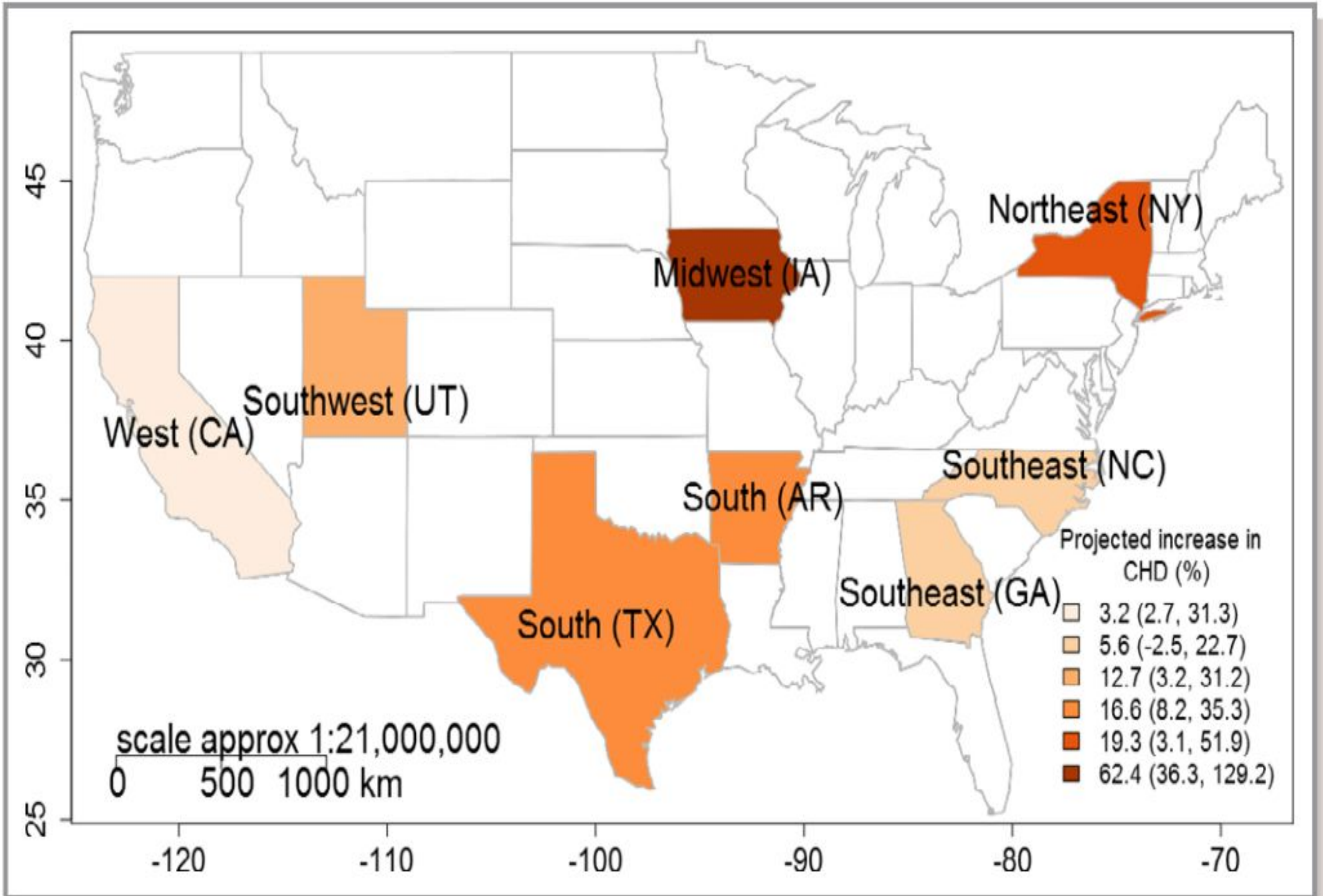
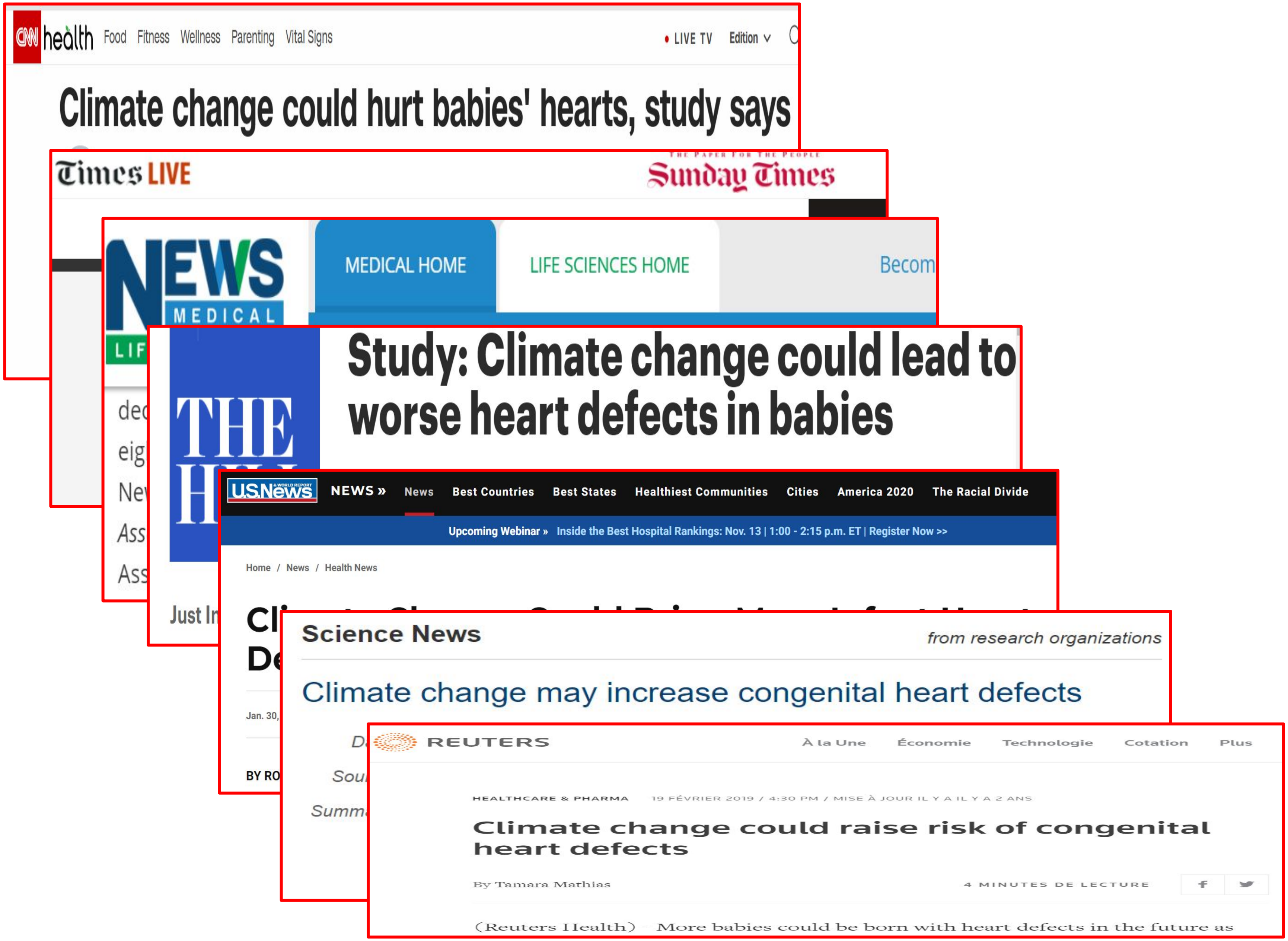


Figure 3. Projected increase in congenital heart defect cases (%) over the projection (2025–2035) period.

Summary of our findings

- This study suggest that all temperature indicators (maximum, median, and minimum temperature) may increase in eight representative states (Arkansas, Texas, California, Iowa, North Caroline, Georgia, New York and Utah) over the next two decades
- It may result in as many as 7,000 additional CHD cases over an 11 year-period in these eight states
- We projected that climate change could impose a greater impact on pregnant women in the South, Northeast, and Midwest regions.
- We projected higher increases in CHD burden for spring and for certain CHD subtypes (conotruncal and septal defects) compared with summer and other CHD subtypes.

Media coverage by > 50 outlets



Implication

1. Pregnant mothers should be cautious of the dangers of extreme heat exposure on their fetus, and reduce outdoor exercise/activities and stay cool during hot weather.
2. Obstetrician and physicians may provide advice on their patients during hot summer and spring days.
3. Pregnant women may be more susceptible to the adverse effects of early heatwave or extreme heat in spring.
4. The increase in more frequent and longer duration of extreme heat events due to climate change would increase the demand for public health agencies on medical preparedness and early warning in the spring.

After every storm, the sun will smile

Contact: slin@albany.edu for any questions

Community Vulnerability Index to hurricanes

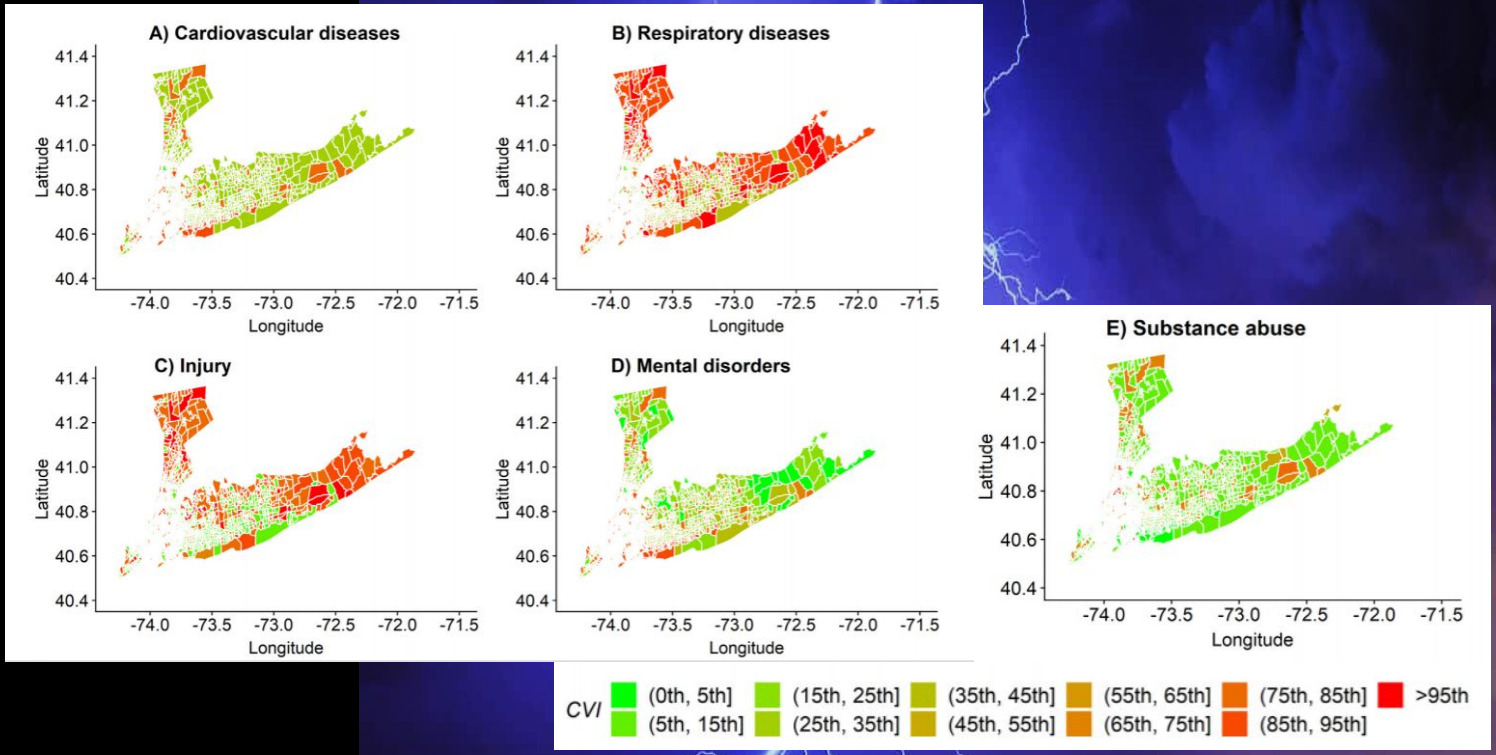


Table 3. Projected Increase in Congenital Heart Defect Burden in United States by Region, Season, and Heat Definition Based on the Previous Positive Findings (2025–2035 Versus 1995–2005)*

Region	Exposure	Criteria	CHD: OR (95% CI)	Projected Increase in Cases (%)		Baseline Cases for the Season†	Projected Increase in Cases (Total N)‡
				Increase	95% CI		
South (AR/TX)	Spring EHE95 frequency	Maximum	Total: 1.32 (95% CI, 1.04–1.67)	11.1	5.8–16.6	21 263	2363 (23 626)
		Median		12.3	5.9–18.9		2607 (23 870)
		Minimum		8.2	5.4–11.0		1739 (23 002)
		Maximum	Conotruncal: 1.72 (1.10–2.69)	17.4	7.0–28.7	1525	265 (1790)
		Median		19.7	7.4–33.5		301 (1826)
		Minimum		11.4	6.0–17.0		174 (1699)
		Maximum	VSD: 1.67 (1.07–2.62)	16.6	6.4–28.0	8334	1387 (9721)
		Median		18.9	6.7–32.6		1573 (9907)
		Minimum		11.0	5.7–16.7		918 (9252)
	Spring EHE95 duration	Maximum	Conotruncal: 1.23 (1.00–1.51)	18.7	4.9–34.1	1525	285 (1810)
		Median		34.0	4.9–70.8		519 (2044)
		Minimum		13.2	4.9–22.1		202 (1727)
		Maximum	VSD: 1.24 (1.01–1.52)	19.3	5.5–34.6	8334	1605 (9939)
		Median		35.3	6.2–72.1		2942 (11 276)
		Minimum		13.6	5.3–22.4		1130 (9464)
West (CA)	Summer EHD90 counts	Maximum	RVOTO: 1.17 (1.00–1.37)	2.7	0.5–4.9	95	3 (98)
		Median		3.2	1.5–4.9		3 (98)
		Minimum		31.3	4.9–64.4		30 (125)
Midwest (IA)	Summer EHD95 counts	Maximum	Septal: 1.25 (1.04–1.51)	129.2	20.4–344.2	1194	1543 (2737)
		Median		102.7	17.8–254.1		1227 (2421)
		Minimum		62.4	13.3–135.0		745 (1939)
	Summer EHE95 frequency	Maximum	Septal: 1.71 (1.09–2.69)	65.2	12.9–142.4	1194	779 (1973)
		Median		49.4	11.1–101.4		590 (1784)
		Minimum		36.3	9.4–70.0		433 (1627)

Table 3. Continued

Southeast (NC/GA)	Summer EHE90 duration	Maximum	VSD: 1.14 (1.01–1.29)	22.7	6.2–42.1	3071	696 (3767)
		Median		5.6	5.0–6.3		173 (3244)
		Minimum		−2.5	−9.0–4.3		−77 (2994)
Northeast (NY)	Spring EHD90 counts	Maximum	Septal: 1.18 (1.05–1.34)	32.5	12.4–58.5	7532	2447 (9979)
		Median		29.8	11.7–52.9		2245 (9777)
		Minimum		14.2	7.6–22.0		1073 (8605)
	Spring EHE90 duration	Maximum	ASD: 1.50 (1.07–2.11)	51.9	11.6–107.4	3801	1973 (5774)
		Median		24.9	8.0–44.7		948 (4749)
		Minimum		17.5	6.9–29.2		663 (4464)
		Maximum	Septal: 1.20 (1.03–1.39)	23.9	7.8–41.7	7532	1802 (9334)
		Median		13.5	6.3–20.9		1016 (8548)
		Minimum		10.4	5.8–15.0		782 (8314)
		Maximum	VSD: 1.27 (1.06–1.52)	30.5	10.7–53.8	3732	1138 (4870)
		Median		16.3	7.6–25.7		608 (4340)
		Minimum		12.1	6.6–17.9		453 (4185)
	Spring EHD95 counts	Maximum	Septal: 1.39 (1.13–1.72)	37.3	16.0–63.5	7532	2812 (10 344)
		Median		33.9	14.9–56.8		2555 (10 087)
		Minimum		5.4	5.1–5.7		405 (7937)
	Spring EHE95 duration	Maximum	ASD: 1.87 (1.11–3.16)	42.5	10.4–84.1	3801	1614 (5415)
		Median		38.6	9.9–75.1		1468 (5269)
		Minimum		1.8	−0.7–4.4		70 (3871)
		Maximum	Septal: 1.30 (1.05–1.62)	19.3	7.5–32.8	7532	1452 (8984)
		Median		17.9	7.2–30.1		1350 (8882)
		Minimum		3.6	4.7–2.5		272 (7804)
		Maximum	VSD: 1.44 (1.11–1.88)	25.4	10.4–42.8	3732	948 (4680)
		Median		23.4	9.9–39.0		874 (4606)
		Minimum		3.1	1.8–4.4		116 (3848)
Southwest (UT)	Spring EHE95 duration	Maximum	Conotruncal: 1.34 (1.00–1.81)	3.2	1.4–4.9	180	6 (186)
		Median		12.7	4.9–21.3		23 (203)
		Minimum		31.2	4.9–65.1		56 (236)
	Summer EHE95 frequency	Maximum	LVOTO: 1.53 (1–2.35)	6.2	4.9–7.5	293	18 (311)
		Median		22.4	4.9–42.9		66 (359)
		Minimum		19.9	4.9–37.3		58 (351)

Evidence from Prior Studies

- Agay-Shay et al. in Israel (2013) and our prior study (Van Zutphen et al., 2012) in NYS found no significant associations between high ambient temperature and total isolated CHDs during summer season, which is consistent with our findings.
- Ager et al. (2017) in Quebec, Canada found that fetuses that were exposed to 15 days of temperature≥30 °C between 2-8 weeks post-conception had 1.06 times the risk of critical CHD defects compared to 0 days for heat exposure (consistent with our results)
- Evidence suggest that both the magnitude and duration of high temperature exposure play important roles in the positive associations between heat exposure and VSD.
- Our prior research found that extreme heat exposure is associated with term low birthweight (trimester 1 exposure, higher in Hispanic) and pregnancy complications (threaten labor, early delivery, diabetes)

Potential Biological Mechanism

- Prior experimental studies suggested that extremely high temperatures could directly cause fetal cell death, leading to placental insufficiency.
- Exposure to extreme heat may trigger a heat-shock response that blocks transcription and translation of normal protein, thus interrupts the normal biochemical/ molecular sequence or causes vascular disruption during the organogenesis period.
- A new animal study by Huston etc. (2017) identified a molecular mechanism for hyperthermia-induced teratogenicity mediated through temperature activated ion channels, TRPV1 and TRPV4, in neural crest cells during critical windows of fetal development.

Climate Change Webinar: Environmental and social contributions to congenital heart disease

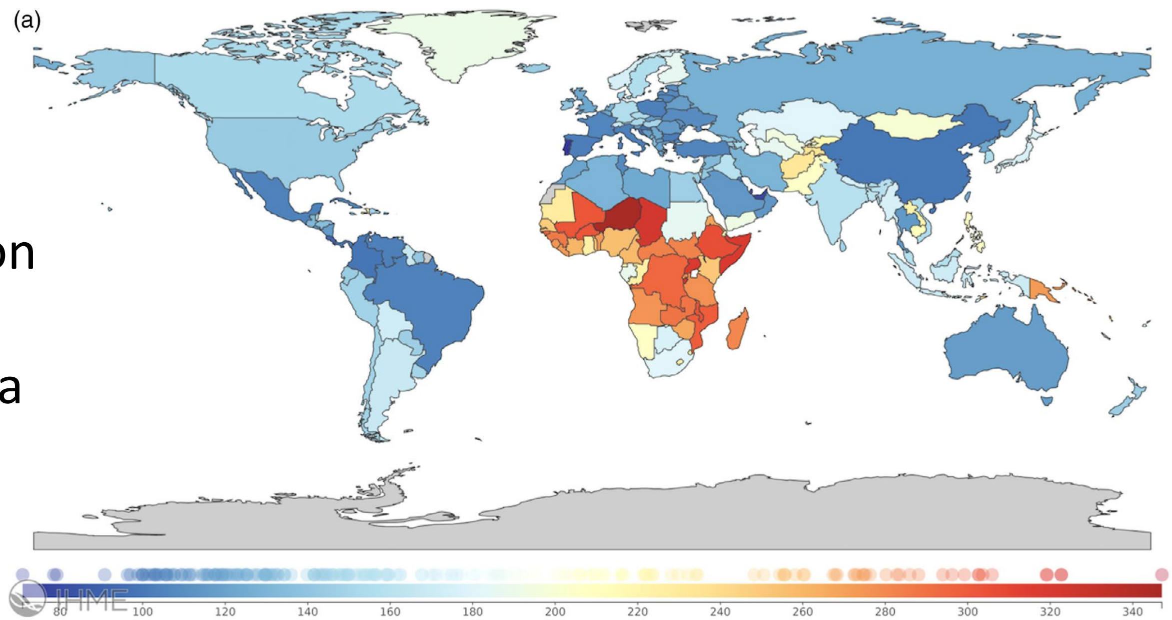
Shabnam Peyvandi, MD MAS
Associate Professor of Pediatrics, Epidemiology & Biostatistics
Associate Director, Fetal Cardiovascular Program

UCSF Benioff Children's Hospital
San Francisco

Birth Prevalence of CHD

- 6-8 per 1000 live births
  - Wide geographic variation

- Leading case of death from a congenital anomaly in first year of life



Zimmerman & Sable, AJMG 2020

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Development of Congenital Heart Disease

Heritable/spontaneous genetic cases (20%)

- Environmental causes
- Social Determinants

Gene-environment Interactions

 Vast majority of CHD cases have an unknown etiology

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Journal of the American Heart Association

ORIGINAL RESEARCH

Environmental and Socioeconomic Factors Influence the Live-Born Incidence of Congenital Heart Disease: A Population-Based Study in California

Shabnam Peyvandi, MD, MAS; Rebecca J. Baer, MS; Christina D. Chambers, PhD; Mary E. Norton, MD; Satish Rajagopal, MD; Kelli K. Ryckman, PhD; Anita Moon-Grady, MD; Laura L. Jelliffe-Pawlowski, PhD; Martina A. Steurer, MD, MAS

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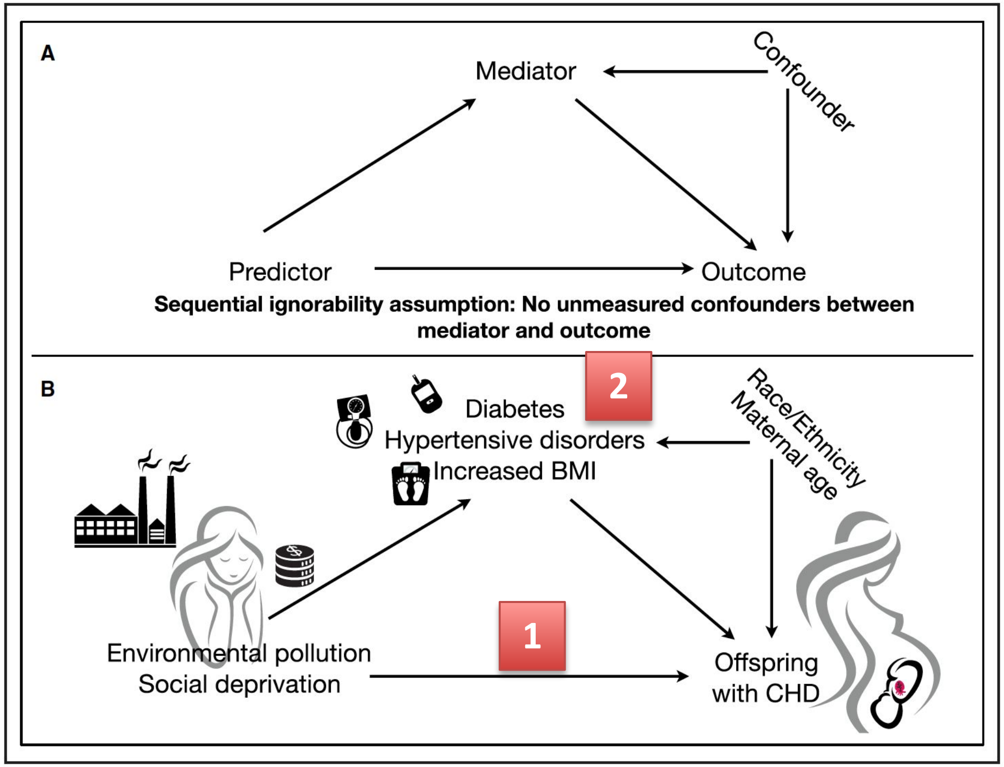
San Francisco

- Primary Aim: Assess the influence of social deprivation and environmental exposure to pollutants on live born incidence of CHD in California

- Secondary Aim: Assess the relative influence of maternal co-morbidities in the causal pathway (proxy for maternal fetal environment)



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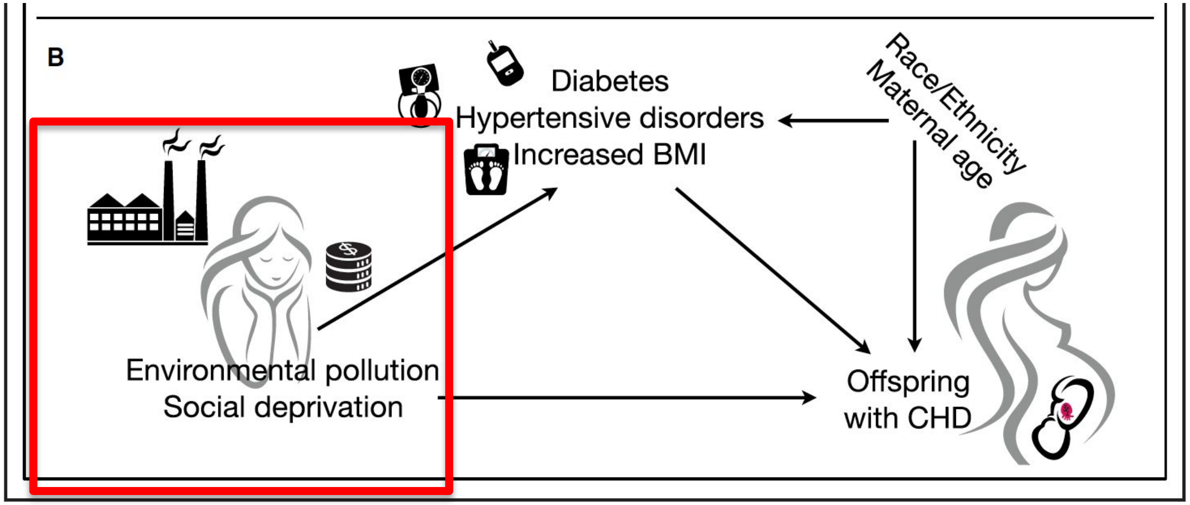
Using Big Data to Understand Birth Prevalence of CHD

CA.GOV

OSHPD

- Data Source: California Office of Statewide Health Planning and Development
  - Population based database of all live born infants in California
  - Linked birth, death certificates and hospital admission records
  - **Study population: Infants without CHD and infants with "significant" CHD (heart defect requiring or likely to require surgery in first year of life) – Primary Outcome**



Primary Predictors:

 Social Deprivation Index (SDI)

- Based on U.S. Census tract
- Community metric of 6 measures of wealth and income (housing, income, education)
- Categorized into 4 quartiles: Quartile 1 (least deprived) Quartile 4 (most deprived)

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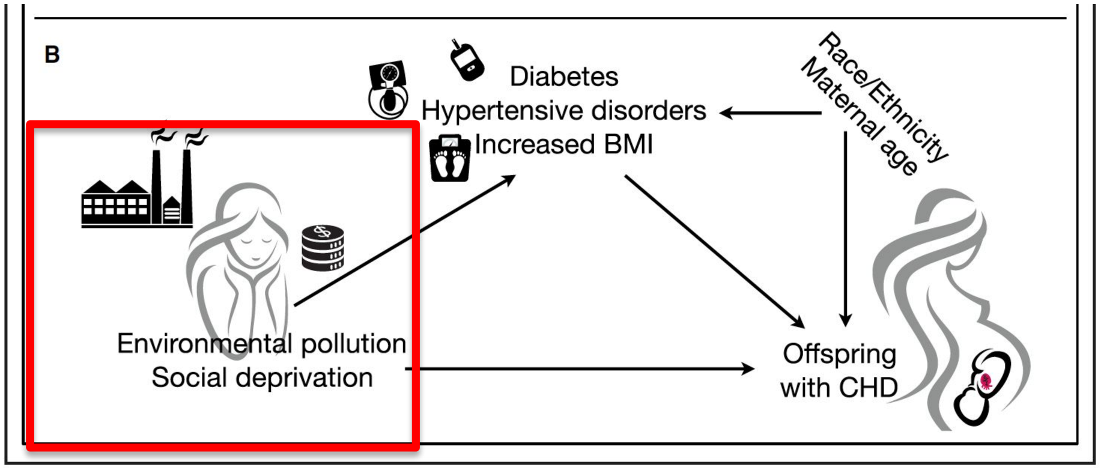

Primary Predictors:

- **Environmental Exposure Index (EEI)**
  - California Communities Environmental Health Screening Tool (CalEnviroScreen 3.0)
  - Levels of exposure to 4 pollutants in community: toxic release from facilities, air quality measured by ozone/particulate matter 2.5, drinking water contaminants, diesel/exhaust pollution
  - Categorized into 4 quartiles: Quartile 1 (least exposure) Quartile 4 (most exposure)

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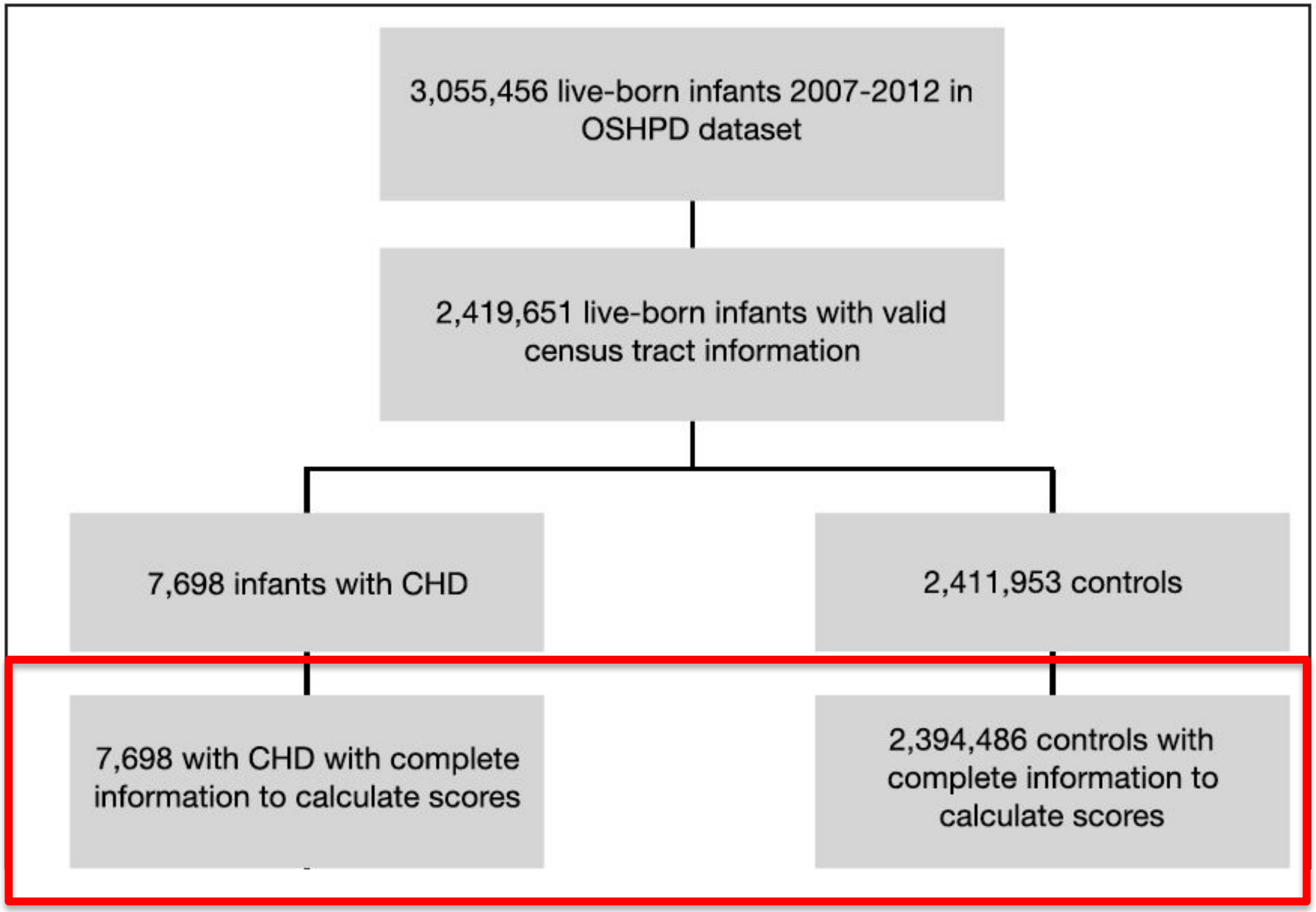

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- Odds of CHD higher among those with the most social deprivation
- Odds of CHD higher among those exposed to greater environmental pollutants
- Odds of CHD higher among those exposed to more maternal conditions (i.e. diabetes, hypertension)

	All CHD (N=7652)	
	Incidence*	aOR (95% CI)†
Social deprivation index		
Quartile 1‡	29	Reference
Quartile 2	32	1.16 (1.08–1.24)
Quartile 3	32	1.18 (1.10–1.27)
Quartile 4	35	1.31 (1.21–1.41)
Environmental index		
Quartile 1‡	29	Reference
Quartile 2	31	1.09 (1.02–1.16)
Quartile 3	32	1.11 (1.04–1.19)
Quartile 4	35	1.23 (1.15–1.31)
Maternal conditions§		
None	28	Reference
1	31	1.12 (1.06–1.18)
2	45	1.56 (1.44–1.68)
3	64	2.20 (1.88–2.56)

**Adjusted for maternal race/ethnicity & age*

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The intersection between SDOH and the Environment

% of population aOR (95% CI)		Social Deprivation Index			
		1st quartile (best)	2nd quartile	3rd quartile	4th quartile (worst)
Environmental Exposure Index	1st quartile (best)	9.3% reference	7.5% 1.21 (1.07-1.37)	4.8% 1.12 (1.06-1.40)	3.4% 1.26 (1.07-1.48)
	2nd quartile	8.3% 1.12 (0.99-1.26)	6.6% 1.28 (1.13-1.45)	6.3% 1.26 (1.11-1.42)	3.9% 1.41 (1.23-1.61)
	3rd quartile	5.1% 1.14 (0.99-1.30)	5.4% 1.21 (1.05-1.39)	7.0% 1.26 (1.10-1.44)	7.6% 1.45 (1.29-1.64)
	4th quartile (worst)	2.3% 1.25 (1.04-1.50)	5.5% 1.39 (1.23-1.56)	6.9% 1.41 (1.24-1.59)	10.1% 1.48 (1.32-1.66)

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The intersection between SDOH and the Environment

Environmental Exposure Index	*% of population aOR (95% CI)*	Social Deprivation Index: 1st quartile (best)	2nd quartile	3rd quartile	4th quartile (worst)
	1st quartile (best)	9.3% reference	7.5% 1.21 (1.07-1.37)	4.8% 1.12 (1.06-1.40)	3.4% 1.26 (1.07-1.48)
	2nd quartile	8.3% 1.12 (0.99-1.26)	6.6% 1.28 (1.13-1.45)	6.3% 1.26 (1.11-1.42)	3.9% 1.41 (1.23-1.61)
	3rd quartile	5.1% 1.14 (0.99-1.30)	5.4% 1.21 (1.05-1.39)	7.0% 1.26 (1.10-1.44)	7.6% 1.45 (1.29-1.64)
	4th quartile (worst)	2.3% 1.25 (1.04-1.50)	5.5% 1.39 (1.23-1.56)	6.9% 1.41 (1.24-1.59)	10.1% 1.48 (1.32-1.66)

- Strong interaction between social deprivation and exposure to pollutants
- Dose effect:
  - Increasing exposure to social deprivation and environmental pollutants associated with increased odds of CHD
- Odds of CHD highest among those in quartile 4 for both indices

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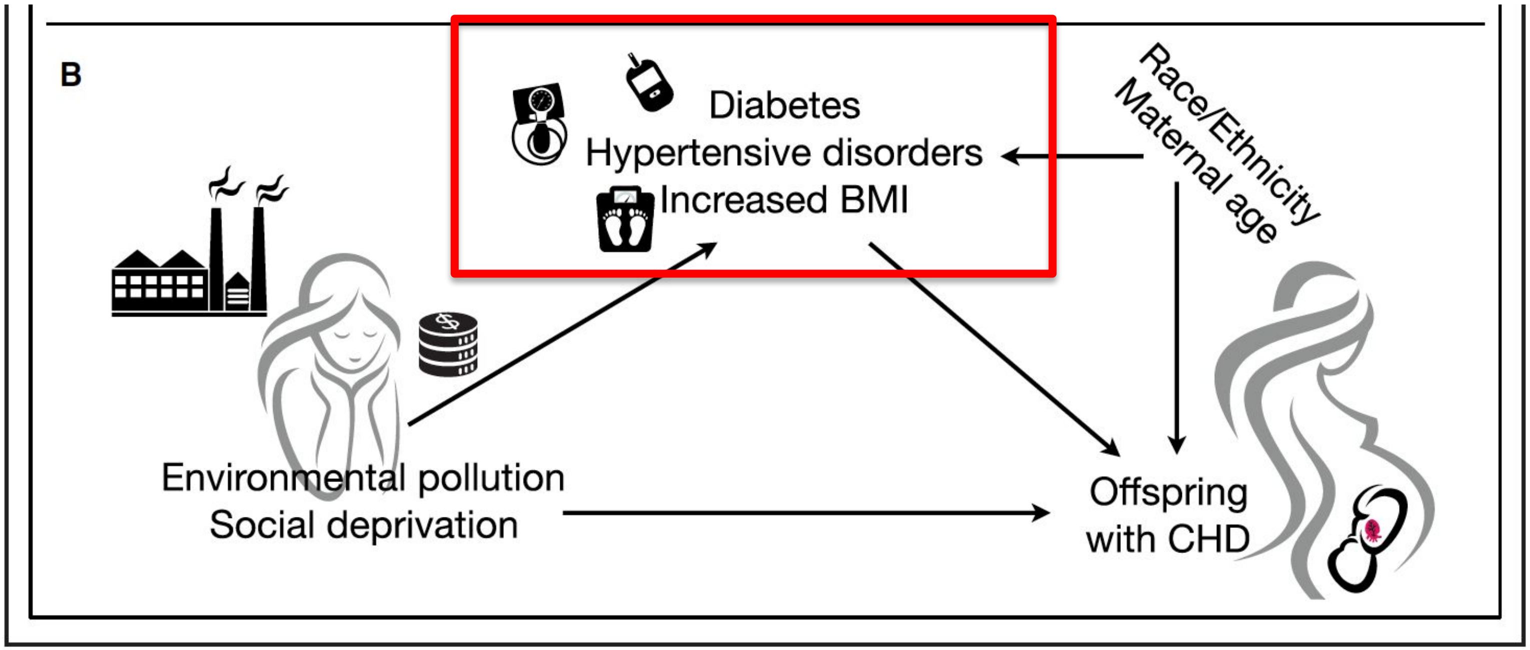
Exploring Causality



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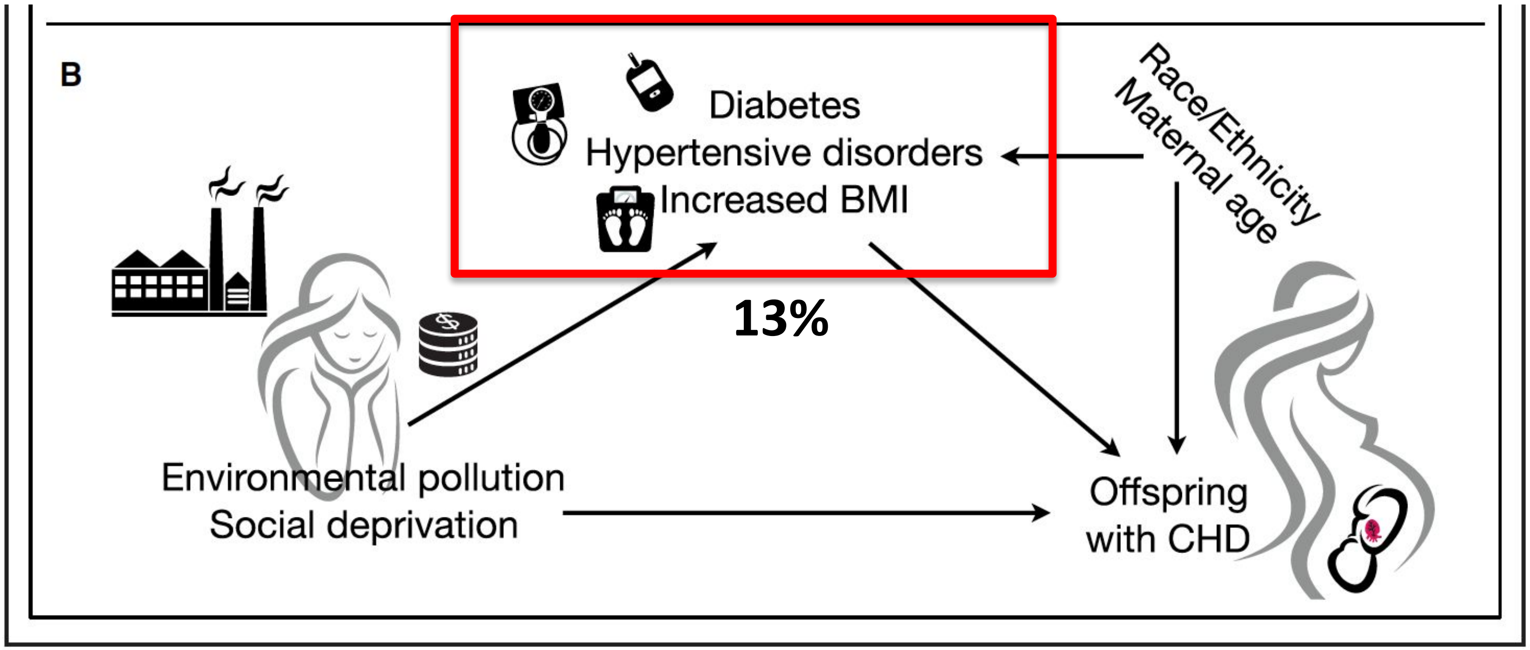
Exploring Causality



- *Only 13% of the relationship between SDI/EEI and having a child with CHD could be explained my maternal health conditions*

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Interpretation of Findings

- Social and environmental factors contribute to the development of CHD in offspring
- There is a strong interaction between social deprivation and exposure to pollutants
  - “Environmental Injustice”- racial and socioeconomic disparities in pollution exposure
- Other factors likely exist in the causal pathway
  - Maternal stress?

Turning data into action

- Targets for social policy initiatives:
  - Minimizing exposures to harmful toxins in socially deprived neighborhoods
    - Proximity to facilities releasing toxins
    - Access to green space
    - Clean drinking water
    - Tangible example– smoke inhalation in California from fires as a result of climate change (proper ventilation in homes required)

Thank you

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CONGENITAL ANOMALIES AND ENVIRONMENTAL HEALTH: A REVIEW AND A SOUTH AFRICAN PERSPECTIVE

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The Impact of Heat Stress on Newborn Health Outcomes

A Focus on Congenital Heart Defects

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IMPACTS OF HIGH ENVIRONMENTAL TEMPERATURES ON CONGENITAL ANOMALIES

- Links between heat exposure and congenital anomalies have not been explored in detail despite animal data and other strands of evidence that indicate such links are likely.
- We reviewed articles on heat and congenital anomalies from PubMed and Web of Science, screening 14,880 titles and abstracts in duplicate for articles on environmental heat exposure during pregnancy and congenital anomalies.

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Review

Impacts of High Environmental Temperatures on Congenital Anomalies: A Systematic Review

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Abstract: Links between heat exposure and congenital anomalies have not been explored in detail despite animal data and other strands of evidence that indicate such links are likely. We reviewed articles on heat and congenital anomalies from PubMed and Web of Science, screening 14,880 titles and abstracts in duplicate for articles on environmental heat exposure during pregnancy and congenital anomalies. Thirteen studies were included. Most studies were in North America (8) or the Middle East (3). Methodological diversity was considerable, including in temperature measurement, gestational windows of exposure, and range of defects studied. Associations were detected between heat exposure and congenital cardiac anomalies in three of six studies, with point estimates highest for atrial septal defects. Two studies with null findings used self-reported temperature exposures. Hypospadias, congenital cataracts, renal agenesis/hypoplasia, spina bifida, and craniofacial defects were also linked with heat exposure. Effects generally increased with duration and intensity of heat exposure. However, some neural tube defects, gastroschisis, anopthalmia/microphthalmia and congenital hypothyroidism were less frequent at higher temperatures. While findings are heterogenous, the evidence raises important concerns about heat exposure and birth defects. Some heterogeneity may be explained by biases in reproductive epidemiology. Pooled analyses of heat impacts using registers of congenital anomalies are a high priority.

RESULTS

Table 1. Associations between heat exposure and congenital heart anomalies.

Author (Year)	Country of Study	Number of Cases	Study Period	Time of Exposure Measurement	Controls or Comparator Group	Study Outcomes
Tikkanen and Heinonen, (1991) [32]	Finland	n = 573	1982–1984	First trimester	n = 1200	No association between self-reported exposure to temperatures during the first trimester of pregnancy ≥20 °C in the work environment and risk of cardiac malformation ($p > 0.05$)
Judge et al. (2004) [28]	New York state, USA	n = 502	1988–1991	1 month before pregnancy to date pregnancy diagnosed	n = 1066	Self-reported exposure to >100 °F (~38 °C) in early pregnancy (2.7% of women). OR of any cardiovascular anomaly=1.13 (95% CI = 0.59, 2.19) and >10 hours/week versus never OR = 1.27 (95% CI = 0.52–3.13)
Van Zutphen et al. (2012) [33] *	New York State, excluding New York City, USA	13 types of anomalies, n ranged from 9 with common truncus to 1579 with VSD	1992–2006 (summer months June–August)	First trimester	n = 59,328	No associations detected between mean and maximum universal apparent temperature, heat waves and days >90th centile, and cardiovascular defects.

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RESULTS

Agay-Shay et al. (2013) [22]	Israel, Tel Aviv	n = 1630 (607 cases with multiple CHDs, 542 with isolated ASDs and 481 with isolated VSDs)	2000–2006	Weeks 3–8 (unclear if this refers to weeks post-conception or gestation)	n = 130,402	Whole year period. OR = 1.03 (95% CI = 1.01; 1.05) for multiple CHDs for exposure to maximum daily peak temperature (per 1 °C increase). Isolated ASD OR = 1.02 (95% CI = 1.00, 1.04) per 1 °C increase in average daily temperature. Quartile 3 temperature versus Q1 OR = 1.34 (95% CI = 1.06, 1.70), Q4 OR = 1.27 (95% CI = 1.00, 1.61). In the cold season exposure to the average ambient temperature and the maximum peak temperature (per 1 °C increase) increased the risk for multiple CHDs (OR = 1.05; 95% CI = 1.00, 1.10, and OR = 1.03, 95% CI = 1.01, 1.05, respectively). Comparing the highest to lowest quartiles of mean temperature increased the risk for multiple CHDs (OR = 1.41, 95% CI = 1.03, 1.94). 1-day increase in the extreme heat events showed increased risk for multiple CHDs (OR = 1.13, 95% CI = 1.06, 1.21) and also for isolated ASDs (OR = 1.10 95% CI = 1.02, 1.19). A 1-day increase in the extreme heat events based on the previous 90 days increased risk for multiple CHDs (OR = 1.02, 95% CI = 1.00, 1.04). VSD point estimates around 1.0, except per 1 °C increase in average daily temperature OR = 1.08 (95% CI = 1.00, 1.16)
Auger et al. (2017) [25]	Quebec, Canada	n = 6482 (n = 539 with critical heart defects and n = 5943 noncritical heart defects)	1988–2012 (summer months April – September)	Weeks 2–8 post-conception	n = 704,209	10 days ≥30 °C higher prevalence versus 0 days, of transposition of great vessels (29.2 vs. 19.2 per 100,000), truncus arteriosus (12.2 vs. 5.5 per 100,000), coarctation of aorta (21.9 vs. 16.5 per 100,000), ASD (413.2 vs. 289.0 per 100,000), defects of the aorta (19.4 vs. 11.9 per 100,000), heterotaxy (14.6 vs. 8.2 per 100,000), and other defects (255.2 vs. 223.0 per 100,000). Single and multiple defects also higher. Higher differences with longer exposure, especially with ASD, 15 days ≥ 30 °C (PR = 1.37, 95% CI = 1.10, 1.70). ASD associations highest in weeks 2 and 8. PR highest week 7, e.g., 32 °C associated with 1.13 times (95% CI: 1.01, 1.26) risk relative to 20°C. Maximum temperatures of 32 °C associated with multiple defects week 8 (PR = 1.31, 95% CI = 1.04, 1.65) compared with 20 °C.

RESULTS

Author (Year)	Country of Study	Number of Cases	Study Period	Time of Exposure Measurement	Controls or Comparator Group	Study Outcomes
Lin et al. (2018) [30]	USA 8 states	n = 5848 congenital heart defects, 4 types	1997–2007	Weeks 3–8 post-conception	n = 5742	Study examines ≥2 days with daily Tmax >95th centile (EHE95). ≥3 days with Tmax above the 90th percentile (EHE90). Duration of EHE90 or EHE95, n total days, and n consecutive days. Most associations null with overall defects, though all point estimates >1.0. VSD and ASD defects not significant, but almost all estimates >1.0, higher in Summer. VSD summer EHE95 OR = 1.18 (95% CI = 0.81–1.72). VSD spring EHE95 OR = 1.06 (95% CI = 0.41–2.74). ASD summer EHE95 OR = 1.32 (95% CI = 0.88–1.99). ASD spring EHE95 OR = 1.15 (95% CI = 0.33–4.04). VSD EHE90 durations of 3–5 days ORs ranged 2.17–2.57 all $p < 0.05$ in summer. OR point estimates generally increased with additional duration of exposure. Higher effect sizes in some regions, e.g., OR = 2.28 for EHE95 in Spring in New York for VSD and 1.87 (95% CI = 1.11, 3.16) for ASD and EHE95 duration. EHE95 total days and left ventricular outflow tract obstruction in Utah OR = 1.53 (95% CI = 1.00, 2.35), and septal defects in Iowa OR = 1.71 (95% CI = 1.09, 2.69). EHE95 duration and conotruncal defects in Utah OR = 1.34 (95% CI = 1.00, 1.81), septal defects in New York OR = 1.30 (95% CI = 1.05, 1.62). Association between temperature and VSD increased with magnitude and duration of high temperature exposure.

CI: confidence interval; OR: odds ratio; Studies listed in chronological order; ASD: atrial septum defect; CHD: congenital heart defect; EHEs: extreme heat events EHE90: defined as at least three consecutive days with daily maximum temperature above 90th percentile; UAT: universal apparent temperature; VSD: ventricular septal defects. * Study assessed defects in multiple organ systems, each presented in their respective tables.

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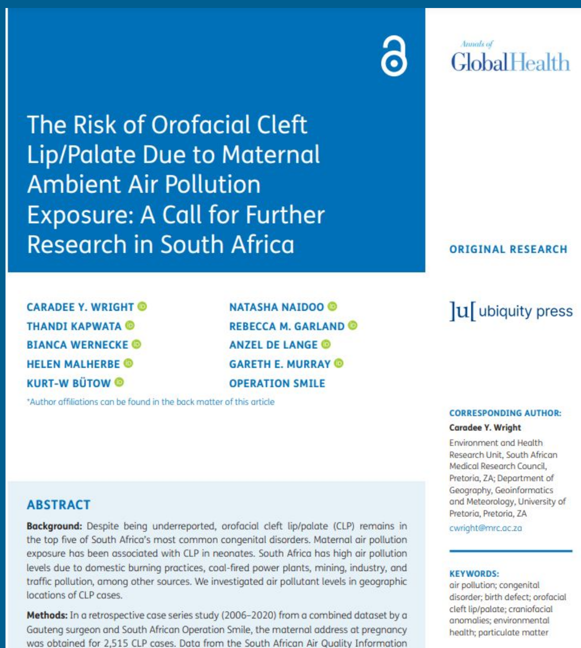
CONCLUSIONS

- Methodological diversity was considerable, including in temperature measurement, gestational windows of exposure, and range of defects studied.
- Associations were detected between heat exposure and congenital cardiac anomalies in three of six studies, with point estimates highest for atrial septal defects.
- Two studies with null findings used self-reported temperature exposures. Hypospadias, congenital cataracts, renal agenesis/hypoplasia, spina bifida, and craniofacial defects were also linked with heat exposure.
- Effects generally increased with duration and intensity of heat exposure. However, some neural tube defects, gastroschisis, anopthalmia/microphthalmia and congenital hypothyroidism were less frequent at higher temperatures.
- While findings are heterogenous, the evidence raises important concerns about heat exposure and birth defects. Some heterogeneity may be explained by biases in reproductive epidemiology.
- Pooled analyses of heat impacts using registers of congenital anomalies are a high priority.

RESEARCH ON OROFACIAL CLEFT LIP AND PALATE AND ENVIRONMENTAL RISK FACTORS IN SOUTH AFRICA

BACKGROUND

- Orofacial cleft lip/palate (CLP) is in the top five of South Africa's most common congenital disorders
- Maternal air pollution exposure has been associated with CLP in neonates, although evidence mostly exists for HICs
- South Africa has high air pollution levels due to domestic burning practices, coal-fired power plants, mining, industry, and traffic pollution, among other sources
- Therefore, more African studies investigating the environmental impacts of CLP are necessary to make recommendations for protective laws and practices



Annals of Global Health

The Risk of Orofacial Cleft Lip/Palate Due to Maternal Ambient Air Pollution Exposure: A Call for Further Research in South Africa

ORIGINAL RESEARCH

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KEYWORDS:
air pollution; congenital disorder; birth defect; orofacial cleft lip/palate; craniofacial anomalies; environmental health; particulate matter

ABSTRACT

Background: Despite being underreported, orofacial cleft lip/palate (CLP) remains in the top five of South Africa's most common congenital disorders. Maternal air pollution exposure has been associated with CLP in neonates. South Africa has high air pollution levels due to domestic burning practices, coal-fired power plants, mining, industry, and traffic pollution, among other sources. We investigated air pollutant levels in geographic locations of CLP cases.

Methods: In a retrospective case series study (2006–2020) from a combined dataset by a Gauteng surgeon and South African Operation Smile, the maternal address at pregnancy was obtained for 2,515 CLP cases. Data from the South African Air Quality Information

- Air Pollution Data
  Daily measurements of PM2.5 and PM10 between 2006 and 2020 sourced from the South African Air Quality Information System

- Study Population
  Two databases - records of patients treated at a hospital in Pretoria, Gauteng by a maxillo-facial and oral surgeon and Operation Smile South Africa

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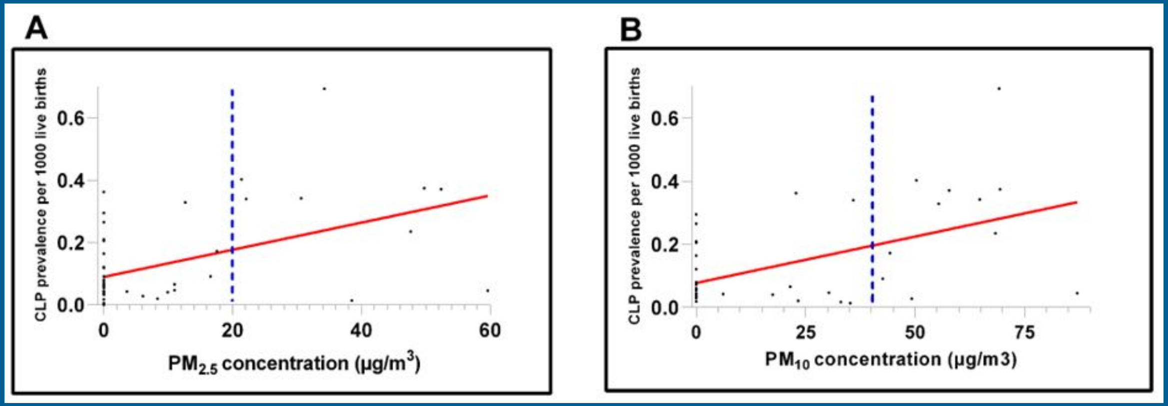
DATA AND STATISTICAL ANALYSIS

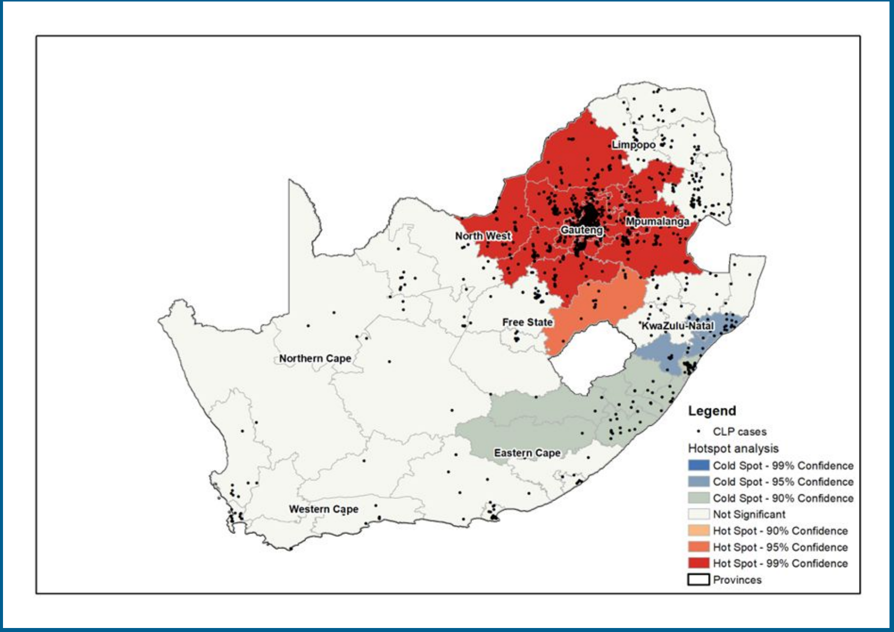
- ArcGIS was used to assign cases of CLP geographic coordinates using maternal address as location
- Aggregated to district municipality level and life-time birth prevalence calculated per 1 000 live births. Yearly live births from Statistics South Africa for the period 2006 to 2020 was used as the denominator
- Correlation analysis used to determine the link between annual average PM2.5 and PM10 concentrations at a site and CLP birth prevalence at the district municipality level
- Hot Spot Analysis tool in ArcGIS 10.3 was used to identify statistically significant spatial clusters of high values (hot spots) and low values (cold spots) of CLP birth prevalence

RESULTS



Statistically significant moderate positive correlations between PM2.5, PM10 and CLP birth prevalence (correlation coefficient (CC) = 061, 95% CI = 0.38–0.77, p = < 0.001 and CC = 0.63, 95% CI = 0.42–0.77, p = <0.001, respectively), when PM concentrations were ≤ 30 µg/m3

RESULTS



- Significant hot spot clusters identified inland - Gauteng and parts of Limpopo, North-West, Mpumalanga and Free State provinces
- Significant cold spot clusters located along the coastal provinces - KwaZulu-Natal and Eastern Cape
- Other parts of the country where data was available did not have any significant clusters
- One of the statistically significant hot spots, the Gert Sibande district in Mpumalanga province, had the second highest CLP birth prevalence rate documented (0.40 per 1,000 live births), although it only had the seventh highest number of CLP cases.

CONCLUSION

- Higher chance of mothers with CLP-affected infants in provinces with higher levels of air pollutants
- Tendency for CLP cases to cluster in certain geographic locations as opposed to a randomly dispersed pattern (z-score = – 68.2, $p < 0.001$)
- Hotspot analysis confirmed that higher concentrations of PM10 and PM2.5 were associated with specified geographic locations of mothers with CLP-affected infants, “hotspot clusters” of cases of CLP were identified in Gauteng, Limpopo, North-West
- Areas with fewer cases of CLP, such as KwaZulu-Natal and the Eastern Cape, had lower PM10 and PM2.5 concentrations and were termed “cold spot clusters
- Varying risks of exposure - air pollutant concentrations in inland and coastal geographical locations are affected by wind speed, precipitation, relative humidity, population density and industrial activities

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Climate Change and Child Health Discussion Series

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Healthy Environment Healthy Children Framework:
https://www.unicef.org/media/91631/file/Healthy-Environments-for-Healthy-Children-Global-Programme-Framework-Summary.pdf

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Climate Change Series:
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Subgroup information, recordings and presentations from previous webinars are available on the subgroup page of the Child Health Task Force website:
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