Climate Change and Vulnerable Populations: Complementary Approaches for Assessing Extreme Heat and Health

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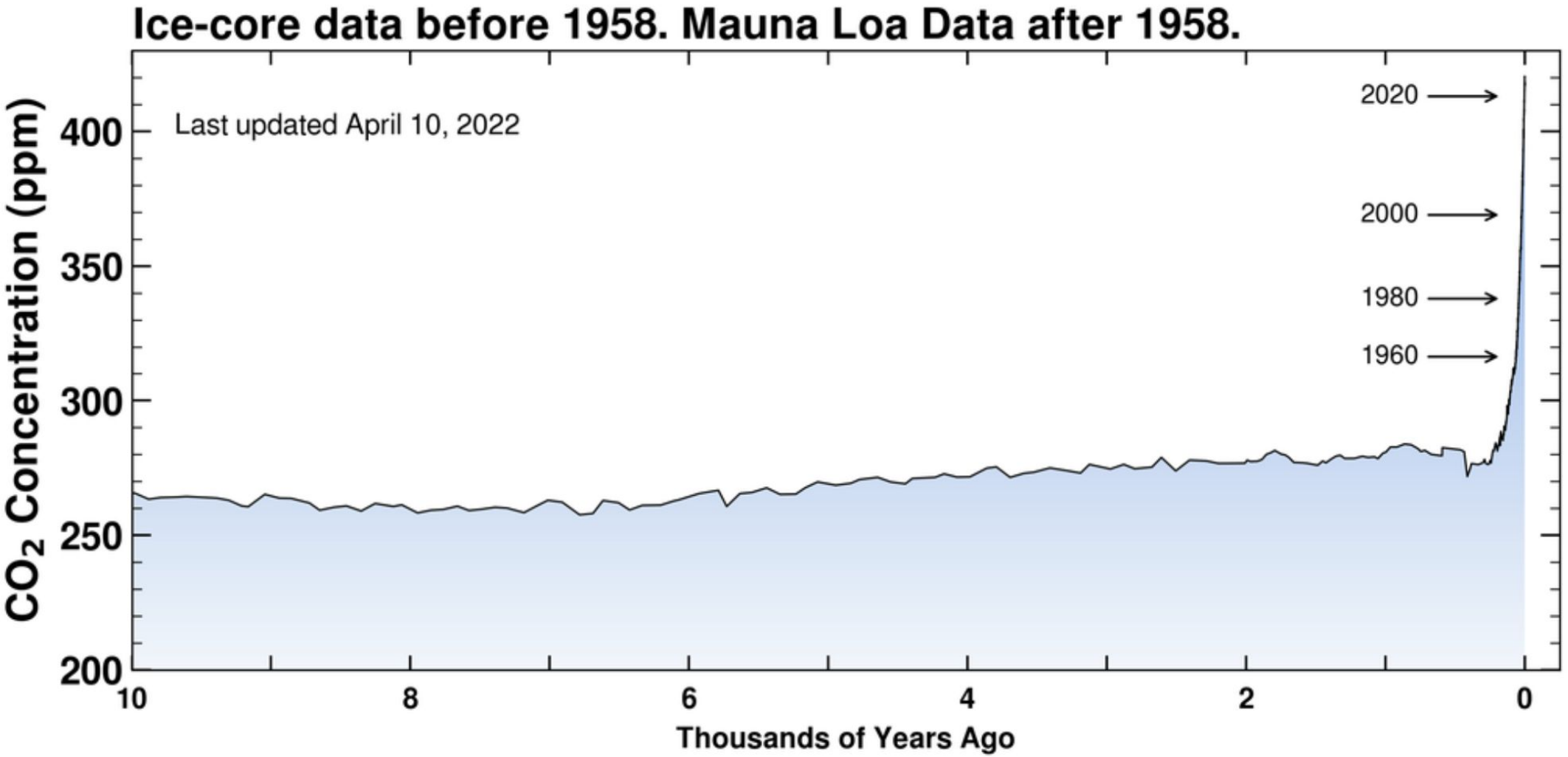
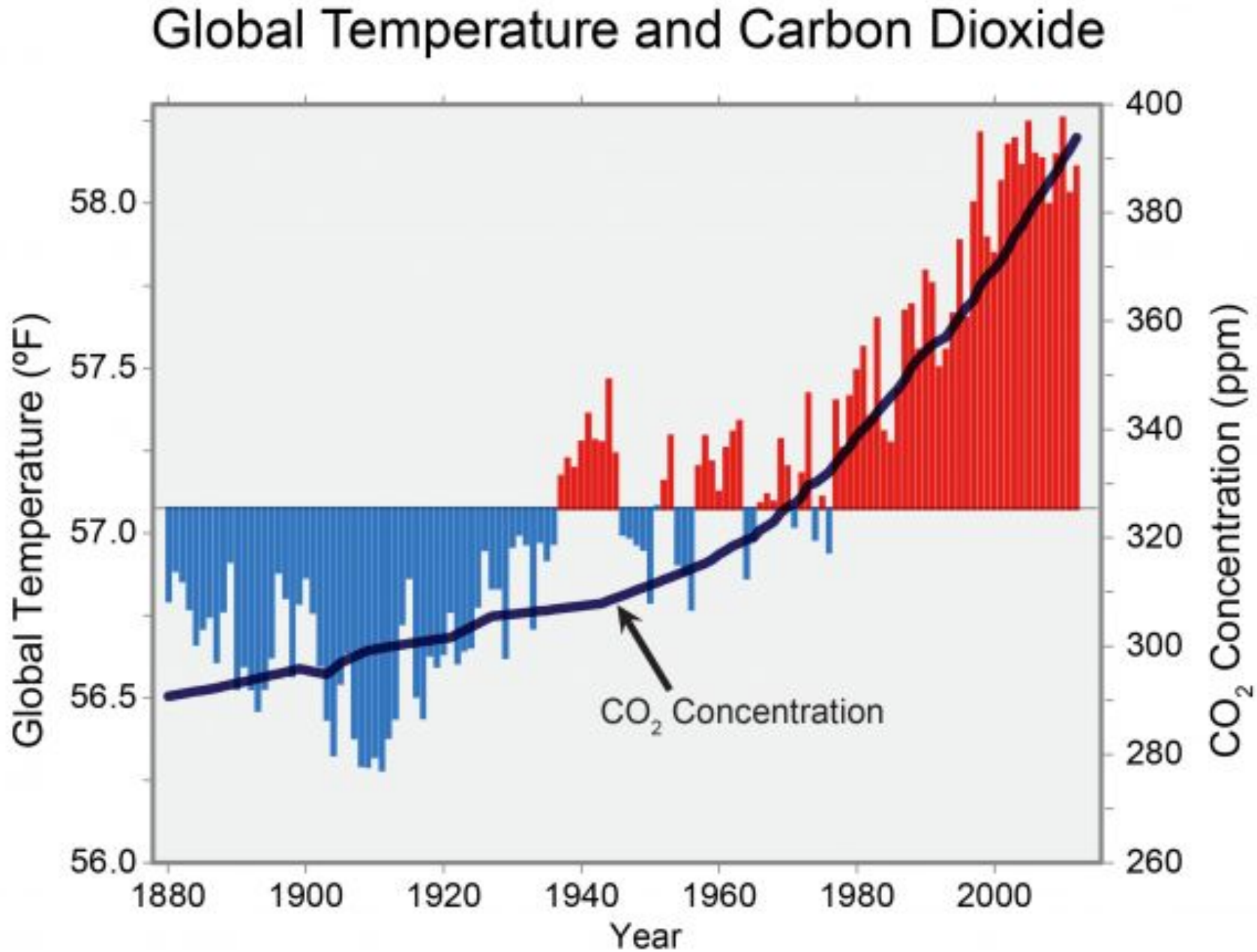
Climate change is caused by human activity

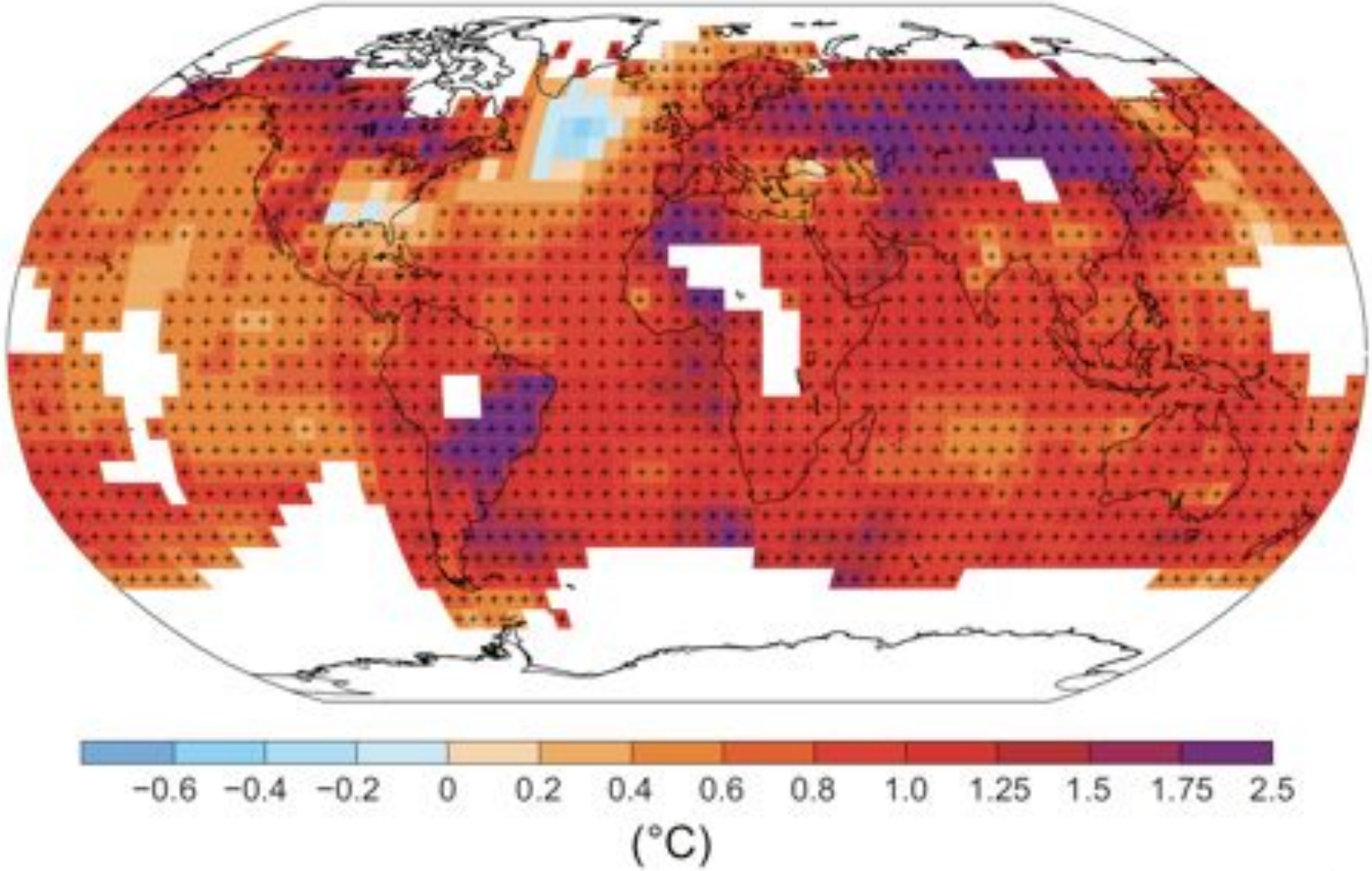


https://scripps.ucsd.edu/programs/keelingcurve/



Globalchange.gov

Our climate has already changed

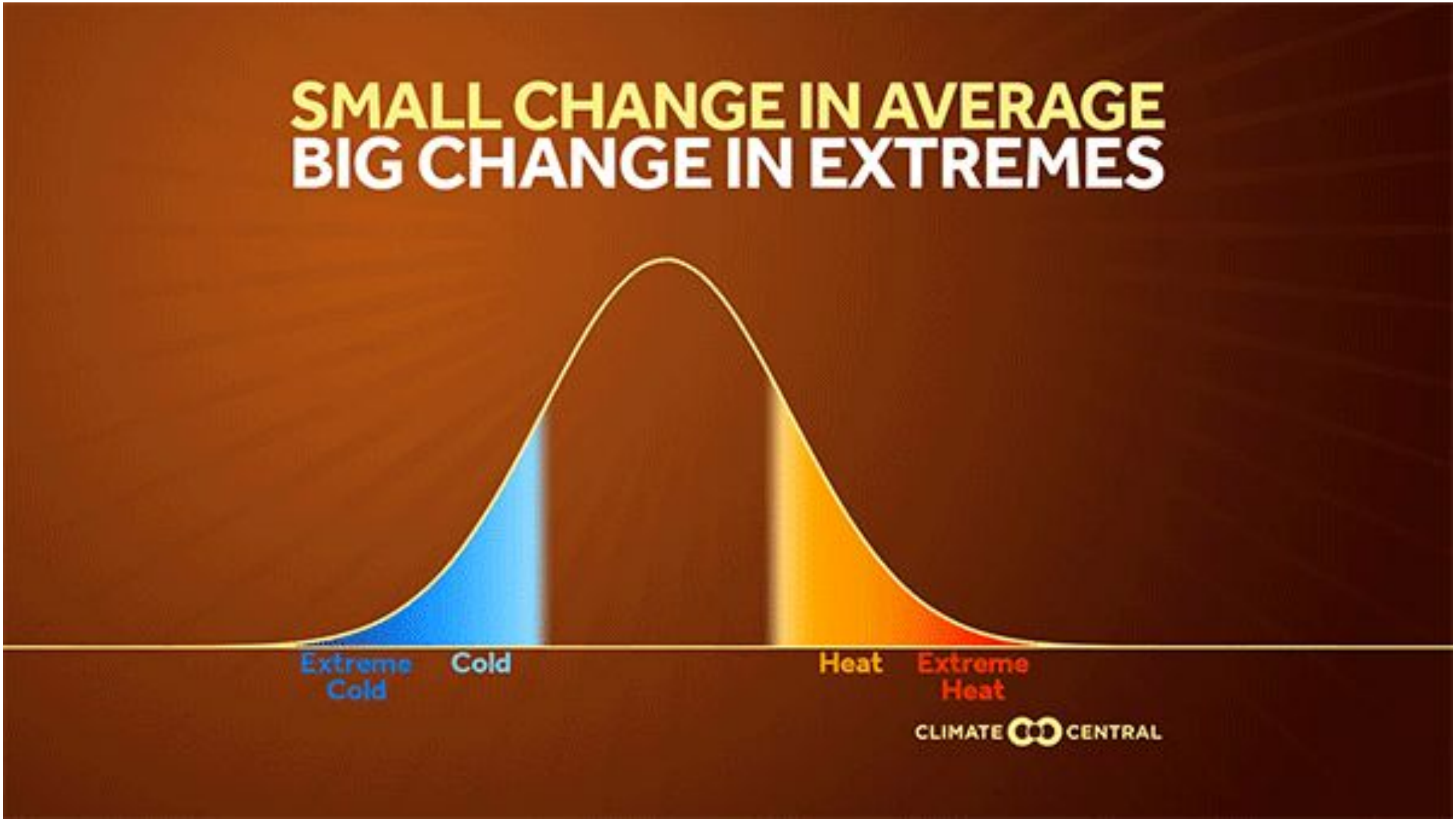


https://www.ipcc.ch/report/ar5/

Climate change affects us all

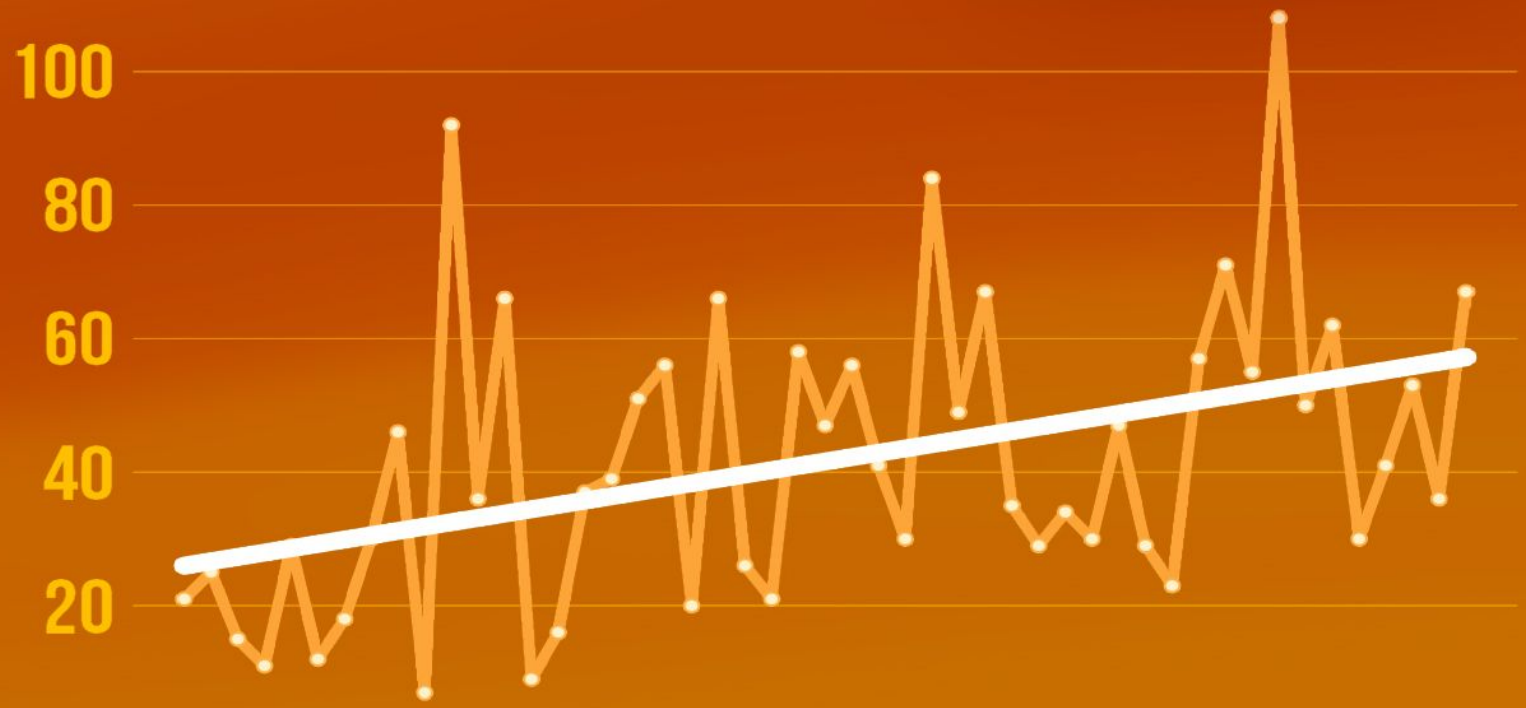
- More extreme weather
  - Heat waves
  - Extreme cold
  - Heavy rains, floods
  - Drought
  - Severe storms
  - Wildfires
- Air pollution
- Sea level rise

- Health impacts
  - Death, injury, hospitalization
  - Asthma exacerbations
  - Mosquito-borne disease
  - Water-borne disease
  - Availability of food and clean water
- Economic impacts
  - Property loss
  - Fishing, ski, and maple syrup
  - Recreational waters


SMALL CHANGE IN AVERAGE
BIG CHANGE IN EXTREMES
Extreme Cold
Cold
Heat
Extreme Heat
CLIMATE CENTRAL

DAYS ABOVE 95°

31.8 MORE DAYS



1970 HOUSTON 2018

Day count based on rate of change since 1970
Source: RCC-ACIS.org

CLIMATE CENTRAL

DAYS ABOVE 100°

Current (1991-2010)

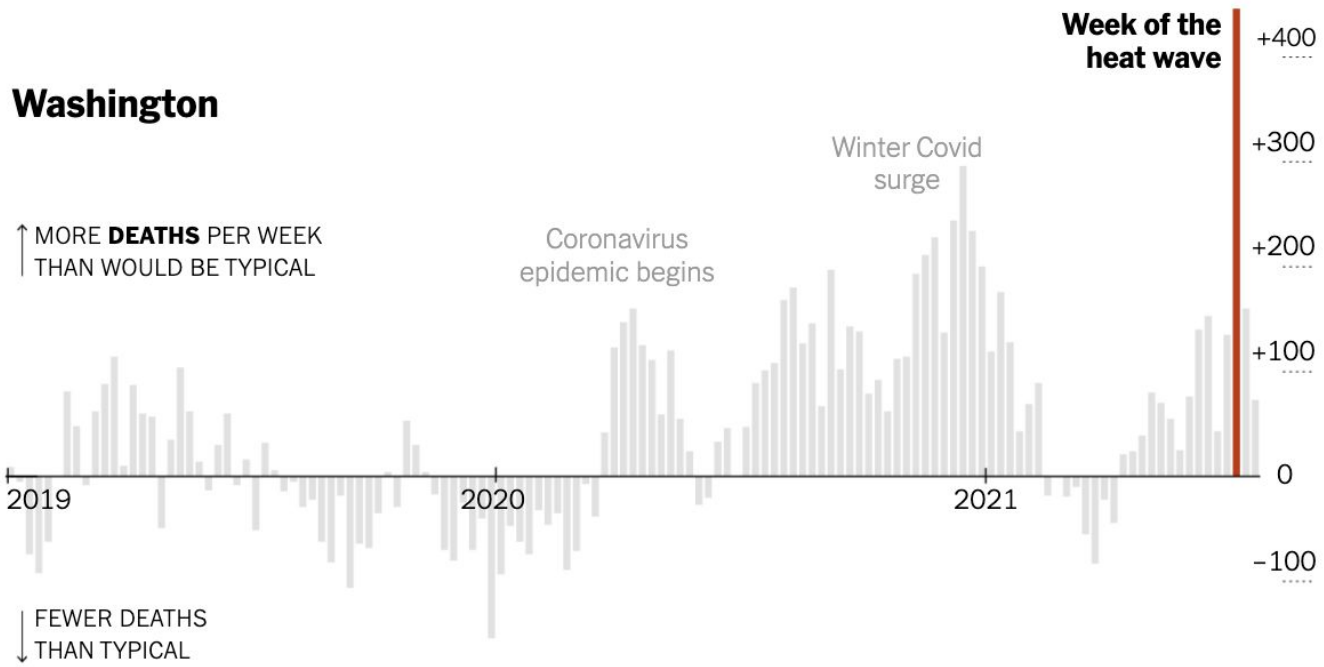
Source: Maurer et al. (2002), Santa Clara University

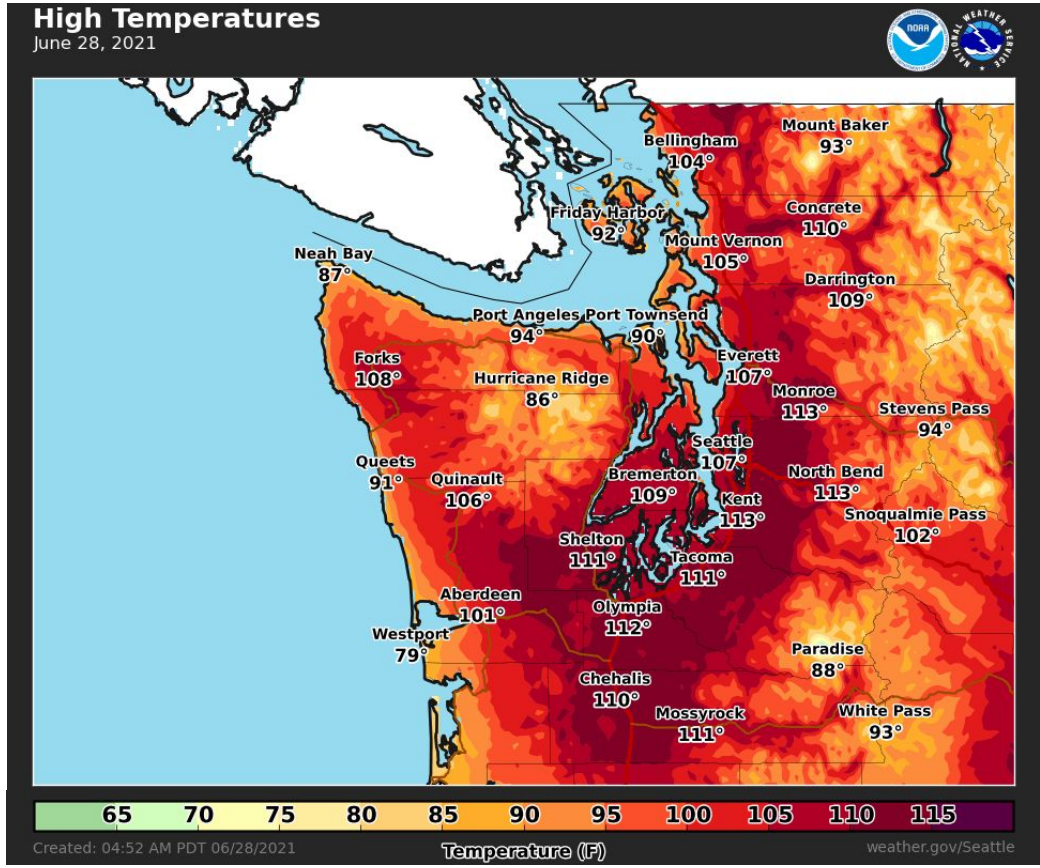
CLIMATE CENTRAL

The New York Times

Hidden Toll of the Northwest Heat Wave: Hundreds of Extra Deaths

By Nadja Popovich and Winston Choi-Schagrin Aug. 11, 2021





NWS https://commons.wikimedia.org/w/index.php?curid=107073128

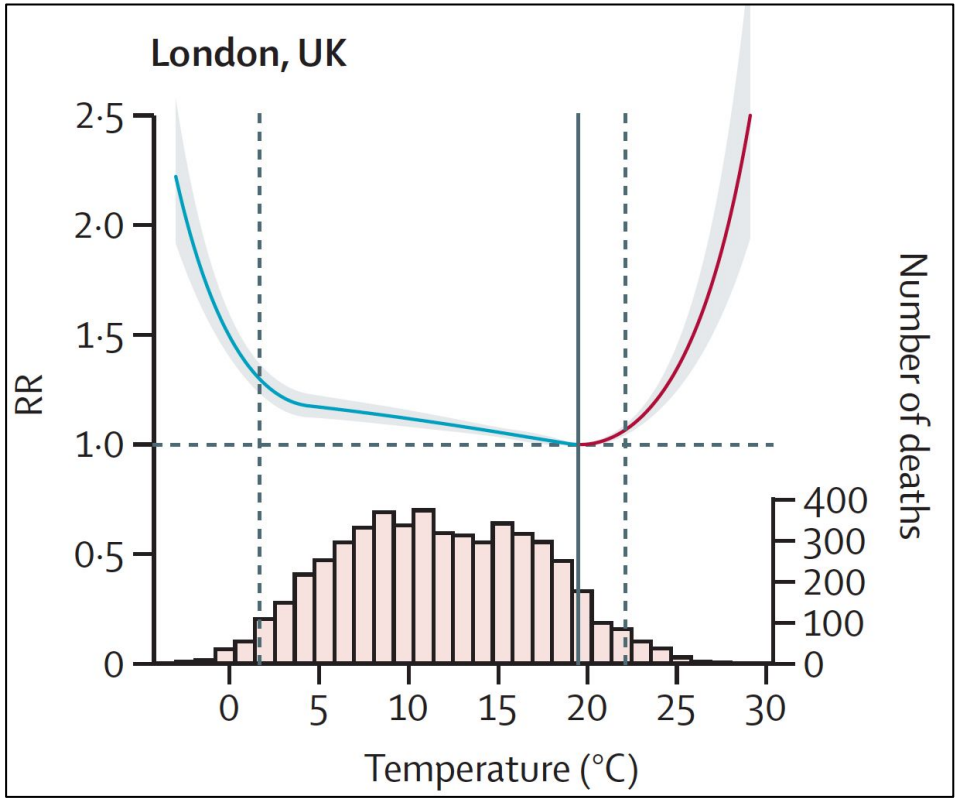
Canada: Disastrous Impact of Extreme Heat

Failure to Protect Older People, People with Disabilities in British Columbia

A woman sits to take a rest as heatwave hits Western Canada on June 30, 2021 in Victoria, British Columbia, Canada. © 2021 Mert Alper Dervis/Anadolu Agency via Getty Images © 2021 Mert Alper Dervis/Anadolu Agency via Getty Images

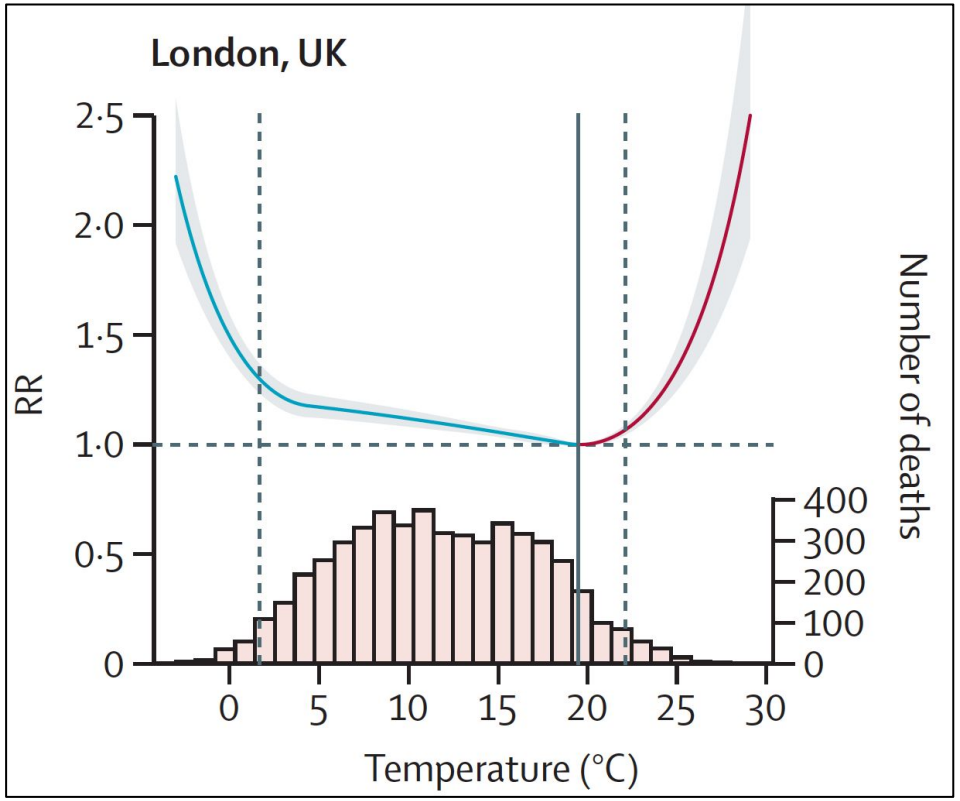
https://www.hrw.org/news/2021/10/05/canada-disastrous-impact-extreme-heat#

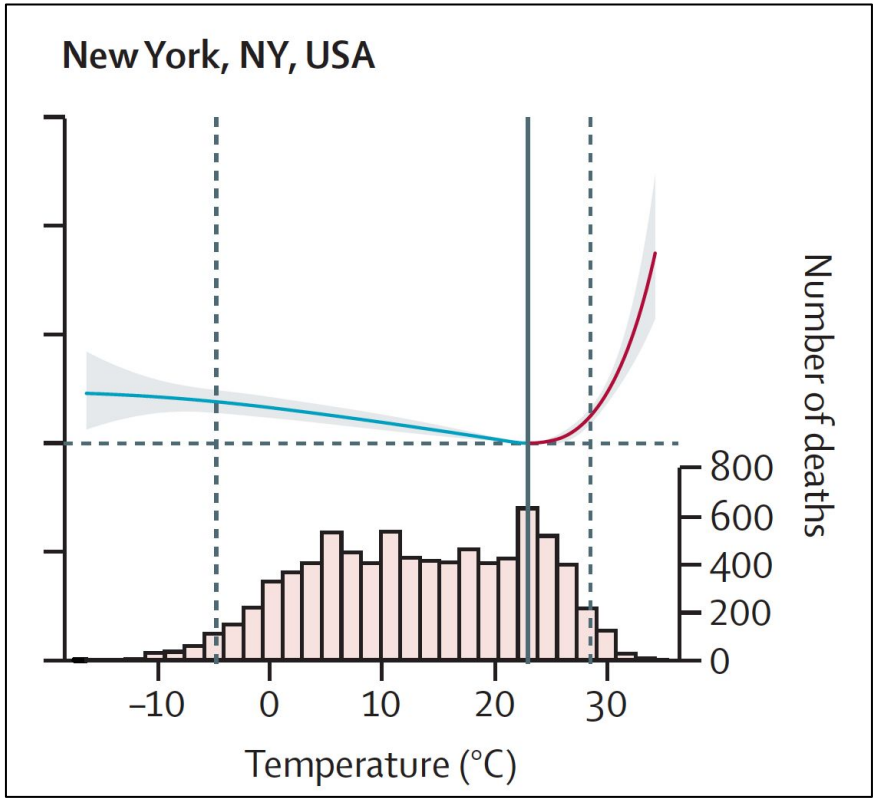
Extreme Temperatures and Risk of Death



Gasparrini et al. *Lancet*, 2015

Extreme Temperatures and Risk of Death





Gasparrini et al. *Lancet*, 2015

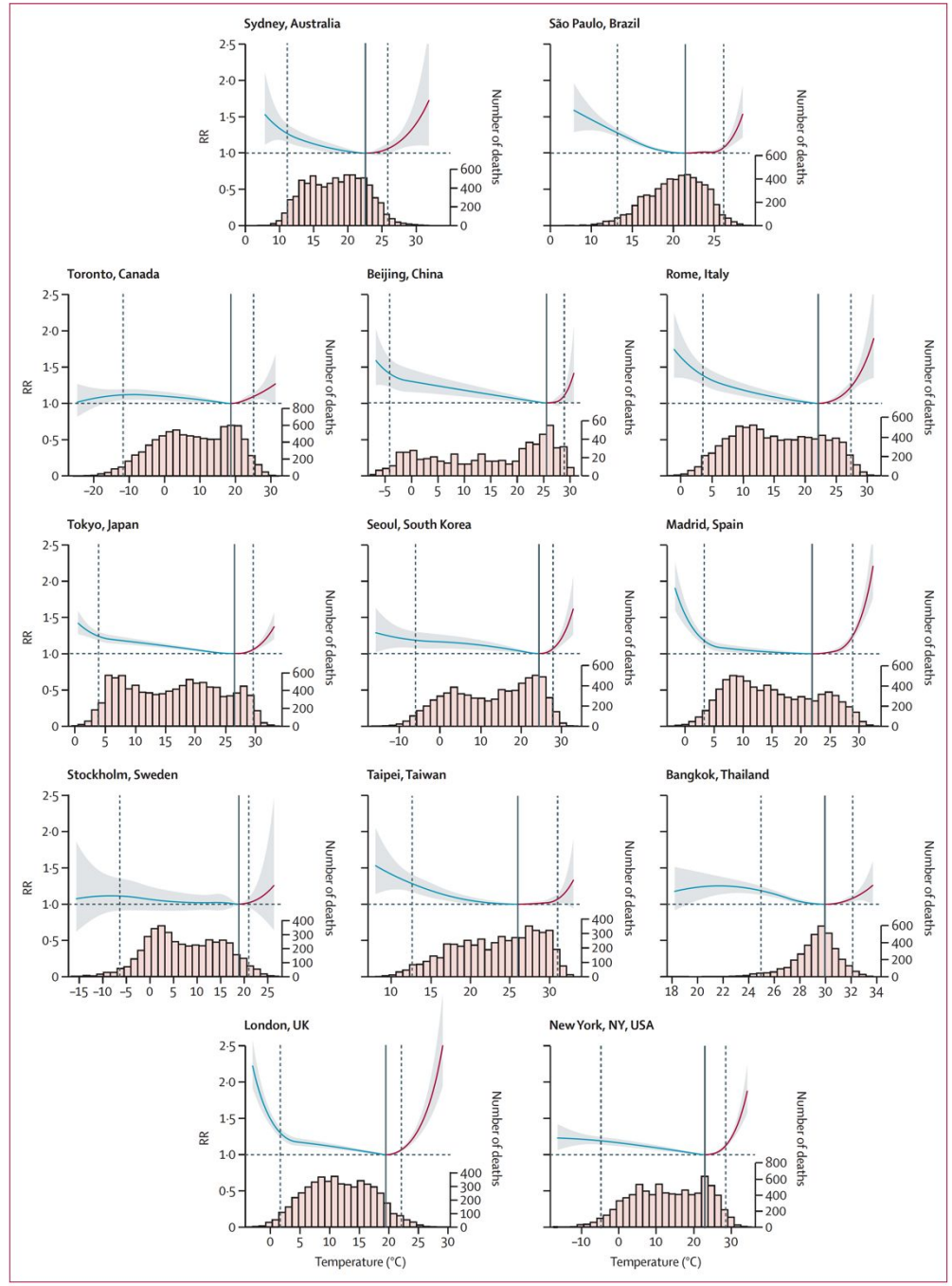
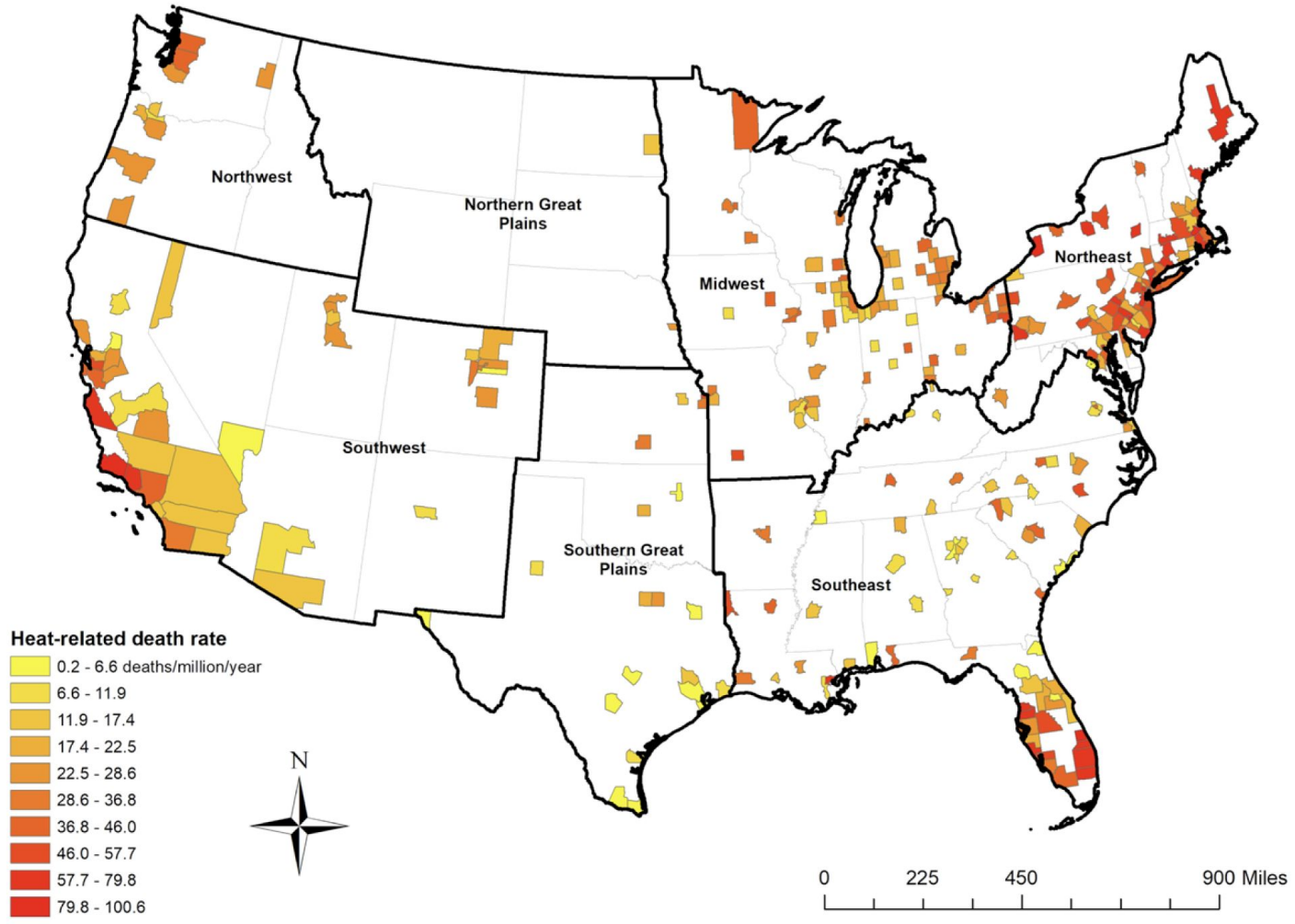


***Figure 1*: Overall cumulative exposure–response associations in 13 cities**
Exposure–response associations as best linear unbiased prediction (with 95% empirical CI, shaded grey) in representative cities of the 13 countries, with related temperature distributions. Solid grey lines are minimum mortality temperatures and dashed grey lines are the 2·5th and 97·5th percentiles. RR=relative risk.

Gasparrini et al. *Lancet*, 2015

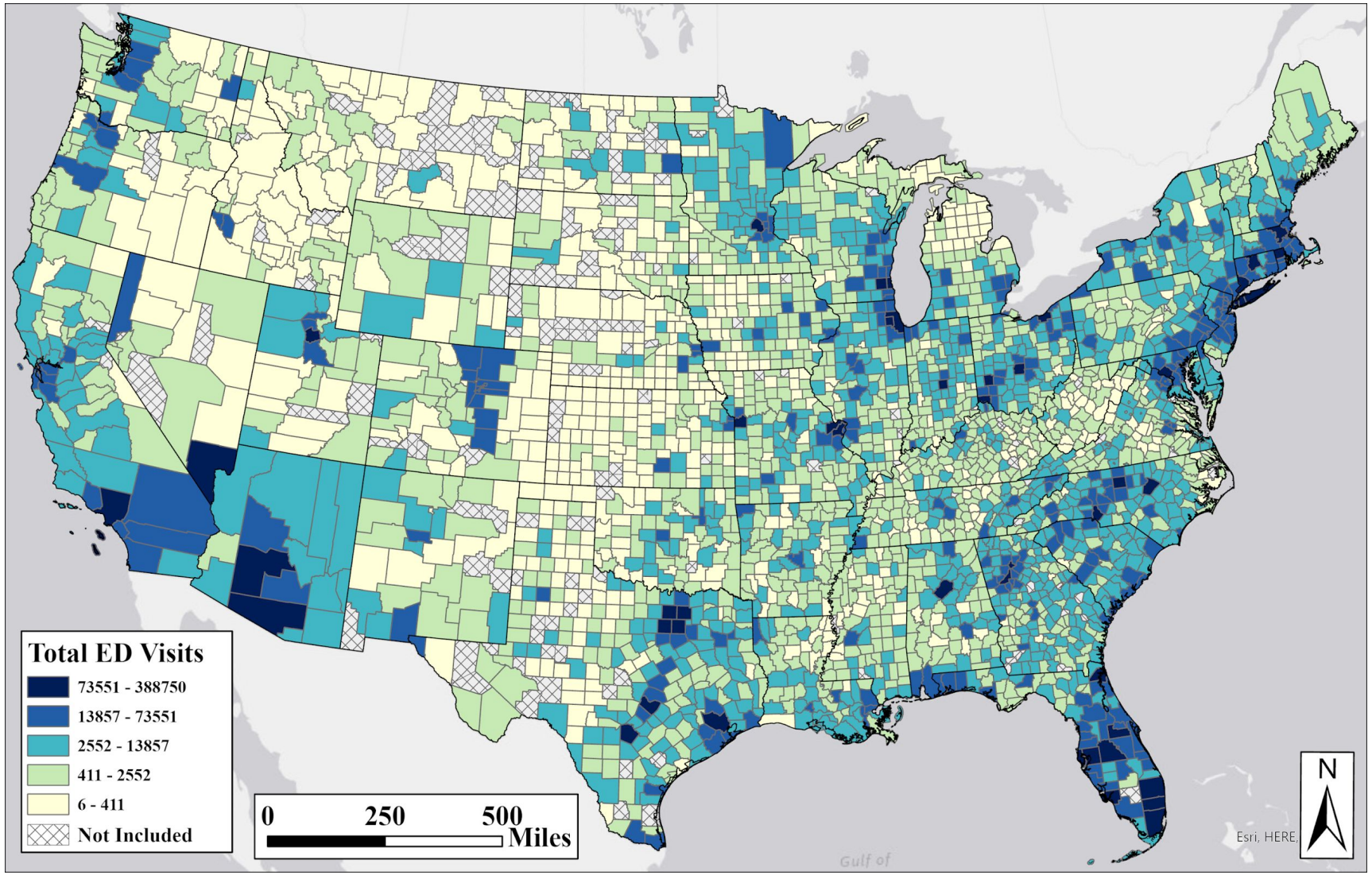
>2300 deaths per year attributable to extreme heat* in the US



* Defined as temperatures > 97.5th percentile of the county-specific distribution

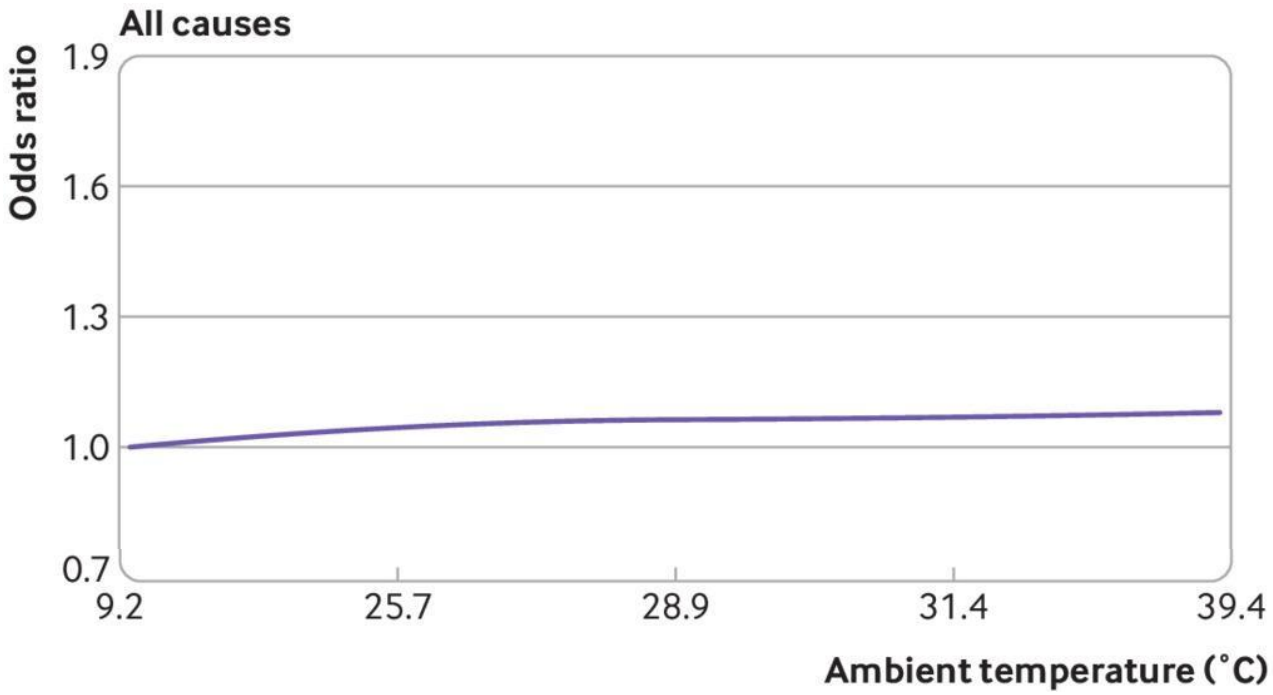
Weinberger et al. *Environ Epidemiol.* 2020

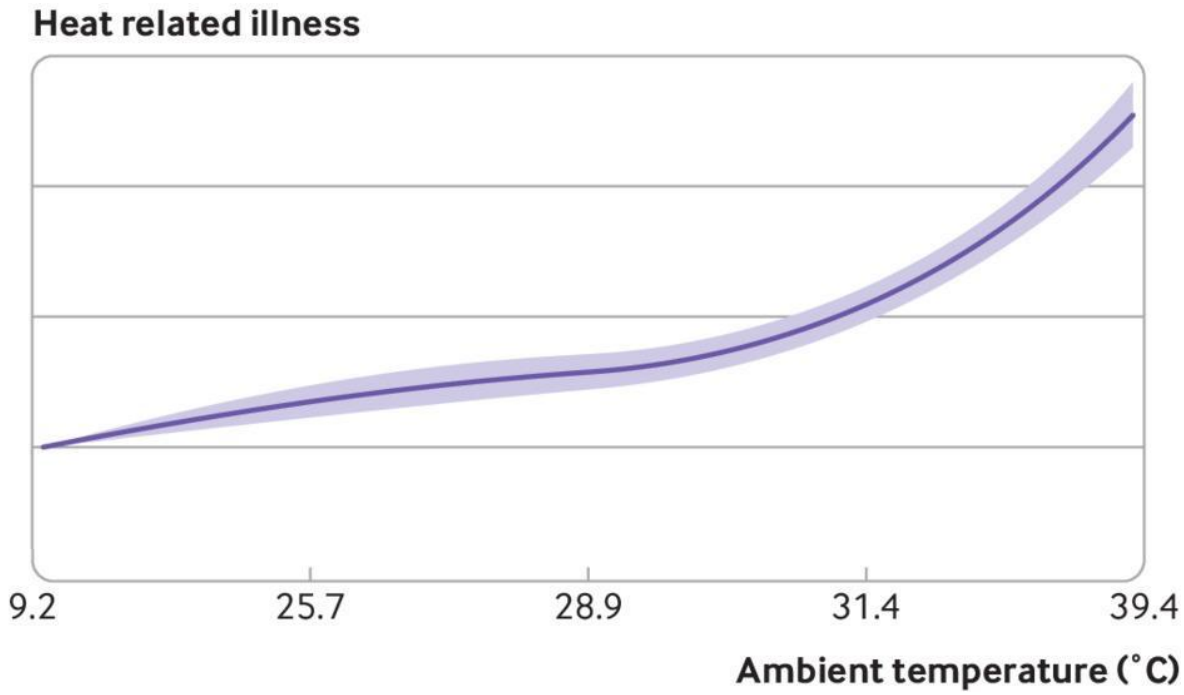
Heat and Emergency Department Visits Among Insured Individuals



Sun et al. *BMJ* 2021.

Heat and Emergency Department Visits Among Insured Individuals





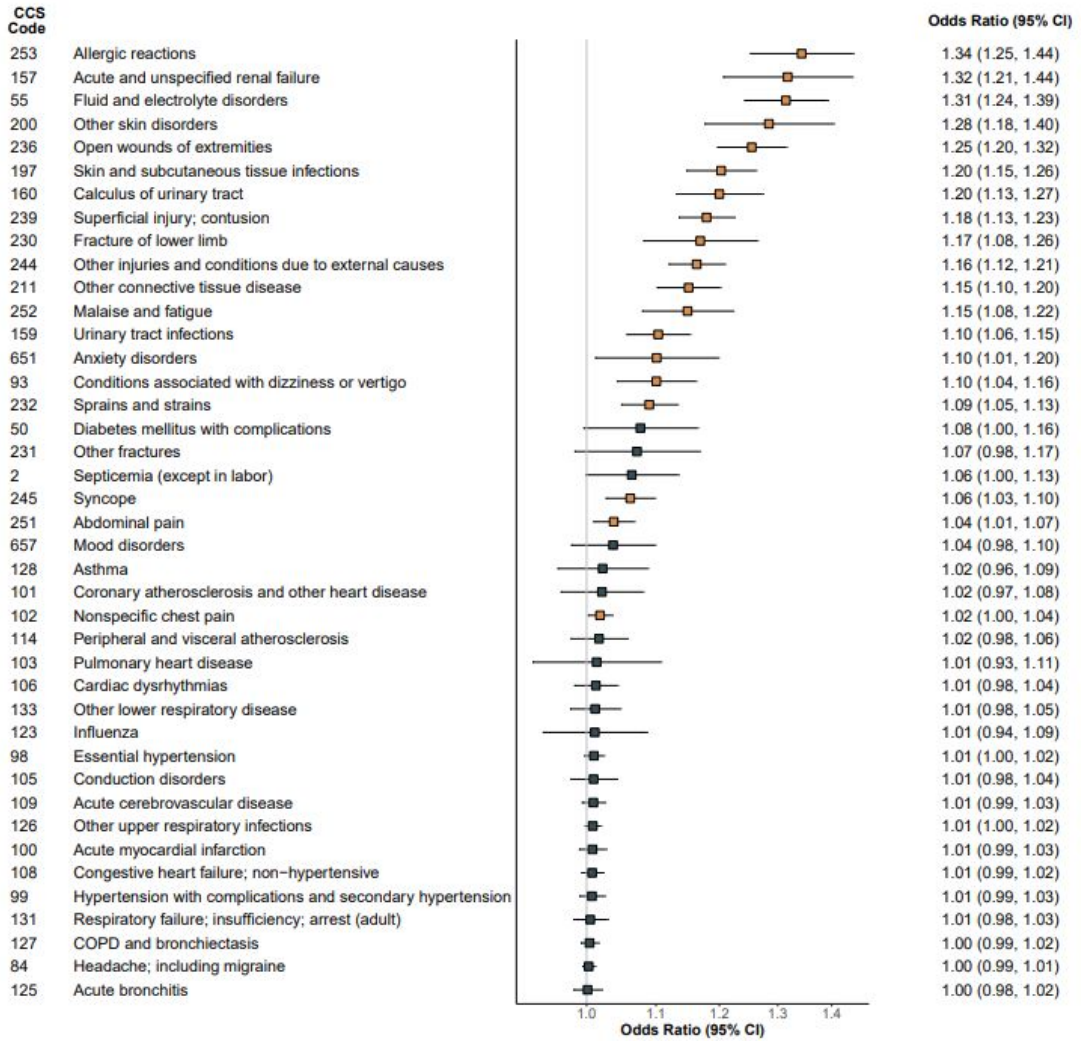
Sun et al. *BMJ* 2021.

Heat poses a health risk to everyone, regardless of age, sex, location, or insurance status

Characteristics	No (%) of ED visits	Excess relative risk (%)	P value	Excess absolute risk (No/100 000 people at risk/day)	P value
Age (years):					
18-24	2 102 380 (9.6)	9.5 (8.0 to 11.0)		8.5 (7.3 to 9.7)	
25-34	2 904 132 (13.2)	9.9 (8.6 to 11.1)		10.2 (9.0 to 11.4)	
35-44	2 906 914 (13.2)	7.4 (6.2 to 8.6)		6.9 (5.8 to 7.9)	
45-54	3 183 433 (14.5)	10.3 (9.1 to 11.5)	<0.001	9.0 (8.0 to 9.9)	<0.001
55-64	3 276 096 (14.9)	8.8 (7.6 to 10.0)		8.0 (7.0 to 9.0)	
65-74	3 228 092 (14.7)	7.6 (6.4 to 8.7)		7.6 (6.5 to 8.8)	
≥75	4 395 623 (20.0)	3.6 (2.7 to 4.6)		4.5 (3.3 to 5.7)	
Sex:					
Men	9 314 254 (42.4)	9.5 (8.8 to 10.2)	<0.001	9.6 (8.9 to 10.2)	<0.001
Women	12 678 437 (57.6)	6.5 (5.9 to 7.1)		7.4 (6.8 to 8.0)	
Low income status*:					
Yes	3 111 751 (41.0)	5.6 (4.6 to 6.6)	0.53	12.6 (10.2 to 14.9)	<0.001
No	4 476 250 (59.0)	6.1 (4.9 to 7.3)		6.0 (5.0 to 7.0)	

Sun et al. *BMJ* 2021.

Heat is associated with ED visits for a wide range of causes



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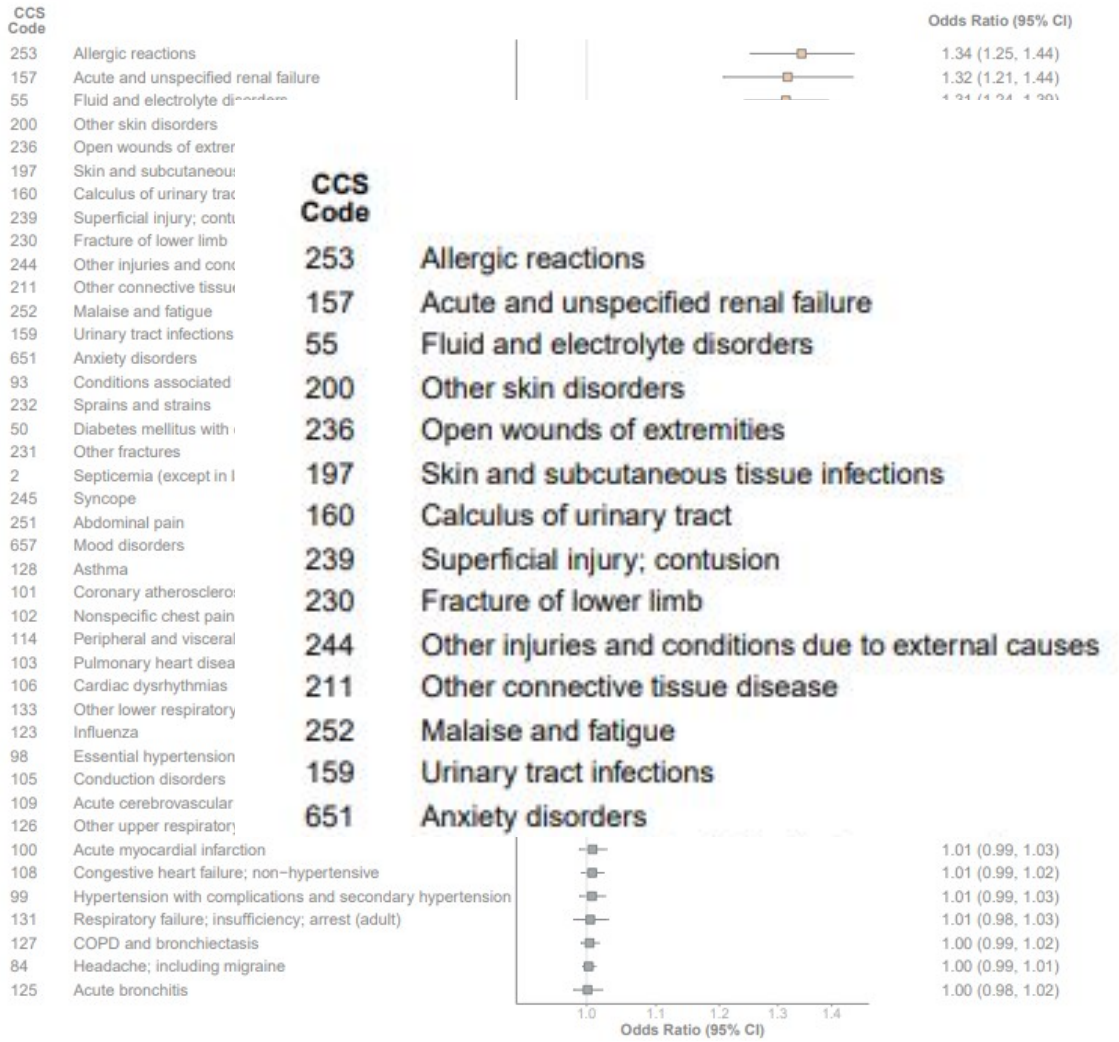
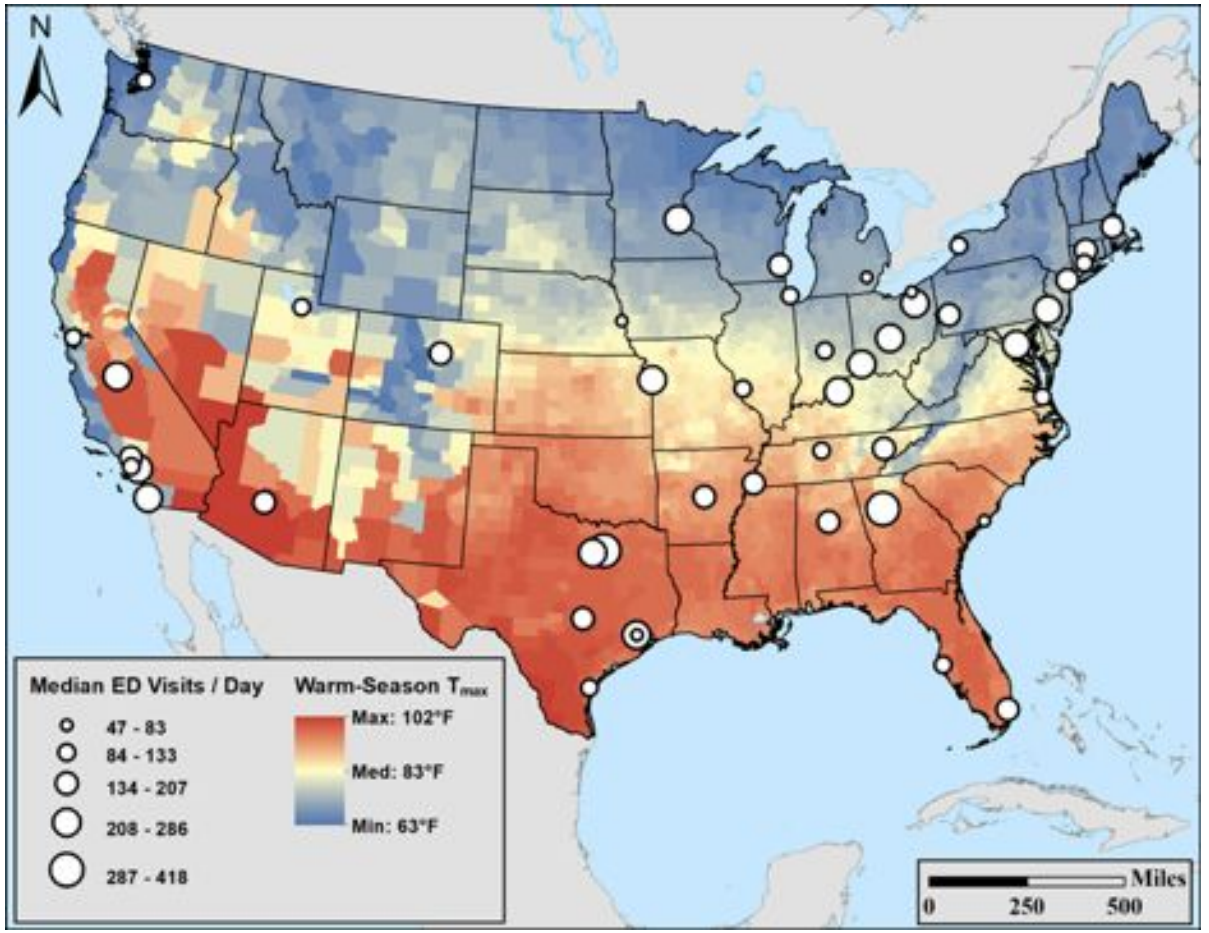


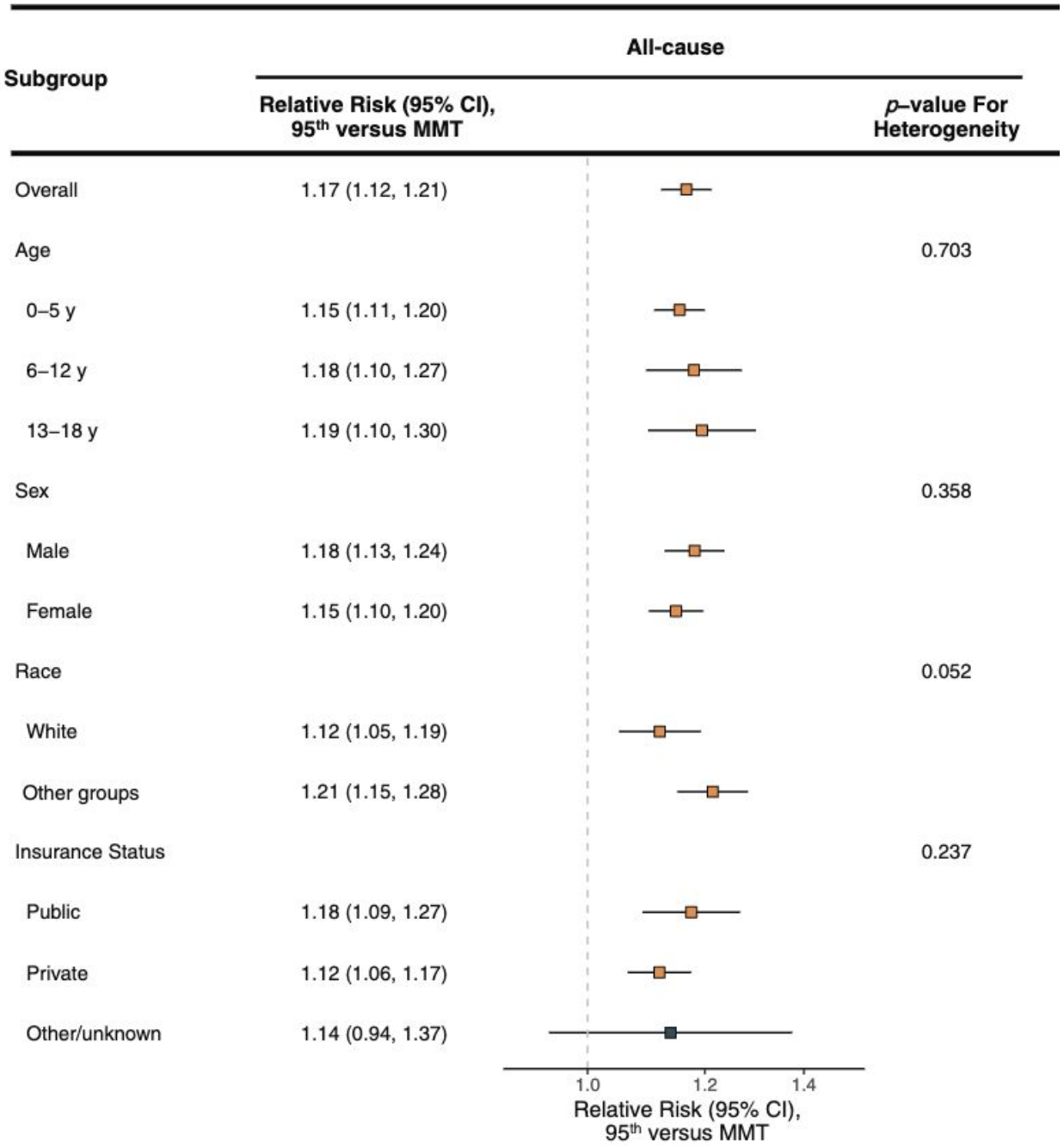
Heat and Emergency Department Visits to US Children's Hospitals

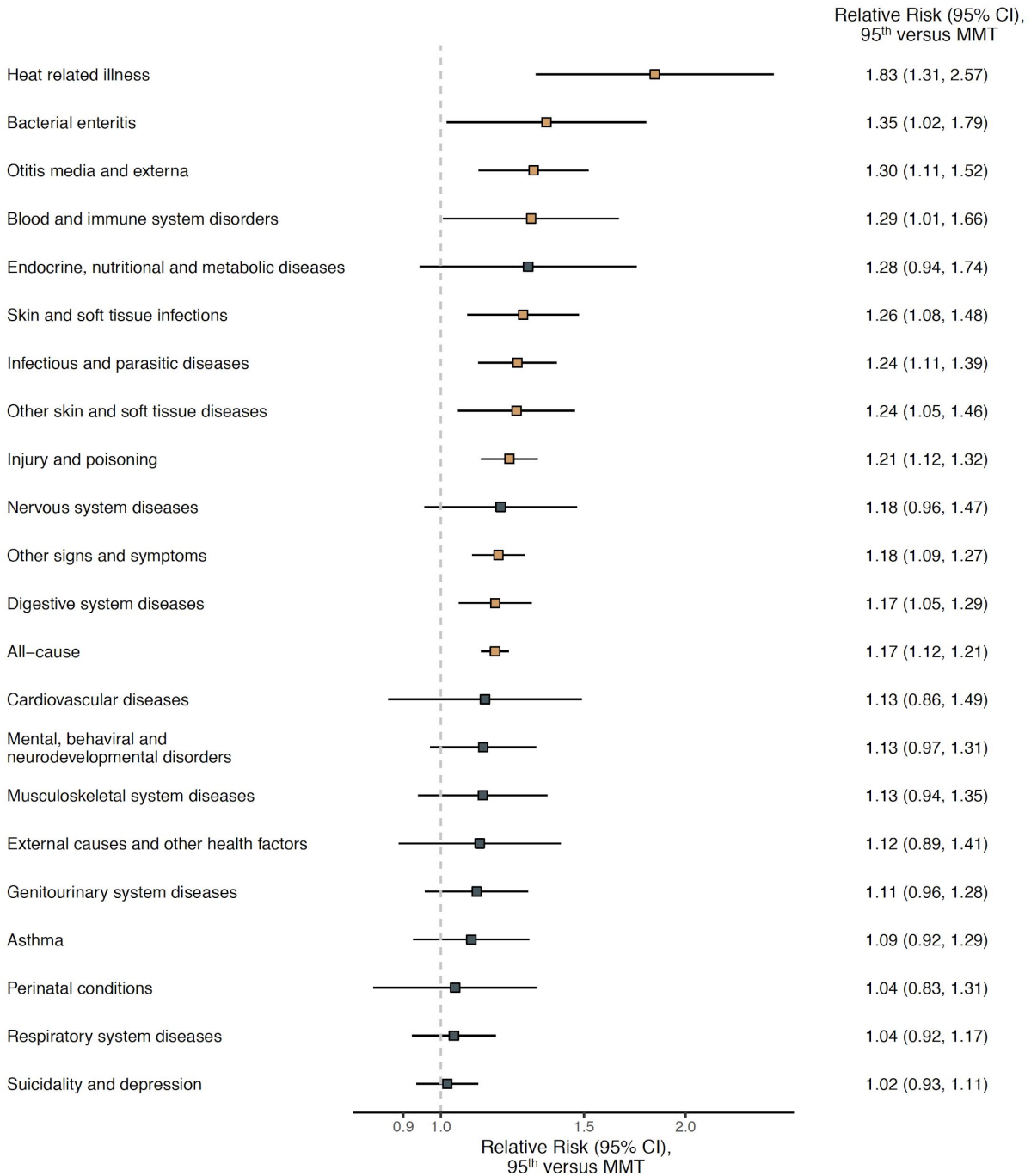
- Multi-center time-series study
- 3.8 million ED visits by children and adolescents
- 47 US children's hospitals
- May to September, 2016 to 2018



Bernstein et al. *EHP* 2022.

Heat poses a health risk to kids, regardless of age, sex, race, or insurance status





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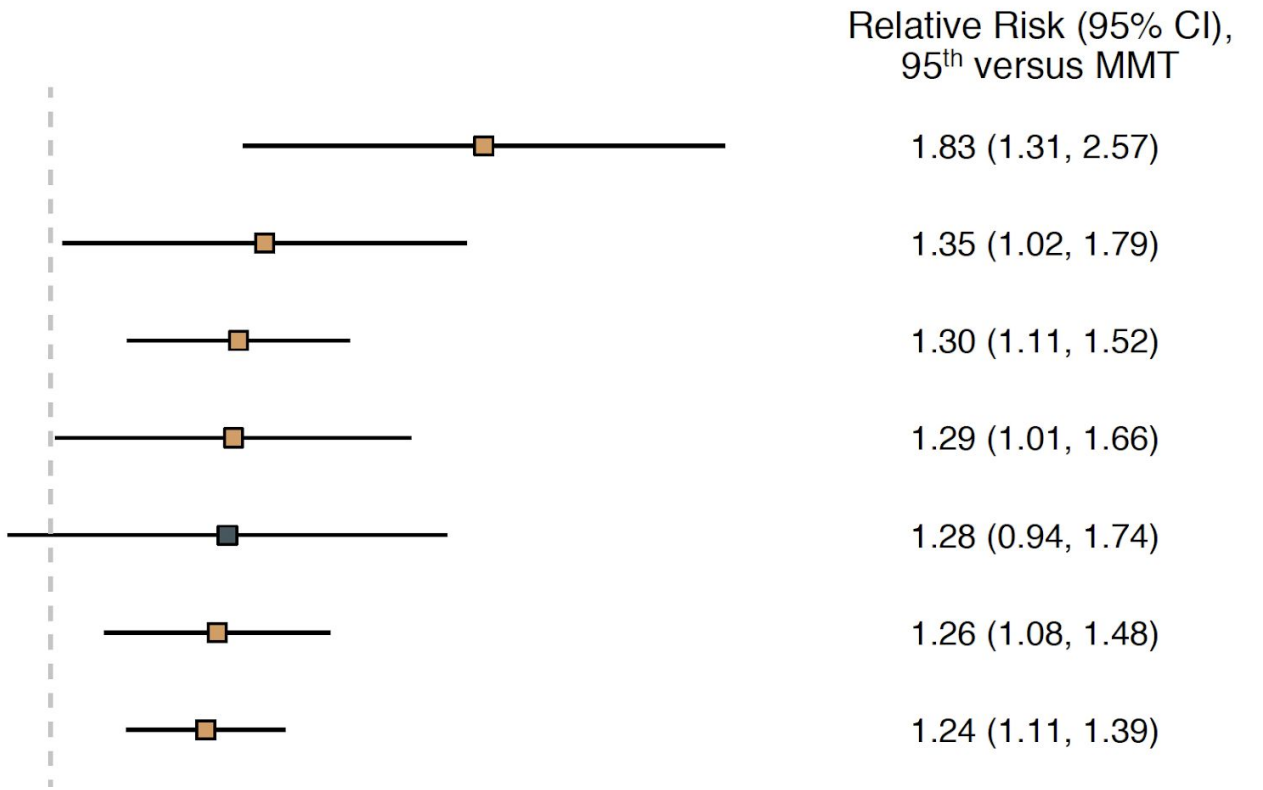
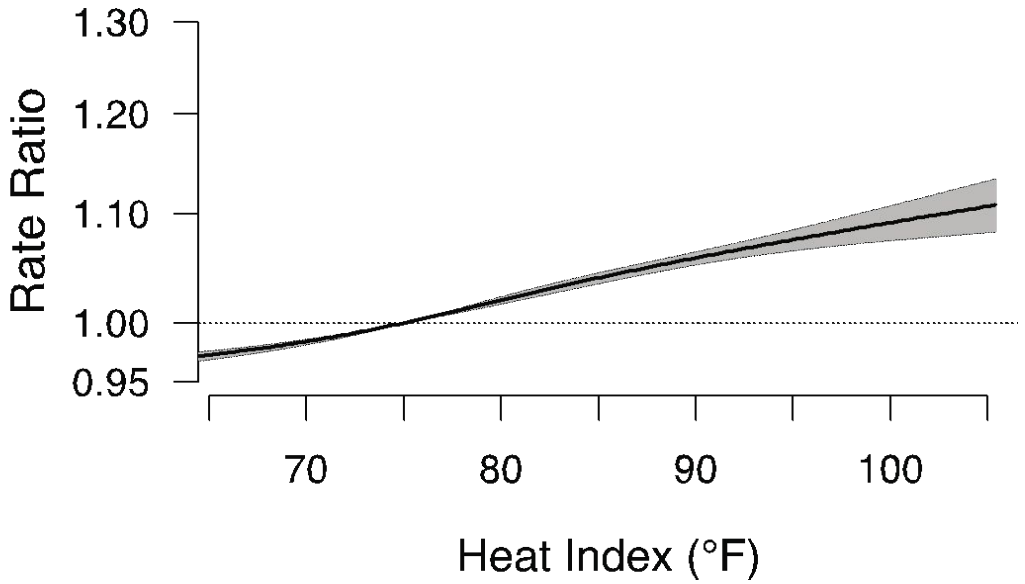


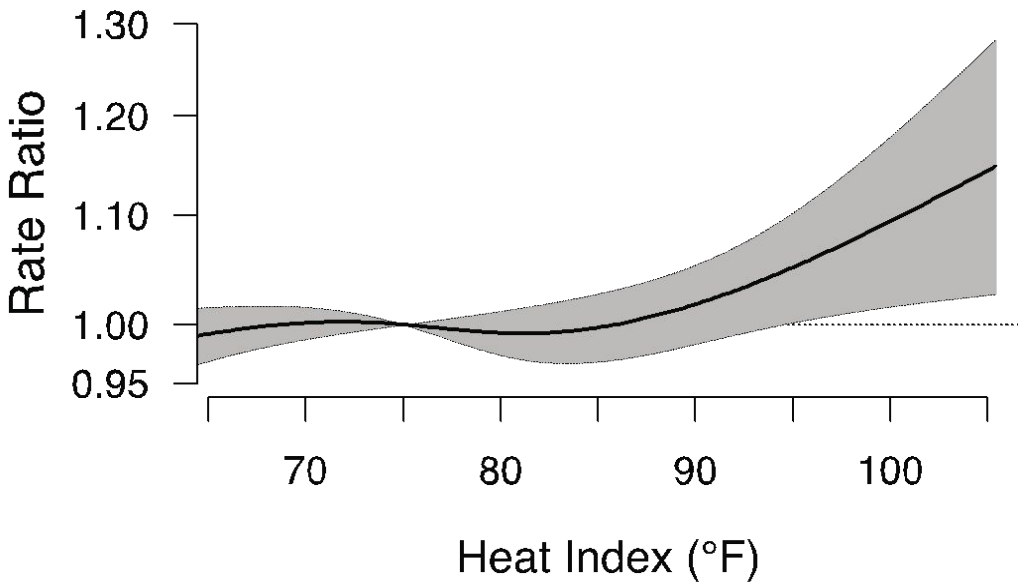
Bernstein et al. *EHP* 2022.

Heat-Related Morbidity and Mortality in 15 New England Towns

Emergency Department Admissions



Deaths



Wellenius et al. *Environ Res.* 2017

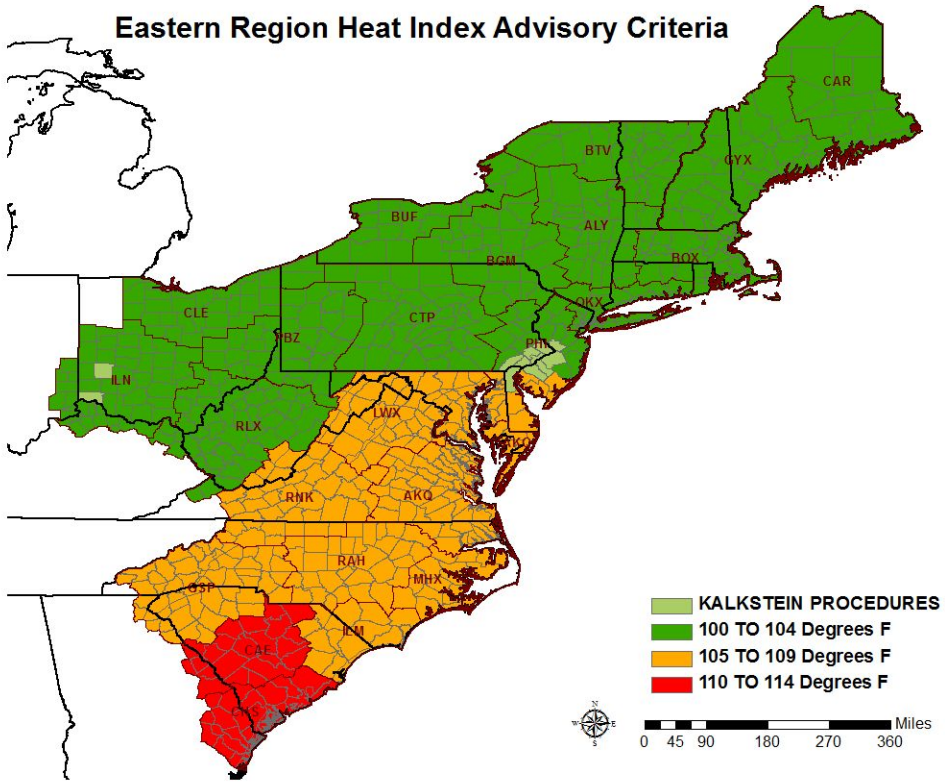
Average annual excess ED visits and deaths attributable to all days at or above each maximum daily heat index.

Maximum Daily Heat Index (°F)	All-Cause ED Visits		All-Cause Deaths	
	Same Day (Lag 0)	Cumulative Effect over Next 7 days (Lag 0-7 days)	Same Day (Lag 0)	Cumulative Effect over Next 7 days (Lag 0-7 days)
75	3,346 (2,905, 3,786)	7,191 (6,387, 7,965)	93 (9, 177)	24 (-76, 120)
80	2,908 (2,514,3,304)	6,524 (5,818, 7,224)	84 (8, 160)	29 (-58, 113)
85	1,675 (1,407,1,937)	4,293 (3,833, 4,746)	44 (7, 107)	39 (-19, 95)
90	694 (539,849)	2127 (1863, 2391)	26 (2, 64)	36 (0.3, 70)
95	197 (127,268)	784 (658, 908)	12 (-1, 30)	22 (3, 39)
100	39 (16, 62)	232 (187, 277)	4 (-1, 9)	8 (2, 14)

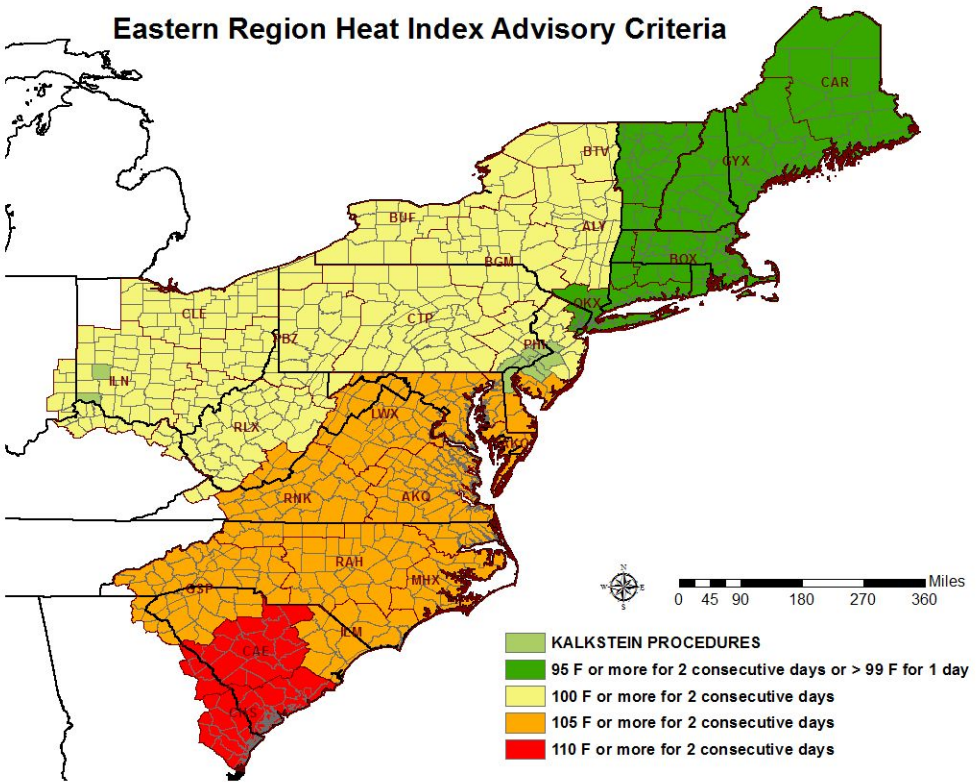
Wellenius et al. *Environ Res.* 2017

Towards Evidence-Based Policy

Summer 2016



Summer 2017



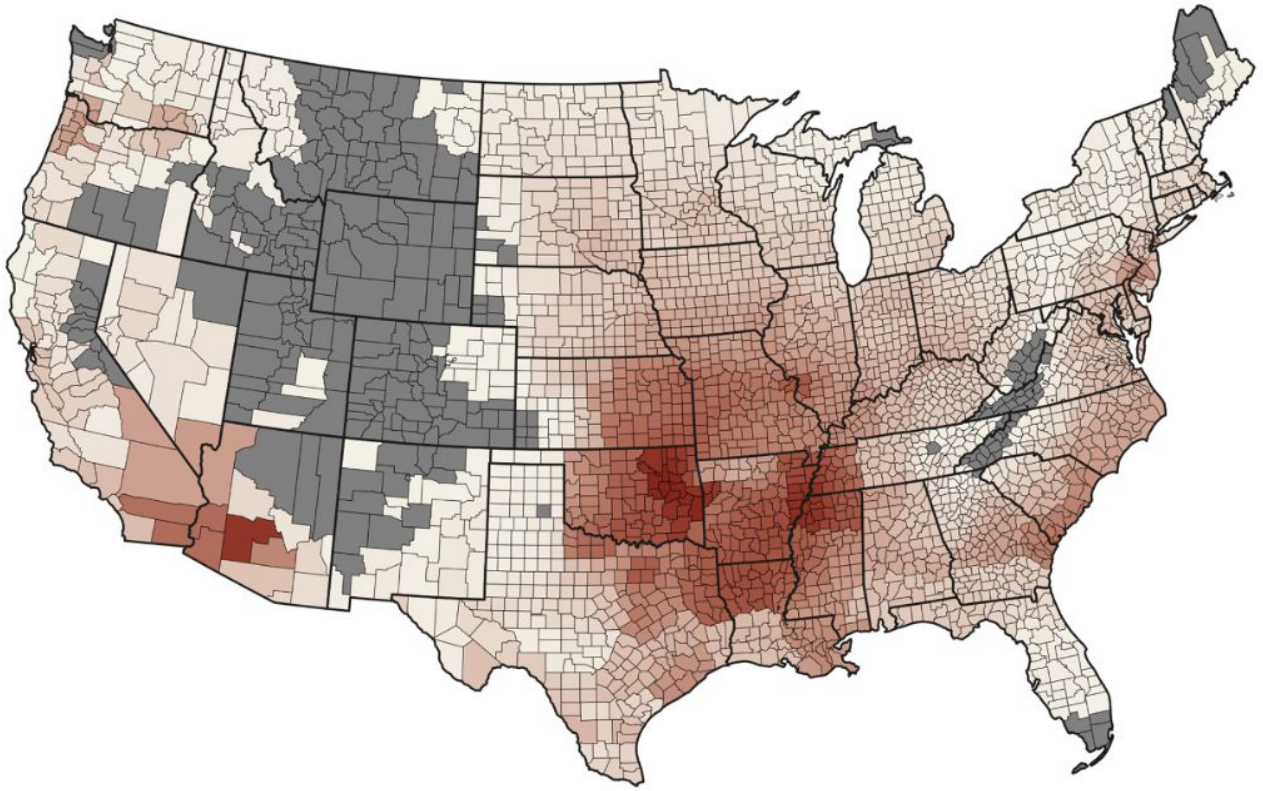
Are NWS Heat Warnings Effective?

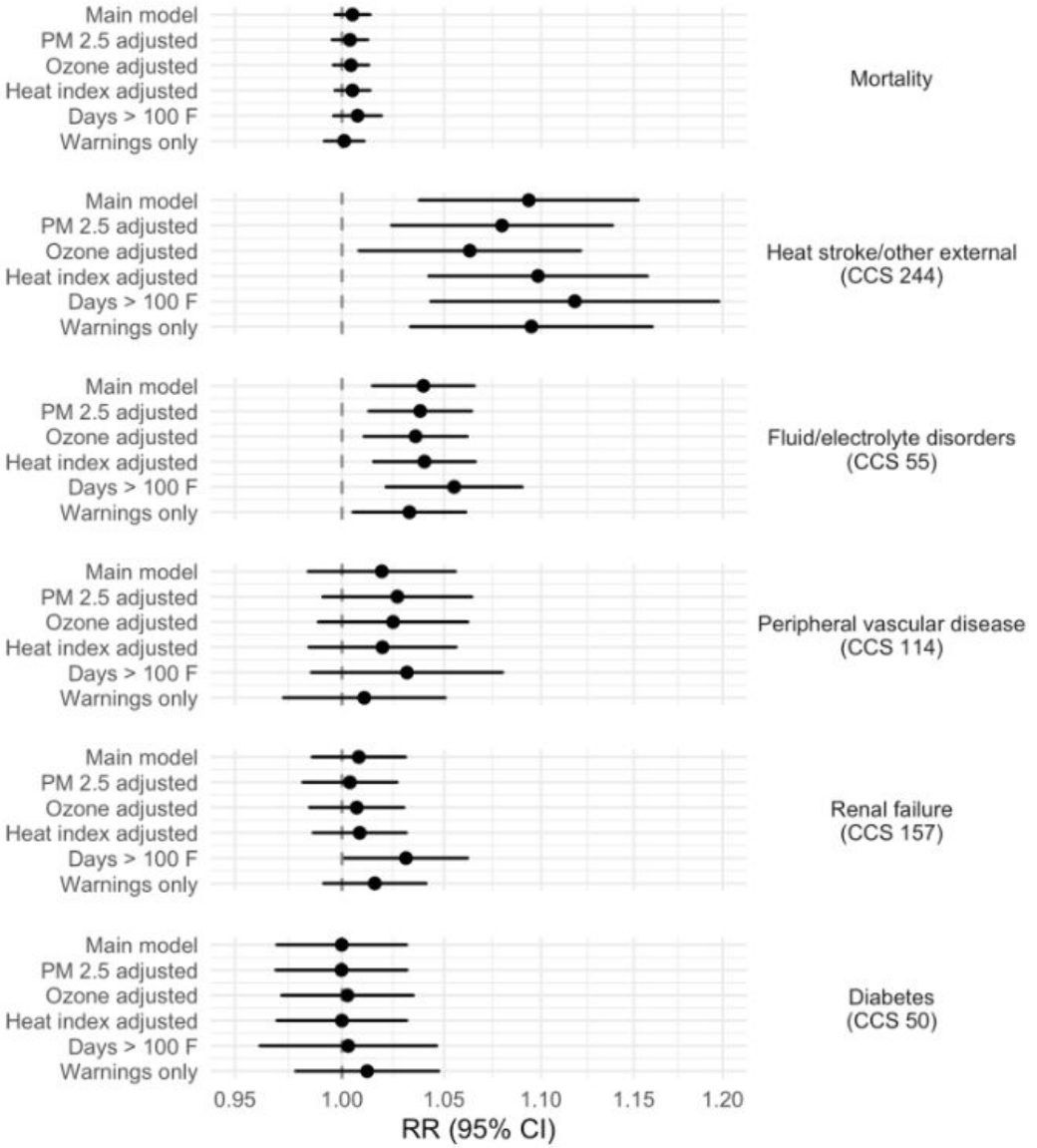
- Local health departments are initiating conversations with NWS about lowering the thresholds used for issuing heat warnings
- Assumes issuing heat advisories/warnings reduces heat-related morbidity and mortality
- Few studies have evaluated this question

Are NWS Heat Warnings Effective?

- Heat warnings are issued based on forecast heat index (HI),
  - But forecasts can be wrong
  - Heat warnings are issued by people
- Examine a set of days with similar HI, with and without heat warnings
- On days of similar HI, is the rate of death lower if a heat warning is issued?

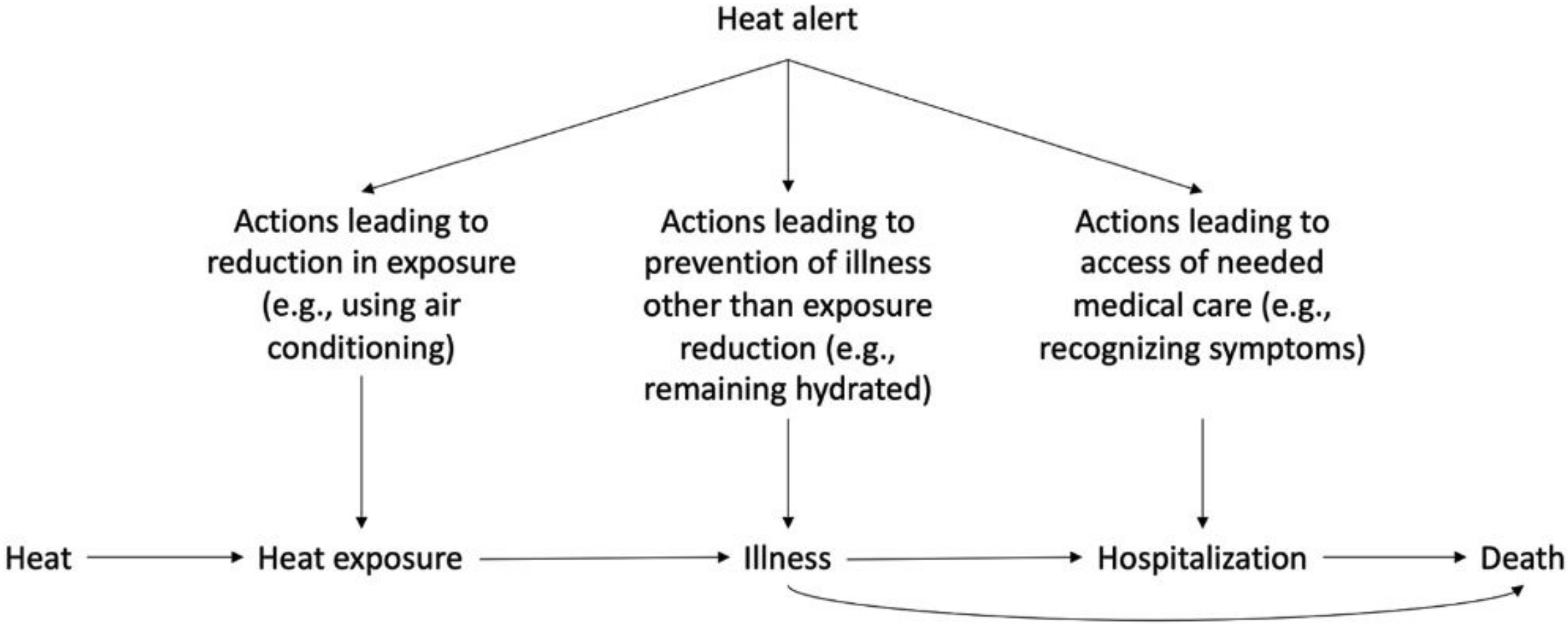
Are NWS Heat Warnings Effective?





Weinberger et al. *Environ Int.* 2021

Conceptual Model



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Heat Health Impacts - Big Picture

- Days of extreme heat linked to more deaths, emergency room visits → significant public health problem
- Even days of moderate temperature can pose risk
- Everyone is at risk, but risks are inequitably distributed
- Much research on the problem, no easy solutions

Team Work!

- Shenghzi Sun
- Amruta Nori-Sarma
- Jennifer Stowell
- Keith Spangler
- Quinn Adams
- Anthony Sun
- Kate Weinberger
- Chad Milando

- U. of British Columbia
- Harvard University
- University of Michigan
- University of Washington
- Brown University
- OptumLabs
- Funding: NIH, Wellcome Trust, RWJF, Google