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

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Climate change is caused by human activity


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https://scripps.ucsd.edu/programs/keelingcurve/
Our climate has already changed

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
DAYS ABOVE 95°

31.8 MORE DAYS

1970

HOUSTON

2018

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

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

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

Washington

MORE DEATHS PER WEEK THAN WOULD BE TYPICAL

Coronavirus epidemic begins

Winter Covid surge

FEWER DEATHS THAN TYPICAL

High Temperatures

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
Extreme Temperatures and Risk of Death

Extreme Temperatures and Risk of Death

Figure 1: Overall cumulative exposure-response associations in 13 cities
Exposure-response associations as best linear unbiased prediction (BLUP) empirical (2 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. HR=relative risk.
>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

Heat and Emergency Department Visits Among Insured Individuals

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

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

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

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>All-cause</th>
<th>Relative Risk (95% CI), 95th versus MMT</th>
<th>p-value For Heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td>1.17 (1.12, 1.21)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>0.703</td>
<td></td>
</tr>
<tr>
<td>0–5 y</td>
<td></td>
<td>1.15 (1.11, 1.20)</td>
<td></td>
</tr>
<tr>
<td>6–12 y</td>
<td></td>
<td>1.18 (1.10, 1.27)</td>
<td></td>
</tr>
<tr>
<td>13–18 y</td>
<td></td>
<td>1.19 (1.10, 1.30)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td>0.356</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>1.18 (1.13, 1.24)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>1.15 (1.10, 1.20)</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td>0.052</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td></td>
<td>1.12 (1.05, 1.19)</td>
<td></td>
</tr>
<tr>
<td>Other groups</td>
<td></td>
<td>1.21 (1.15, 1.28)</td>
<td></td>
</tr>
<tr>
<td>Insurance Status</td>
<td></td>
<td>0.237</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td>1.18 (1.09, 1.27)</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td>1.12 (1.06, 1.17)</td>
<td></td>
</tr>
<tr>
<td>Other/unknown</td>
<td></td>
<td>1.14 (0.94, 1.37)</td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Maximum Daily Heat Index (°F)</th>
<th>All-Cause ED Visits</th>
<th>All-Cause Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Same Day (Lag 0)</td>
<td>Cumulative Effect over Next 7 days (Lag 0-7 days)</td>
</tr>
<tr>
<td>75</td>
<td>3,346 (2,905, 3,786)</td>
<td>7,191 (6,387, 7,965)</td>
</tr>
<tr>
<td>80</td>
<td>2,908 (2,514,3,304)</td>
<td>6,524 (5,818, 7,224)</td>
</tr>
<tr>
<td>85</td>
<td>1,675 (1,407,1,937)</td>
<td>4,293 (3,833, 4,746)</td>
</tr>
<tr>
<td>90</td>
<td>694 (539,849)</td>
<td>2127 (1863, 2391)</td>
</tr>
<tr>
<td>95</td>
<td>197 (127,268)</td>
<td>784 (658, 908)</td>
</tr>
<tr>
<td>100</td>
<td>39 (16, 62)</td>
<td>232 (187, 277)</td>
</tr>
</tbody>
</table>

Wellenius et al. Environ Res. 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?
Conceptual Model

Heat alert

- Actions leading to reduction in exposure (e.g., using air conditioning)
- Actions leading to prevention of illness other than exposure reduction (e.g., remaining hydrated)
- Actions leading to access of needed medical care (e.g., recognizing symptoms)

Heat → Heat exposure → Illness → Hospitalization → Death

Weinberger et al. Environ Int. 2021
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 Milano

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- University of Michigan
- University of Washington
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