Public Health Impacts of Climate Change: Regional Health Vulnerabilities to Heat, Air Pollution, and Pollen

Perry Sheffield, MD, MPH
Assistant Professor, Pediatrics and Preventive Medicine
Mount Sinai School of Medicine
Deputy Director, Pediatric Environmental Health Specialty Unit for EPA Region 2

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With acknowledgements to Dr. Pat Kinney
Pathways by Which Climate Change May Affect Human Health

IPCC 2007
# Health Effects of Climate Change - Direct

<table>
<thead>
<tr>
<th>Climate Impacts</th>
<th>Direct Health Effects</th>
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<tbody>
<tr>
<td>More intense and frequent Heat Waves</td>
<td>Heat stress, cardiovascular disease</td>
</tr>
<tr>
<td>Stagnant Air Masses, Air Pollution</td>
<td>Asthma, respiratory illness, cardiovascular disease</td>
</tr>
<tr>
<td>More Frequent Heavy Rainfall Events</td>
<td>Drowning, direct injury</td>
</tr>
</tbody>
</table>
Health Effects of Climate Change - Indirect

**Climate Impacts**

- Effects on key ecosystem parameters
- Heavy precipitation events will become more frequent
- Increase in areas affected by drought

**Indirect Health Effects**

- Impacts on vector-borne and zoonotic disease
- Water-borne diseases, harmful algal blooms,
- Changes in food sources, malnutrition, forced migration
What is Needed to Fill the Knowledge Gap

- Expanded surveillance systems to track key indicators of climate-relevant exposures, vulnerabilities, and health responses
- Expanded empirical research to better understand climate-health mechanisms, including vulnerability factors
- Expanded research to project future health impacts under climate change and vulnerability scenarios
Deadly Paris Heatwave 2003

Adapted from: Vandentorren et al., AJPH 2004;94:1518-1520.
Temperature Extremes and Health: Impacts of Climate Variability and Change in the United States

Marie S. O’Neill, PhD
Kristie L. Ebi, PhD, MPH

Exposures to temperature extremes have been associated with both mortality and morbidity. At the population level, the distribution and magnitude of these health impacts depend on intrinsic factors, including population and regional vulnerabilities, social and cultural context, and Other determinants of climate change on temperature and health, including the factors that will affect temperature-related morbidity and mortality.

Objective: We evaluated temperature-related morbidity and mortality for the 2007 U.S. national assessment of impacts of climate change and variability on human health.

Methods: We assessed literature published since the 2000 national assessment, evaluating epidemiologic studies.
Vulnerability factors (O’Neill & Ebi, JOEM 2009)

1. **Underlying medical conditions**
   - Heart and lung diseases, e.g.

2. **Demographics**
   - Race, age, education

3. **Housing**
   - Top floor apartments, air conditioning

4. **Community geography**
   - Heat island, vegetation density
Ground-level ozone formation is sensitive to temperature, sunlight, and other climate factors, as well as local pollution precursor emissions.

Ozone formation:

Oxygen ($O_2$) + Volatile Organic Compounds (VOC) + Nitrogen Oxides (NOx) → Ozone ($O_3$)

Downscaling climate and air quality projections to regional scales

Can we project future health impacts at policy-relevant spatial scales?

400x500 km grid from global-scale model

36x36 km grid from regional-scale model
Figure 2. (a) Summertime average daily maximum 8-hour O$_3$ concentrations for the 1990s and changes in summertime average daily maximum 8-hour O$_3$ concentrations for the (b) 2020s, (c) 2050s, and (d) 2080s A2 scenario simulations relative to the 1990s, in parts per billion. Five consecutive summer seasons were simulated in each decade.
Modeled changes in:
Mean 1-hr max O3 (ppb)  O3-related deaths (%)
% change in O3-related asthma ED visits (2020s A2 vs 1990s) for children aged 0–17 years in 14 metropolitan NYC counties

Sheffield et al., AJPM, 2011.
Percent increases in summer daily 1-hr max O3 in 50 large cities

Fig. 1 Increase in summertime daily 1-hr maximum ozone concentrations (from 1990s to 2050s)

Bell et al, Climatic Change, 2007
Upper tail of ozone concentration distribution is more sensitive to climate

Frequency distribution of the simulated daily ozone maxima averaged over southern Germany during summer (June-August) for the years 1991-2000 and 2031-2039. Right side: zoom of the high-ozone portion of the curve. Forkel and Knoche 2006.
Climate, Pollen and Asthma: possible mechanisms

From: Beggs and Bambrick, EHP 2005
Start Date of Birch Pollen Season in Brussels 1970-2006 Days after Jan 1 (5-year running means)

Emberlin et al., Int J Biomet, 2002
Warming by latitude and increased length of ragweed pollen season in central North America

<table>
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<tbody>
<tr>
<td>Georgetown, TX</td>
<td>30.63°N</td>
<td>17</td>
<td>198 ± 7</td>
<td>320 ± 7</td>
<td>195 ± 7</td>
<td>313 ± 7</td>
<td>-4 d</td>
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<td>Oklahoma City, OK</td>
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<td>19</td>
<td>212 ± 7</td>
<td>300 ± 10</td>
<td>227 ± 9</td>
<td>316 ± 15</td>
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<td>Rogers, AR</td>
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<td>15</td>
<td>231 ± 7</td>
<td>295 ± 8</td>
<td>227 ± 6</td>
<td>296 ± 8</td>
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<td>Papillion, NE</td>
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<td>21</td>
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<td>281 ± 6</td>
<td>208 ± 4</td>
<td>288 ± 10</td>
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<td>Madison, WI</td>
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<td>27</td>
<td>208 ± 2</td>
<td>272 ± 4</td>
<td>205 ± 3</td>
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<td>LaCrosse, WI</td>
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<td>271 ± 3</td>
<td>205 ± 5</td>
<td>276 ± 5</td>
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<td>Minneapolis, MN</td>
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<td>270 ± 6</td>
<td>206 ± 7</td>
<td>284 ± 7</td>
<td>+16 d*</td>
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<tr>
<td>Fargo, ND</td>
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<td>15</td>
<td>216 ± 4</td>
<td>252 ± 8</td>
<td>217 ± 4</td>
<td>269 ± 8</td>
<td>+16 d*</td>
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<tr>
<td>Winnipeg, MB, Canada</td>
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<td>16</td>
<td>207 ± 7</td>
<td>264 ± 6</td>
<td>197 ± 7</td>
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<td>+25 d*</td>
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<td>Saskatoon, SK, Canada</td>
<td>52.07°N</td>
<td>16</td>
<td>206 ± 12</td>
<td>250 ± 6</td>
<td>197 ± 13</td>
<td>268 ± 7</td>
<td>+27 d*</td>
</tr>
</tbody>
</table>

Ziska et al. 2011. PNAS.
Ragweed allergen production increases as a function of CO$_2$ concentration.

Key Take-Home Messages

- Health effects from heat, air pollution, and pollen are more challenging to address as climate changes in the U.S.
- Along with climate change, vulnerability factors will be key in determining health impacts.
- Empirical research is beginning to reveal links between climate and adverse health outcomes.
- Scenario-based modeling will play an important role in regional adaptation planning.