Preventing heat-related deaths: what we know, what we can do

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(BC Centre for Disease Control)
OVERVIEW

1. Epidemiology of heat-related mortality
2. Approaches for assessing susceptibilities to heat-health effects
3. Measures to increase individual and population resilience to the effects of heat.
Figure 15. A police report notes the conditions of a decedent's apartment: "suspicious odor," "unopened mail," "extremely hot," "windows were shut."
Heat wave (prolonged period of excessively hot weather; no universal definition of a heat wave: the term is relative to the usual weather in the area) **Chicago, 1995:** refrigerator trucks by city morgue

Klinenberg, 2003
Heat wave-related deaths in Chicago during July 1995

Semenza, NEJM 1996
Minimum and maximum temperatures, vs. daily excess mortality: France 2003

Fouillet, 2006
Excess deaths by age and “number of hot days”:
France, August, 2003

<table>
<thead>
<tr>
<th>Number of Days Exceeding 30 Year Average by 5° - T Min 9° - T Max</th>
<th>&lt; 55 Years</th>
<th>55 - 74</th>
<th>≥ 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>55</td>
<td>1.1</td>
<td>201</td>
</tr>
<tr>
<td>2 - 3</td>
<td>125</td>
<td>1.2</td>
<td>316</td>
</tr>
<tr>
<td>4 - 7</td>
<td>265</td>
<td>1.3</td>
<td>694</td>
</tr>
<tr>
<td>≥ 8</td>
<td>260</td>
<td>1.3</td>
<td>1078</td>
</tr>
</tbody>
</table>

P<0.05
Excess Deaths by Medical Cause: France, August 2003

<table>
<thead>
<tr>
<th>Cause</th>
<th>Obs-Exp</th>
<th>Obs/ Exp</th>
<th>[95% CI ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehydration</td>
<td>1628</td>
<td>11.9</td>
<td>[11 - 13]</td>
</tr>
<tr>
<td>Heatstroke</td>
<td>1313</td>
<td>165.1</td>
<td>[100 - 270]</td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>365</td>
<td>82.1</td>
<td>[42 - 159]</td>
</tr>
<tr>
<td>Circulatory System</td>
<td>3064</td>
<td>1.4</td>
<td>[1.4 - 1.4]</td>
</tr>
<tr>
<td>Respiratory System</td>
<td>1365</td>
<td>1.9</td>
<td>[1.8 - 2.0]</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>933</td>
<td>1.1</td>
<td>[1.1 - 1.1]</td>
</tr>
<tr>
<td>Nervous System</td>
<td>1001</td>
<td>2</td>
<td>[1.9 - 2.1]</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>748</td>
<td>1.8</td>
<td>[1.7 - 1.9]</td>
</tr>
<tr>
<td>Pregnancy, Childbirth</td>
<td>-4</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
## Excess Deaths by Place of Death, Marital Status:
France, August 2003

Fouillet, 2006

<table>
<thead>
<tr>
<th>Place of Death</th>
<th>&lt; 55 Years</th>
<th>55 - 74</th>
<th>≥ 75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>343</td>
<td>1.2</td>
<td>951</td>
</tr>
<tr>
<td>Institution</td>
<td>2</td>
<td>1.2</td>
<td>190</td>
</tr>
<tr>
<td>Hospital</td>
<td>239</td>
<td>1.1</td>
<td>1038</td>
</tr>
<tr>
<td>Street</td>
<td>29</td>
<td>1.1</td>
<td>9</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>434</td>
<td>1.3</td>
<td>645</td>
</tr>
<tr>
<td>Divorced</td>
<td>124</td>
<td>1.2</td>
<td>358</td>
</tr>
<tr>
<td>Widowed</td>
<td>24</td>
<td>1.4</td>
<td>486</td>
</tr>
<tr>
<td>Married</td>
<td>211</td>
<td>1.2</td>
<td>834</td>
</tr>
</tbody>
</table>

p < 0.05
Italy, 2003: the heat wave affected both city and country

Comparing (June, July, Aug 2003 to June, July, Aug 2002):

In 21 provincial capitals:

\[23698 - 20564 = 3134\] (13.2\%) excess deaths

(Conti, 2004)

All Italy:

\[145898 - 130139 = 15759\] (10.8\%) excess deaths

(ISTAT, 2006)
Heat wave impact: would they have died shortly anyway?  

*a small percentage*  

Kalkstein

Fig. 5. Daily summer mortality around a New York heat wave, 1966. *Solid shading* shows mortality during the heat wave; *stippling* shows mortality in the immediately following period.
Daily mortality vs. temperature, outside of heat waves (typical European City)
Summer Deaths vs. 4-Day Apparent Tmax, *Stockholm and Helsinki*, 1990-2000

Baccini, 2007
Relative Risk of Death for Fraser Health Authority
Associated with Temperatures at Abbotsford Airport, 1986-2008

- All-cause, all-age mortality
- Confidence limits
Influence of day during summer on the effect (% increase) of temperature on overall mortality

Baccini, 2007
Heat-related mortality is associated with variability of summer temperatures (12 US cities)

Braga, 2001
Lagged deaths to 30 days (illustrating displaced mortality of up to 60%), all ages (coefficient=\% excess per above-threshold °C)

Baccini, 2007
North/South temperature vs. mortality response gradient

Keatinge, 2003

Fig. 1. Mortality at different mean daily temperatures. Pooled data for each region at age 55+, 1971–1997. The areas of circles are proportional to the number of days at each temperature.
Average annual rate of heat-related deaths/million in the US from «excess heat» by age group, 1979–1997

*Underlying cause of death attributed to excess heat exposure classified according to ICD-9 code E900.0 “due to weather conditions (deaths”).

Source: Centers for Disease Control and Prevention (2002).
Risk factors for hot day death: four Italian cities

Stofaggia, 2006
Of what do people die in the heat?

« Among all deaths at 33+ degrees C (in Kyushu), the proportion from « excessive heat» never exceeded 0.4%. This suggests that heat stroke is not a major contributor. »

Honda Y, Ono M, Sasaki A, Uchiyama I, 1995
Urban micro-climates in Montréal

- Importance de considérer ce qui est à proximité de l’îlot de chaleur urbain. Le milieu environnement influence directement le comportement thermique des secteurs.
  Exemple:
  2 secteurs de densité résidentielle moyenne, situés tous deux dans Mercier/Hochelaga-Maisonneuve, cumulent des températures très différentes (35°C et 29°C). Le secteur le plus chaud est à proximité d’une zone industrielle (Emballages Paperboard inc.) alors que le plus frais côtoie une zone de verdure.
Satellite imagery-based heat capture index, Montreal  (more orange means hotter)
Acute mortality risks in hot versus cool Montreal neighbourhoods, 1990-2003**

**Smargiassi et al., Epi and Comm Health
However, heat-related deaths are not only a city problem (Rajpal, Wisc Med J 2000)

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Rate (per 100,000)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20-44</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45-64</td>
<td>7</td>
<td>0.63</td>
</tr>
<tr>
<td>65-84</td>
<td>13</td>
<td>2.20</td>
</tr>
<tr>
<td>&gt;85</td>
<td>1</td>
<td>1.10</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14</td>
<td>0.54</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>0.26</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>19</td>
<td>0.37</td>
</tr>
<tr>
<td>Black</td>
<td>2</td>
<td>0.69</td>
</tr>
<tr>
<td>County</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milwaukee</td>
<td>11</td>
<td>1.15</td>
</tr>
<tr>
<td>Other Counties</td>
<td>10</td>
<td>0.71</td>
</tr>
<tr>
<td>TOTAL</td>
<td>21</td>
<td>0.40</td>
</tr>
</tbody>
</table>

¹Rates for numbers less than 20 are unreliable.
²Includes: Calumet, Crawford, Dane, Fond du Lac, Manitowoc, Racine, Waukesha, Winnebago and Wood Counties
Indoor temperature on the first floor (Ta 1st floor) and third floor (Ta 3rd floor) of a building compared with the outdoor temperature (Ta DWD) in Freiburg, Germany.

Source: Andreas Matzarakis, Meteorologisches Institut, Universität Freiburg, Freiburg, Germany, personal communication, 2003.
Identifying susceptibilities, preventing deaths
Levels of heat-health prevention

• Rapid treatment
• Hot day messaging/protective response
• Identification of susceptibilities / pre-heat wave adaptation
• Increase in personal and social resilience
• Urban adaptation
• Greenhouse gas reduction
Rapid treatment
Hot day messaging/protective responses
Organizing the response: the Haddon matrix and heat-wave related mortality

<table>
<thead>
<tr>
<th>Influencing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
</tbody>
</table>
| Pre-event | Cardiovascular disease  
Anti-cholinergic medications | Climate | Urban heat island  
Indoor heat retention | Forecast quality, confidence  
Social cohesion |
| Event | Awareness of over-heating  
Protective behaviour | Degree, duration of heat episode | Neighbourhood temperature  
Indoor temperature | Heat warning diffusion  
Working « buddy system » |
| Post-event | Physical reserves | Rapid cooling capacity | Emergency Network  
Rehabilitation services |  |
Identification of susceptibilities
1. potential for pre-heat wave adaptation

- risk of heat-related death occurs at lower temperatures among populations living in temperate regions where extreme heat is typically uncommon
- risk of heat-related death is higher in cities with greater temperature variability
- extreme heat episodes earlier in spring and summer typically extract a greater toll of heat-related deaths than late-summer heat waves of equal intensity
Range of thermal comfort

![Diagram showing the range of thermal comfort with adaptation points at 16°C and 30°C.](image_url)
Pertinent age-associated physiologic changes

- Lower cardiac contractility and lessened ability to redistribute blood to the skin
- Fewer and less efficient sweat glands
- Chronic dehydration
- *Plus lower temperature sensitivity, social isolation, disinclination to adopt protective behaviours*
Experimental evidence on acclimatization

- young male miners, athletes, and soldiers exposed to vigorous exercise in heated thermal chambers show improved heat stress responses (heart rate, core temperature, stroke volume) after a period of several days.
- A significant increase in plasma and interstitial volume, and a rise in total body water is observed by day 5, with a smaller but still significant increase in plasma volume and total body water by day 17.
- In thermal chamber experiments where subjects simulated an eight-hour-day’s work, over two weeks of random temperature exposure, older men showed a pattern of consistently higher core temperature, less sweat during work and more during rest, and indicators of increased cardiac strain.
Identification of susceptibilities
2. air conditioner ownership
Heat-related mortality, by US city, is associated with % air conditioner use

Braga, 2001
3. KAP Surveys: How do Montreal’s heart and lung patients cope with heat?

Tom Kosatsky¹, Lucie Richard², Annie Renouf¹, Julie Dufresne¹, Dave Stieb³, Nadia Giannetti⁴, Jean Bourbeau⁵

Montreal Public Health¹, Faculty of Nursing, University of Montreal², Air Pollution Effects Division, Health Canada³, Heart Failure and Heart Transplant Centre, Royal Victoria Hospital⁴, COPD Clinic and Pulmonary Rehabilitation Programme, Montreal Thoracic Institute⁵

Funded by: Climate Change Action Funds Contract, NR Canada A-575
Awareness of heat and its consequences

- Informed about weather daily
  - Yes: 80%
  - No: 20%

- Ever heard a heat advisory
  - Yes: 90%
  - No: 10%

- My doctor told me I am vulnerable to heat
  - Yes: 60%
  - No: 40%

- My doctor/pharmacist told me my meds make me vulnerable
  - Yes: 70%
  - No: 30%
Intention to buy a home air conditioner? (N=61)

- Non: 67%
- Oui: 33%
Importance of personal and social resilience (two adjoining neighbourhoods: Chicago 1995)

Klinenberg, 2003
Planning for prevention: adaptive measures and informational networks for heat-wave mitigation in urban areas (after Wilhelmi)

Pre-event

- Flyers
- Neighborhood meetings
- Risk communication
- Heat shelters
- Planting trees
- National Weather Service
- City Planners
- Unions
- Housing developers
- Internet
- Local TV & Radio
- Social Services
- Community heat education
- Community « buddy » system
- Forecasting
- Changing roof tops
- National Weather Service
Urban adaptation/GHG reduction
Let’s get with it!
Projection of CO$_2$ concentrations and of mean world temperature until 2100
Temperature (on the average over September during 10 years) of Kanto, Japan. - a case of Urban Heat Island -

Source: Data from Japan Meteorological Agency
http://www.data.jma.go.jp/
City heat, July 20, 2004, Tokyo
Changes in the probability of extreme weather events

Montreal: June 1994 heat wave with attendant mortality

![Graph showing temperature and daily deaths during June 1994 with peak mortality on June 18th]
Alone in his apartment during the 1995 Chicago heat wave
Preventing heat-related deaths: what we know, what we can do

1. Beyond heat waves, warmer temperatures overall are associated with above-expected levels of daily deaths.

2. Longer lasting high temperature episodes, and early summer events are most strongly associated with excess mortality.

3. Cities are heat sinks, and persons living in warmer urban areas and/or on upper floors without air cooling are at particularly high risk.

4. Age, pre-existing heart and psychiatric disease, living alone and social isolation, are risk factors for individuals.
Preventing heat-related deaths: what we know, what we can do

5. Identifying how local populations respond to heat, and targeting vulnerable places, people and practices are essential to the development of a heat-mortality prevention plan.

6. Among plan components are urban adaptation, increasing knowledge and awareness, augmenting social support and developing messages and programs to cool and hydrate the vulnerable.
Thanks (Audrey Smargiassi, Lucie Richard, Celine Plante, Vanita Sahni, Karen Glassford, Terry Spock, Me-Linh Le, Shakoor Hajat)

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National Collaborating Centre for Environmental Health

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