Research to support public health action on heat and health

Tom Kosatsky
Environmental Health Services
BCCDC
May 2011
Hottest 7-day period on record (Abbotsford Airport) since 1986. This unprecedented event was associated with ~122 excess deaths.

Weekly average 2004-2010 = 281 (stable over this period)
Deaths by cause during the 2009 BC Lower Mainland heat event and during comparison weeks

<table>
<thead>
<tr>
<th>cause of death</th>
<th>2009 hot weather event</th>
<th>8 previous weeks summer 2009</th>
<th>5 same weeks summer 2004-8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>all</td>
<td>413</td>
<td>1</td>
<td>2325</td>
</tr>
<tr>
<td>heat*</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>respiratory</td>
<td>52</td>
<td>13</td>
<td>251</td>
</tr>
<tr>
<td>cardiovascular</td>
<td>112</td>
<td>27</td>
<td>660</td>
</tr>
<tr>
<td>other</td>
<td>245</td>
<td>60</td>
<td>1411</td>
</tr>
</tbody>
</table>

ICD – 10 code X30 = exposure to excessive natural heat
death caused **directly** by heat:
**some of what we know**
heat-related deaths in Chicago during July 1995

Whitman, 1997
heat wave, Chicago 1995
refrigerator trucks outside City morgue

Klinenberg, 2002
deaths versus survival during the 1995 Chicago heat wave

Klinenberg, 2002

nearby Hispanic neighbourhood during the 1995 heat wave: life is outdoors

Chicago, poor African-American neighbourhood

Figure 29. Ogden Avenue, once a major commercial artery in North Lawn-dale. Photo by Caitlin Zaloom.
heat-related deaths, Cincinnati, Ohio, July 12–August 10, 1999 (n=18)* in some cases, date of death was estimated by the Coroner based on criteria such as decomposition of the body, temperature in the residence, date last seen alive, and/or date of last newspaper found at the premises of the decedent

Kaiser, 2001
**protective and risk factors** associated with heat-related death, Cincinnati, Ohio, 1999

<table>
<thead>
<tr>
<th>Variable</th>
<th>Case subjects [n(%)]a</th>
<th>Controls [n(%)]a</th>
<th>Crude odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced outside activity</td>
<td>3 (25)</td>
<td>22 (65)</td>
<td>0.2 (0.02–0.9)</td>
</tr>
<tr>
<td>Working fan</td>
<td>16 (94)</td>
<td>32 (97)</td>
<td>0.5 (0.01–39)</td>
</tr>
<tr>
<td>Mental illness</td>
<td>8 (47)</td>
<td>4 (12)</td>
<td>14.0 (1.8–633)</td>
</tr>
<tr>
<td>Income ≤$10,000/year</td>
<td>8 (67)</td>
<td>10 (42)</td>
<td>8.2 (0.9–393)</td>
</tr>
<tr>
<td>Living alone</td>
<td>11 (65)</td>
<td>13 (38)</td>
<td>7.6 (0.9–355)</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychotropic</td>
<td>4 (24)</td>
<td>3 (9)</td>
<td>3.3 (0.5–38.1)</td>
</tr>
<tr>
<td>Anticholinergic</td>
<td>6 (35)</td>
<td>3 (9)</td>
<td>4.0 (0.9–24.7)</td>
</tr>
</tbody>
</table>

aPercentage may be different for same number because of missing values.

Kaiser, 2001
prognostic factors in heat wave–related deaths: *a meta-analysis* Bouchama, 2007
prognostic factors in heat wave–related deaths: *a meta-analysis*

Bouchama, 2007
hyperpyrexia due to air-conditioning failure in a nursing home

JOHN Z. SULLIVAN-BOLYAI, MD, MPH
ROBERT M. LUMISH, MD EDWARD W. P. SMITH, MD JAMES T. HOWELL, MD, MPH DENNIS J. BREGMAN, MS MARJORIE LUND, RN, MPH ROBERT C. PAGE, MD, 1979

Table 1. Mean age distribution of residents with and without fever in a nursing home, southeastern Florida, August 1976

<table>
<thead>
<tr>
<th>Residents</th>
<th>Mean age (years)</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperpyrexia cases:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients who died</td>
<td>78.6</td>
<td>8.5</td>
</tr>
<tr>
<td>Survivors</td>
<td>83.9</td>
<td>7.6</td>
</tr>
<tr>
<td>Others</td>
<td>81.6</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Table 2. Distribution of residents in a nursing home, by ambulation code, southeastern Florida, August 1976

<table>
<thead>
<tr>
<th>Hyperpyrexia cases</th>
<th>Code</th>
<th>Patients who died</th>
<th>Survivors</th>
<th>Other residents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4:</td>
<td>1</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

1 Mann-Whitney U test, $P > 0.05$. 
Structural changes in the cerebral cortex of normotensive and hypertensive rats after hyperthermia and their modification with growth hormone (GH) treatment. Heat stress induced marked neuronal damage (A) in the cerebral cortex after 4 h. Several neurons were distorted, and chromatolysis (arrows) is clearly evident in many nerve cells. The magnitude and intensity of neuronal damage was further enhanced in hypertensive rats (B). Thus, loss of neurons, perineuronal edema, degeneration of neuronal cell membranes, sponginess, and edema (*) are more frequent in this group (arrows).

Pretreatment with GH (50 g/kg/min for 60 min before heat exposure) in normotensive (sham operated) rats exhibited marked neuroprotection (C, D). Many nerve cells appear normal, and edematous expansion of the neuropil is less intense. Only a few nerve cells (arrowheads) show cell damage (C, D). On the other hand, GH treatment in hypertensive rats after heat stress (E, F) was not that effective, degenerated neurons and perineuronal edema (arrowheads) are still frequent in this group. Edematous expansion of the neuropil was also seen (*) in hypertensive rats treated with GH.

Bars: A, B = 25m; C, D = 30m; E, F = 40m. Paraffin sections (3 m, Nissl). Meransu, 2007
deaths during extreme heat events beyond numbers expected
Montreal: June 1994 heat wave with attendant mortality

° C max

- temperature
- non-traumatic deaths

daily deaths

mean death rate

June 1994
BC Lower Mainland Daily Mortality, Summer 2009
Average of 2-DAY Maximum Temperature (Abbotsford)

Kosatsky, Pollock, Henderson, 2011 submitted
who died and where during 2009 Vancouver heat event and during comparison weeks

<table>
<thead>
<tr>
<th></th>
<th>2009 hot weather event</th>
<th>8 preceding 2009 weeks (average)</th>
<th>5 preceding same summer weeks (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85+</td>
<td>114</td>
<td>92</td>
<td>81</td>
</tr>
<tr>
<td>75-84</td>
<td>110</td>
<td>86</td>
<td>84</td>
</tr>
<tr>
<td>65 - 74</td>
<td>80</td>
<td>42</td>
<td>44</td>
</tr>
<tr>
<td>&lt; 65</td>
<td>108</td>
<td>70</td>
<td>71</td>
</tr>
<tr>
<td>where</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hospital</td>
<td>184</td>
<td>156</td>
<td>-</td>
</tr>
<tr>
<td>home</td>
<td>89</td>
<td>48</td>
<td>-</td>
</tr>
<tr>
<td>institution</td>
<td>118</td>
<td>79</td>
<td>-</td>
</tr>
<tr>
<td>other</td>
<td>20</td>
<td>7</td>
<td>-</td>
</tr>
</tbody>
</table>
changes in BC Lower Mainland mortality by population density 

summer 2009
<table>
<thead>
<tr>
<th>Gender</th>
<th>Marital Status</th>
<th>Deaths expected (a)</th>
<th>Deaths observed</th>
<th>OR [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N(%)</td>
<td>N(%)</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>Married</td>
<td>36 (45,0)</td>
<td>95 (32,3)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44 (55,0)</td>
<td>199 (67,7)</td>
<td>1.71 [1,20-2,44]</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>80 (100,0)</td>
<td>294 (100,0)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>Married</td>
<td>12 (12,8)</td>
<td>61 (9,4)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>81,7 (87,2)</td>
<td>587 (90,6)</td>
<td>1.41 [0,91-2,19]</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>93,7 (100)</td>
<td>648 (100,0)</td>
<td></td>
</tr>
</tbody>
</table>

(a) mean of number of deaths in reference years (2000-2001-2002)
(b) single, divorced or widowed
**general** relationship between maximum daily temperature and mortality in a European city.
summer deaths by 4-day apparent Tmax, 15 PHEWE cities, 1990-2000

Baccini, 2008
Bayesian *meta-analyses* of the temperature-mortality function for Mediterranean and Northern European city groupings  

Baccini, 2008
estimated percent change associated with a 10°F (4.7°C) increase in mean daily apparent temperature and non-accidental mortality by age group in nine counties, California, May through September, 1999–2003. 

Basu, 2008
Urban micro-climate in Montreal

- Importance de considérer ce qui est à proximité de l’îlot de chaleur urbain. Le milieu environnant 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

(the redder, the hotter)
acute mortality risks in **hot** versus **cool** Montreal neighbourhoods, 1990-2003

*Smargiassi, 2009*
annual number of days with heat stress in Berlin

indoor temperature on the first (Ta 1st floor) and third floor (Ta 3rd floor) of a building compared with outdoor temperature (Ta DWD) in Freiburg, Germany
effect on indoor temperature of apartment level and heat capture zone, Montreal
research to build community adaptive capacity
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
Study objectives

• Describe health-related behaviours around heat in a vulnerable population

• Develop a predictive model to explain the adoption of protective behaviours

• Evaluate the impact of high heat warnings on this population

• Suggest strategies to better reach and influence this group
Study characteristics

-238 persons with chronic lung and heart disease recruited at five Montreal university hospital clinics

-Face-to-face survey queried knowledge, awareness, attitudes and practices around extreme heat

-Interviews conducted June-September 2005, a record hot summer, with daily mean temperatures 2.4°C above the long-term seasonal average
KAP around heat: study architecture
238 respondents: demography and residential characteristics

- **Gender:**
  - Female
  - Male

- **Age Groups:**
  - < 60
  - 60-64
  - 65-70
  - 70-79
  - > 80

- **Residential Status:**
  - Live alone
  - With others

- **Residential Type:**
  - Apartment
  - Single family
  - Duplex/triplex

- **Cooling Appliances:**
  - Have air conditioner
  - No air conditioner

- **Additional Features:**
  - Have fan
  - No fan
intention to buy a home air conditioner? (N=61)
### Knowledge about extreme heat (n = 238)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>If after a hot day, temperature remains high at night, it has a worse effect on health (should answer &quot;true&quot;)</td>
<td>87</td>
</tr>
<tr>
<td>People suffering from lung or heart disease are hospitalised more often during heat waves (&quot;true&quot;)</td>
<td>97</td>
</tr>
<tr>
<td>Heat can affect your health even before you feel any of the warning signs (&quot;true&quot;)</td>
<td>95</td>
</tr>
<tr>
<td>The humidex is based on two factors. Which? (&quot;temperature and humidity&quot;)</td>
<td>46</td>
</tr>
<tr>
<td>Heat waves have a greater effect on people’s health when they occur (&quot;at the beginning of summer&quot;)</td>
<td>12</td>
</tr>
</tbody>
</table>
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: 50%
  - No: 50%

- My doctor/pharmacist told me my meds make me vulnerable to heat:
  - Yes: 80%
  - No: 20%
Actions: On a hot day, I "often" or "always"

- Spend time in a cool space
- Open windows at night
- Use a fan
- Drink at least 1 litre of water
- Reduce my diuretic dose
- Ask for help with daily activities

Legend:
- No home a/c
- Have home a/c
Resistance to heat warnings

- **Are warnings important for your health?** *(persons who recall hearing warnings)*
  - Somewhat or very
  - Not

- **If MD advised to acquire air conditioner, would you?** *(persons without a/c)*
  - Probably
  - Probably not

- **In an emergency, if you were advised to spend the night in an air conditioned shelter?** *(persons without a/c)*
  - Would
  - Refuse
Conclusion:
Portrait of 238 persons vulnerable to extreme heat
• perceive their susceptibility
• have confidence in prevention
• listen for and trust forecasts of hot weather
• when it’s hot, seek out cool environments or implement other recommended health protective measures

Gaps identified
• need for better understanding of how to cue their protective behaviours
• pre-heat wave planning can be improved
• optimisation of medical therapy in the face of hot weather
• need to reach and influence those resistant to taking effective preventive and emergency measures, even if urged by their caregivers or by city authorities.
causal model depicting links between perceived benefits, perceived barriers, perceived severity, cues to action and AC use, with standardized causal coefficients.

(Unstandardized residual variances for Cues to Action and AC use were constrained to 0.3. The coefficient linking AC use to AC was constrained to 1.0)
What I did yesterday (Q2), versus What heat advisories say we should do (Q1)

<table>
<thead>
<tr>
<th>Activity</th>
<th>I did % (n=62)</th>
<th>We should % (n=49)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spent time in an air conditioned environment</td>
<td>87</td>
<td>33</td>
</tr>
<tr>
<td>( \text{stay in an air conditioned environment/go to the mall} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used a fan</td>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td>Cooled off with a wet towel, a cool bath or shower</td>
<td>65</td>
<td>2</td>
</tr>
<tr>
<td>( \text{Take a bath} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced or put off activities which require physical effort</td>
<td>82</td>
<td>39</td>
</tr>
<tr>
<td>( \text{reduce/limit physical activities} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not go outdoors (31/62)</td>
<td>51</td>
<td>82</td>
</tr>
<tr>
<td>( \text{not go outside/stay inside} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopped outdoor activities which require physical effort (24/31)</td>
<td>77</td>
<td>5</td>
</tr>
<tr>
<td>( \text{limit outdoor activities/do not exercise outdoors} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Looked for shaded areas outdoors (25/31)</td>
<td>81</td>
<td>29</td>
</tr>
<tr>
<td>( \text{Stay where it is shaded/do not stay in the sun} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drank at least one litre of water per day</td>
<td>86</td>
<td>43</td>
</tr>
<tr>
<td>Did someone ask you or did you inform someone of how you were doing?</td>
<td>83</td>
<td>0</td>
</tr>
<tr>
<td>Did someone offer you help or did you ask for help with your daily activities?</td>
<td>33</td>
<td>0</td>
</tr>
</tbody>
</table>
Preparedness of European cities for heat emergencies
PHEWE city survey objectives

1. Describe prevention activities related to population health during extreme weather events in 16 PHEWE cities

2. Support development of best practices
Preliminary Assessment: October 2004

- E-mailed, mailed questionnaire
- Addressed to directors of PHEWE city health departments
- cc PHEWE co-ordinators
- Solicited an « involved, knowledgeable respondent »
- Provided framework for follow-up interview
- In English
Cities surveyed and responding

Tom Kosatsky, 2006

Cities surveyed and responding:

- Helsinki
- Stockholm
- Paris
- Krakow
- Zurich
- Milan
- Budapest
- Turin
- Ljubljana
- Barcelona
- Roma
- Athens

PHEWE CITIES
PREPAREDNESS SURVEY PARTICIPANTS

Primary respondent affiliation:
- National Ministry
- City Health
- Academic
- Civil Defense
- City Health

Secondary respondent (5):
- National Ministry
- City Health
- Civil Defense
- Academic

Map showing cities in Europe with survey participation.
Extreme weather mandates

Environmental Health Protection

Disaster Preparedness

Emergency Response
City has a health disaster plan

all 8 revised since 2000

Covers
earthquakes 4
chemical spills 6
floods 5
cold 4
heat 5
Co-operative agreements

with weather service

with civil defense
Limits of the survey

1. Preliminary questionnaires, not plan review
2. Responses are a function of local public health context
3. Language?
4. 9/17 responded
5. Information provided was not validated
6. High apparent respondent influence
# Haddon matrix and heat-wave related mortality

## Influencing factors

<table>
<thead>
<tr>
<th>Phase</th>
<th>Host</th>
<th>Agent/vehicle</th>
<th>Physical environment</th>
<th>Social environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-event</td>
<td>Cardiovascular disease</td>
<td>Climate</td>
<td>Urban heat island</td>
<td>Forecast quality, confidence</td>
</tr>
<tr>
<td></td>
<td>Anti-cholinergic medications</td>
<td></td>
<td>Indoor heat retention</td>
<td>Social cohesion</td>
</tr>
<tr>
<td>Event</td>
<td>Awareness of over-heating</td>
<td>Degree, duration of heat episode</td>
<td>Neighbourhood temperature</td>
<td>Heat warning diffusion</td>
</tr>
<tr>
<td></td>
<td>Protective behaviour</td>
<td></td>
<td>Indoor temperature</td>
<td>Working « buddy system »</td>
</tr>
<tr>
<td>Post-event</td>
<td>Physical reserves</td>
<td>Rapid cooling capacity</td>
<td></td>
<td>Emergency Network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rehabilitation services</td>
</tr>
</tbody>
</table>
Work in progress!!
changes in mean summer temperature (May-August), temperatures of onset, and size of heat-related mortality. Heat-related mortality per million men and women aged 55+ between 1971 and 1997. Median regression lines. Bars are 95% confidence limits. *Slope, $P<0.05$ (Keatinge and Donaldson, 2003)
daily deaths (all ages, all cause) for Vancouver North Metropolitan area associated with temperature at Vancouver Airport, **1986-1996**

![Graph showing daily deaths vs mean temperature for 1986-1996 and 1997-2008.](image-url)
thank you