Heat Health Action Plans & Warning Systems

REUNIÓN PILOTO DE ALCANCE ALERTA SOBRE SALUD TÉRMICA Y ACCIONES DE PREPARACIÓN PARA CHILE
Santiago, Chile August 26-27, 2019

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Global Alarm
European Heatwave
Jun-Aug 2003

- **Widespread impacts**: Drought, energy, fire, agriculture, water, health impacts
- **Total excess death toll 70,000**
- **Vulnerable populations** older adults, young children, and the homeless, as well as those with chronic health conditions and those using certain medications

**Health effects**
- Heat-stroke - normally we sweat, and this keeps us cool on hot days. On very hot days our bodies may not be able to keep cool enough by sweating alone, and our core body temperature may rise. This can lead to headaches, dizziness and even death.
- Dehydration - this is the loss of water from our bodies. It can cause tiredness and problems with breathing and heart rates.
- Sunburn - damage to the skin which can be painful and may increase the risks of getting skin cancer.
- Air pollution - it is thought that one third of the deaths caused by the heatwave in the UK were caused by poor air quality.
- Drowning - some people drowned when trying to cool off in rivers and lakes.
Heat-Health Action Plans (HHAP)

1. Agreement of a Lead Agency
2. **Accurate and timely heat health warning and alert systems (HHWS)**
3. Heat-related information / communications plan
4. Reduction in indoor heat exposure
5. Special care for vulnerable populations
6. Preparedness of the health and social care system
7. Long-term urban planning
8. Real-time surveillance
9. Evaluation
Chapters

1. Introduction: Heatwaves and Health
2. Heat and Health: Impacts and vulnerability
3. Assessment of Heat Stress: heatwaves, exposure, thermal assessment methods
4. Heat-Health Warning Systems
5. Communicating heat health warnings and heat related information to stakeholders and the public
6. Intervention strategies
7. Evaluation of health warnings and health protection measures
8. Planning for heat events and the intra-seasonal to seasonal scale
9. Longer term Initiatives for managing heatwaves
Causal Chain of heat impacts on health

Ch. 2
Heat Stress leads to:
- Severe dehydration
- Blood clotting
- Stroke
- Organ damage

It can aggravate:
- Kidney disorders
- Mental health
- Cardiac conditions
- Pulmonary conditions

Case-fatality rate of untreated heat stroke is 65-80%
All vital organs are highly sensitive to thermal fluctuation.

Table. Organs Damaged by Physiological Mechanisms Triggered by Heat Exposure

<table>
<thead>
<tr>
<th>Organs</th>
<th>Ischemia</th>
<th>Heat Cytotoxicity</th>
<th>Inflammatory Response</th>
<th>Disseminated Intravascular Coagulation</th>
<th>Rhabdomyolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>1</td>
<td>7</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Heart</td>
<td>2</td>
<td>6</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Intestines</td>
<td>3</td>
<td>9</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Kidneys</td>
<td>4</td>
<td>1</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Liver</td>
<td>5</td>
<td>1</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Lungs</td>
<td>6</td>
<td>1</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>Pancreas</td>
<td>8</td>
<td></td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>
Ch. 2

Heat Impacts on Health

DIRECT

Illness and death
- Dehydration
- Heat cramps
- Heat stroke
- Respiratory disease
- Cardiovascular disease
- Diabetes mellitus
- Renal disease
- Stroke
- Birth outcome impacts
- Mental health conditions
- Other chronic disease

INDIRECT

Health services
- Increased ambulance calls and slower response times
- Increased hospital admissions
- Medications go bad if not stored properly

Accidents
- Drowning
- Work-related accidents
- Injuries and poisonings

Illness
- Outbreaks of gastrointestinal disease
- Marine algal blooms

Infrastructure
- Power
- Water
- Transport
- Productivity
Who’s most at risk from extreme heat health impacts?

- People with disabilities, pregnant or already ill
- The poor, displaced and homeless
- Children and the elderly
- Outdoor manual workers
- Athletes

Vulnerability

Source: Health Canada
Impact Measures

- Excess mortality
- Ambulatory Calls
- Morbidities
  - Cardiovascular
  - Mental health

- Non-health impacts
  *lost-productivity
What is a heat wave?

- No universal definition of a heatwave

- A period of marked unusual hot weather (max, min and daily avg. temp) over a region persisting at least three* consecutive days during the warm period of the year based on local climatological conditions (station-based), with thermal conditions recorded above given thresholds.

(WMO, 2018 TT-DEWCE)
Heat waves are locally determined, relative to expected conditions.

Countries/cities adopt local criteria for issuing heat wave advisories, based on locally relevant thresholds of temperature/humidity levels that have a statistically significant influence on morbidity and mortality rates.
<table>
<thead>
<tr>
<th>Country</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td><strong>Tmax, Tmin and Ozone</strong> Maximum and minimum daily temperature and Ozone Niveau 1: Tmin above 18 and Tmax above 30, Niveau 2: Niveau 1 and/or 240 µg/m³ ozone 180 µg/m³ (in French so not clear). 3 day mean Tmax ≥30 °C; Tmin: ≥18 °C</td>
</tr>
<tr>
<td>Czechia</td>
<td><strong>Yellow:</strong> T max &gt; 31 °C, UO &gt; 50%, <strong>Orange:</strong> T max &gt; 34 °C, UO &gt; 50%, <strong>Red:</strong> T max &gt; 37 °C, UO &gt; 50%</td>
</tr>
<tr>
<td>France</td>
<td><strong>Tmax and Tmin</strong> Maximum and minimum daily temperature Level 2: when thresholds are to be reached within three days, Level 3: when the thresholds are reached, Level 4: when the thresholds are reached and when the heat wave tends to be prolonged or when exceptional conditions are met (e.g. drought, electricity blackout)</td>
</tr>
<tr>
<td>Germany</td>
<td><strong>Tmin and Perceived Temperature (Klima Michel Model)</strong> Minimum daily temperature and thermodynamic model Severe heat stress: PT ≥ 32 °C (exact threshold depends on weather situation of last 30 days but does not exceed 34 °C); Extreme heat stress: PT ≥ 38 °C. Warnings if thresholds are exceeded for 2 consecutive days and Tmin (night between) &gt; 16–18 °C</td>
</tr>
<tr>
<td>The Netherlands</td>
<td><strong>Tmax</strong> (the plan only indicates &gt;5 subsequent days above 27 degrees... it doesn't specify max, or mean temperature in the plan --&gt; probably KNMI data does) Maximum daily temperature (this is not explicitly indicated in the plan) 5+ days above 27°C</td>
</tr>
<tr>
<td>Multinational</td>
<td><strong>Heat-Shield Index:</strong> modified WBGT index. A modified WBGT index calculated from validated formulas using weather station data. This includes open in-sun (non-sheltered) and in-shade (sheltered) conditions for both long-term projections and short-term warning of environmental heat-stress conditions.</td>
</tr>
<tr>
<td>Hungary</td>
<td><strong>Tmean</strong> 1: Daily mean temperature likely reaches or exceeds 25 °C 3 day Tmean &gt; 26.6 °C (98% frequency)</td>
</tr>
</tbody>
</table>
1. Heatwaves
2. Periods of sequential high–nighttime temperature
3. Compound heat–wave periods
4. Heat spells occur outside heat–season
5. Microclimates
   – Urban centers
   – Housing conditions (slums/skyscrapers)
   – Occupational settings
Heat exposure and risk management is location and context specific.

Research collaboration is key to incorporate the differentiated needs of vulnerable groups, and inform appropriate and effective responses.
Considerations:

Santiago

Urban Heat Island?
Extreme heat events increasing. Cities are hotter.

**Why is city heat deadly?**

Indicators that modify the effect of heat - *higher mortality associated with increases in:*

- population density,
- fine particles (PM$_{2.5}$),
- gross domestic product (GDP)
- Gini index (a measure of income inequality),
- Lower availability of health services

- Higher levels of green spaces were linked with a decreased effect of heat

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Temperature-attributable mortality study across 340 cities - a meta-regression model 50 million deaths in 22 countries - adjusted by country and weather variables

### Ch. 3
Assessment of Heat Stress: heatwaves, exposure, thermal assessment methods

<table>
<thead>
<tr>
<th>Index</th>
<th>Definition</th>
<th>Current use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat index (HI)</td>
<td>Combines air temperature and relative humidity to determine an apparent temperature (how hot it feels)</td>
<td>Widely used in the United States when temperatures are $&gt;26^\circ C$ and relative humidity is $\geq 40$ percent</td>
</tr>
</tbody>
</table>
| Humidex                   | Combines temperature and humidity into one number to reflect perceived temperature on the following scales of comfort related to the body's coping mechanisms:  
  - Less than 29 – no discomfort  
  - 30–39 – some discomfort  
  - 40–45 – great discomfort  
  - Above 45 – dangerous  
  - Above 54 – heat stroke imminent | Widely used in Canada  
  > 40 considered high Humidex during which all unnecessary activity should be curtailed |
| Apparent temperature (AT) | An estimate of what the temperature "feels like"  
  - Uses absolute humidity with a dewpoint of $14^\circ C$ as a reference level from which air temperature is adjusted | Widely used in Australia  
  AT is measurable over a range of temperatures above $20^\circ C$ and considers the cooling effects of the wind at lower temperatures |
| Net effective temperature (NET) | Considers the effect of air temperature, wind speed and relative humidity | Monitored in Hong Kong, China and Portugal  
  Alerts for temperature extremes typically issued when NET is forecast to be lower or higher than the 2.5th percentile or 97.5th percentile, respectively |
| Wet-bulb globe temperature (WEGT) | Combines temperature and humidity into a single number  
  - Affected by wind and radiation  
  - A measure of $35^\circ C$ is thought to be the threshold for human survivability (Sherwood and Huber 2010) | Monitored in Australia  
  Widely used among researchers as an easily measured heat-stress index in occupational medicine |
Considerations for Chile:
Temperate & Subtropical Systems
Ch. 4

Common Steps in Heat Health EWS
• Information must be appropriate to the decisions

• There are NO:
  – Common definitions of heatwaves
  – Common thresholds of heat-health outcome responses
  – One size fits all systems

• **Local** systems must be build on **local** conditions of:
  – Physiological acclimatization and vulnerability
  – Weather conditions and forecast availability
  – Data on historical heat-health outcomes and population responses
  – Social and Health System Response capacity
  – Local culture and behaviour
1. LOCAL WEATHER FORECASTS
2. HEAT EXPOSURE RESPONSE ASSESSMENT AND MODELING
3. THRESHOLDS OF HEAT-HEALTH ACTION TRIGGERS
4. ALERT/ACTION AND COMMUNICATION PLAN
5. ISSUANCE OF WARNINGS
6. INTERVENTION AND RESPONSE STRATEGIES
7. EVALUATION
Heat Forecast

**Data Availability**
- Is there health, temperature and humidity data available for the city?
- Is the data reliable?
- At what scale is the data collected?
- How frequently is the data collected?
- How far back do the records go?

**Forecasts**
- How far in advance are temperature forecasts available?
- Are forecasts available throughout the year?
- How accurate are the forecasts?
- How often are the forecasts issued?
- Could temperature forecasts be improved including increasing accuracy or lead time?

**Threshold**
- At what time of year do heatwaves typically occur in this city?
- Can we compare weather and health (impact) data to determine when the heat becomes dangerous?
Considerations: Forecast Skill

Potential to improve global heat wave preparedness
HEAT EXPOSURE-RESPONSE ASSESSMENT AND MODELING

- **Cumulative**: takes heat exposure over multiple days
- **Non-linear**: Changing risk across temperature range
- Implications for issuing alerts – binary or graduated?

Gasparrini et al., 2015 Lancet
Setting thresholds depends on how many lives you expect to save?

Figure 4. Example of the relationship between temperature and excess mortality during summer (left) and cumulative excess mortality (right): T1–T3 thresholds; a, b, c – amount of mortality that can be prevented when applying the different thresholds in case of a 100 per cent effective Heat–Health Warning System.

Source: Koppe, 2005
Heat Health Impact Based Forecasting

Improving the Health Forecasting Alert System for Cold Weather and Heat-Waves In England: A Proof-of-Concept Using Temperature-Mortality Relationships

Giacomo Masato¹ *, Angie Bone², Andrew Charlton-Perez¹, Sean Cavany¹, Robert Neat², Rutger Dankers³, Helen Discre¹, Katie Carmichael², Virginia Murray²
Heat EWS Information Flows

Ch. 4

Diagram:
- Historical data / experience
- Selection of heat event definition
- Weather forecast
- Warning criteria
- Criteria fulfilled
- yes
- no
- warning
- communication
- Target groups
- Specific interventions
- Seasonal awareness
- Education and information
Meeting Decision-needs:

How much lead time?
Planning plan across timescales – not just focus on heatwave events.
Seasonal and Annual Planning

- Engage social workers and community members to improve heat education. (February)
- Improve flexibility in the number of ambulances and reduce response time. (March)
- Conduct an after-action review of the past hot season. (August)
- Develop a 'high vulnerability' index to identify subgroups that are at a high risk. (December)

Heat action requires long-term, seasonal and short-term planning.

- Raise awareness of people through simple messages. For example, “stay in the shade, and hydrated.” (February - April)
Adapting to heat over longer time-scales
Heat warning messages must be tested for understanding before they are issued to the public.
Employers should create a heat emergency plan to ensure the safety of workers during a heatwave.

1. Outdoor workers are most likely to fall ill because of their high exposure to heat.
2. Ensure workers have adequate breaks, shade, and drinking water points.
3. Reschedule outdoor work to be done early in the morning or late in the evening when it is cooler.
Interventions

Response Measures

During a Heatwave

- Conduct public awareness campaigns
- Increase access to water
- Plan for a sudden increase in electricity demand
- Home outreach visits to vulnerable people
- Evacuate vulnerable people from their homes to cooling centres
- Operate a telephone helpline to provide guidance
- Keep electricity and water services on despite non-payment
- Ensure a functional health system
- Enhance emergency management systems
Evaluating Heat Preparedness & Response

**HEATWAVE DEFINITION**
Was the right mix of metrics chosen?

**THRESHOLD USED TO TRIGGER ACTION**
Was the threshold triggered at the appropriate time? Was it too late or too soon?

**INTERNAL COMMUNICATION**
How efficiently did municipal departments, municipal staff, and key partners receive critical updates during the response? Did the different agencies within the city work together effectively?

**EXTERNAL MESSAGES**
Did the general public access and understand the warnings? How did they perceive the risks? Were the alerts effective at catalyzing appropriate action?

**INTERNAL ACTION**
Did key departments, partners, and personnel understand their roles clearly? Were these identified roles appropriate? Did they have the anticipated impact?

**COMMUNITY ACTIONS**
Did people heed the warnings and follow the advice? Were some pieces of advice followed over others? Which vulnerable groups took the most action? Which vulnerable groups need to be reached more effectively in the future? And how?
Success factors

All well-functioning action and alert systems rely on:

1. Heat risk must be understood and managed across timescales – short-term heat early warning system must be complemented by seasonal and sub-seasonal preparedness

2. Strong cross-disciplinary and multi-agency collaboration

3. Tailored to location, context, and population characteristics

4. Effective communication between stakeholders including national and local governments, universities, media, healthcare and social protection systems, NGOS and humanitarian actors, as well as, affected populations.