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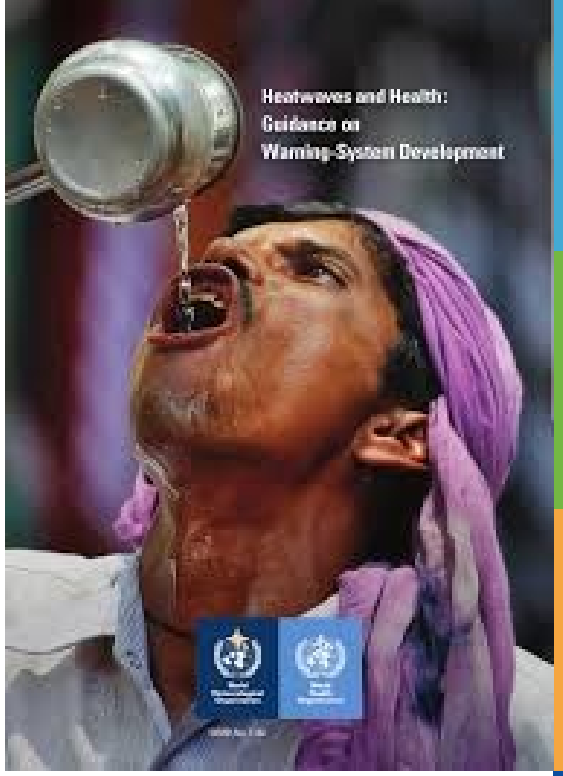
JOINT OFFICE FOR CLIMATE AND HEALTH



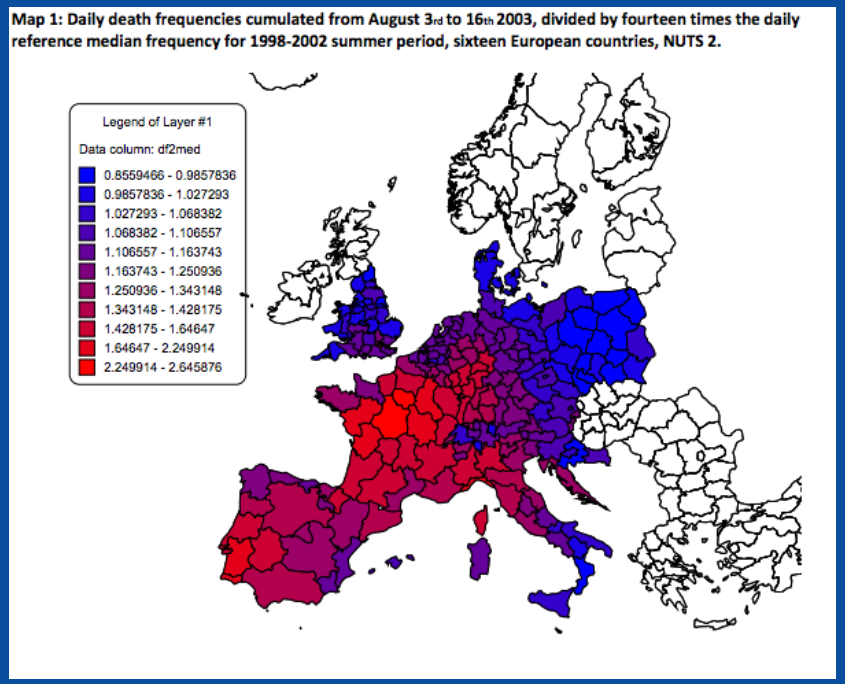
Heat Health Action Plans & Warning Systems

REUNIÓN PILOTO DE ALCANCE ALERTA SOBRE SALUD TÉRMICA Y ACCIONES DE PREPARACIÓN PARA CHILE

Santiago, Chile August 26-27, 2019

Joy Shumake-Guillemot, Msc, DrPH
jshumake-guillemot@wmo.int

Global Alarm
European Heatwave Jun-Aug 2003

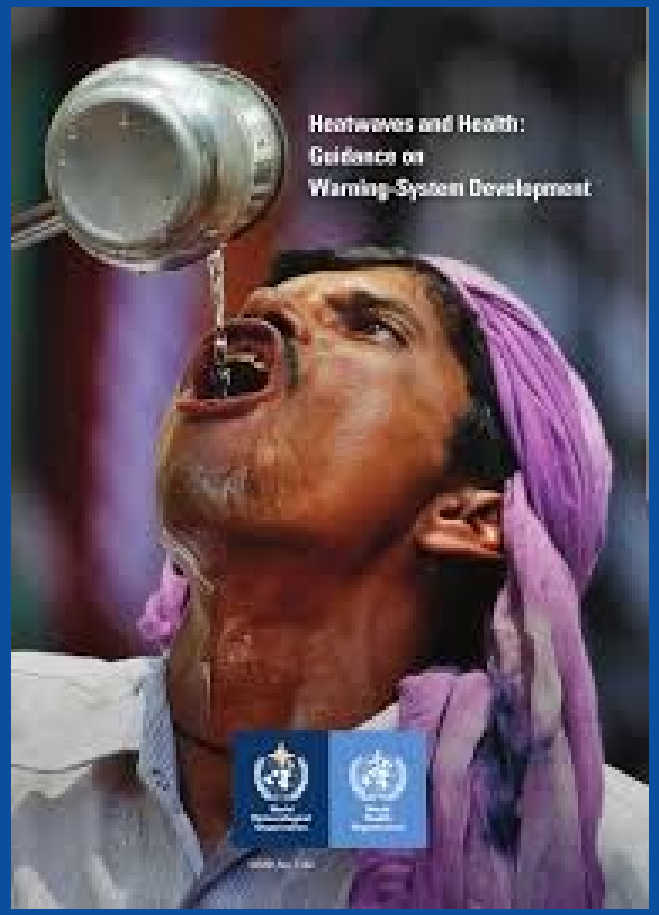


- **Widespread impacts:** Drought, energy, fire , agriculture, water, health impacts
- **Total excess death toll 70,000**
- **Vulnerable populations** older adults, young children, and the homeless, as well as those with chronic health conditions and those using certain medications
- **Health effects**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

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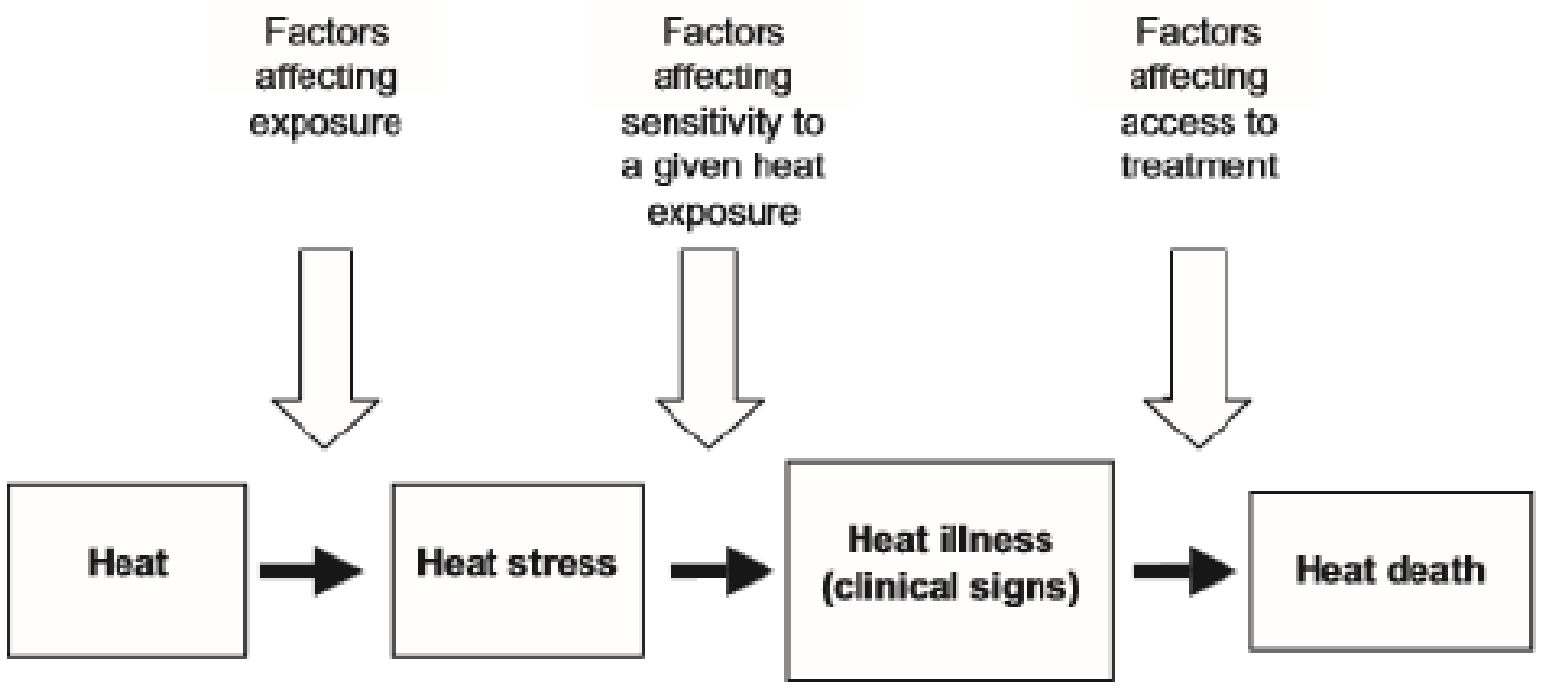
Ch. 2

Causal Chain of heat impacts on health



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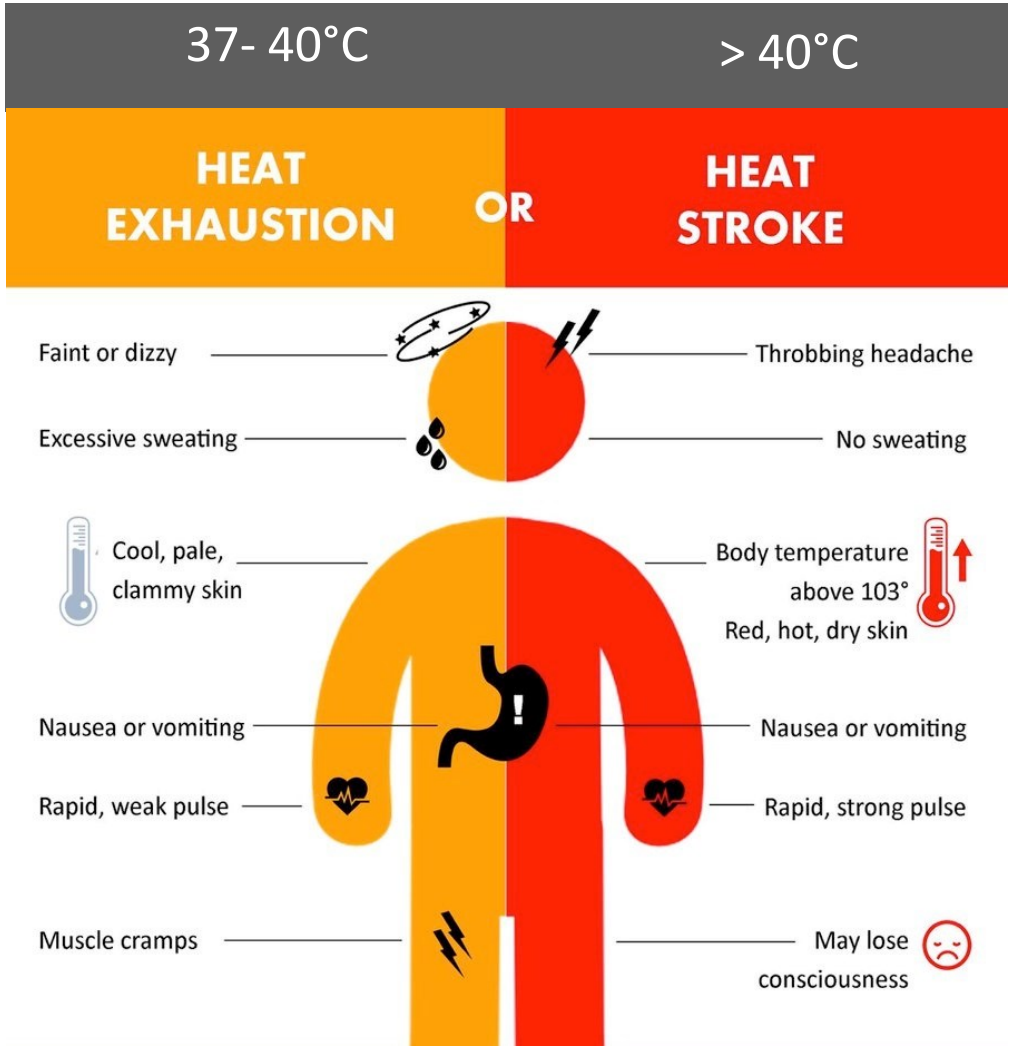
Ch. 2

Heat Stress leads to:

- Severe dehydration
- Blood clotting
- Stroke
- Organ damage

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

HEAT STRESS IS A SERIOUS HEALTH THREAT FOR HUMANS



Case-fatality rate of untreated heat stroke is 65-80%

Ch. 2

All vital organs are highly sensitive to thermal fluctuation

Twenty-Seven Ways a Heat Wave Can Kill You:
Deadly Heat in the Era of Climate Change

Camilo Mora, PhD; Chelsie W.W. Counsell, MSc; Coral R. Bielecki, BS; Leo V Louis, BS

Table. Organs Damaged by Physiological Mechanisms Triggered by Heat Exposure

Organs	Mechanisms				
	Ischemia	Heat Cytotoxicity	Inflammatory Response	Disseminated Intravascular Coagulation	Rhabdomyolysis
Brain	①	⑦	⑬	⑳	
Heart	②	⑧	⑭		
Intestines	③	⑨	⑮	㉑	
Kidneys	④	⑩	⑯	㉒	㉕
Liver	⑤	⑪	⑰	㉓	㉖
Lungs		⑫	⑱	㉔	㉗
Pancreas	⑥		⑲		

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

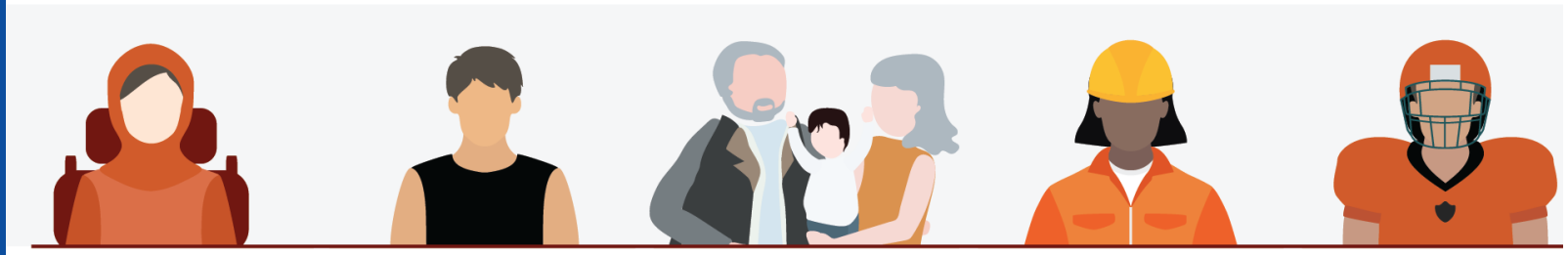
Infrastructure

- Power
- Water
- Transport
- Productivity

Ch. 2

Vulnerability

Who's most at risk from extreme heat health impacts?



People with disabilities, pregnant or already infirm

The poor, displaced and homeless

Children and the elderly

Outdoor manual workers

Athletes

Source: Health Canada

Ch. 2

Heat & Health Impacts

Impact Measures

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

- **Non-health impacts**

*lost-productivity

Ch. 3

Assessment of Heat Stress:
heatwaves, exposure, thermal assessment methods

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)

Ch. 3

Assessment of Heat Stress:

Heatwaves

Heatwave Definition

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.

Relative Humidity (%)

Air Temperature °F	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	103	106	110	114	119	124	129	135			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

Heat Index (Apparent Temperature)

With Prolonged Exposure and/or Physical Activity

Extreme Danger
Heat stroke or sunstroke highly likely
Danger
Sunstroke, muscle cramps, and/or heat exhaustion likely
Extreme Caution
Sunstroke, muscle cramps, and/or heat exhaustion possible
Caution
Fatigue possible

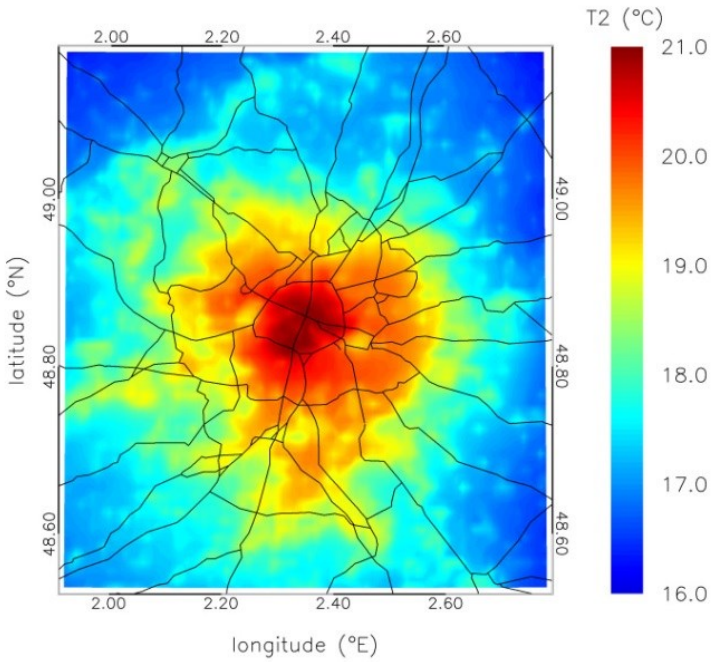
Belgium	Tmax,Tmin and Ozone	Maximum and minimum daily temperature and O-zone	Niveau 1: Tmin above 18 and Tmax above 30, Niveau 2: Niveau 1 and/or 240 µg/m3 ozone 180 µg/m3 (in French so not clear). 3 day mean Tmax: ≥30 °C; Tmin: ≥18 °C (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3290979/)
Czechia	Yellow: T max > 31 ° C, UO> 50%, Orange: T max > 34 ° C, UO> 50%, Red: T max > 37 ° C, UO> 50%		
France	Tmax and Tmin	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)
Germany	Tmin and Perceived Temperature (Klima Michel Model)	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) > 16–18 °C)
The Netherlands	Tmax (the plan only indicates >5 subsequent days above 27 degrees... it doesn't specifiy max, or mean temperature in the plan --> probably KNMI data does)	Maximum daily temperature (this is not explicitely indicated in the plan)	5+ days above 27C
Multinational	Heat-Shield Index: 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 shortterm warning of environmental heat-stress conditions.	
Hungary	Tmean	1: Daily mean temperature likely reaches or exceeds 25	3 day Tmean > 26.6 °C (98% frequency)

Ch. 3

Assessment of Heat Stress:
Heatwaves , **Exposure**

Other heat exposure dangers?

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



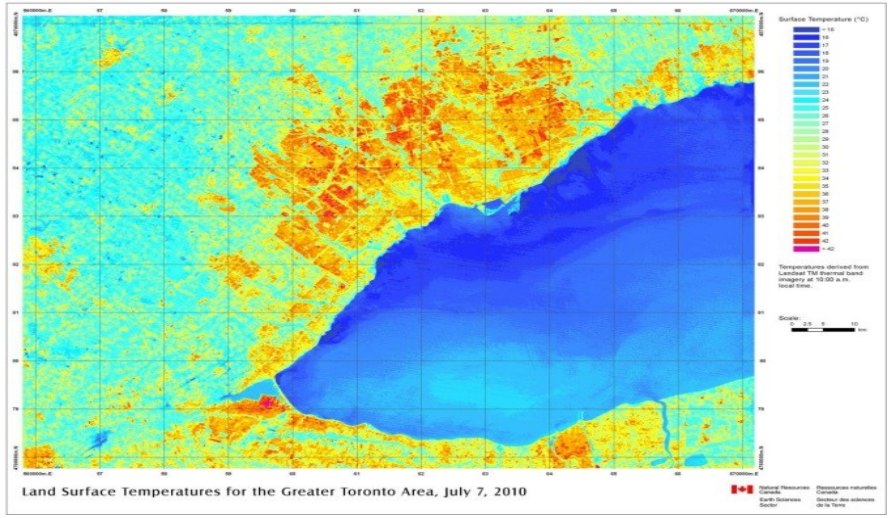
Ch. 3

Assessment of Heat Stress:
Heatwaves , **Exposure**

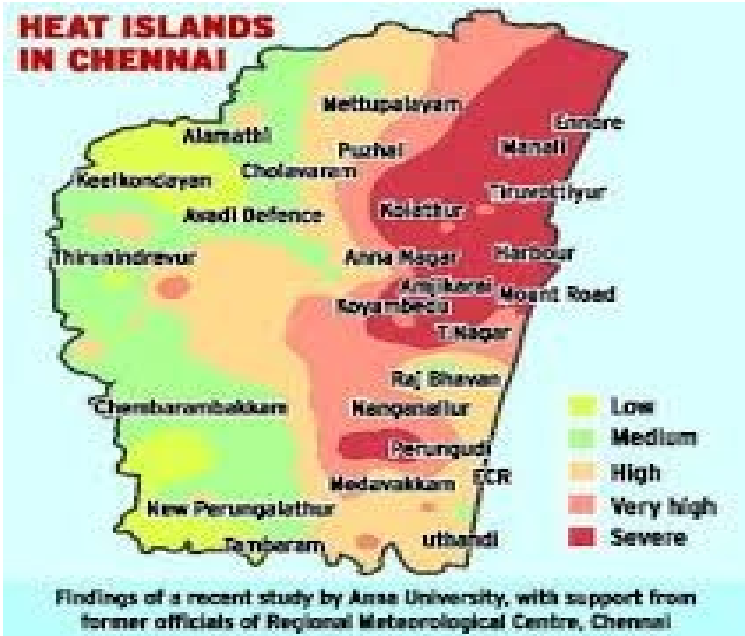
Heat **exposure** and risk management is **location and context specific**

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

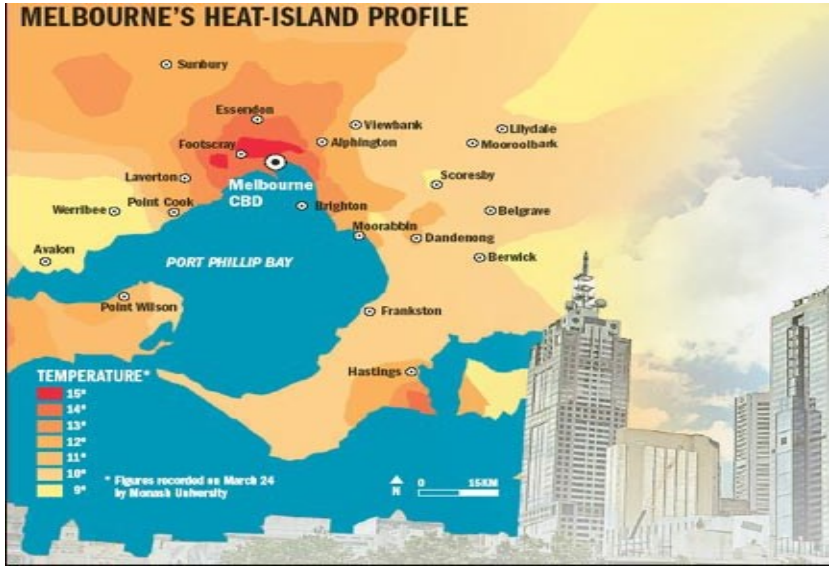
Toronto



Chennai

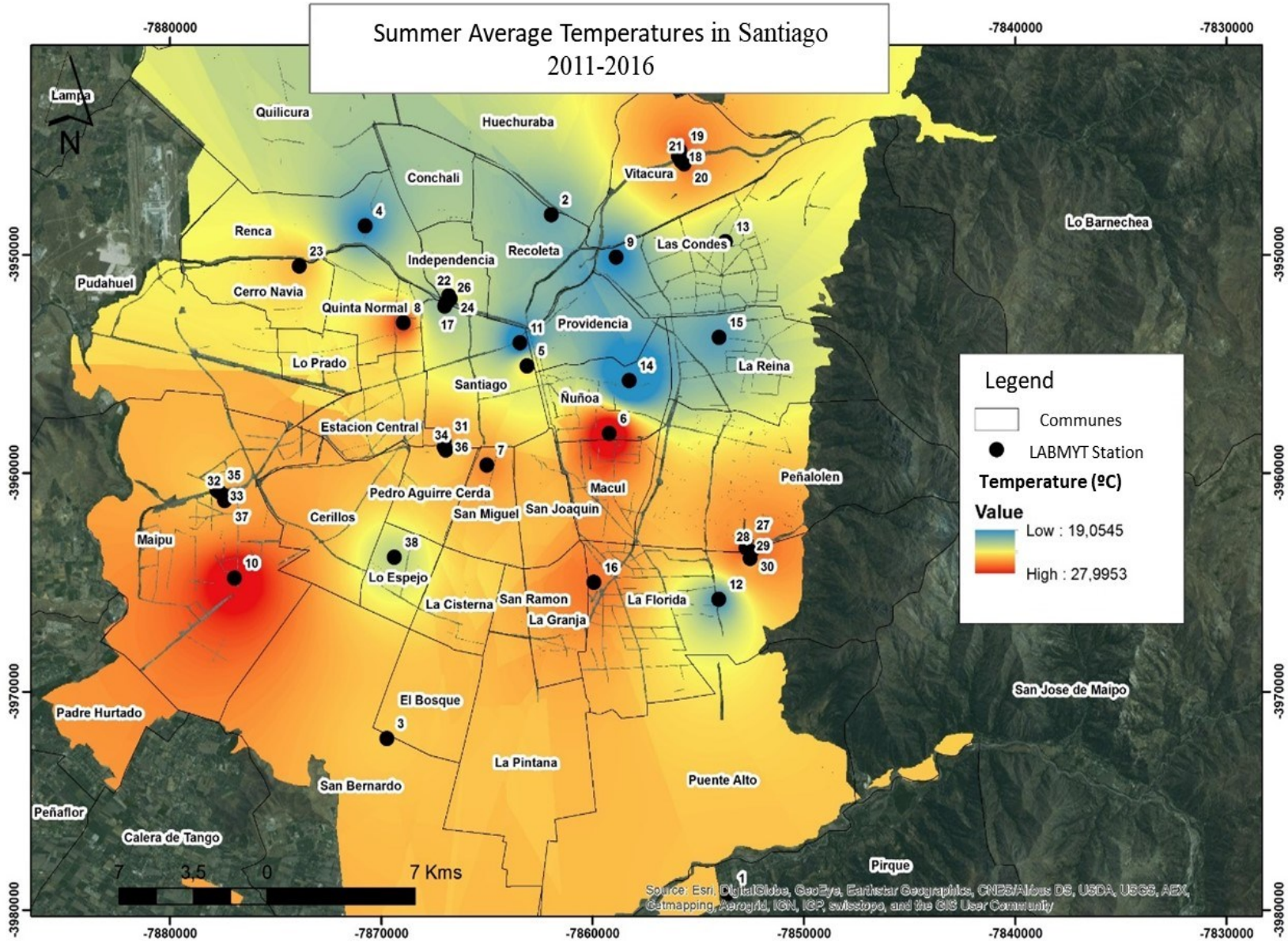


Melbourne



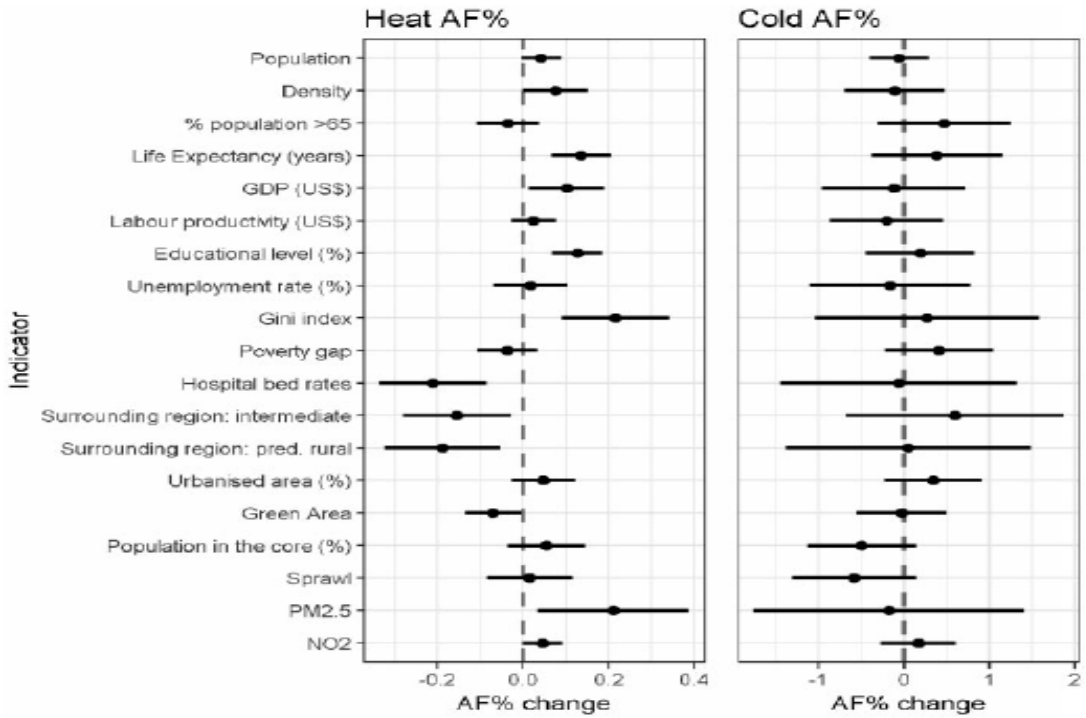
Considerations:

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

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

Sera, Francesco, et al. "How urban characteristics affect vulnerability to heat and cold: a multi-country analysis." *International journal of epidemiology* (2019).

Ch. 3

Assessment of Heat Stress:

heatwaves, exposure, **thermal assessment methods**

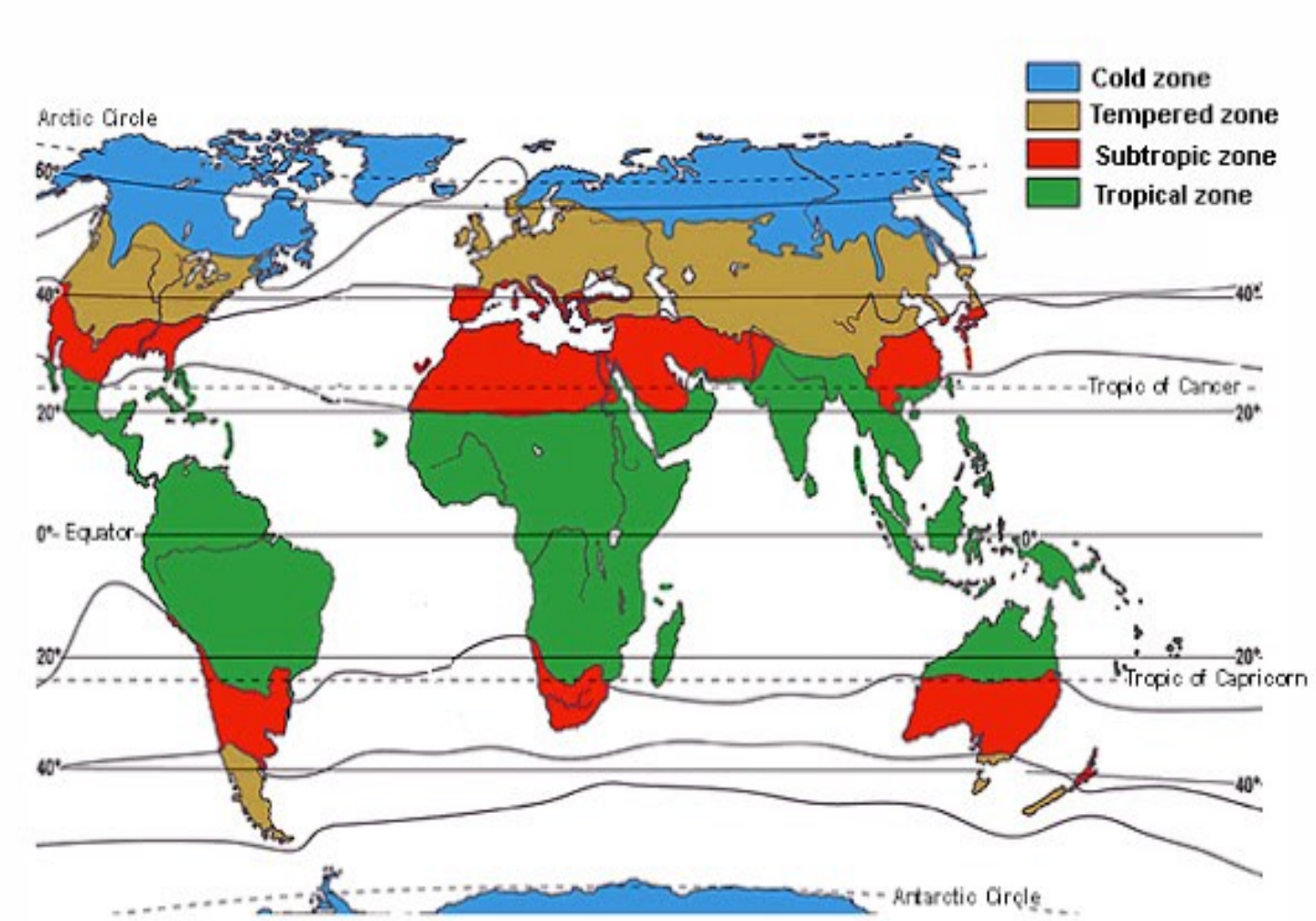
Common Thermal Assessment Indices for quantifying heat-health risks

Index	Definition	Current use
Heat index (HI)	• Combines air temperature and relative humidity to determine an apparent temperature (how hot it feels)	• Widely used in the United States when temperatures are >26°C and relative humidity is ≥ 40 percent
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°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°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 (WBGT)	• Combines temperature and humidity into a single number • Affected by wind and radiation • A measure of 35°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

Ch. 4

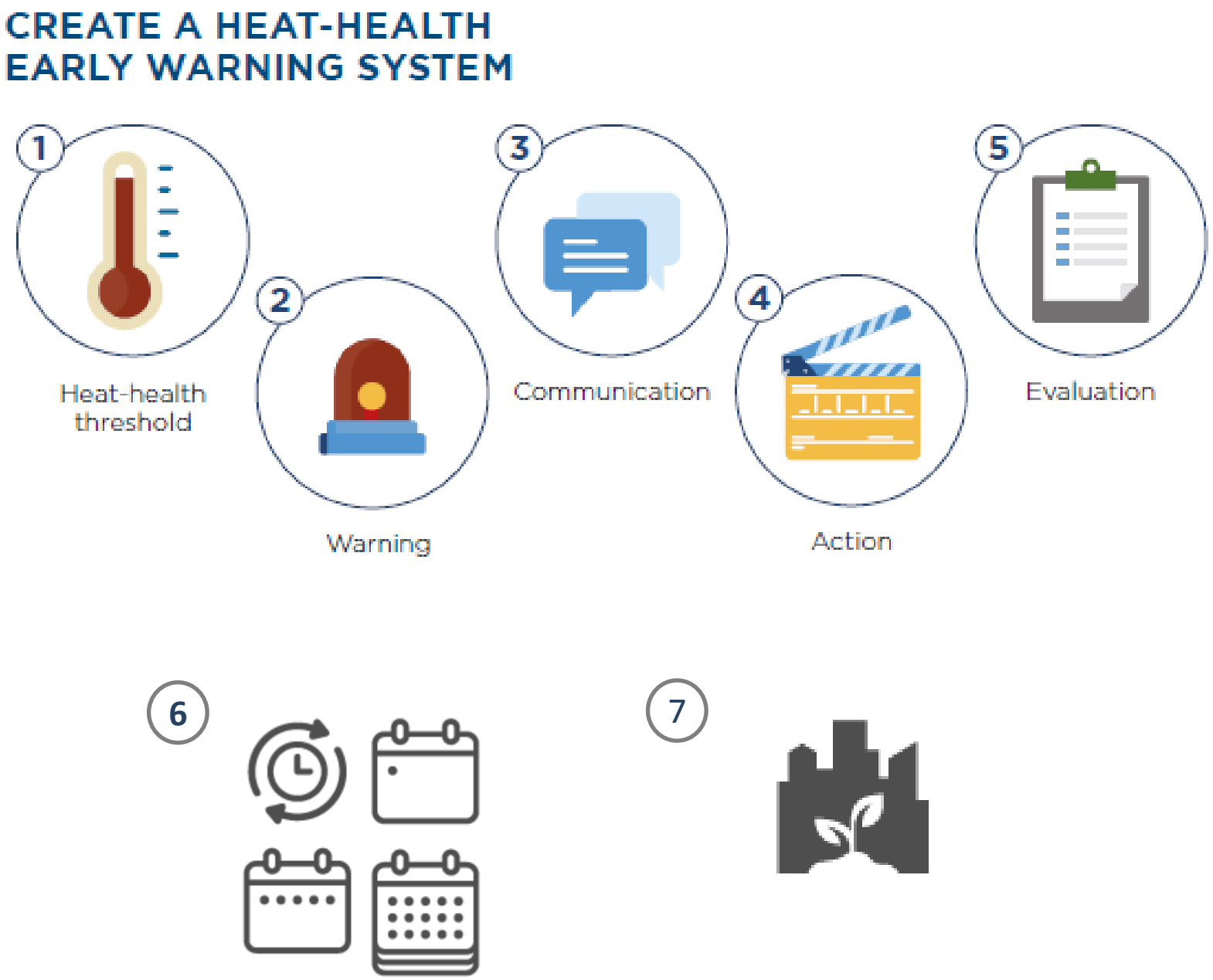
Considerations for Chile:

Temperate & Subtropical Systems



Ch. 4

Common Steps in Heat Health EWS



COMMON PRINCIPLES OF HHWS

- 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

Ch. 4

Framework for HHWS

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

Ch. 4

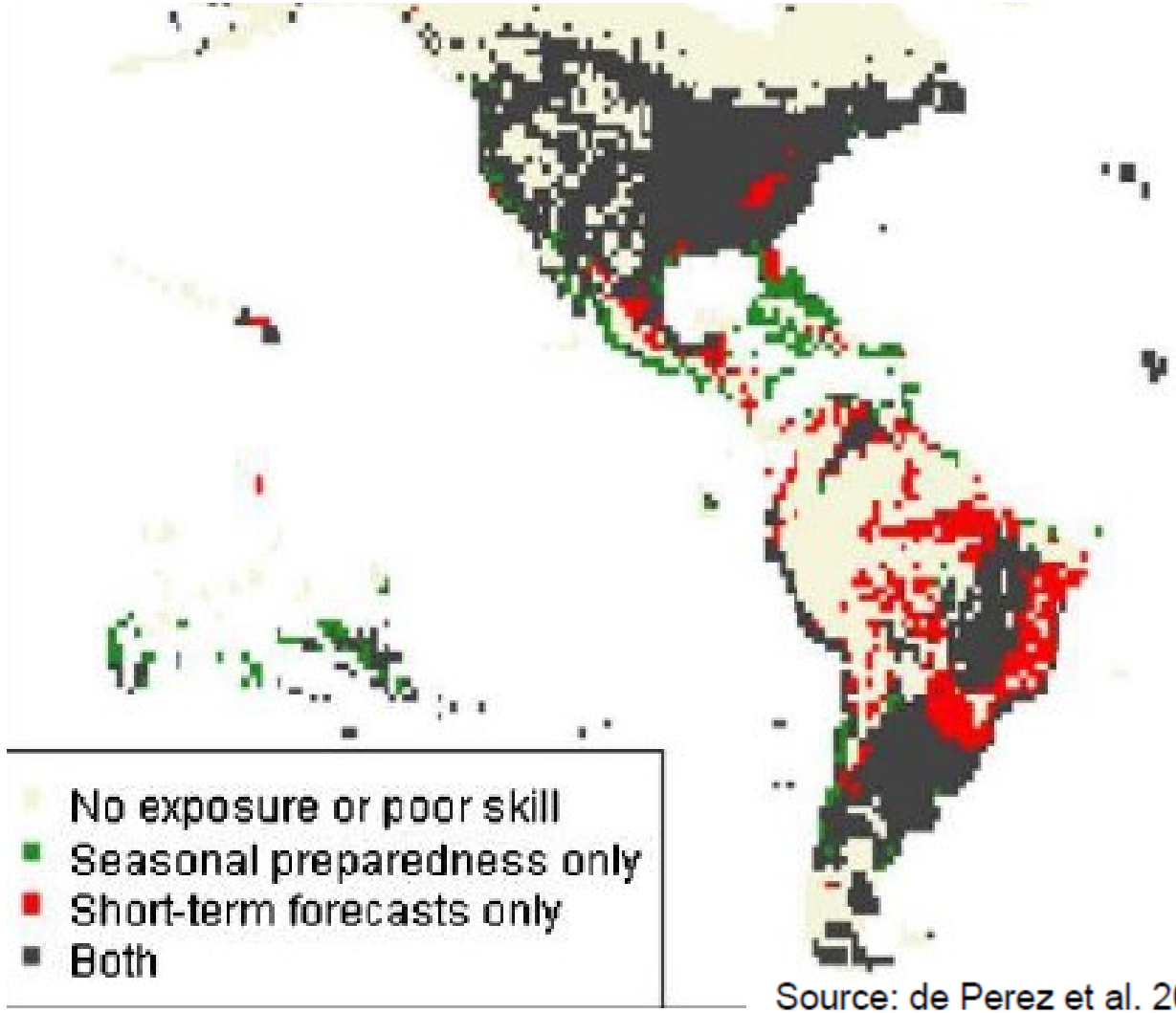
Heat Forecast

Ch. 4

Considerations:
Forecast Skill

Potential to improve global heat wave preparedness

Note: This image shows what type of preparation might be possible for heat waves based on current forecast skill. Black areas offer both skillful short-term forecasts and seasonality of heat waves in either the NOAA or European Centre for Medium-Range Weather Forecast (ECMWF) models. Green areas are regions where only seasonality could be used for preparation. Red areas are regions where only skillful short-term forecasts can be used for preparation. Cream-colored areas have no exposure or have neither distinct climatology nor forecast skill.

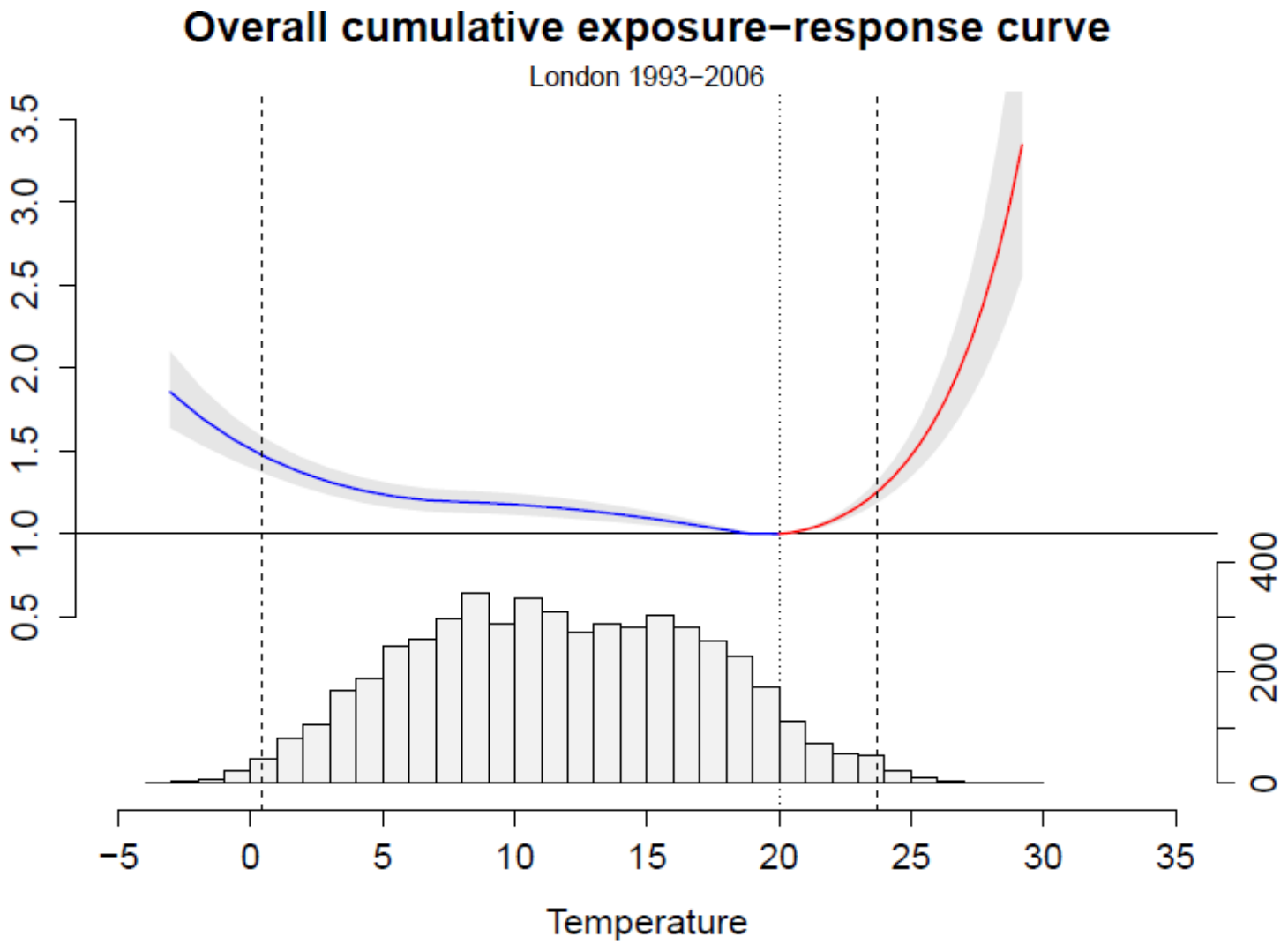


Source: de Perez et al. 2018

Ch. 4

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

Ch. 4

Setting thresholds depends on how many lives you expect to save?

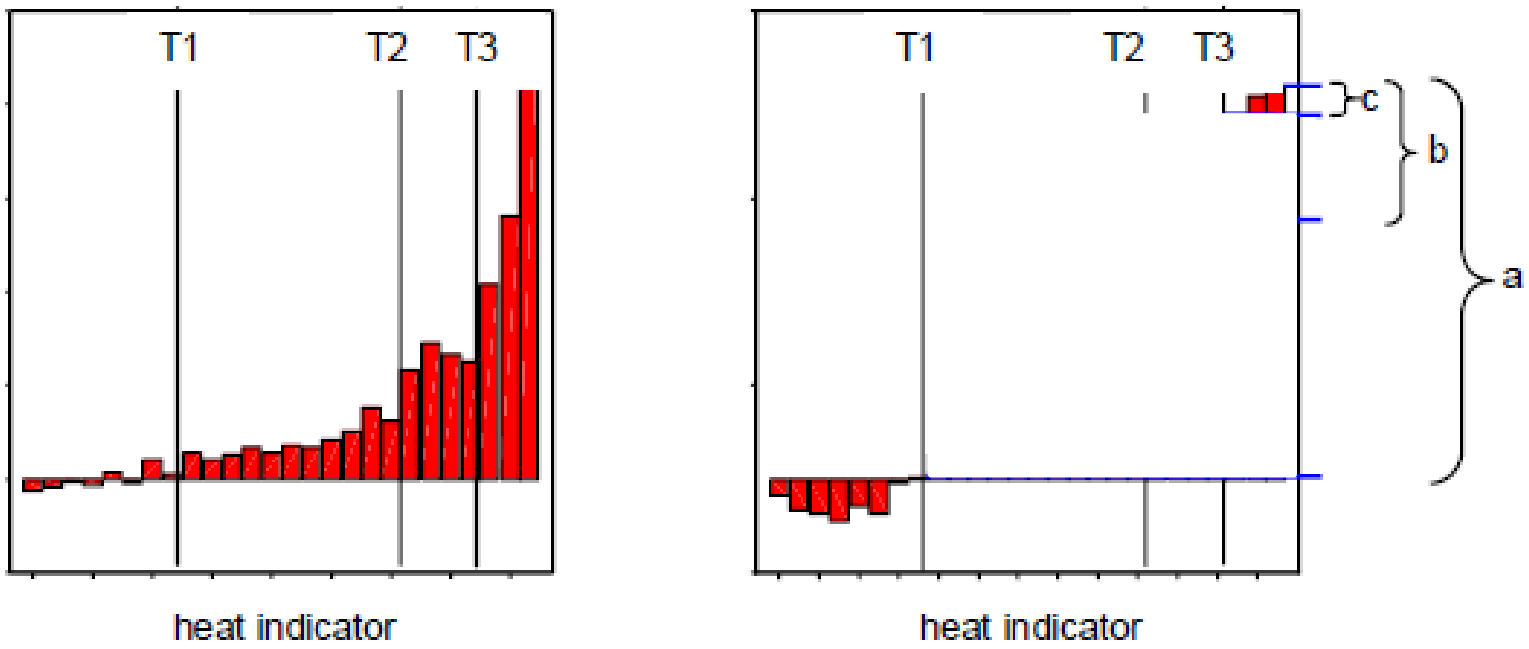
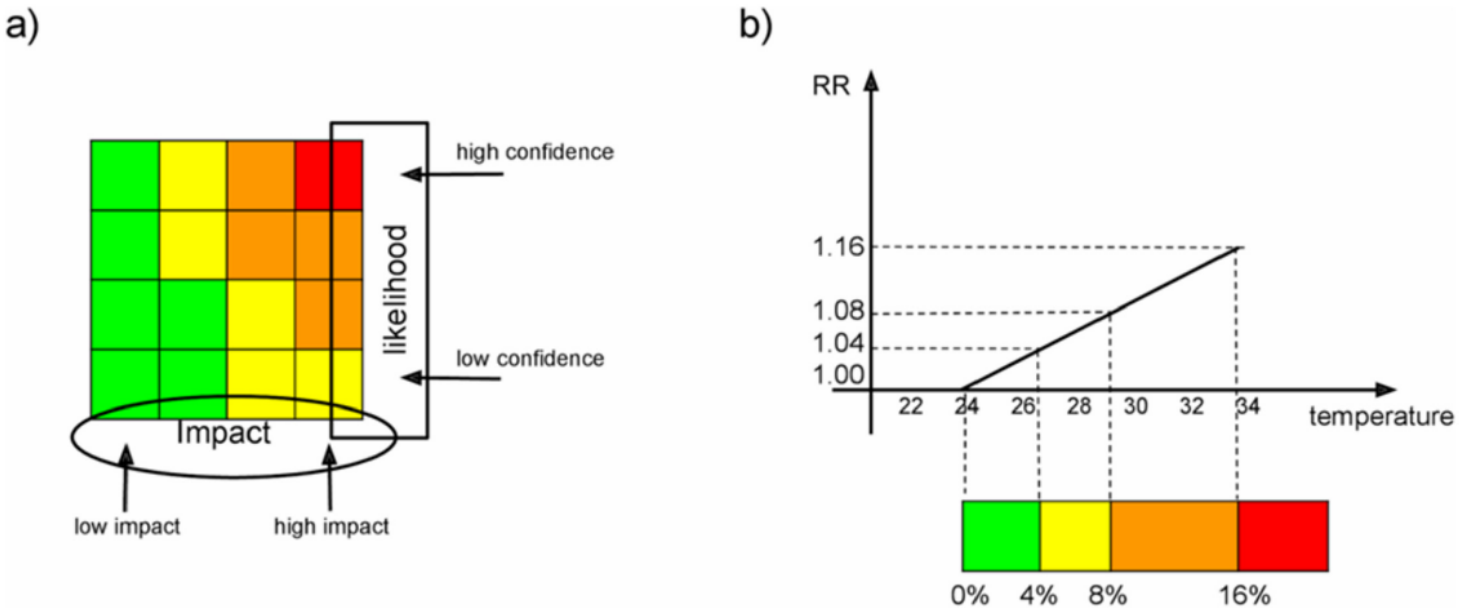


Figure 4. Example of the relationship between temperature and excess mortality during summer (left) and cumulative excess mortality (right): T1–T3 thresholds; a, b, c – amount of mortality that can be prevented when applying the different thresholds in case of a 100 per cent effective Heat–Health Warning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

Source: Koppe, 2005

Heat Health Impact Based Forecasting

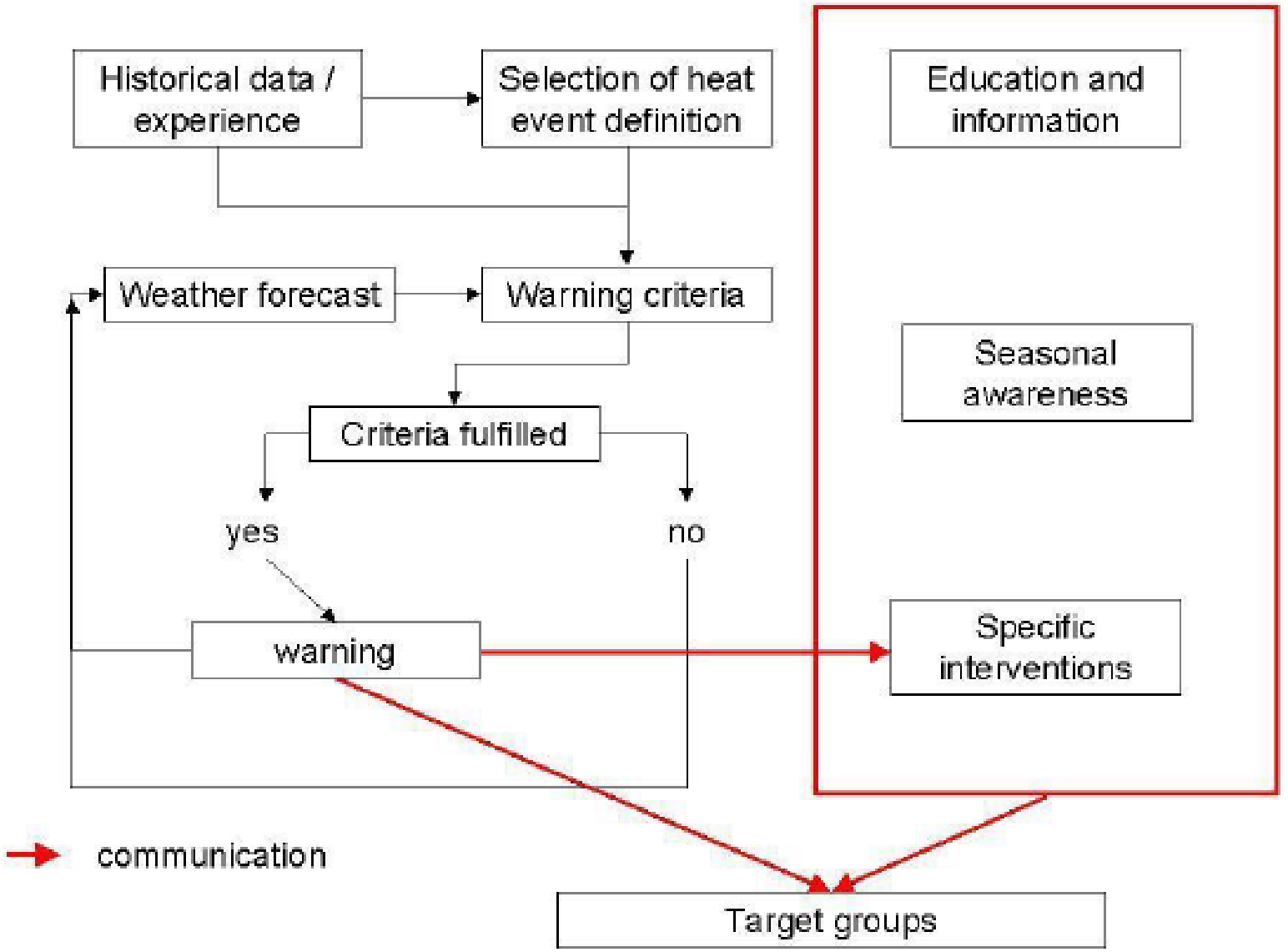


Improving the Health Forecasting Alert System for Cold Weather and Heat-Waves In England: A Proof-of-Concept Using Temperature-Mortality Relationships

Giacomo Masato[1]*, Angie Bone[2], Andrew Charlton-Perez[1], Sean Cavany[1], Robert Neal[3], Rutger Dankers[3], Helen Dacre[1], Katie Carmichael[2], Virginia Murray[2]

Ch. 4

Heat EWS Information Flows



Ch. 4

Meeting Decision-needs:

How much lead time?

2–3 DAYS LEAD TIME

Broadcast tips on how to stay cool during a heatwave.

Alert hospitals, clinics and emergency services.

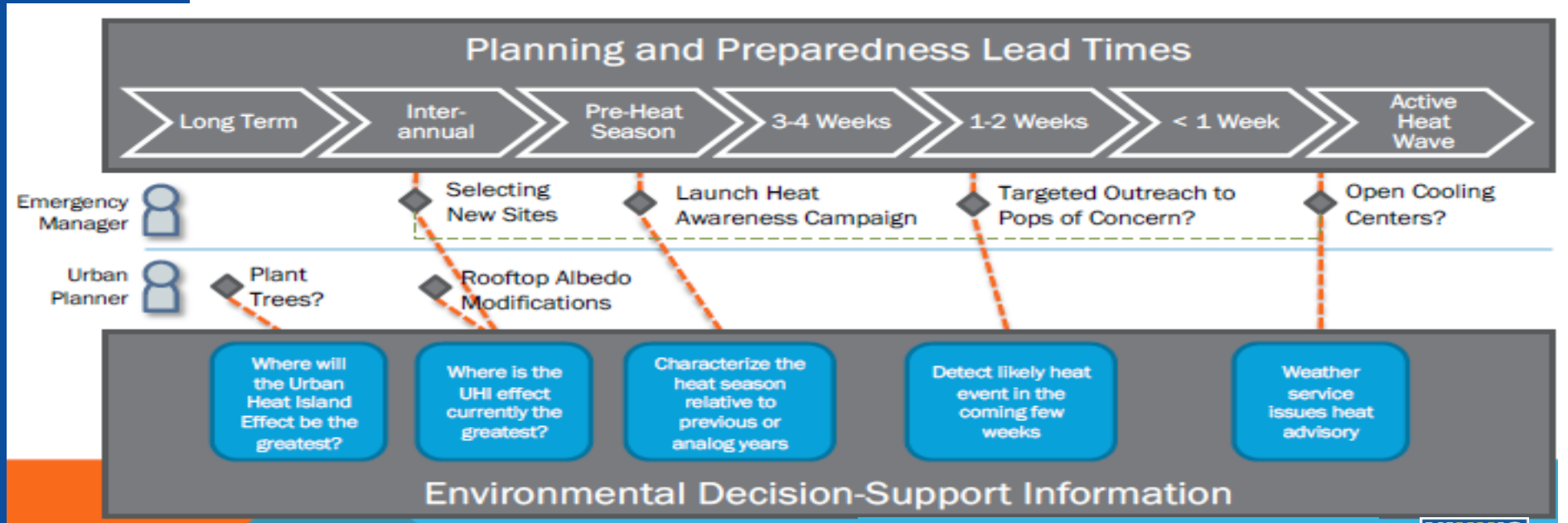
Contact high-risk individuals living alone or via nursing homes, senior care centres and neonatal wards; evaluate their health status and environmental conditions.

Staff existing cooling centres; ensure signage is visible so that people know when the centre is open; stock with first aid materials, drinking water, games/activities for children and any other context-specific equipment.

Ch. 8-9

Planning plan across timescales – not just focus on heatwave events.

Level 0	**Long-term planning** - All year
Level 1	**Heatwave and Summer preparedness programme** - 1 June – 15 September
Level 2	**Heatwave is forecast – Alert and readiness** - 60% risk of heatwave in the next 2 to 3 days
Level 3	**Heatwave Action** - temperature reached in one or more Met Office National Severe Weather Warning Service regions
Level 4	**Major incident – Emergency response** - central government will declare a Level 4 alert in the event of severe or prolonged heatwave affecting sectors other than health



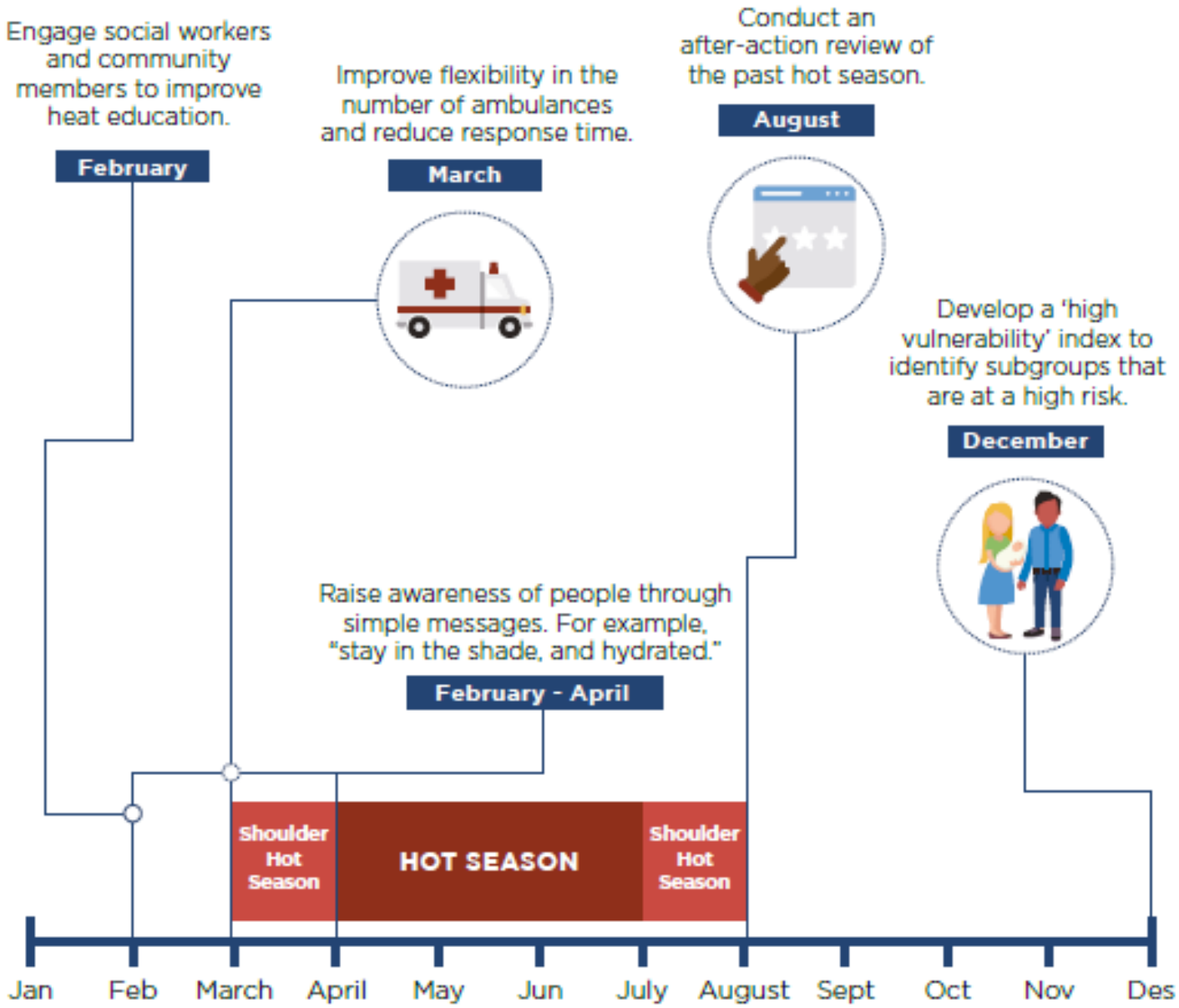
For more information see:
Ray, A. J., & Webb, R. S. (2016).
Understanding the user context: decision calendars as frameworks for linking climate to policy, planning, and decision-making.
Climate in Context, 27–50. doi:10.1002/9781118474785.ch2

NIHHIS
NATIONAL INTEGRATED HEAT HEALTH INFORMATION SYSTEM

Ch. 8-9/4

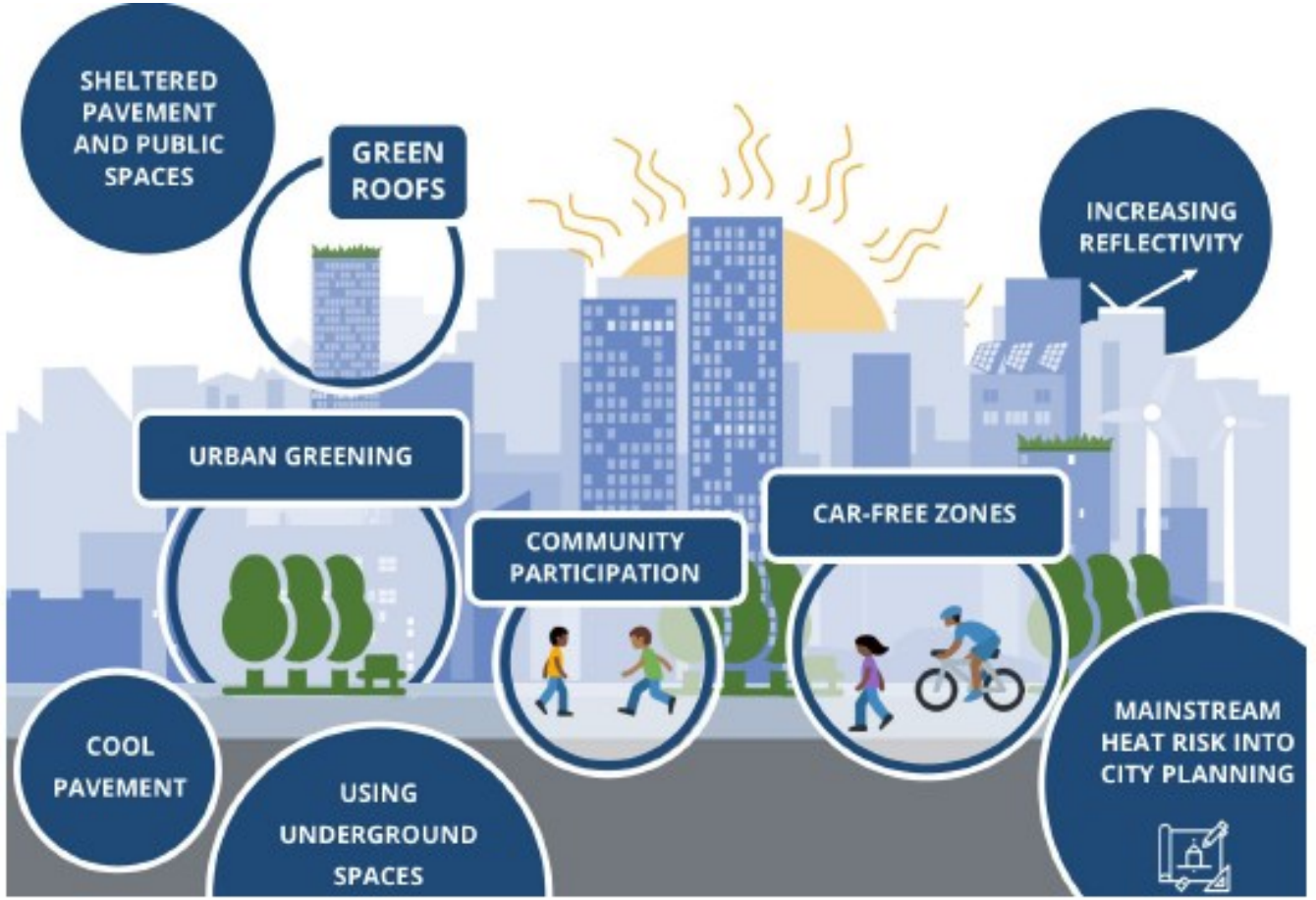
Seasonal and Annual Planning

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



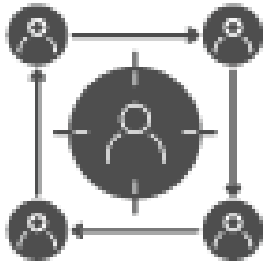
Ch. 8-9

Adapting to heat over longer time-scales



Ch. 5

Communicating with the Public



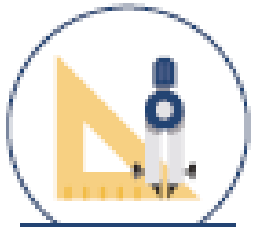
Heat warning messages must be tested for understanding before they are issued to the public.

Timing

When is the heatwave due to start?

Location

Which areas of the city will be affected?

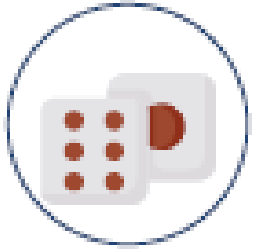


Scale

How high are temperatures likely to rise?

Impact

Who is most likely to be impacted by the heatwave?



Probability

What are the chances of this heatwave occurring?

Response

What should at-risk populations do to protect themselves?

Ch. 5

Tailored Communication and Protection:

Workers

Employers should create a heat emergency plan to ensure the safety of workers during a heatwave.

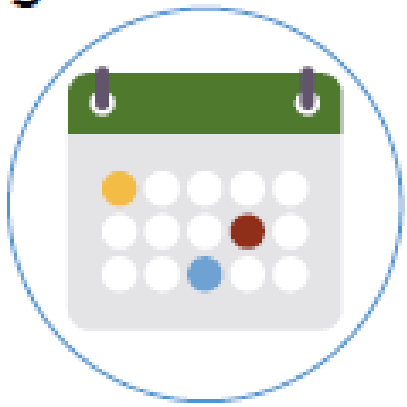
1

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.

Ch. 6

Interventions

Response Measures

During a Heatwave

Ch. 7

Evaluating Heat Preparedness & Response

GLOBAL HEAT HEALTH INFORMATION NETWORK

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.