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

Tom Kosatsky
National Collaborating Centre for Environmental Health
(BC Centre for Disease Control)

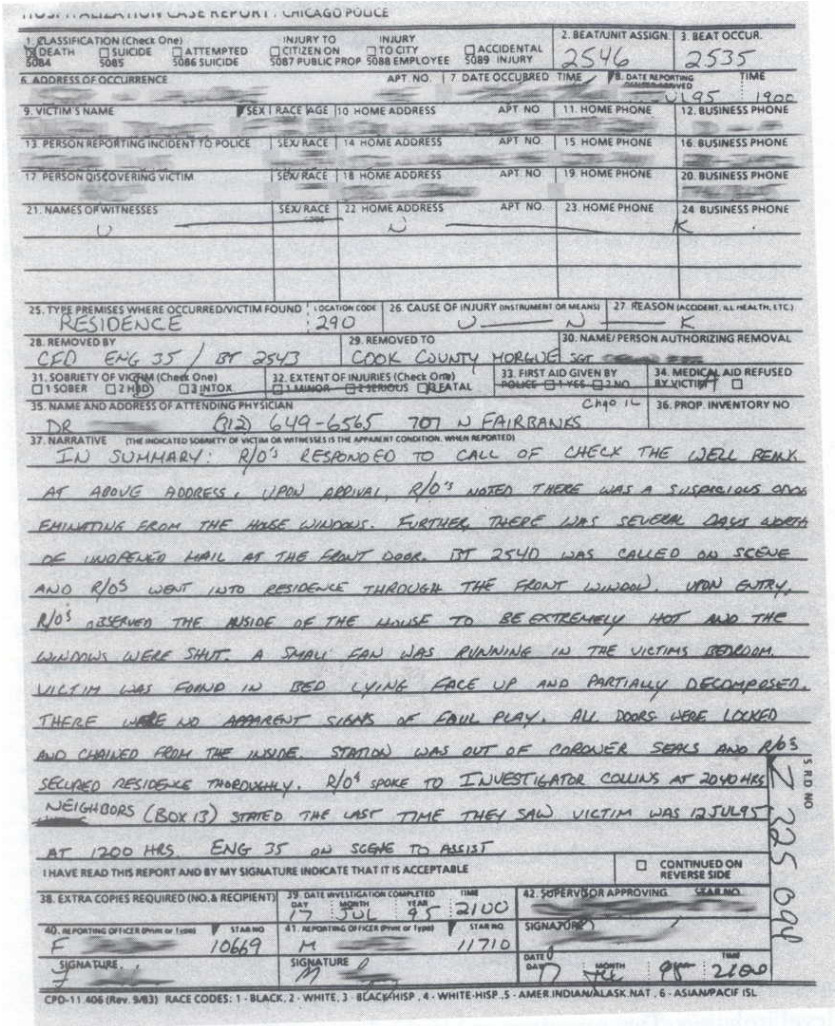
National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale

BC Centre for Disease Control
An Agency of the Provincial Health Services Authority

VERVIEW

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**.

Heat-related mortality: police report, Chicago 1995



HOSPITALIZATION CASE REPORT / CHICAGO POLICE

1. CLASSIFICATION (Check One): ☒ DEATH 5084 ☐ SUICIDE 5085 ☐ ATTEMPTED 5086 SUICIDE ☐ INJURY TO CITIZEN ON 5087 PUBLIC PROP. ☐ INJURY TO CITY 5088 EMPLOYEE ☐ ACCIDENTAL 5089 INJURY
2. BEAT/UNIT ASSIGN. 2546
3. BEAT OCCUR. 2535
6. ADDRESS OF OCCURRENCE
APT. NO.
7. DATE OCCURRED TIME
8. DATE REPORTING 12 JUL 95 TIME 1900
9. VICTIM'S NAME | SEX | RACE | AGE
10. HOME ADDRESS APT. NO.
11. HOME PHONE
12. BUSINESS PHONE
13. PERSON REPORTING INCIDENT TO POLICE | SEX/RACE
14. HOME ADDRESS APT. NO.
15. HOME PHONE
16. BUSINESS PHONE
17. PERSON DISCOVERING VICTIM | SEX/RACE
18. HOME ADDRESS APT. NO.
19. HOME PHONE
20. BUSINESS PHONE
21. NAMES OF WITNESSES | SEX/RACE
22. HOME ADDRESS APT. NO.
23. HOME PHONE
24. BUSINESS PHONE
25. TYPE PREMISES WHERE OCCURRED/VICTIM FOUND: RESIDENCE | LOCATION CODE: 290
26. CAUSE OF INJURY (INSTRUMENT OR MEANS)
27. REASON (ACCIDENT, ILL HEALTH, ETC.)
28. REMOVED BY: CFD ENG 35 / BT 2543
29. REMOVED TO: COOK COUNTY MORGUE
30. NAME/PERSON AUTHORIZING REMOVAL: SGT
31. SOBRIETY OF VICTIM (Check One): ☐ 1 SOBER ☐ 2 HBD ☐ 3 INTOX
32. EXTENT OF INJURIES (Check One): ☐ 1 MINOR ☐ 2 SERIOUS ☒ FATAL
33. FIRST AID GIVEN BY: POLICE ☐ 1 YES ☐ 2 NO
34. MEDICAL AID REFUSED BY VICTIM ☐
35. NAME AND ADDRESS OF ATTENDING PHYSICIAN: DR (312) 649-6565 707 N FAIRBANKS
36. PROP. INVENTORY NO.
37. NARRATIVE (THE INDICATED SOBRIETY OF VICTIM OR WITNESSES IS THE APPARENT CONDITION, WHEN REPORTED)

IN SUMMARY: R/O'S RESPONDED TO CALL OF CHECK THE WELL BEING AT ABOVE ADDRESS. UPON ARRIVAL, R/O'S NOTED THERE WAS A SUSPICIOUS ODOR EMINATING FROM THE HOUSE WINDOWS. FURTHER, THERE WAS SEVERAL DAYS WORTH OF UNOPENED MAIL AT THE FRONT DOOR. BT 2540 WAS CALLED ON SCENE AND R/O'S WENT INTO RESIDENCE THROUGH THE FRONT WINDOW. UPON ENTRY, R/O'S OBSERVED THE INSIDE OF THE HOUSE TO BE EXTREMELY HOT AND THE WINDOWS WERE SHUT. A SMALL FAN WAS RUNNING IN THE VICTIMS BEDROOM. VICTIM WAS FOUND IN BED LYING FACE UP AND PARTIALLY DECOMPOSED. THERE WERE NO APPARENT SIGNS OF FOUL PLAY. ALL DOORS WERE LOCKED AND CHAINED FROM THE INSIDE. STATION WAS OUT OF CORONER SEALS AND R/O'S SECURED RESIDENCE THOROUGHLY. R/O'S SPOKE TO INVESTIGATOR COLLINS AT 2040 HRS. NEIGHBORS (BOX 13) STATED THE LAST TIME THEY SAW VICTIM WAS 12 JUL 95 AT 1200 HRS. ENG 35 ON SCENE TO ASSIST

5. R.D. NO. Z 225 604

I HAVE READ THIS REPORT AND BY MY SIGNATURE INDICATE THAT IT IS ACCEPTABLE
☐ CONTINUED ON REVERSE SIDE

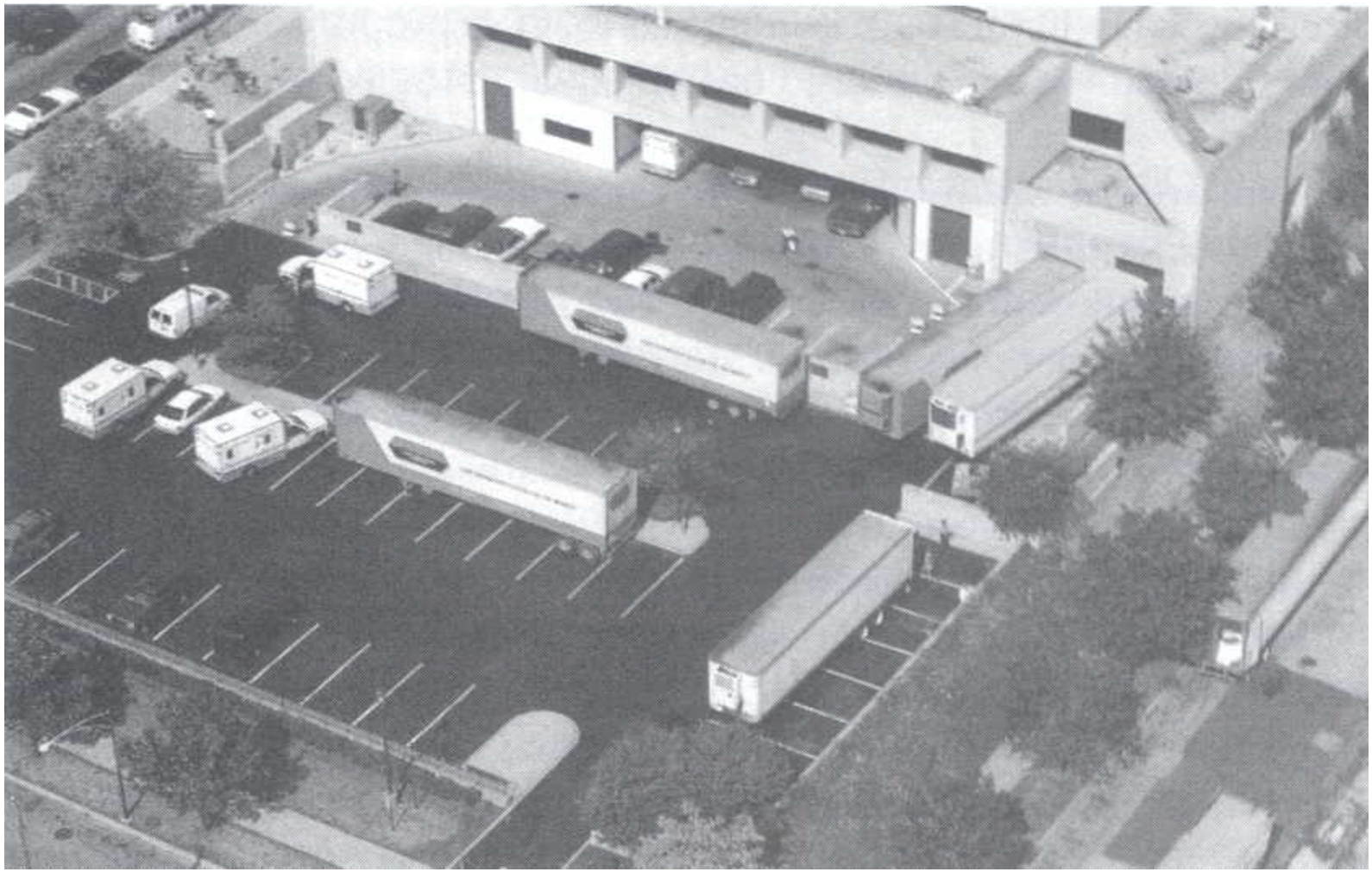
38. EXTRA COPIES REQUIRED (NO. & RECIPIENT)
39. DATE INVESTIGATION COMPLETED: DAY 13 MONTH JUL YEAR 95 TIME 2100
42. SUPERVISOR APPROVING STAR NO.
40. REPORTING OFFICER (Print or Type): F STAR NO. 10669
41. REPORTING OFFICER (Print or Type): M STAR NO. 11710
SIGNATURE
SIGNATURE
DATE 13 MONTH JUL YEAR 95 TIME 2100

CPD-11.406 (Rev. 9/83) RACE CODES: 1 - BLACK, 2 - WHITE, 3 - BLACK/HISP., 4 - WHITE-HISP., 5 - AMER. INDIAN/ALASK. NAT., 6 - ASIAN/PACIF. ISL.

Figure 15. A police report notes the conditions of a decedent's apartment: "suspicious odor," "unopened mail," "extremely hot," "windows were shut."

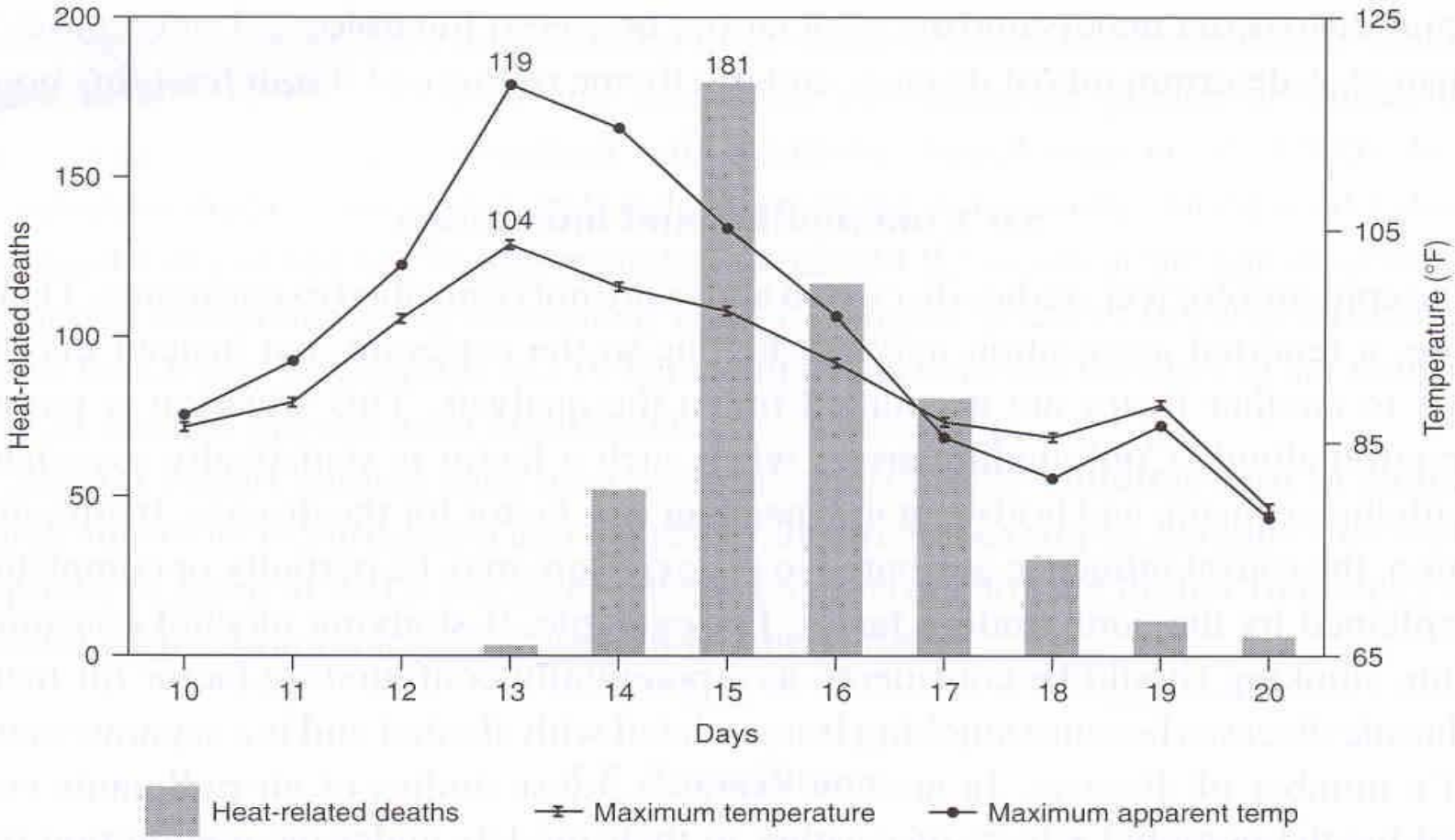
Heat wave (prolonged period of excessively hot weather; no universal definition of a heat wave: the term is relative to the usual weather in the area) **Chicago,1995: refrigerator trucks by city morgue**

Klinenberg, 2003



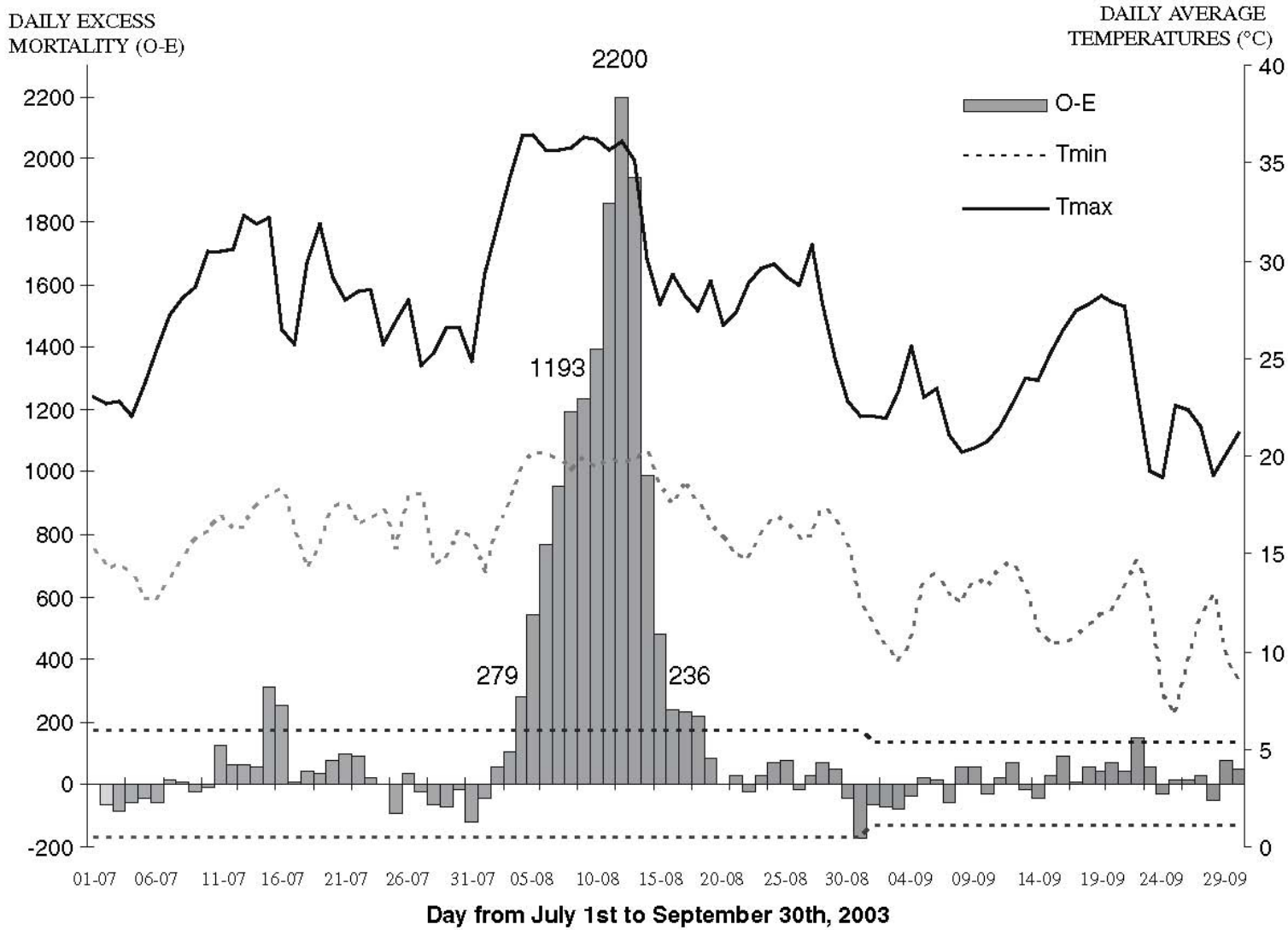
Heat wave-related deaths in Chicago during July 1995

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

Fouillet, 2006

Number of Days Exceeding 30 Year Average by 5° - T Min 9° - T Max	< 55 Years		55 – 74		≥ 75	
	Deaths Obs-Exp	Obs/Exp	Deaths Obs-Exp	Obs/Exp	Deaths Obs-Exp	Obs/Exp
0 – 1	55	1.1	201	1.1	1591	1.4
2 – 3	125	1.2	316	1.2	1390	1.4
4 – 7	265	1.3	694	1.4	3500	1.8
≥ 8	260	1.3	1078	1.6	5249	2.2

$P<0.05$

Excess Deaths by Medical Cause: France, August 2003

Fouillet, 2006

Cause	Obs-Exp	Obs/Exp	[95% CI]
Dehydration	1628	11.9	[11 – 13]
Heatstroke	1313	165.1	[100 – 270]
Hyperthermia	365	82.1	[42 – 159]
Circulatory System	*3064*	*1.4*	[1.4 – 1.4]
Respiratory System	1365	1.9	[1.8 – 2.0]
Neoplasms	933	1.1	[1.1 – 1.1]
Nervous System	1001	2	[1.9 – 2.1]
Psychiatric	748	1.8	[1.7 – 1.9]
Pregnancy, Childbirth	-4	0.0	

Excess Deaths by Place of Death, Marital Status: France, August 2003

Fouillet, 2006

Place of Death	< 55 Years		55 – 74		≥ 75	
	Deaths Obs-Exp	Obs/Exp	Deaths Obs-Exp	Obs/Exp	Deaths Obs-Exp	Obs/Exp
Home	343	1.2	951	1.6	3836	1.9
Institution	2	1.2	190	1.9	2382	1.9
Hospital	239	1.1	1038	1.3	4719	1.4
Street	*29*	*1.1*	*9*	*1.1*	*-7*	*0.9*
Marital Status						
Single	434	1.3	645	1.8	1392	2.1
Divorced	124	1.2	358	1.5	573	2.0
Widowed	24	1.4	486	1.5	7186	1.8
Married	*211*	*1.2*	*834*	*1.2*	*2682*	*1.5*

$p < 0.05$

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

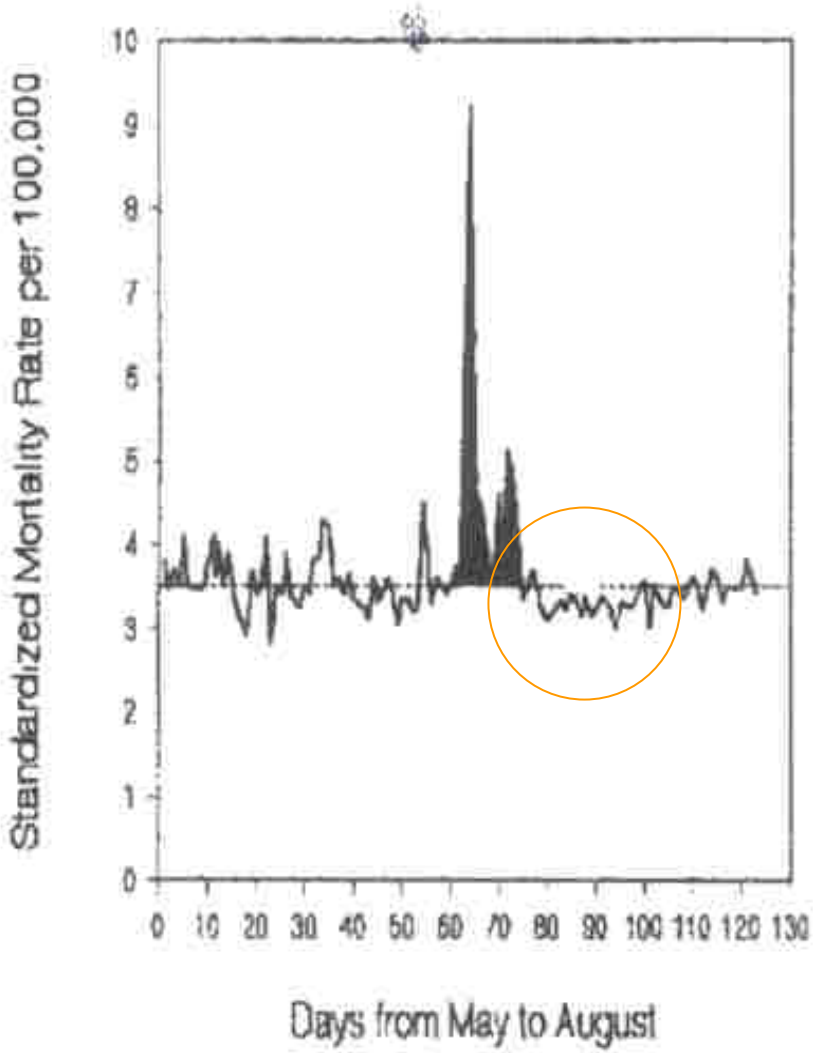
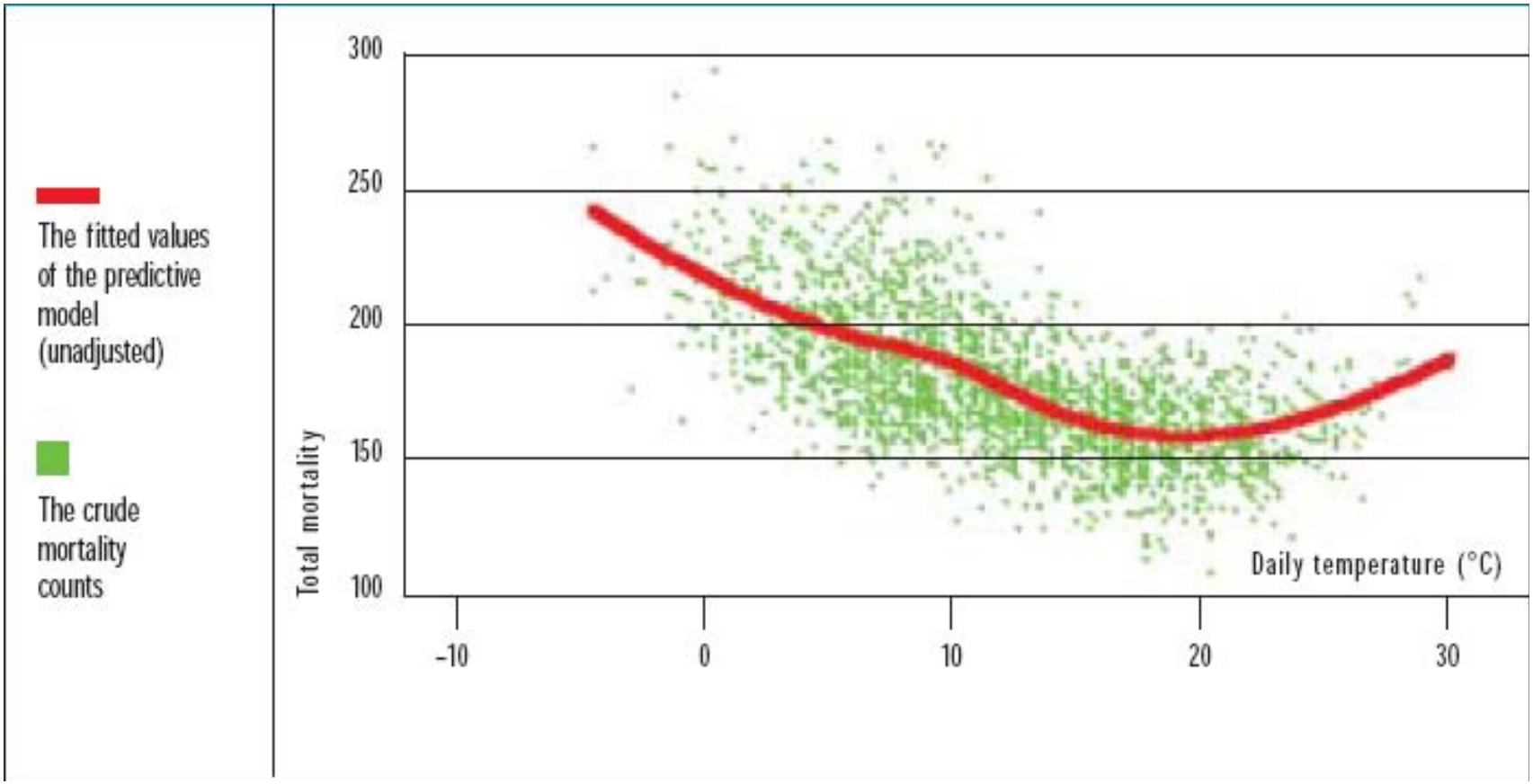


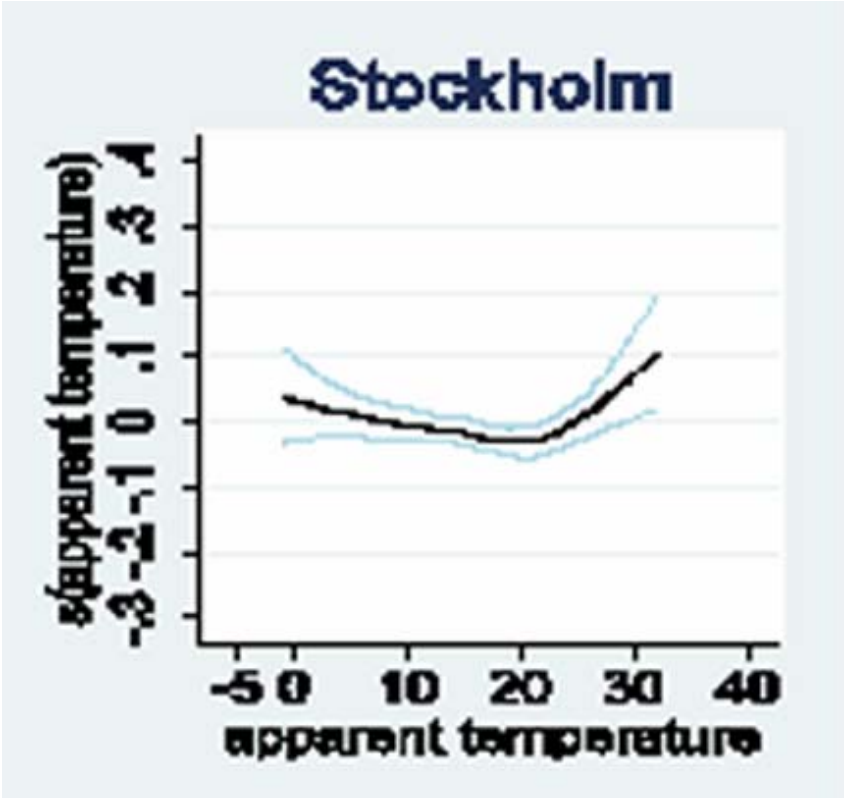
Fig. 5. Daily summer mortality around a New York heat wave, 1966. *Solid shading* shows mortality during the heat wave; *stippling* shows mortality in the immediately following period

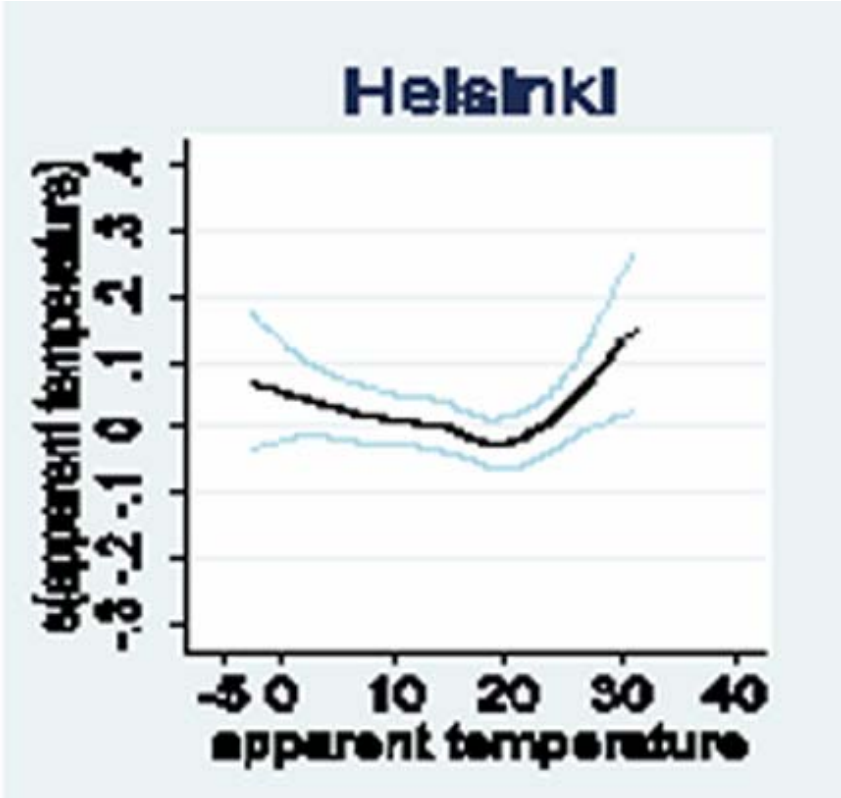
Daily mortality *vs.* temperature, outside of heat waves (*typical European City*)

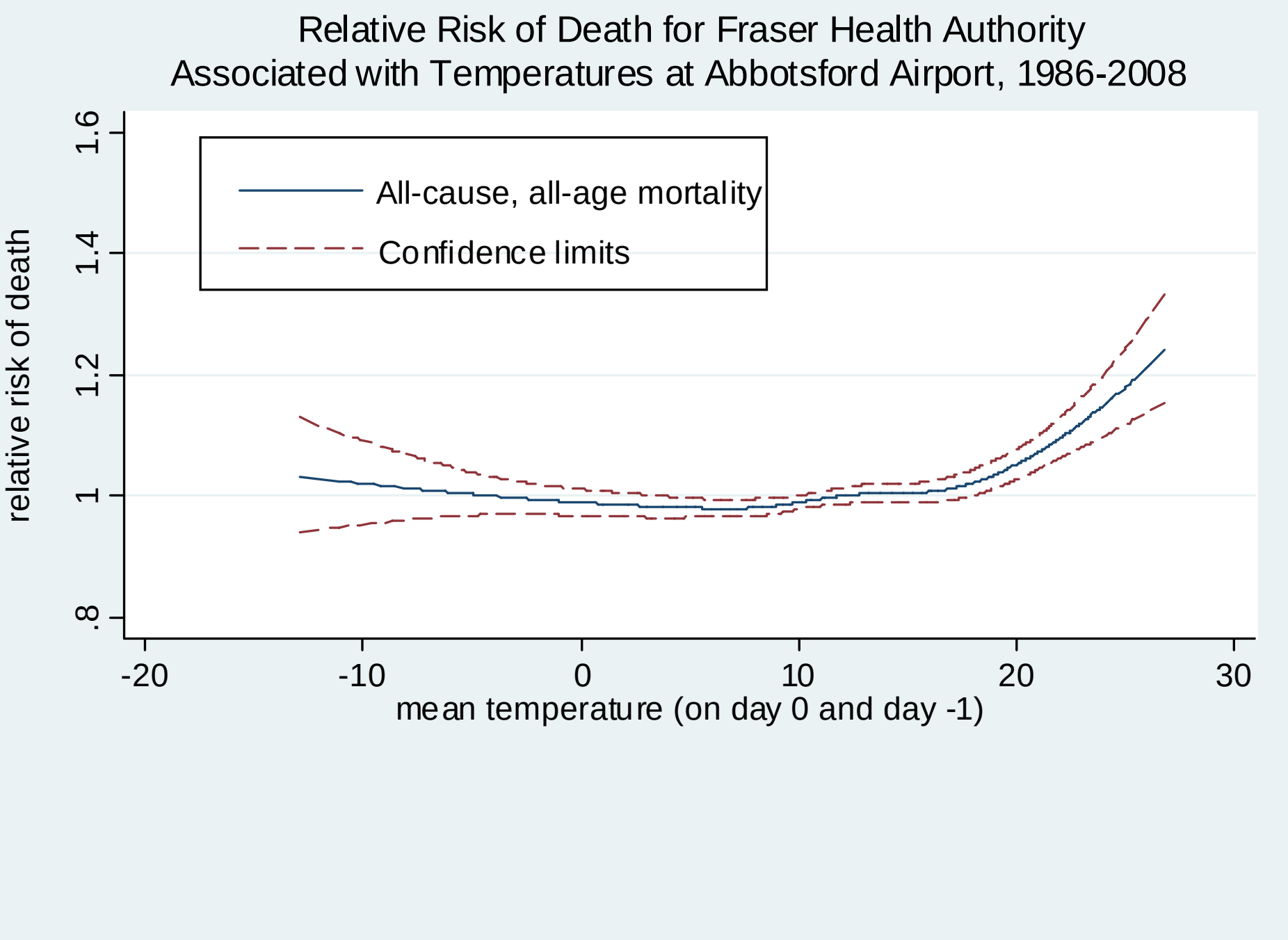


Summer Deaths *vs.* 4-Day Apparent Tmax, *Stockholm and Helsinki*, 1990-2000

Baccini, 2007

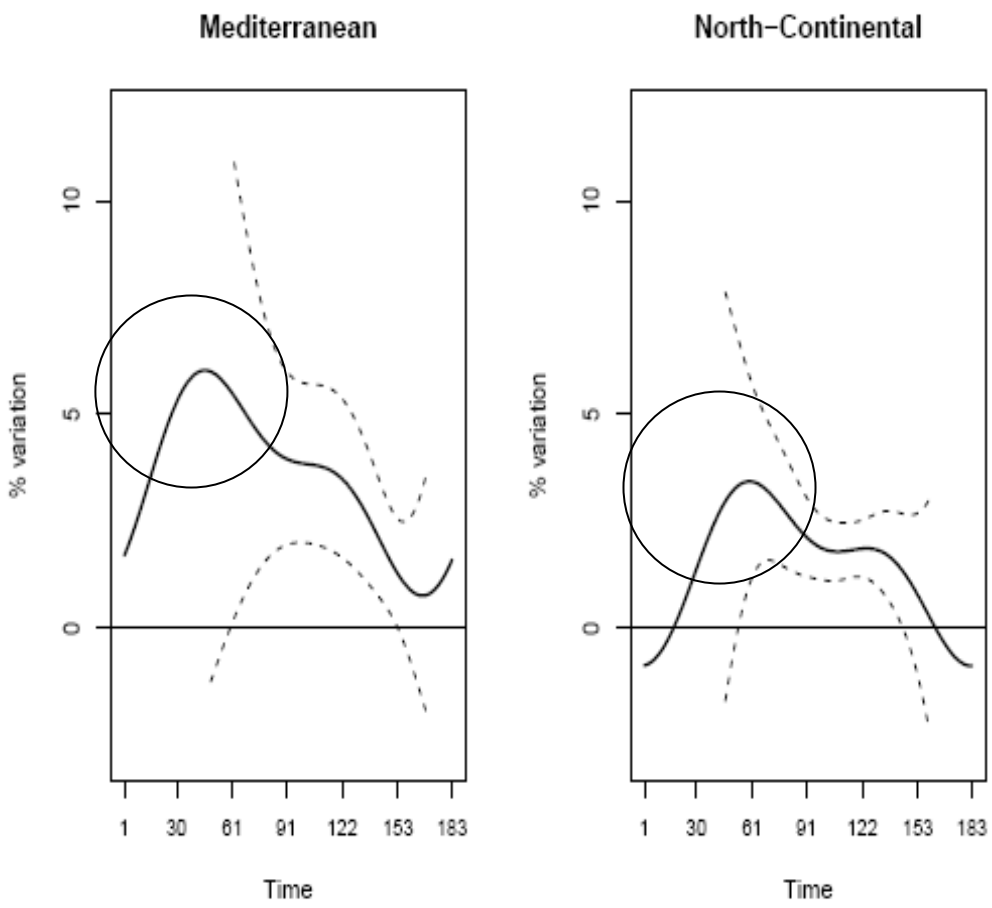





Relative Risk of Death for Fraser Health Authority
Associated with Temperatures at Abbotsford Airport, 1986-2008
All-cause, all-age mortality
Confidence limits
relative risk of death
.8
1
1.2
1.4
1.6
-20
-10
0
10
20
30
mean temperature (on day 0 and day -1)

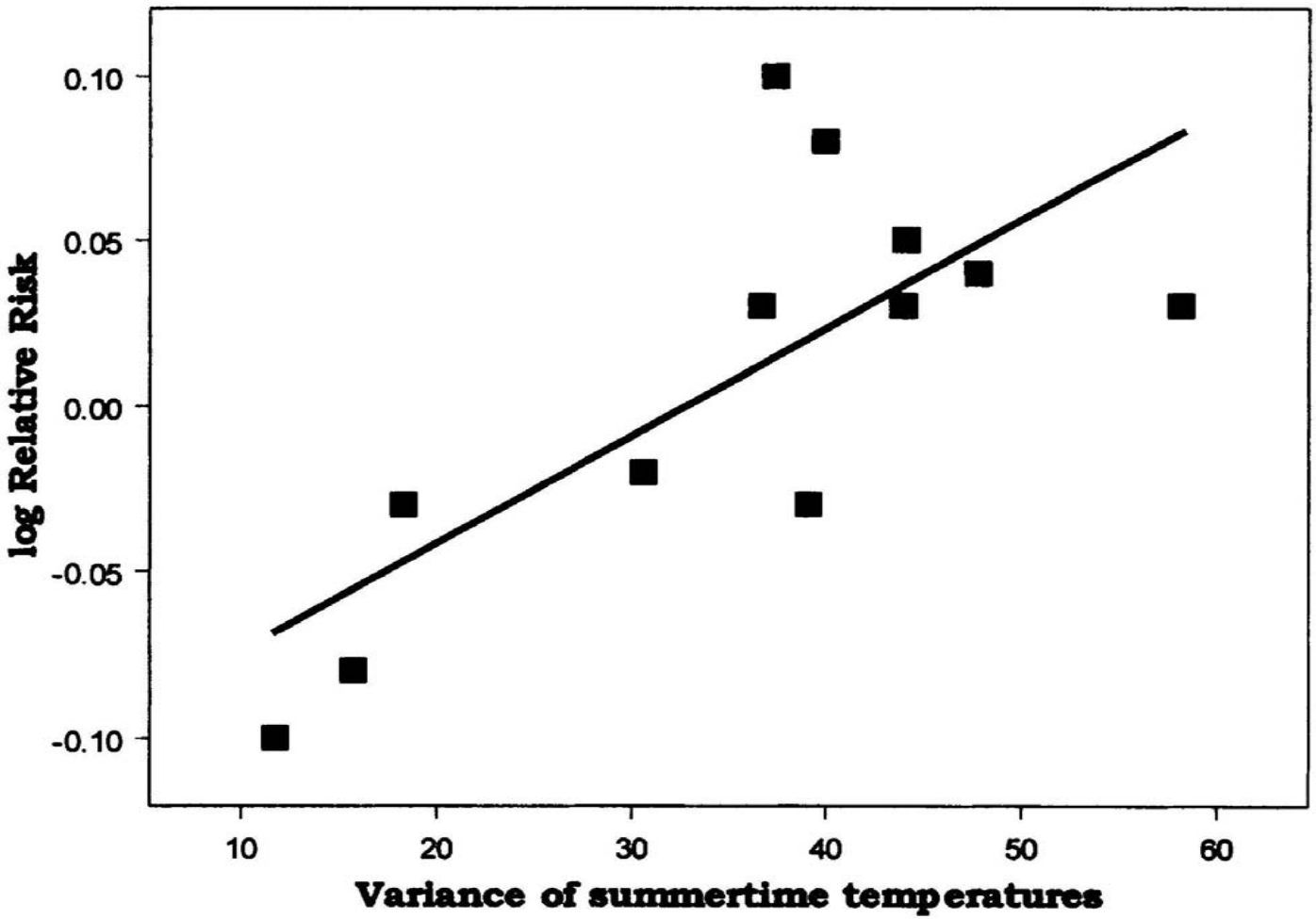
Influence of day during summer on the effect (% increase) of temperature on overall mortality

Baccini, 2007



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

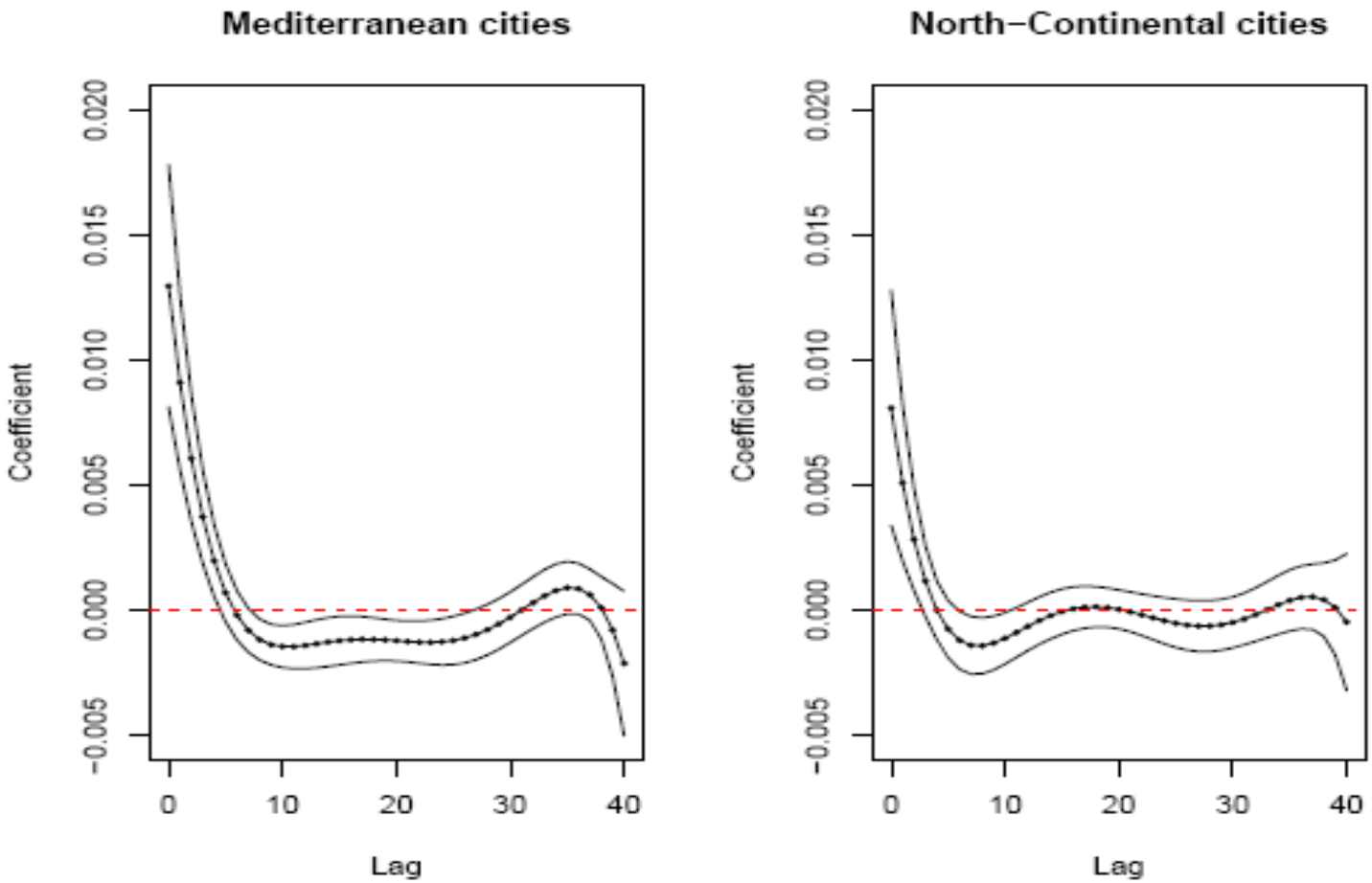
Braga, 2001



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

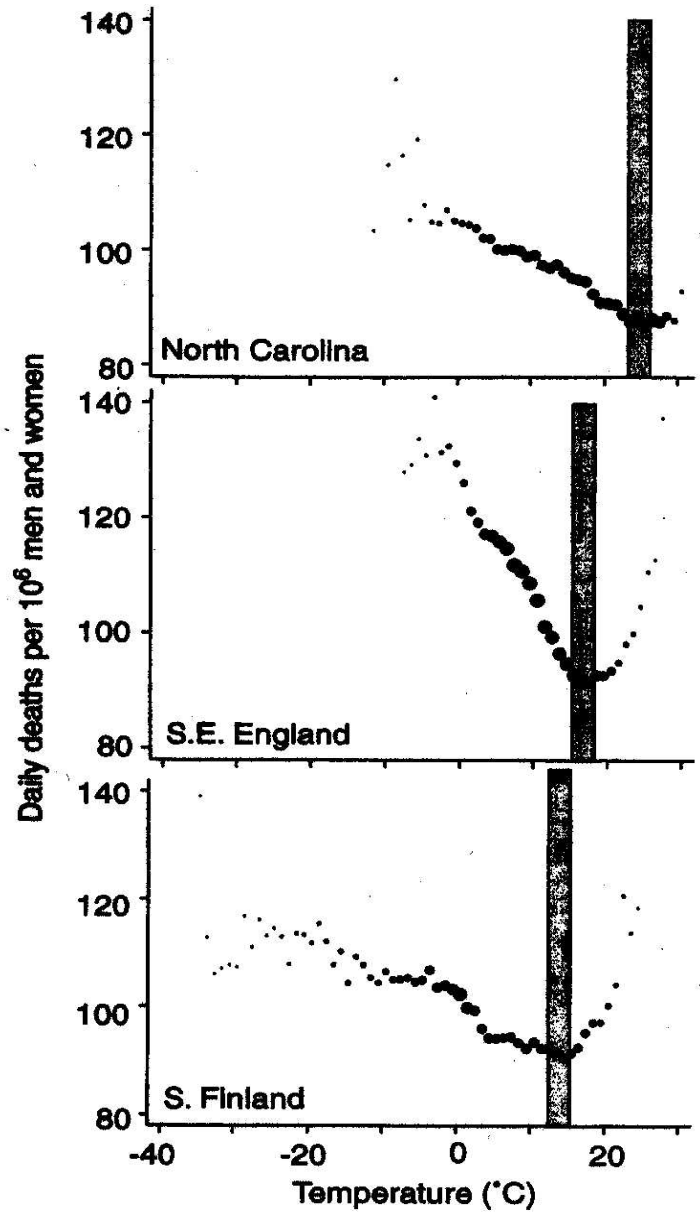
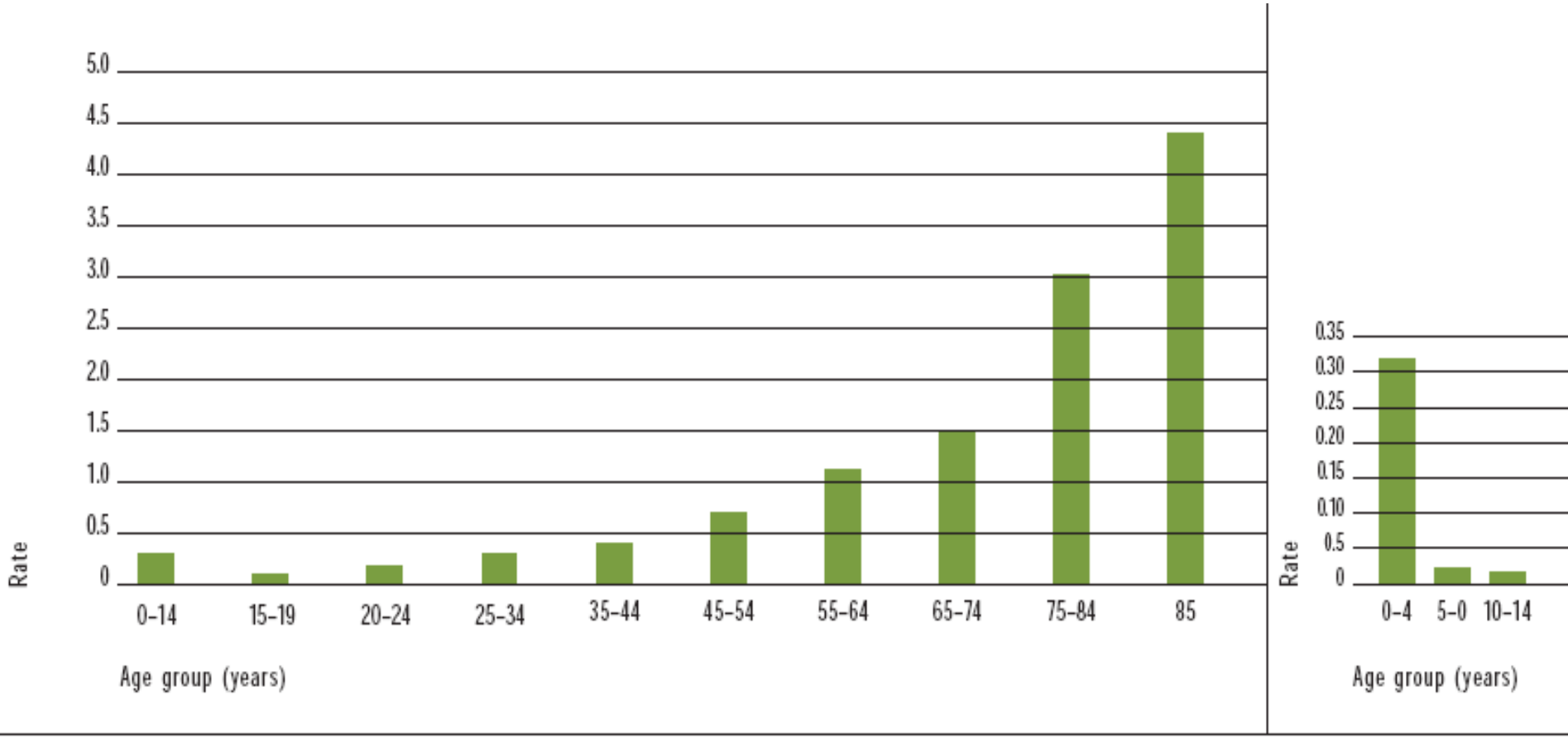


Fig. 1. Mortality at different mean daily temperatures. Pooled data for each region at age 55+, 1971–1997. The areas of circles are proportional to the number of days at each temperature.

Average annual rate of heat-related deaths/ million in the US from « excess heat » by age group, 1979–1997

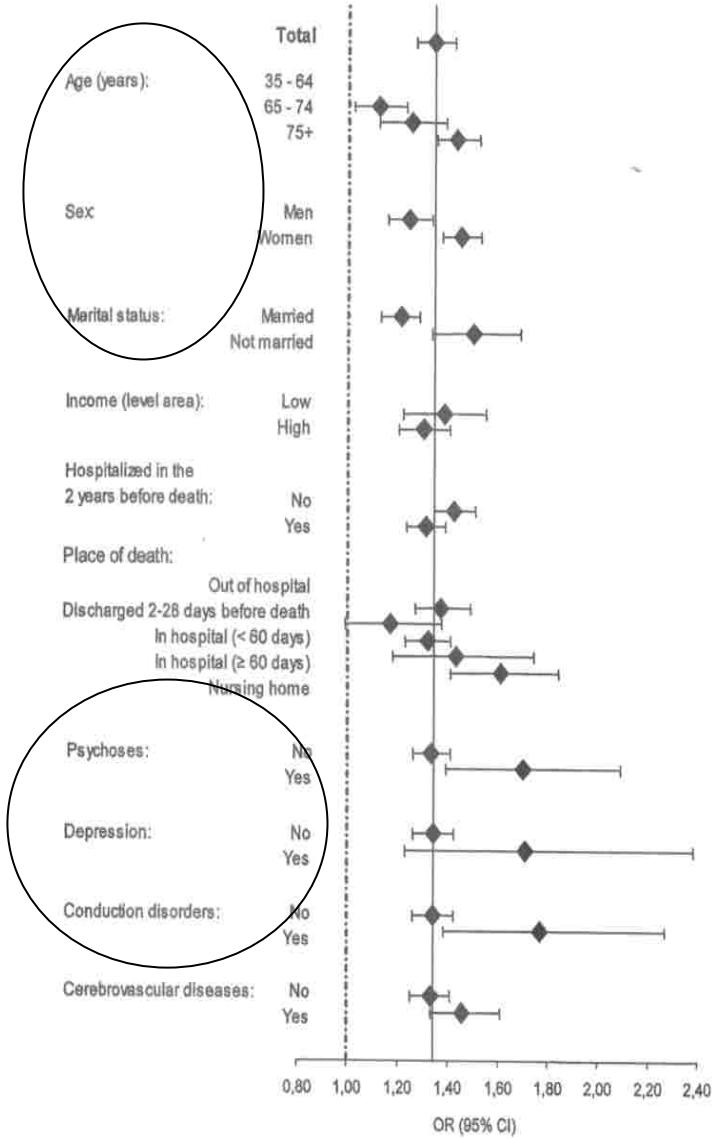


[a] *Underlying cause of death attributed to excess heat exposure classified according to ICD-9 code E900.0 "due to weather conditions (deaths)".*

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?

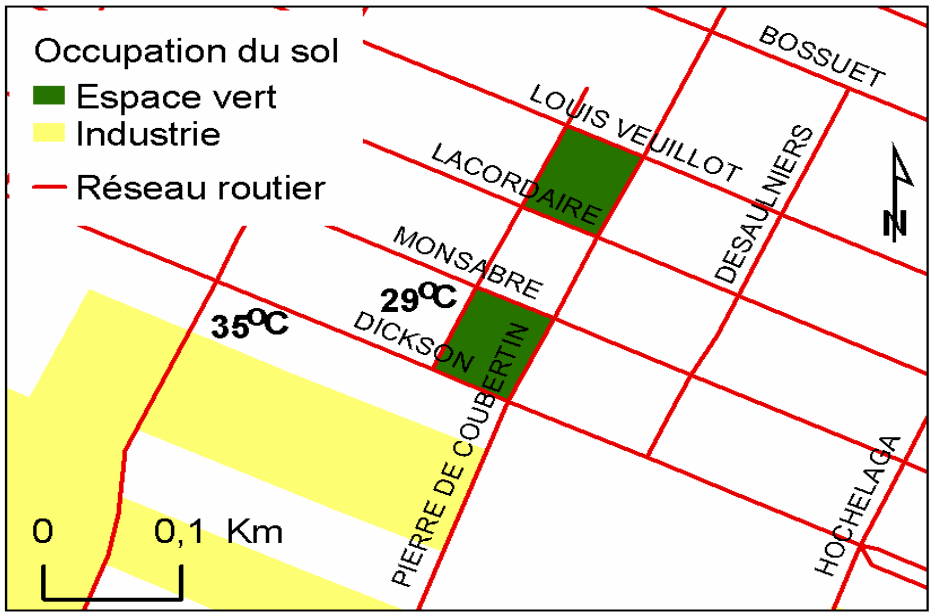
« Among all deaths at 33+ degrees C (in Kyushu), the proportion from

« excessive heat» never exceeded 0.4%. This suggests that heat stroke is not a major contributor. »

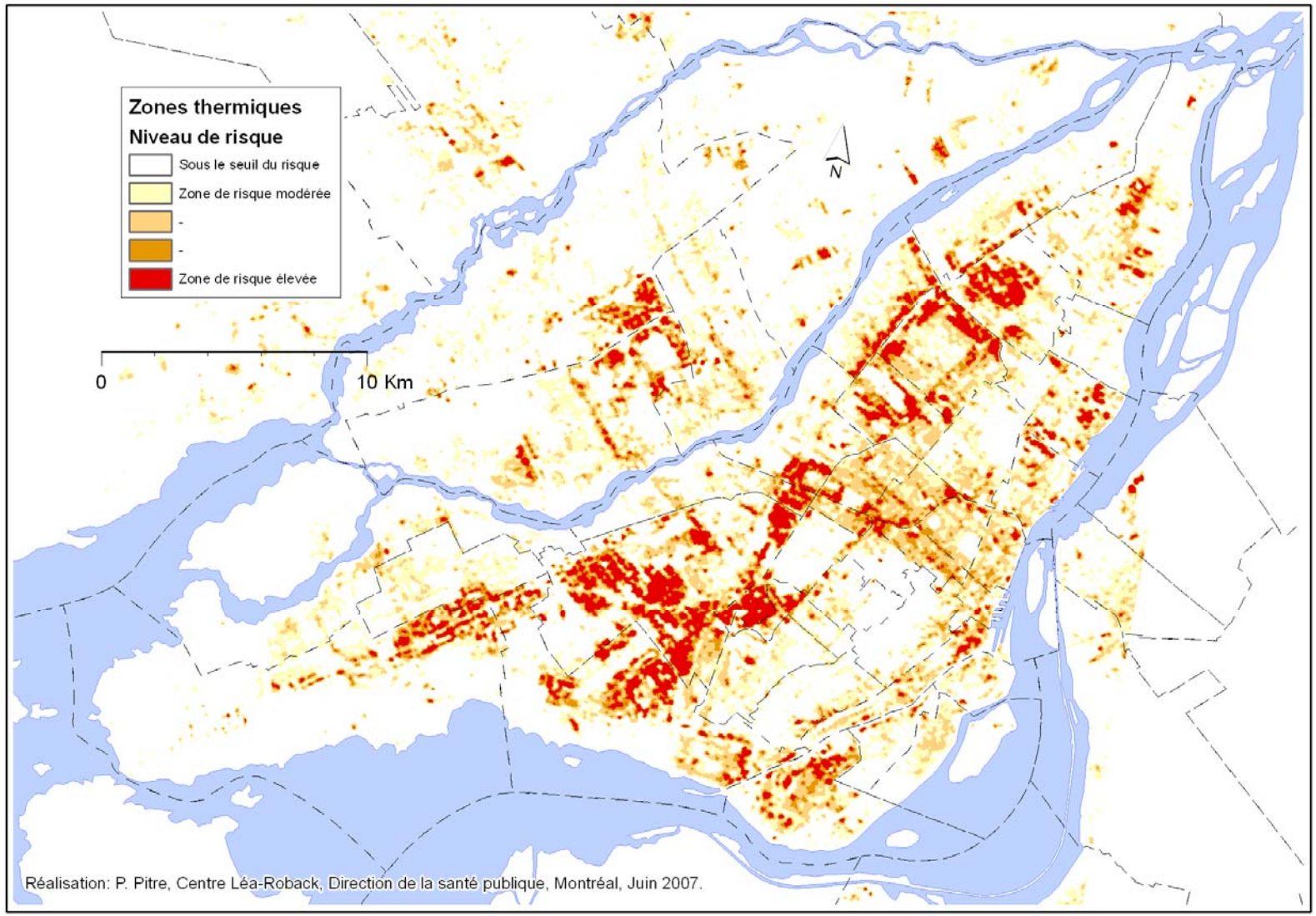
Honda Y, Ono M, Sasaki A, Uchiyama I, 1995

Urban micro-climates in Montréal

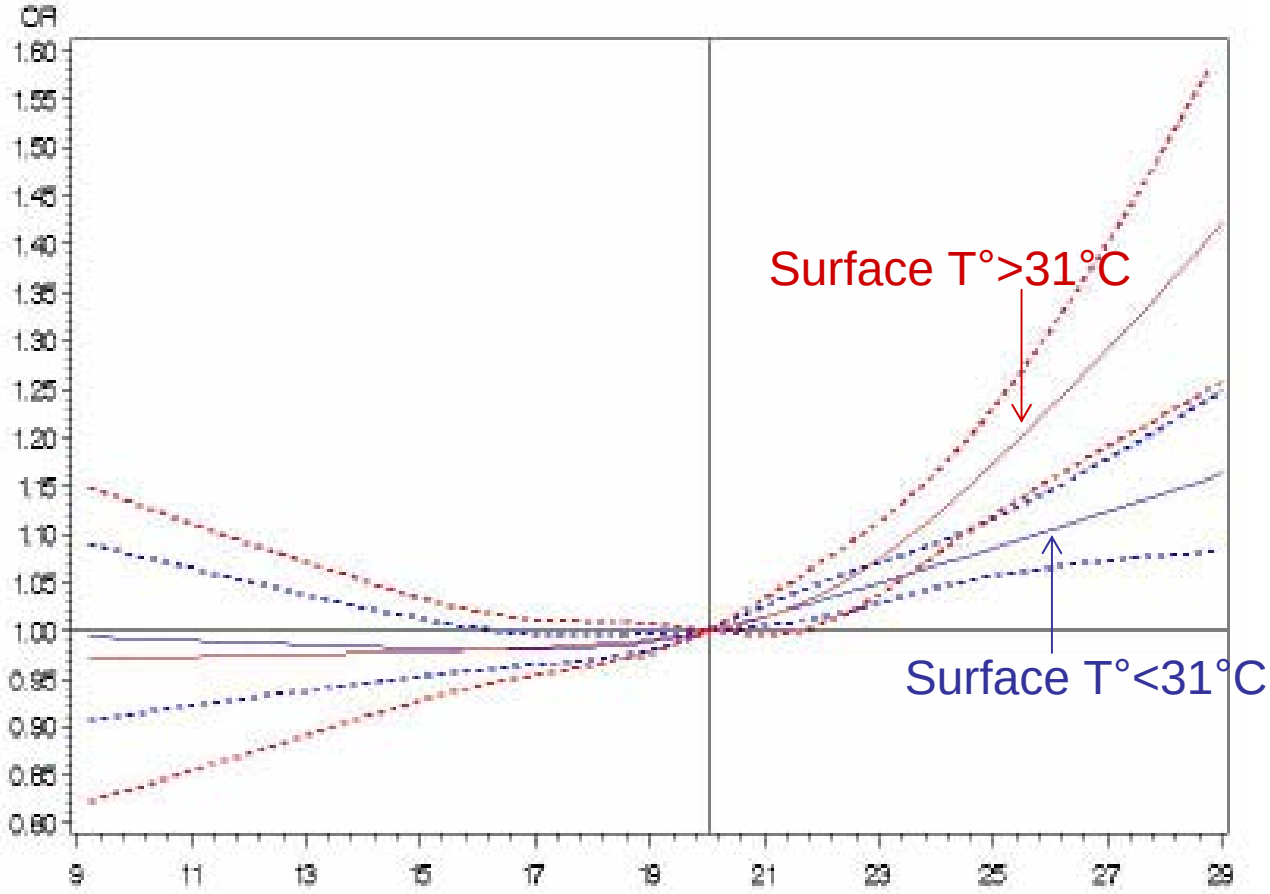
- Importance de considérer ce qui est à proximité de l'îlot de chaleur urbain. Le milieu environnent influence directement le comportement thermique des secteurs
  Exemple:
  2 secteurs de densité résidentielle moyenne, situés tous deux dans Mercier/Hochelaga-Maisonneuve, cumulent des températures très différentes (35oC et 29oC). 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**



Daily mean T° at Dorval airport, day of death

***Smargiassi et al., Epi and Comm Health*

However, heat-related deaths are not only a city problem

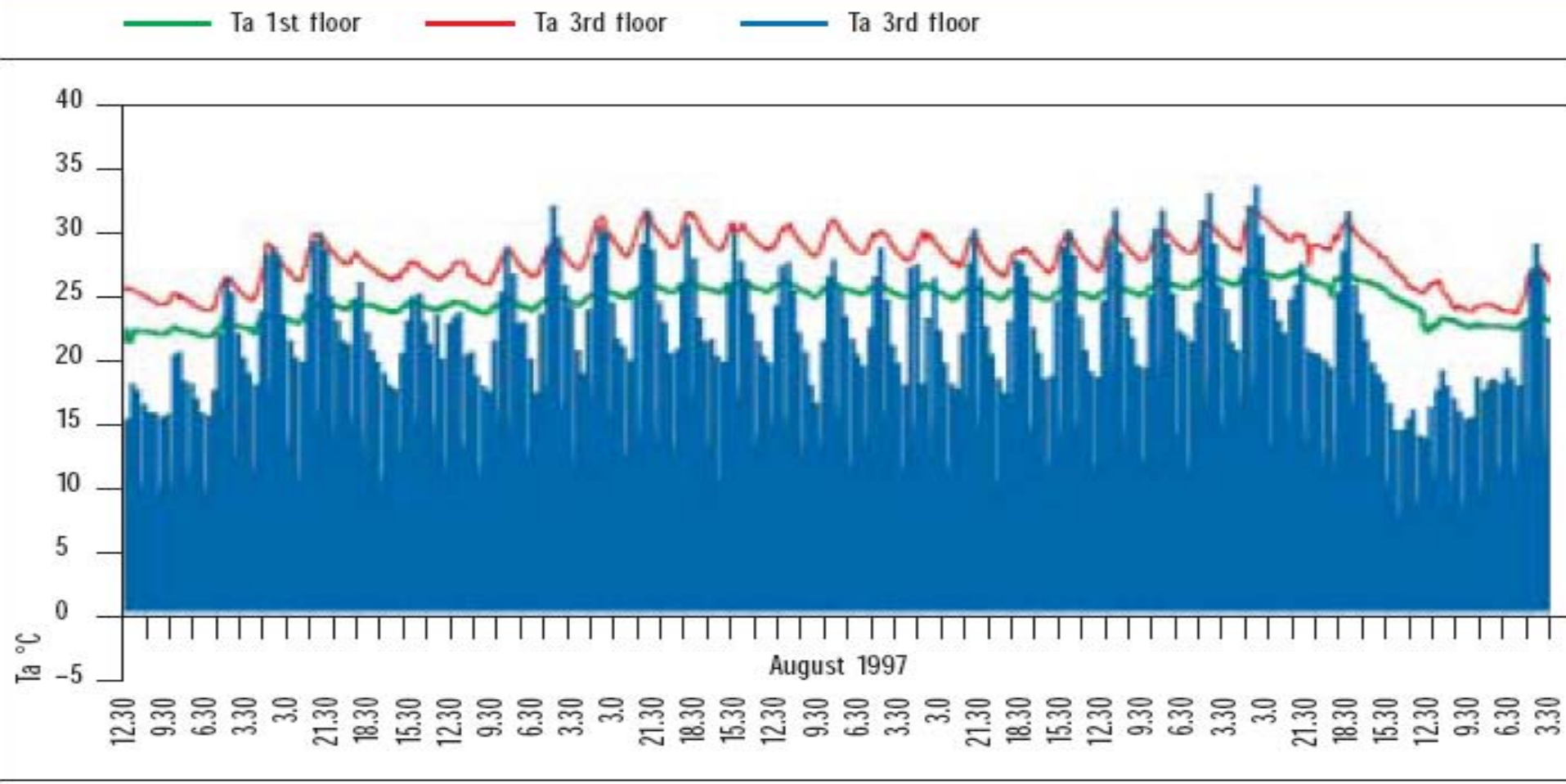
(Rajpal, Wisc Med J 2000)

Table 1. Characteristics of Decedents from Excessive Heat in Wisconsin in 1999

Group	Number	Rate (per 100,000)[1]
Age (years)		
<20	0	0
20-44	0	0
45-64	7	0.63
65-84	13	2.20
>85	1	1.10
Gender		
Male	14	0.54
Female	7	0.26
Race		
White	19	0.37
Black	2	0.69
County		
Milwaukee	11	1.15
Other Counties[2]	10	0.71
TOTAL	**21**	**0.40**

[1]Rates for numbers less than 20 are unreliable.
[2]Includes: 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



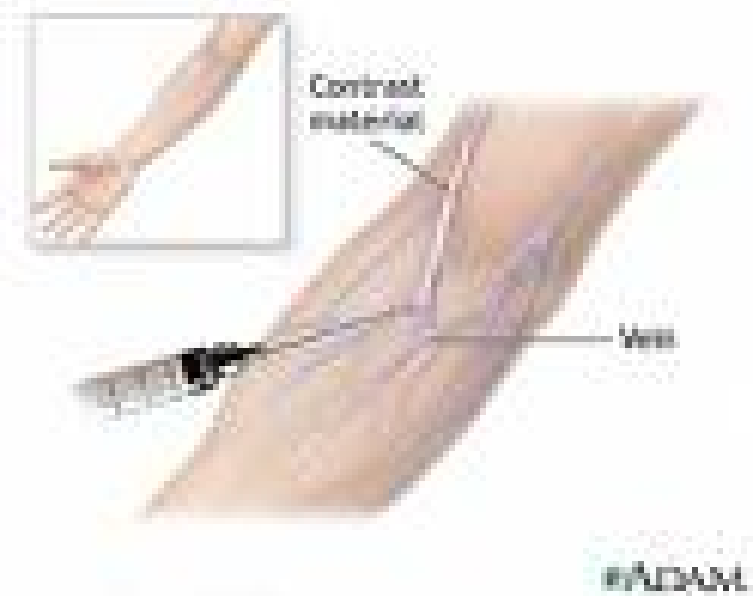
Source: Andreas Matzarakis, Meteorologisches Institut, Universität Freiburg, Freiburg, Germany, personal communication, 2003.

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

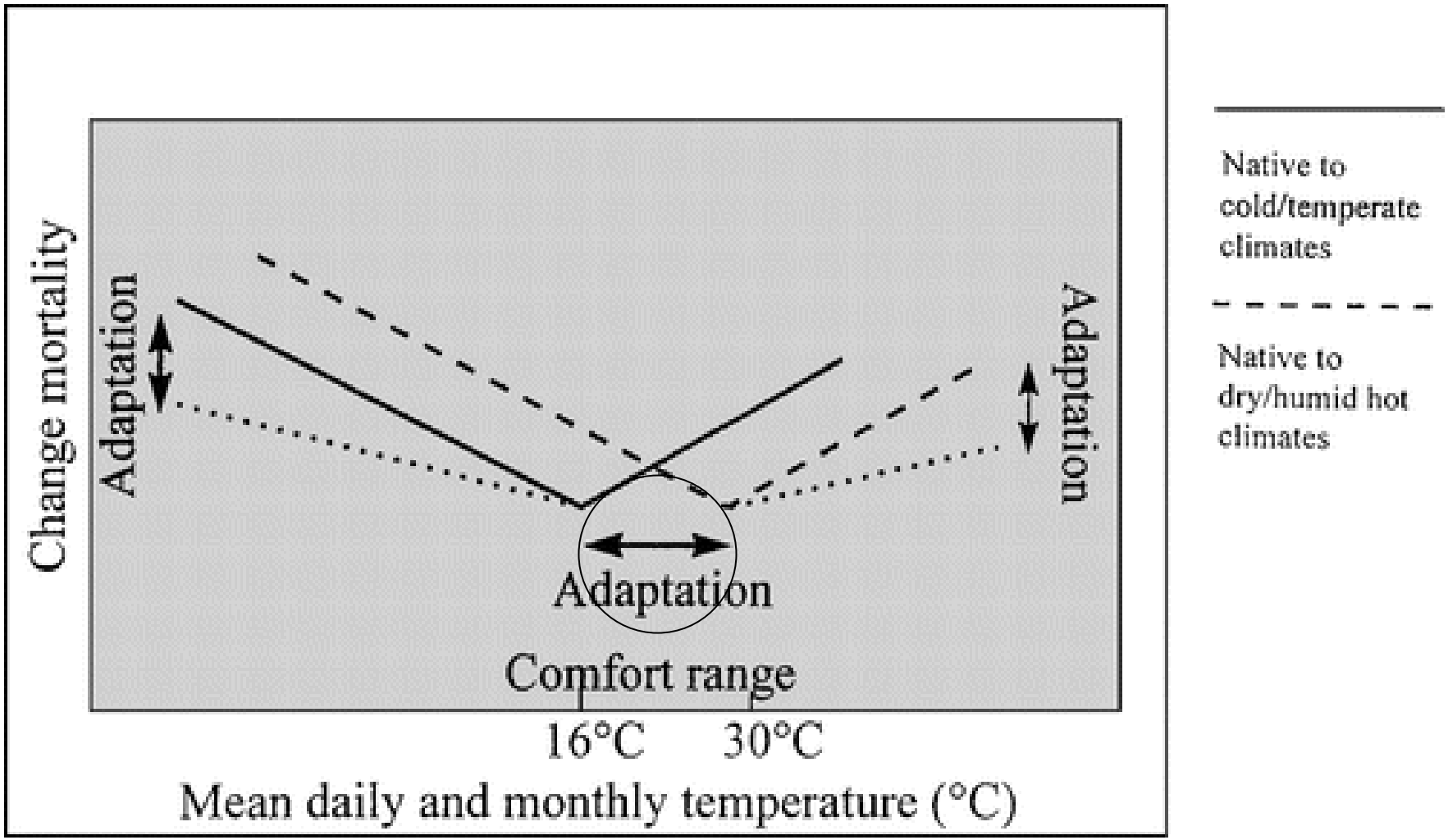
Organizing the response: the Haddon matrix and heat-wave related mortality

Influencing factors				
Phase	**Host**	**Agent/vehicle**	**Physical environment**	**Social environment**
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



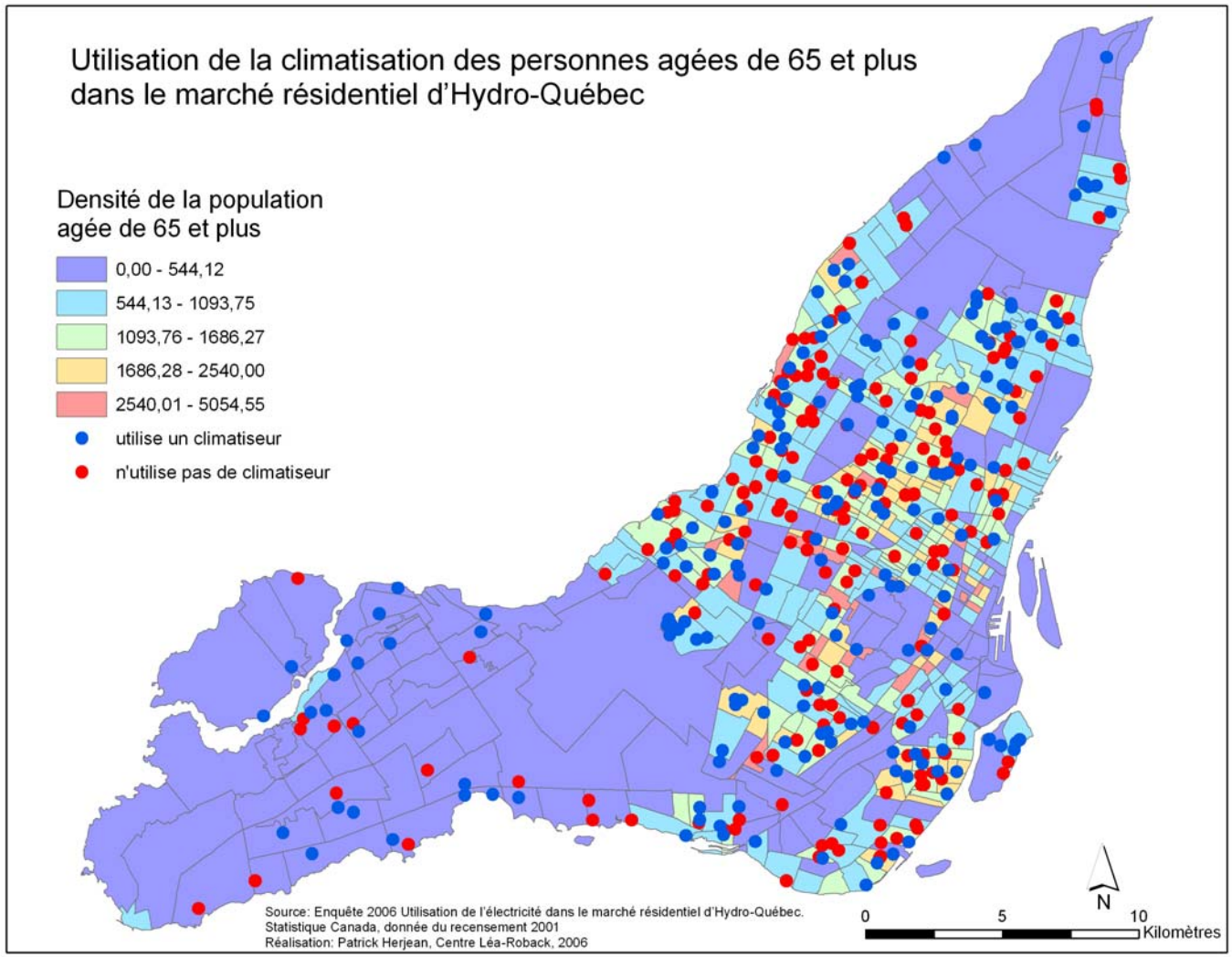
Pertinent age-associated physiologic changes

- **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

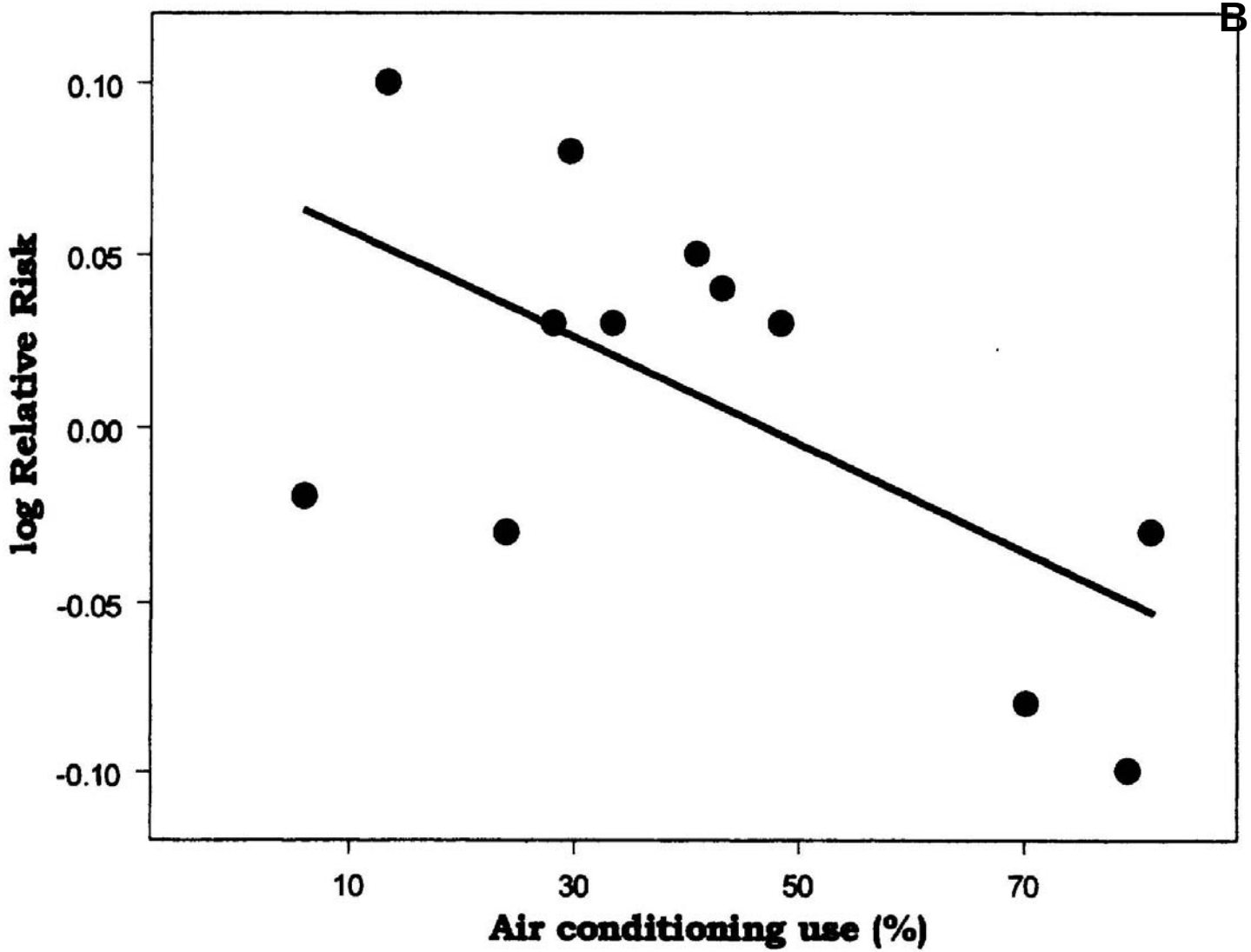
- young male miners, athletes, and soldiers exposed to vigorous exercise in heated thermal chambers show improved heat stress responses (heart rate, core temperature, stroke volume) after a period of several days
- a significant increase in plasma and interstitial volume, and a rise in total body water 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



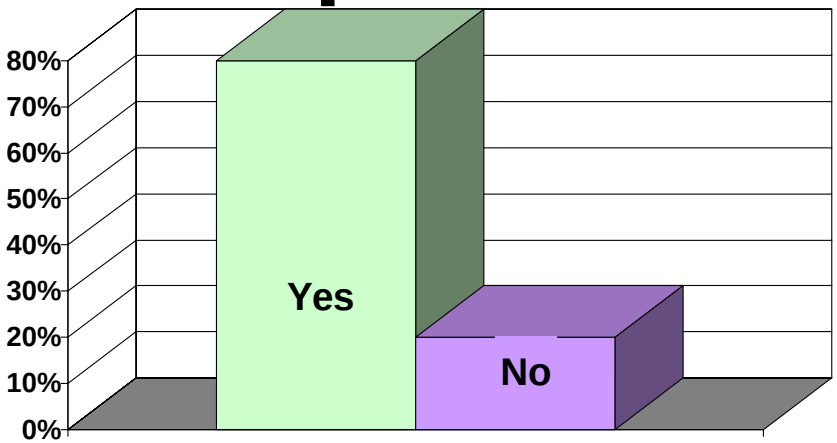
3. KAP Surveys: How do Montreal's heart and lung patients cope with heat

Tom Kosatsky[1], Lucie Richard[2] , Annie Renouf[1], Julie Dufresne[1], Dave Stieb[3], Nadia Giannetti[4] ,Jean Bourbeau[5]

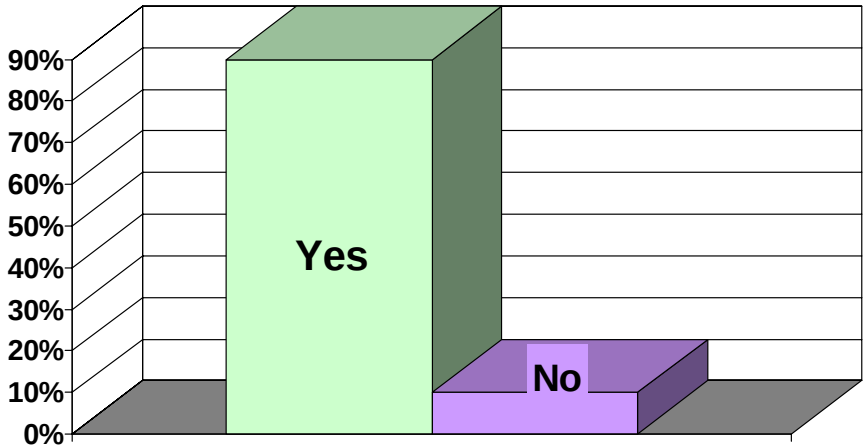
Montreal Public Health[1], Faculty of Nursing, University of Montreal[2], Air Pollution Effects Division, Health Canada[3], Heart Failure and Heart Transplant Centre, Royal Victoria Hospital[4], COPD Clinic and Pulmonary Rehabilitation Programme, Montreal Thoracic Institute[5]

Funded by: Climate Change Action Funds Contract, NR Canada A-575

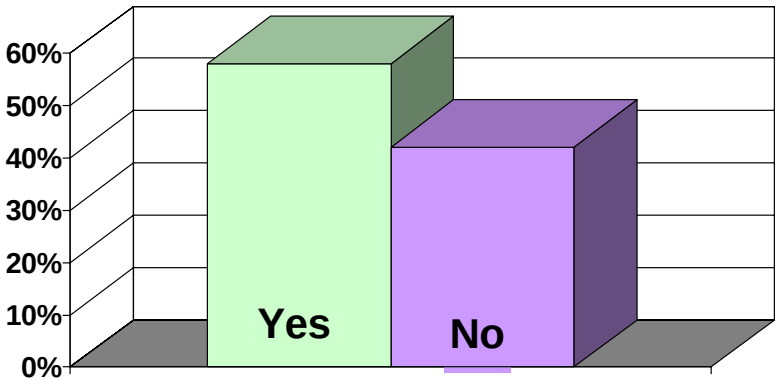
Awareness of heat and its consequences



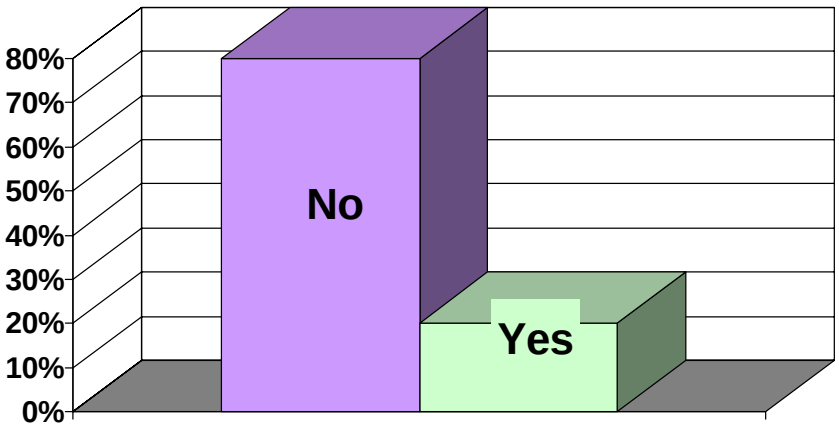
Informed about weather daily



Ever heard a heat advisory

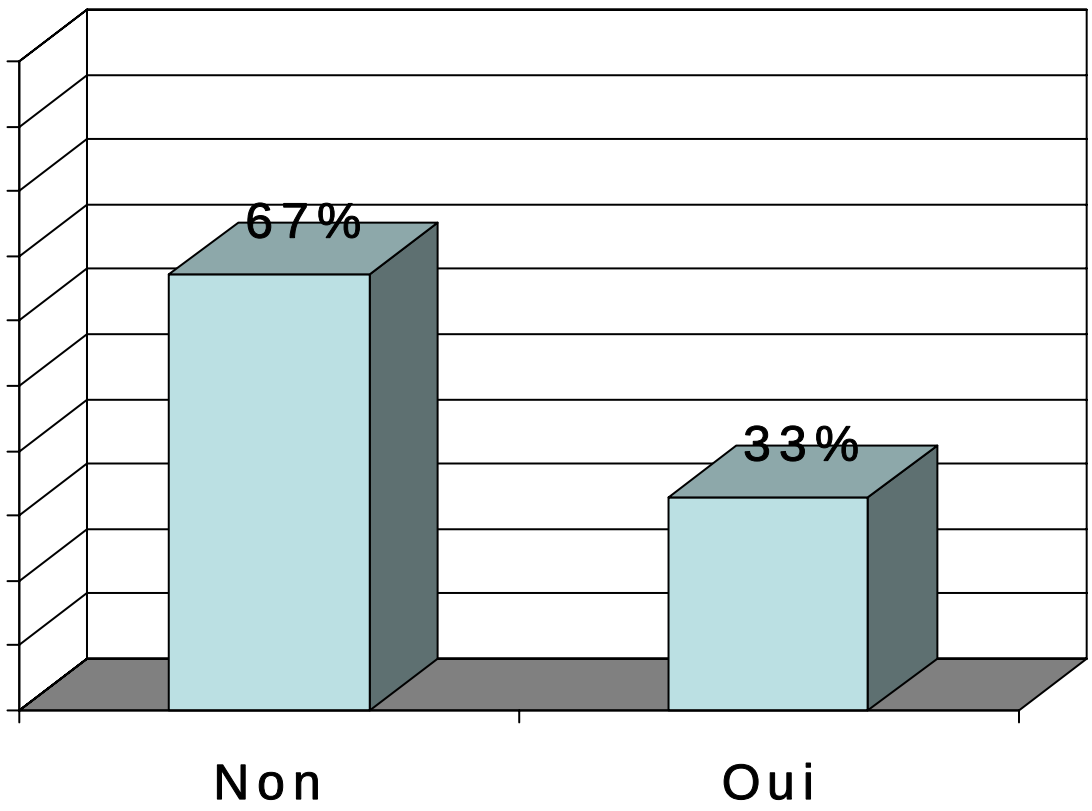


My doctor told me I am vulnerable to heat



My doctor/pharmacist told me my meds make me vulnerable

Intention to buy a home air conditioner? (N=61)

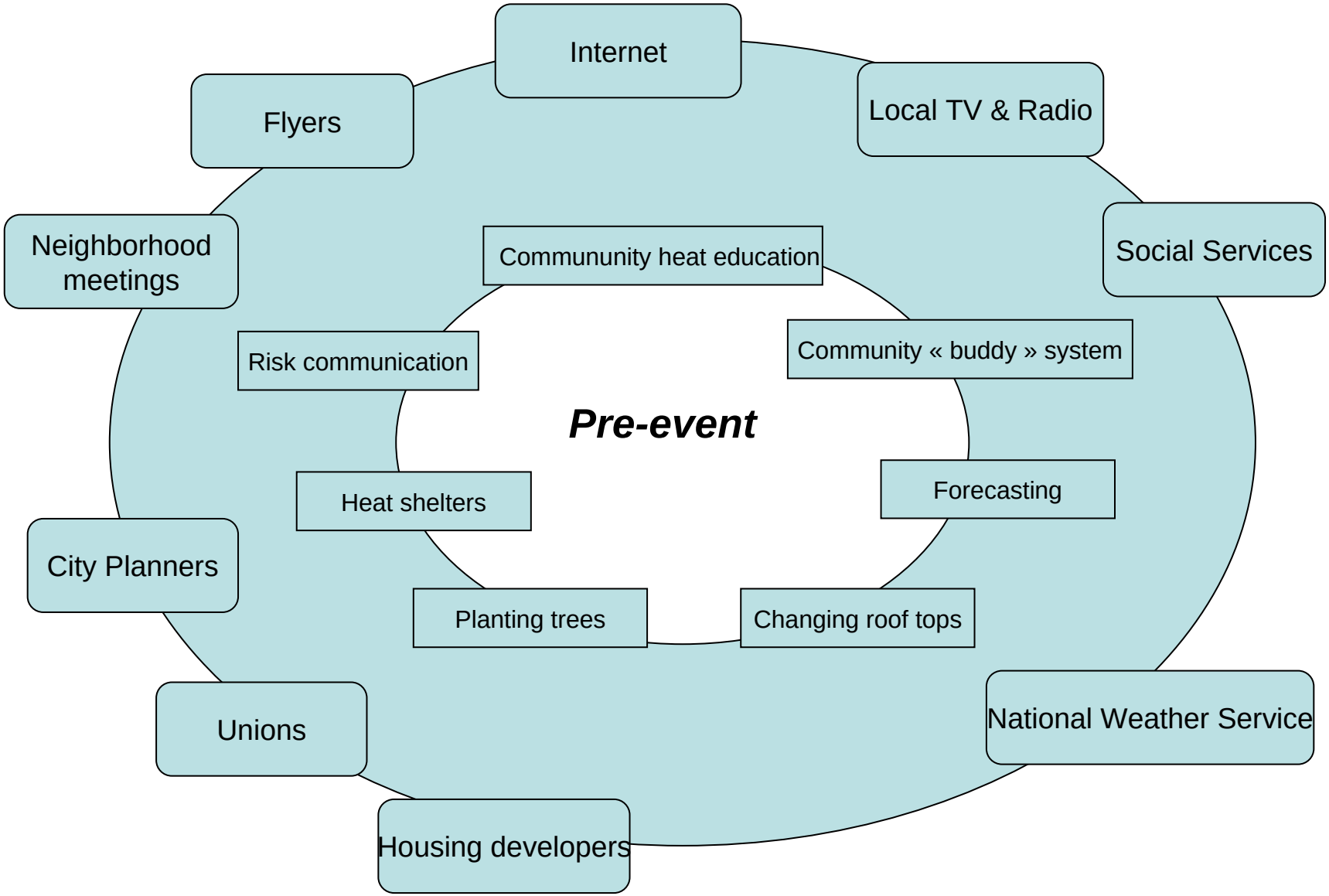


Importance of personal and social resilience (two adjoining neighbourhoods: Chicago 1995

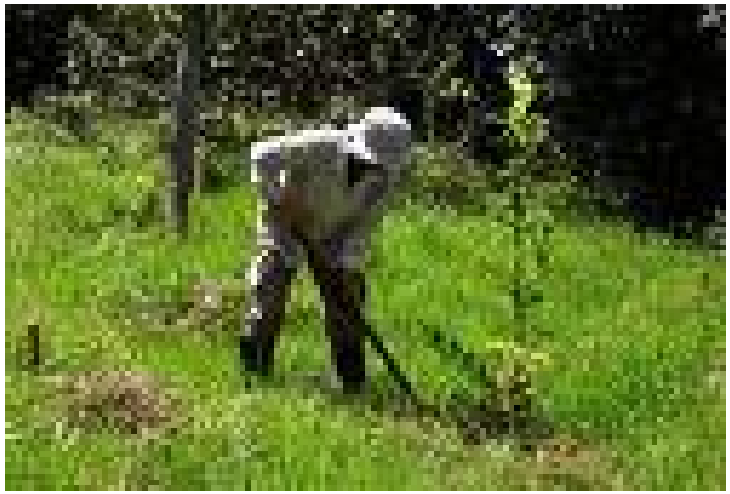
Klinenberg, 2003

Figure 29. Ogden Avenue, once a major commercial artery in North Lawndale. Photo by Caitlin Zaloom.

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

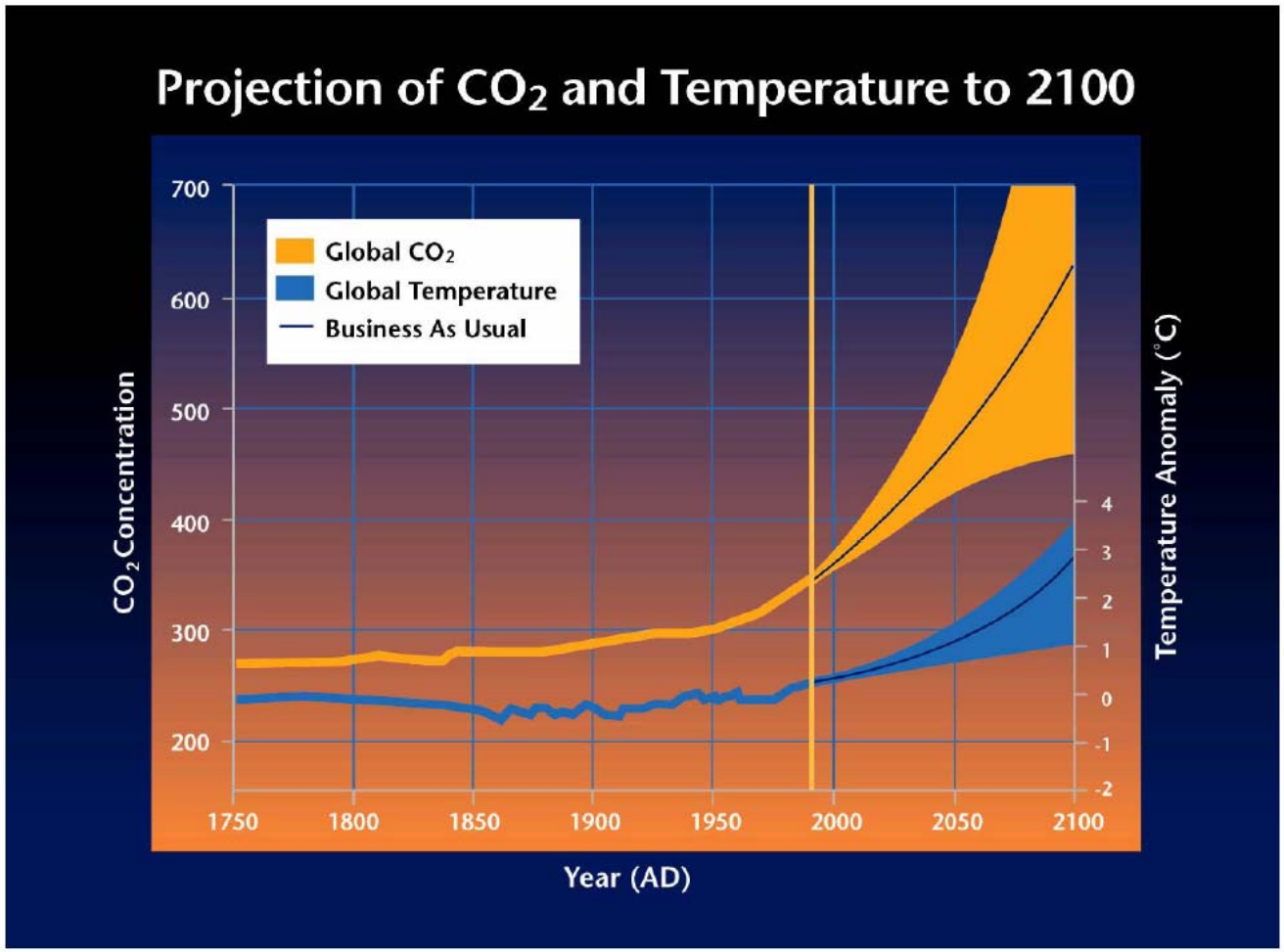


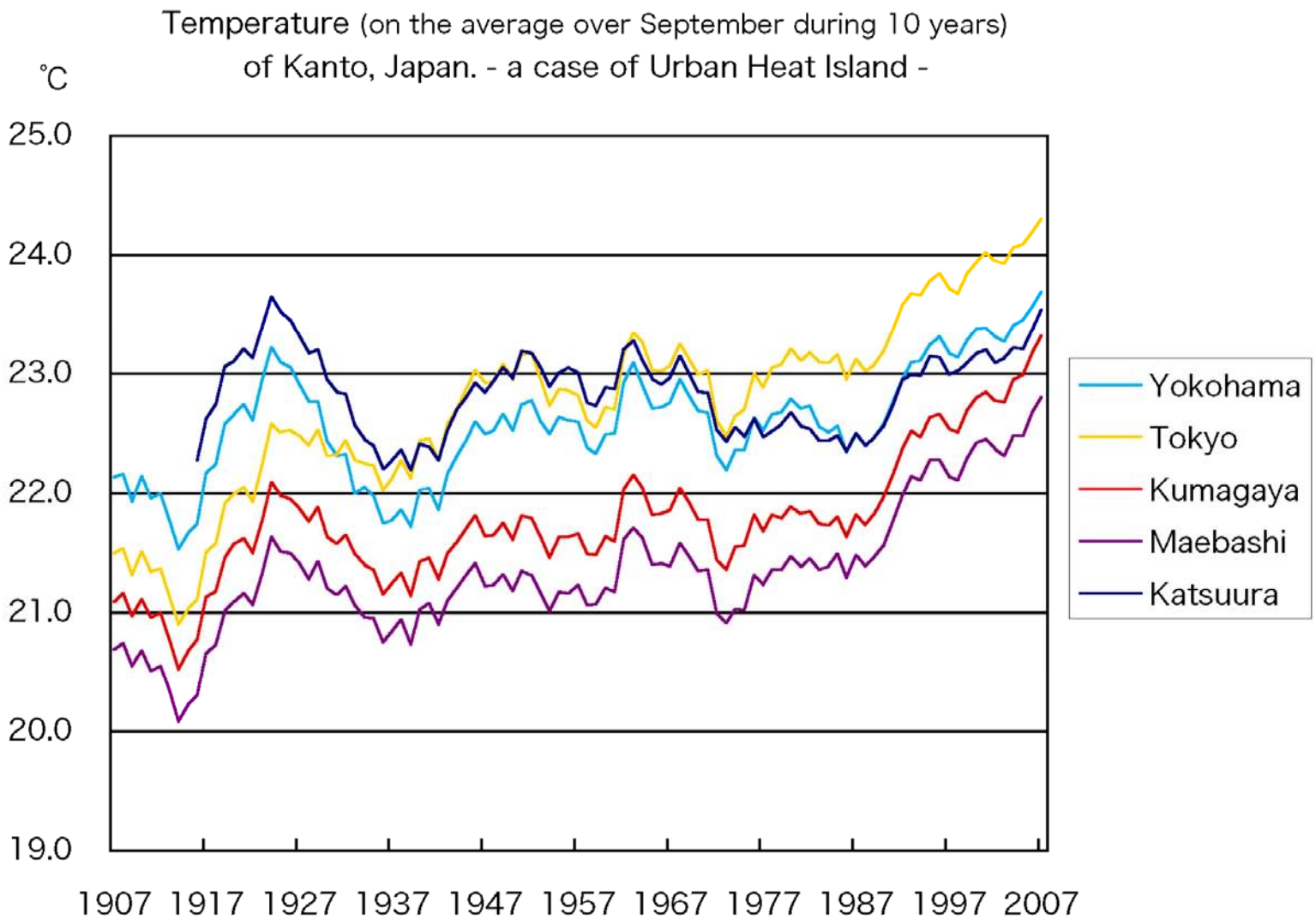
Urban adaptation/GHG reduction



Let’s get with it!

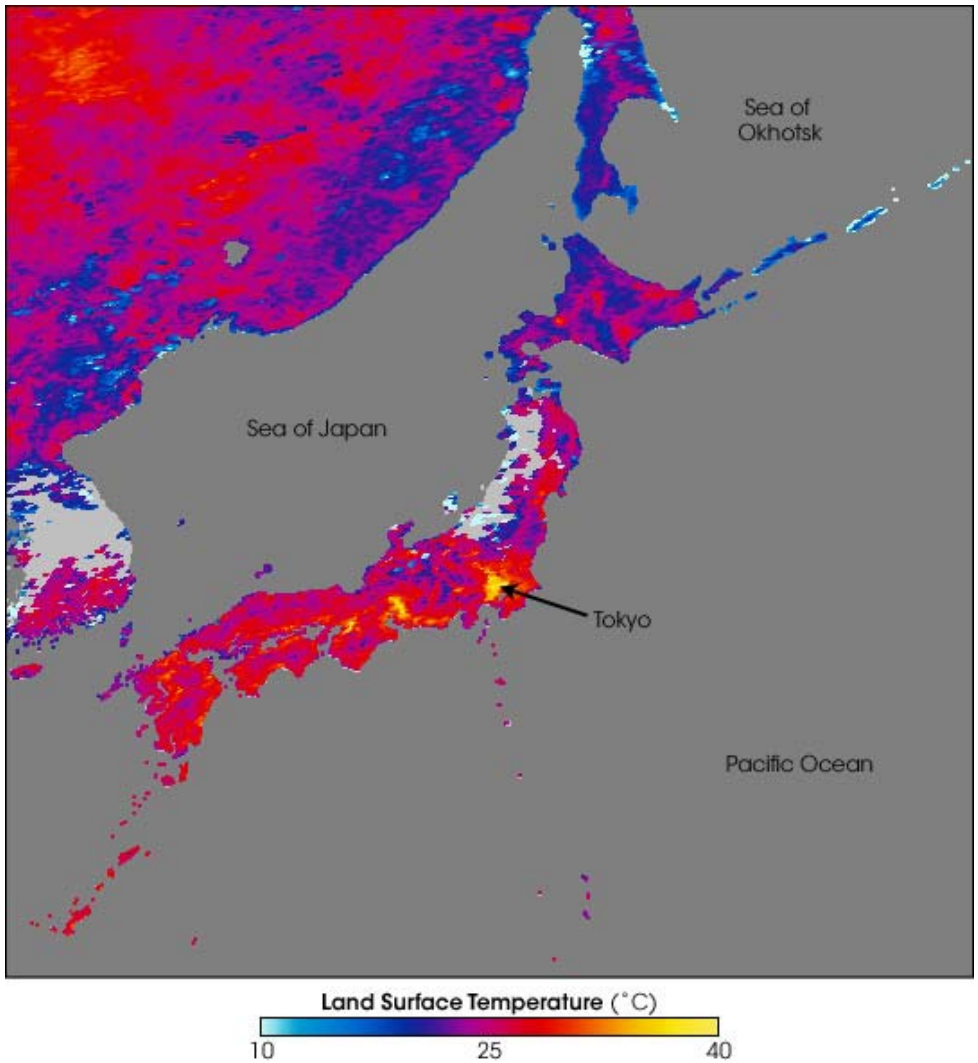
Projection of CO_2 concentrations and of mean world temperature until 2100



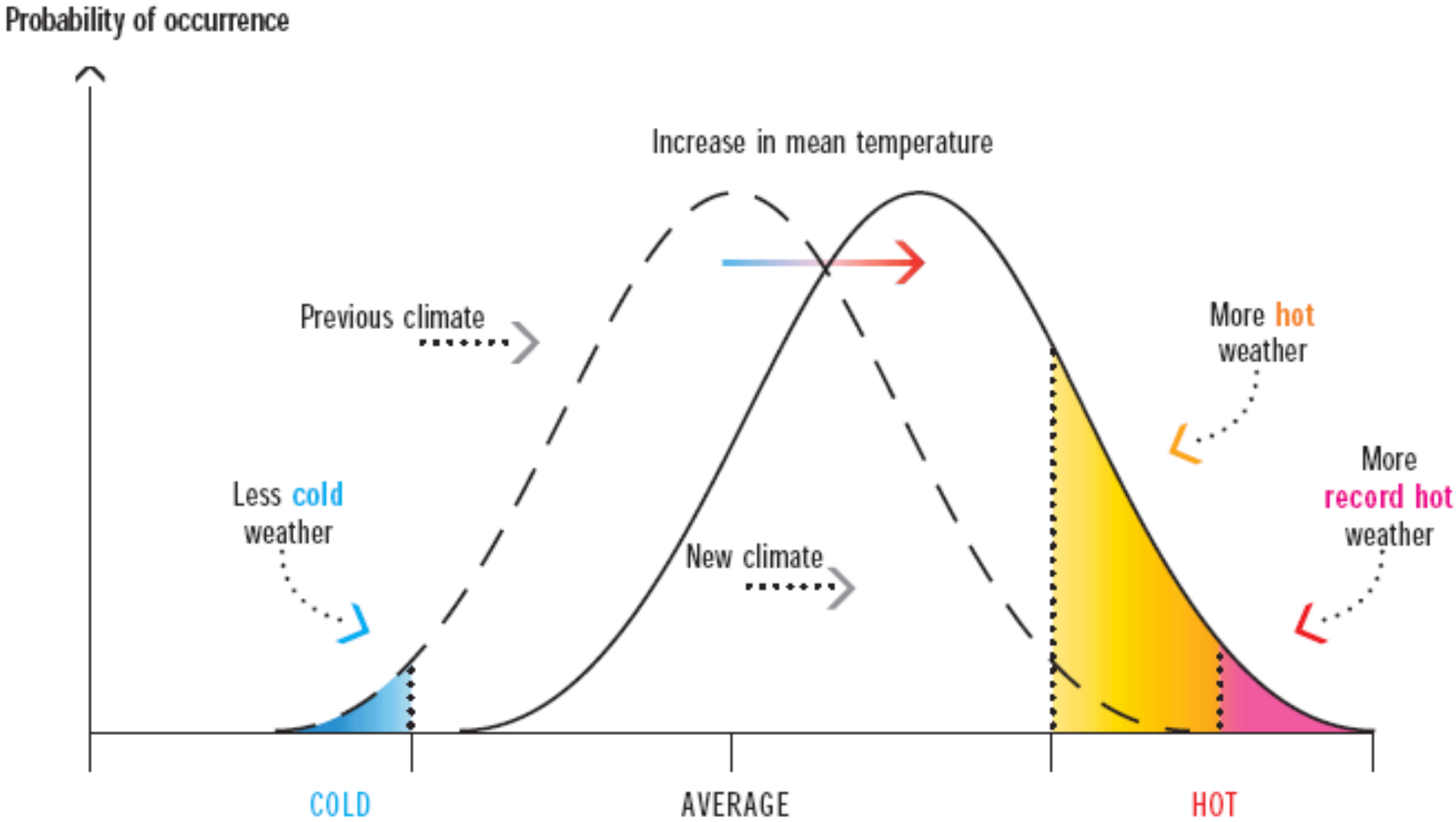


Source: Data from Japan Meteorological Agency
http://www.data.jma.go.jp/

City heat, July 20, 2004, Tokyo

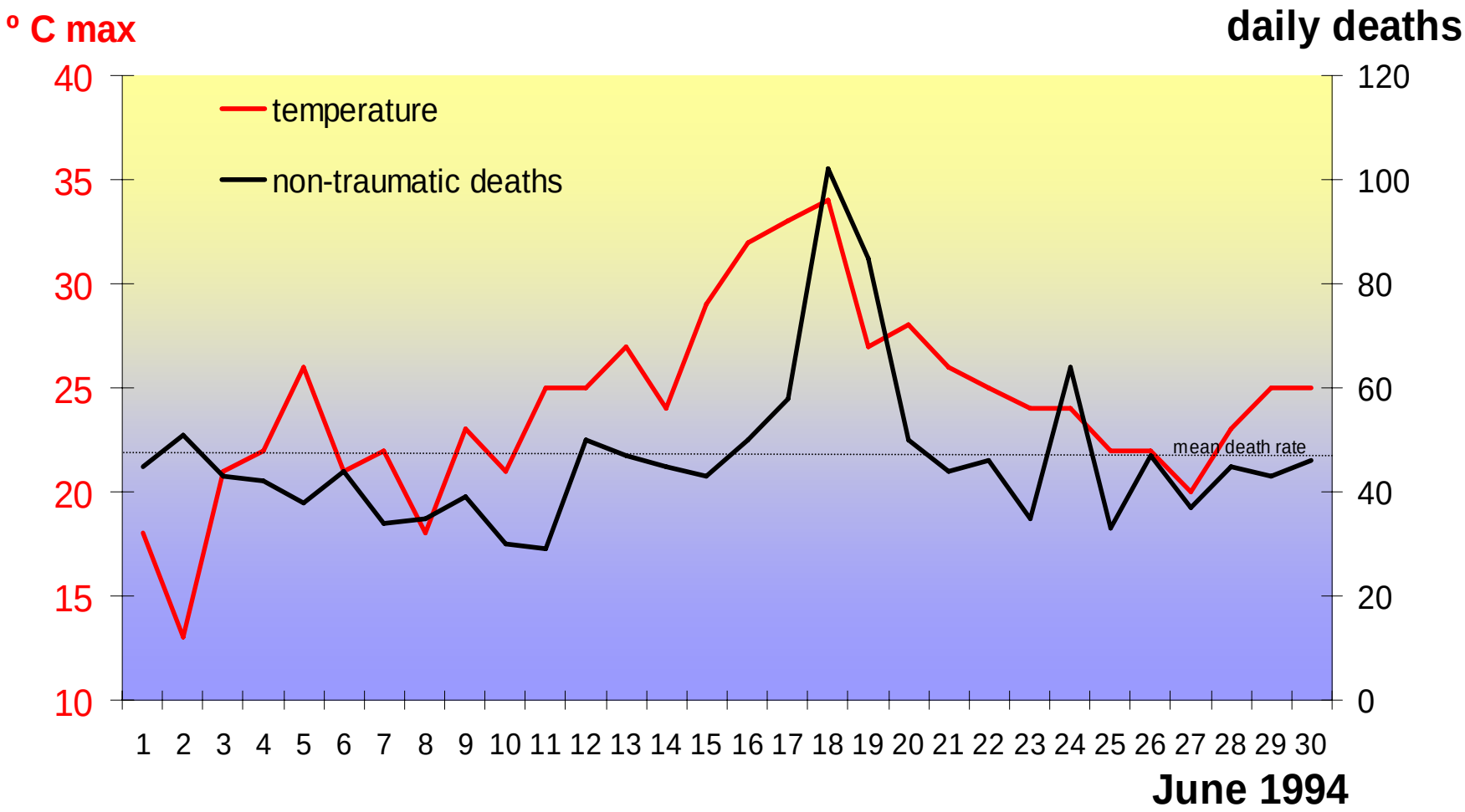


Changes in the probability of extreme weather events



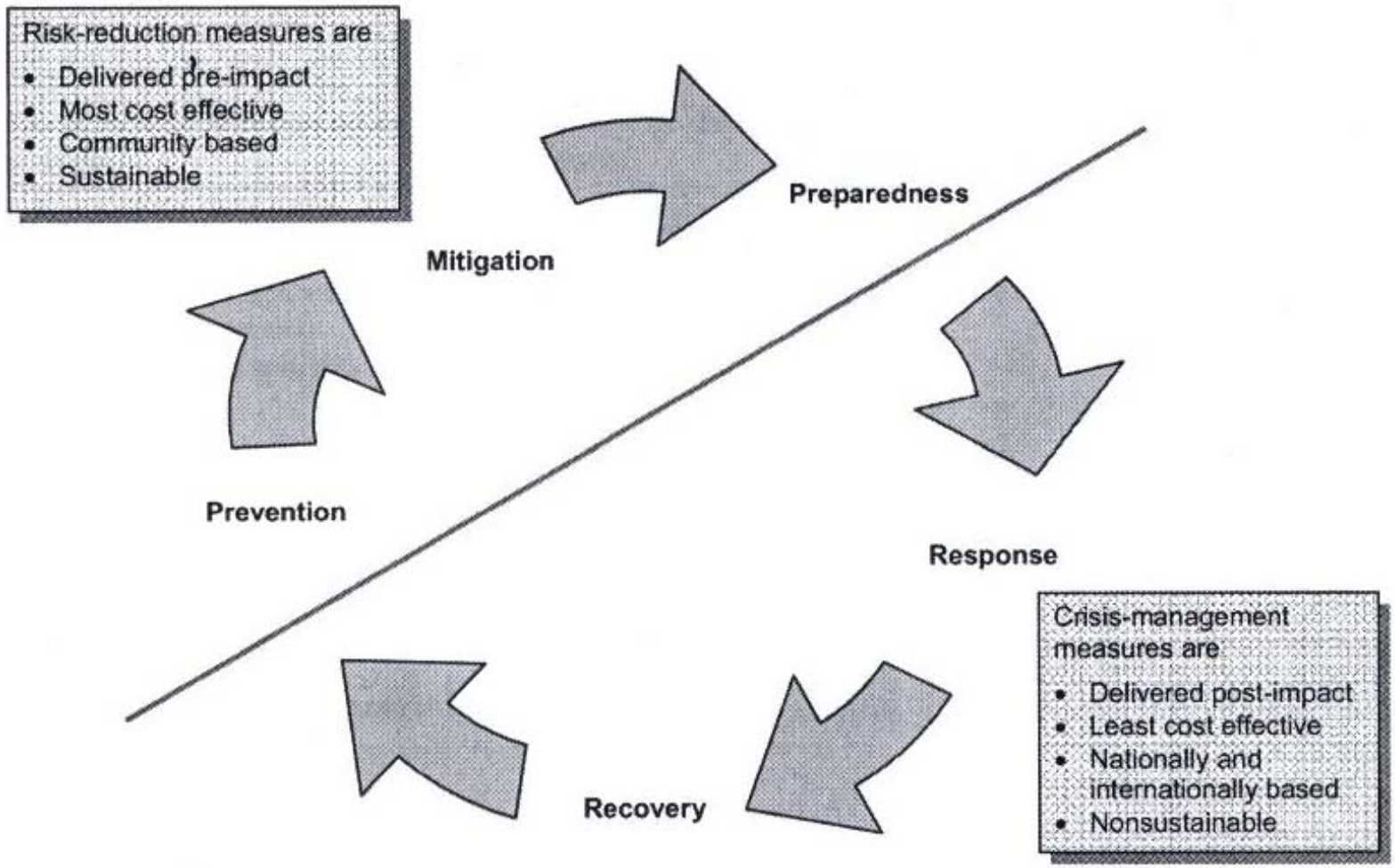
Source: Houghton et al. (2001).

Montreal : June 1994 heat wave with attendant mortality



Alone in his apartment during the 1995 Chicago heat wave

Disaster Risk Management Cycle Comparing Risk-Reduction Measures to Crisis-Management Measures, (Keim 2008)



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

1. Beyond heat waves, warmer temperatures over-all 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)

Tom Kosatsky, BCCDC

tom.kosatsky@bccdc.ca

604-660-6630

National Collaborating Centre for Environmental Health

Working on a range of environmental health issues, primarily serving the public health community including public health inspectors, physicians, and nurses

Visit our website at www.ncceh.ca to view a variety of documents and other products, such as:

- » Course presentations
- » Summaries of recent journal articles
- » Environmental health legislation