Urban Heat and Health: Assessing the Risks

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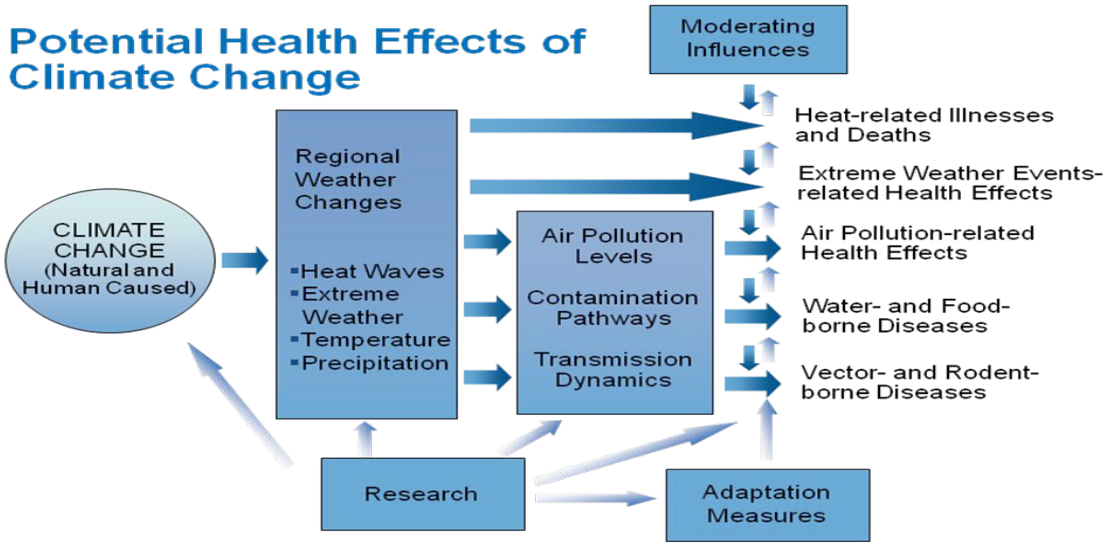
Overview

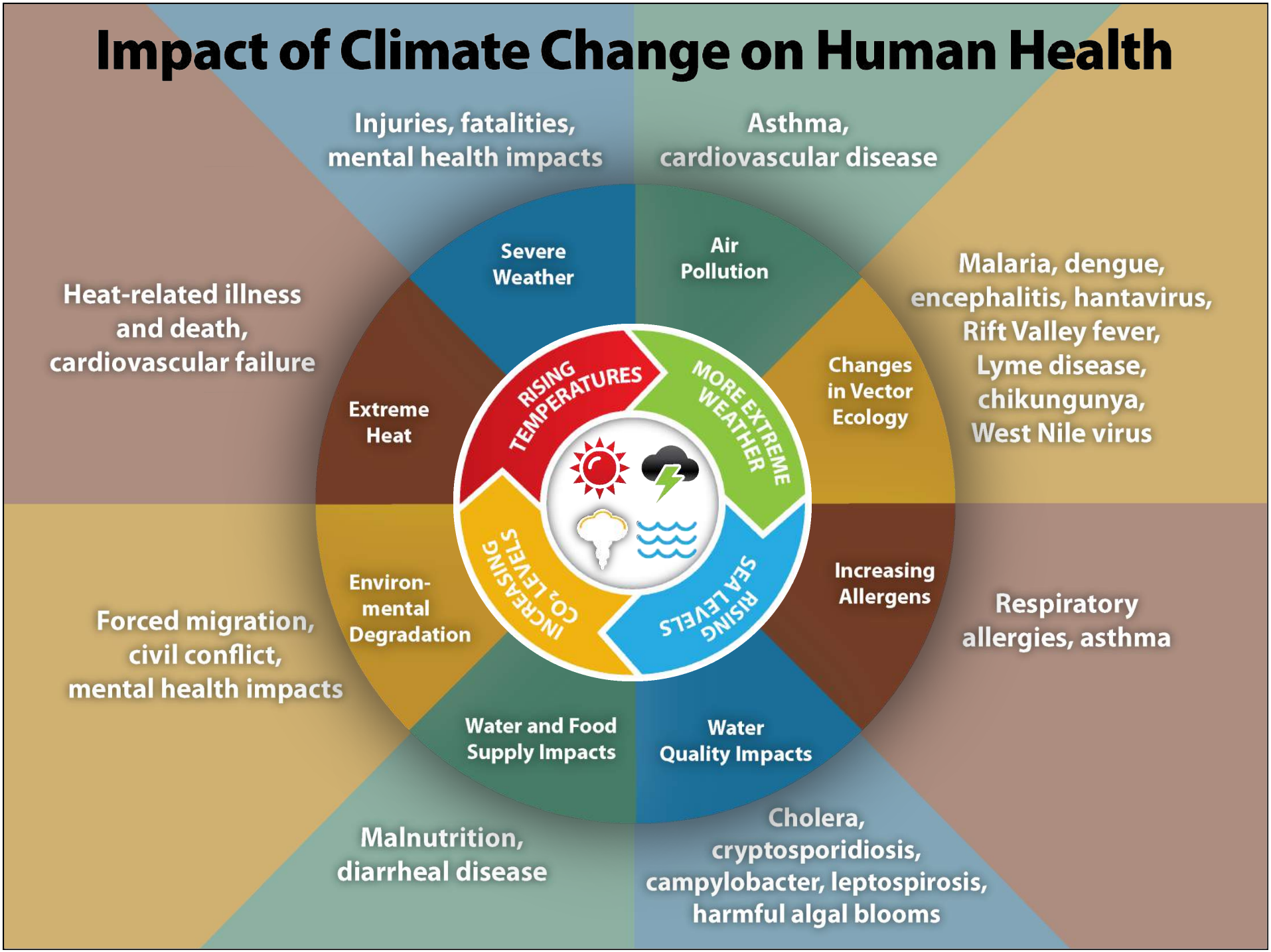
- A brief review of climate-sensitive disease
- Heat and mortality: expanding the discussion
- Heat and morbidity: some new information
- Thoughts and policy considerations in response to yesterday's discussions



At the urban scale

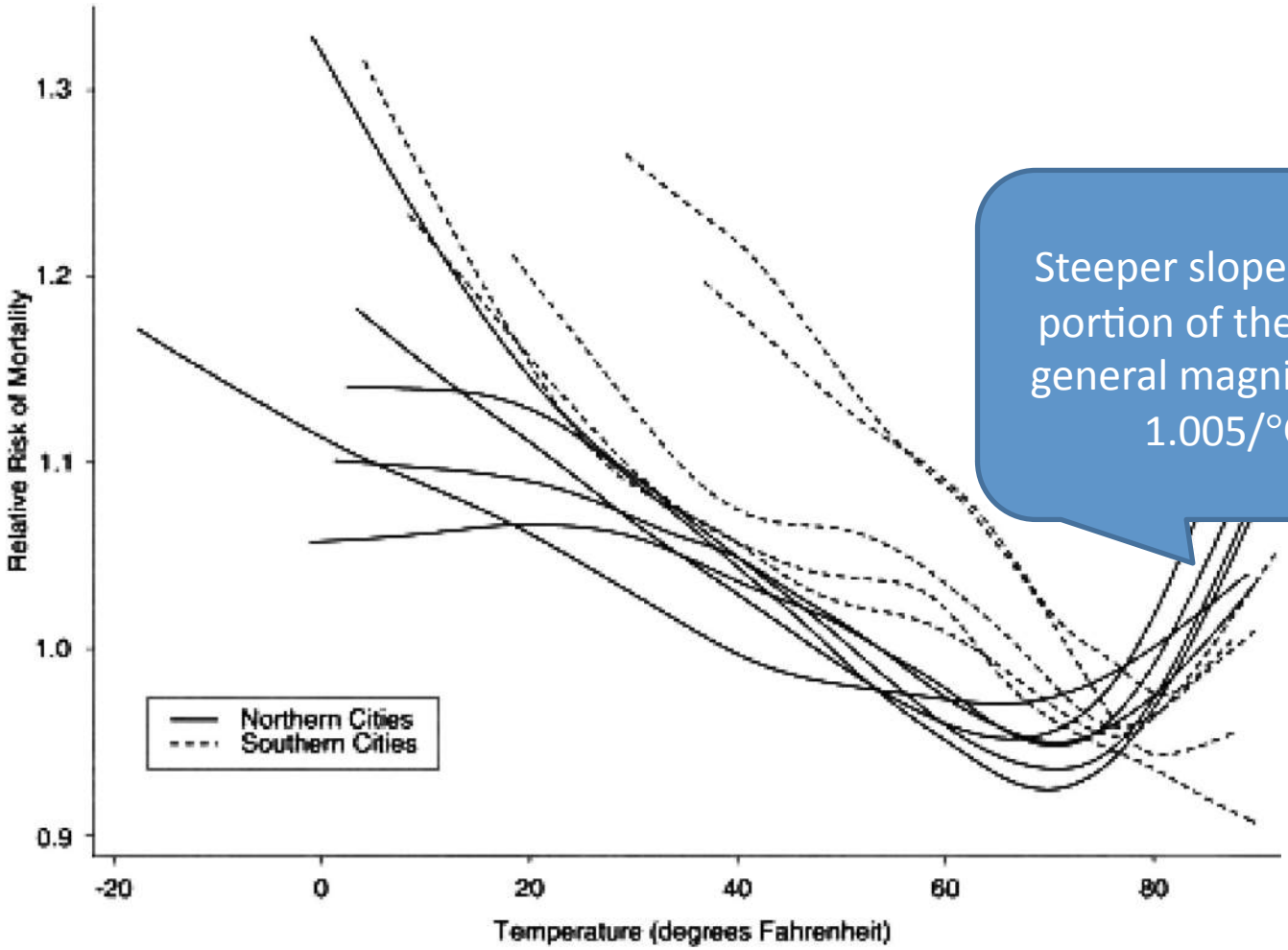
CLIMATE-SENSITIVE DISEASE

Impact of Climate Change on Human Health



HEAT AND MORTALITY

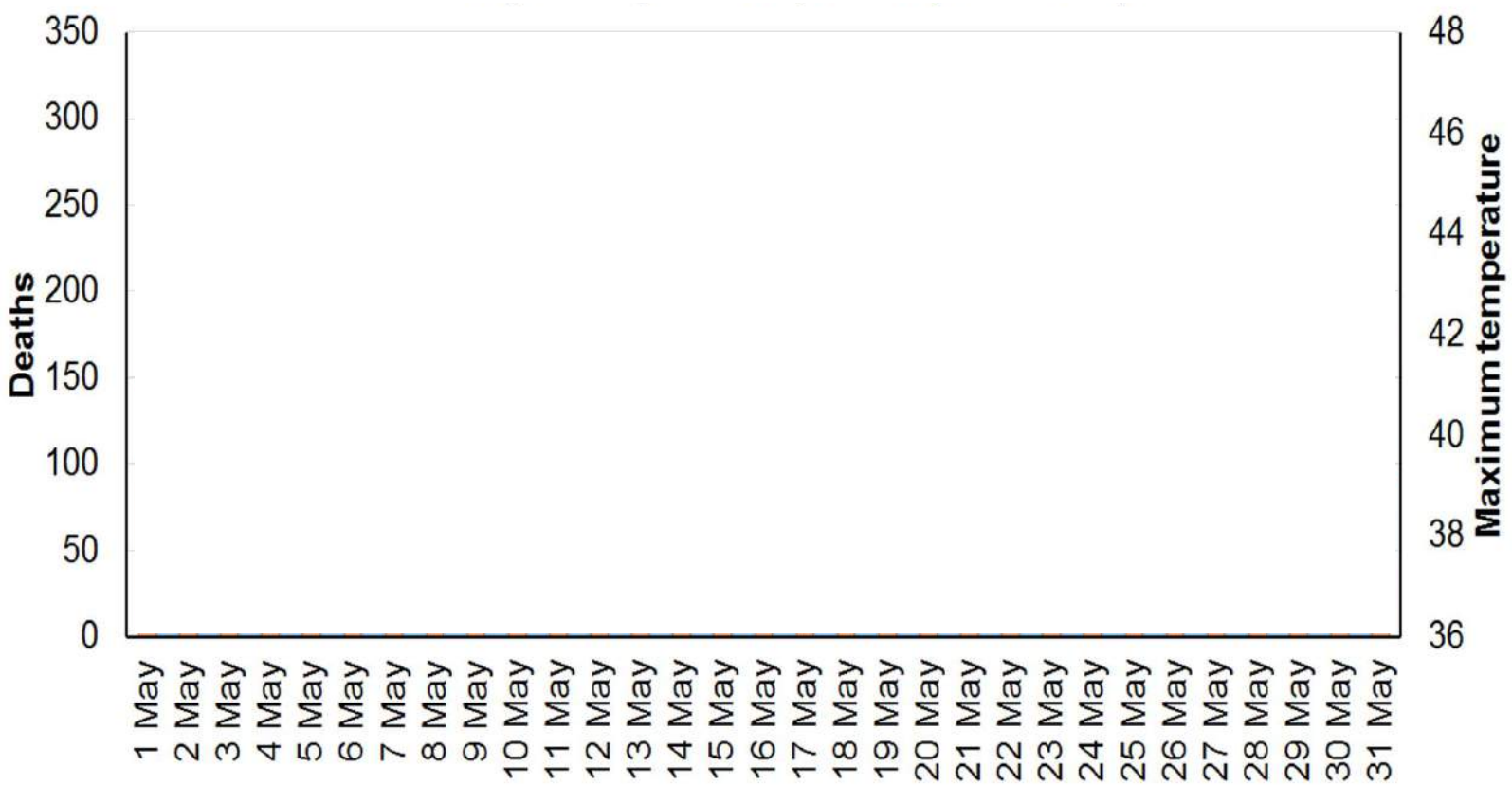
Temperature-Mortality Relationship



Steeper slope on this portion of the curve; general magnitude of 1.005/°C

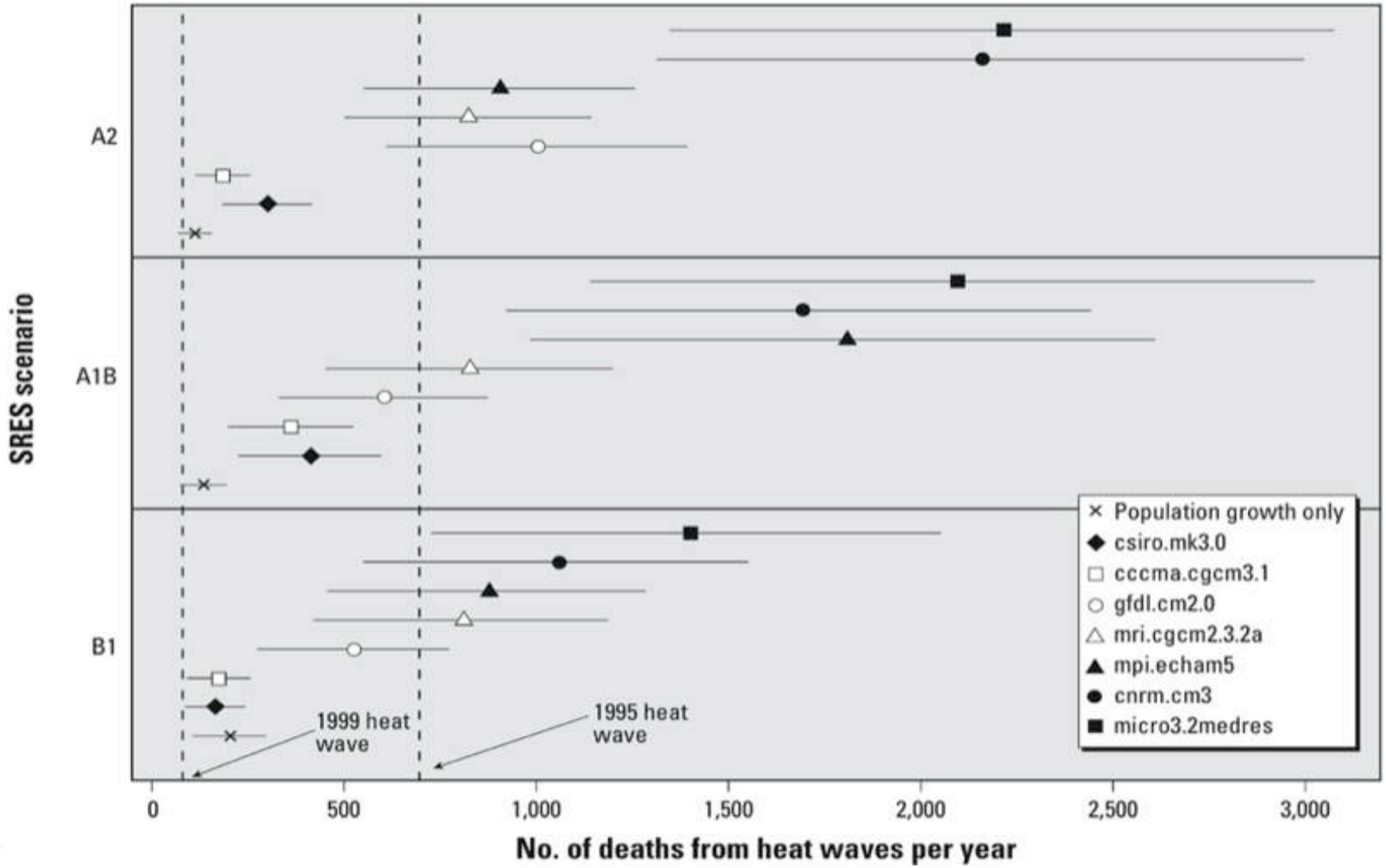
Curriero et al. 2002

Dramatic During Extreme Heat Events



Azhar et al. 2014 doi:10.1371/journal.pone.0091831.g002

Magnitude of Projected CC Impacts



Peng et al. *Environ Health Perspect* 119:701-706 (2010). http://dx.doi.org/10.1289/ehp.1002430

Another Approach

Table 1 | Baseline and projected annual temperature-related years of life lost in Brisbane, Australia.

	Baseline	Climate change scenario							
		1 °C increase		2 °C increase		3 °C increase		4 °C increase	
		Projection	Change	Projection	Change	Projection	Change	Projection	Change
					Men				
Hot days	616	1,040	424	1,648	1,032	2,466	1,850	3,510	2,894
	(412–840)	(720–1,349)	(303–544)	(1,171–2,122)	(756–1,315)	(1,764–3,149)	(1,347–2,360)	(2,562–4,468)	(2,105–3,721)
Cold days	2,461	2,038	−423	1,633	−828	1,255	−1,206	914	−1,547
	(1,498–3,386)	(1,238–2,817)	(−595–−247)	(959–2,278)	(−1,148–−495)	(703–1,770)	(−1,654–−727)	(478–1,321)	(−2,123–−940)
Whole year	3,077	3,078	1	3,281	204	3,721	644	4,424	1,347
	(2,119–4,002)	(2,224–3,879)	(−202–211)	(2,456–4,054)	(−204–631)	(2,842–4,589)	(4–1,323)	(3,312–5,552)	(416–2,323)
					Women				
Hot days	903	1,493	590	2,321	1,418	3,413	2,510	4,791	3,888
	(704–1,088)	(1,200–1,780)	(481–699)	(1,878–2,745)	(1,160–1,679)	(2,792–4,056)	(2,045–2,983)	(3,920–5,693)	(3,150–4,627)
Cold days	2,592	1,903	−689	1,351	−1,241	922	−1,670	599	−1,993
	(1,703–3,349)	(1,145–2,629)	(−861–−523)	(732–1,925)	(−1,561–−925)	(433–1,379)	(−2,115–−1,233)	(223–966)	(−2,549–−1,441)
Whole year	3,495	3,396	−99	3,672	177	4,335	840	5,390	1,895
	(2,647–4,384)	(2,660–4,121)	(−292–95)	(2,964–4,389)	(−204–536)	(3,527–5,162)	(250–1,417)	(4,386–6,433)	(1,090–2,727)
					Total				
Hot days	1,519	2,533	1,014	3,969	2,450	5,879	4,360	8,301	6,782
	(1,214–1,821)	(2,079–2,978)	(840–1,178)	(3,272–4,610)	(2,049–2,845)	(4,892–6,827)	(3,656–5,062)	(6,956–9,622)	(5,675–7,893)
Cold days	5,053	3,941	−1,112	2,984	−2,069	2,177	−2,876	1,513	−3,540
	(3,759–6,313)	(2,851–4,996)	(−1,337–−871)	(2,082–3,842)	(−2,484–−1,624)	(1,453–2,871)	(−3,462–−2,255)	(952–2,067)	(−4,286–−2,753)
Whole year	6,572	6,474	−98	6,953	381	8,056	1,484	9,814	3,242
	(5,297–7,809)	(5,315–7,590)	(−372–199)	(5,801–8,056)	(−156–980)	(6,804–9,346)	(633–2,425)	(8,302–11,392)	(2,011–4,596)

Baseline for the years 1996 to 2003 centred on 2000; projection for the years 2046 to 2053 centred on 2050. Hot days are a daily mean temperature above 23 °C, and cold days below 23 °C. We chose this temperature as it was the turning point in the association between temperature and years of life lost for both men and women (Fig. 2). 95% confidence intervals are shown in parenthesis.

Heat and Mortality: In Sum

- There is a clear, significant relationship
- Mortality counts, particularly for extreme heat events, can be high, and excess rates can be startling
- The true public health impact of mortality depends, to some degree, on the extent to which death is premature
- Age-, gender-, and location-specific relationships are important to estimating impacts

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HEAT AND MORBIDITY

Heat Illness – A Spectrum

- Mild
  - Heat rash
  - Heat edema
  - Heat cramps
- Moderate
  - Heat exhaustion
- Severe
  - Heat stroke
  - 17.6-26.5 cases/100,000 population in US (Jones et al. 1982)
  - 25-250 cases/100,000 in Saudi Arabia (Ghaznawi et al. 1987)

- Physiology and associated syndromes
  - Dehydration
    - Renal insufficiency
    - Nephrolithiasis
  - Physiologic stress
    - Myocardial infarction
  - Hyperviscosity
    - Cerebrovascular accident
  - Inflammation
    - Multi-organ dysfunction in heat stroke

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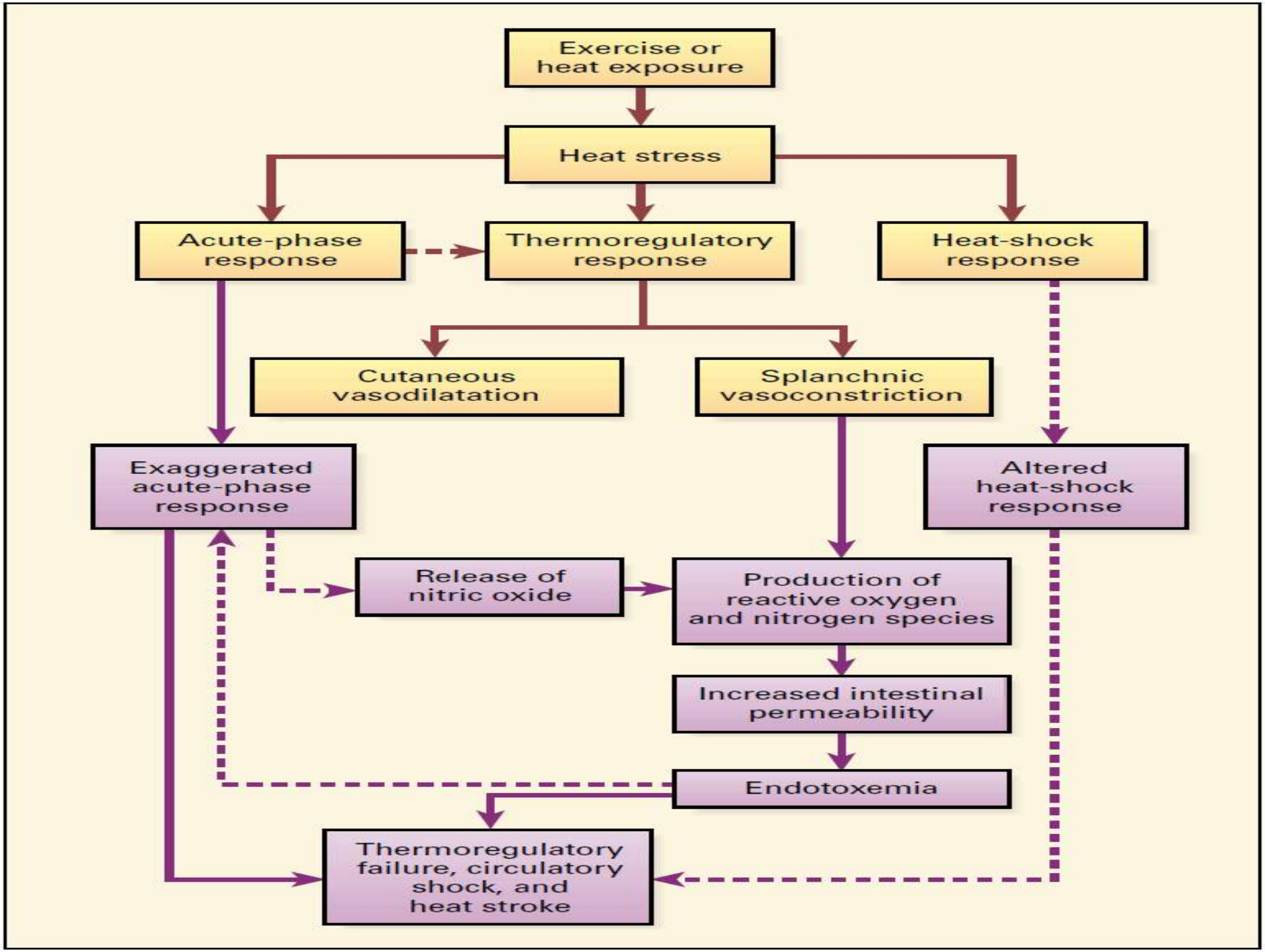
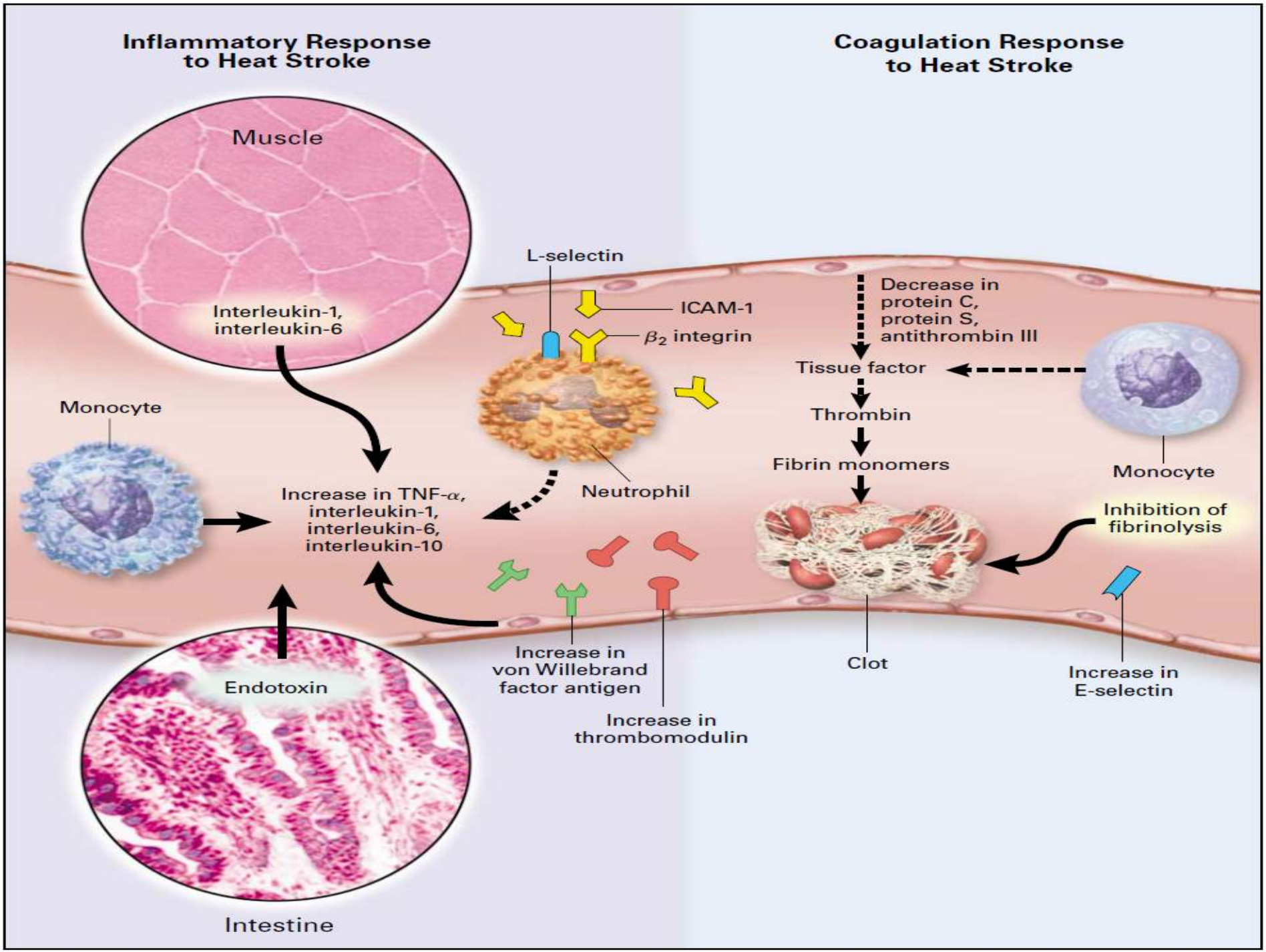

Exercise or heat exposure
Heat stress
Acute-phase response
Thermoregulatory response
Heat-shock response
Cutaneous vasodilatation
Splanchnic vasoconstriction
Exaggerated acute-phase response
Altered heat-shock response
Release of nitric oxide
Production of reactive oxygen and nitrogen species
Increased intestinal permeability
Endotoxemia
Thermoregulatory failure, circulatory shock, and heat stroke


Inflammatory Response to Heat Stroke
Coagulation Response to Heat Stroke
Muscle
Interleukin-1, interleukin-6
L-selectin
ICAM-1
β_2 integrin
Decrease in protein C, protein S, antithrombin III
Tissue factor
Thrombin
Fibrin monomers
Monocyte
Monocyte
Neutrophil
Increase in TNF-α, interleukin-1, interleukin-6, interleukin-10
Inhibition of fibrinolysis
Increase in von Willebrand factor antigen
Increase in thrombomodulin
Clot
Increase in E-selectin
Endotoxin
Intestine

2006 CA Hea th Impacts

Absolute increase of 16,166 ED visits during two-week heat wave

Heat illness cases only 13.2% of total increase

Diagnosis	Reference period	H			Hospitalizations riod	Heat-wave period	RR (95% CI)
All causes	485,785	501,951	1.03 (1.02–1.04)		191,826	193,008	1.01 (1.00–1.01)
Internal causes	386,229	399,699	1.03 (1.03–1.04)		172,864	173,843	1.01 (1.00–1.01)
Diabetes	37,321	38,315	1.03 (1.01–1.04)		27,644	27,920	1.01 (0.99–1.03)
Electrolyte imbalance	30,076	35,020	1.16 (1.15–1.18)		25,647	28,003	1.09 (1.07–1.11)
Cardiovascular diseases	45,613	46,515	1.02 (1.01–1.03)		48,327	48,821	1.01 (1.00–1.02)
Acute MI	2,822					3,688	1.02 (0.97–1.06)
Cerebrovascular disease	7,397					8,138	0.98 (0.95–1.02)
Respiratory illnesses	64,051					37,226	1.01 (1.00–1.03)
Nephritis and nephrotic syndrome	12,185					14,801	1.05 (1.02–1.07)
Acute renal failure	5,085	5,8	1.15 (1.11–1.19)		6,541	7,288	1.11 (1.08–1.15)
Heat-related illnesses	403	2,537	6.30 (5.67–7.01)		61	619	10.15 (7.79–13.43)

The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits

Kim Knowlton,[1,2] Miriam Rotkin-Ellman,[3] Galatea King,[4] Helene G. Margolis,[4,5] Daniel Smith,[4] Gina Solomon,[3,6,7] Roger Trent,[8] and Paul English[4]

Available: http://ehp.niehs.nih.gov/11594/

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National Estimates of Heat Illness in ED

- ED is increasingly the primary source of acute care in the US
- Highly utilized by a populations vulnerable to heat
- Over 80% of heat illness presentations come through the ED (Merrill et al. 2008)
- Two prior estimates, both potentially incomplete

- Sanchez et al. (2010)
  - 20,775 ED visits per year 2001-2004 from environmental exposures –
  - NEISS (66 hospitals)
  - Nonfatal cases only
  - First-listed diagnosis only
- Noe et al. (2012)
  - 12 visits/100,000 pop/year from 2004-2005 among Medicare recipients
  - First-listed diagnosis only

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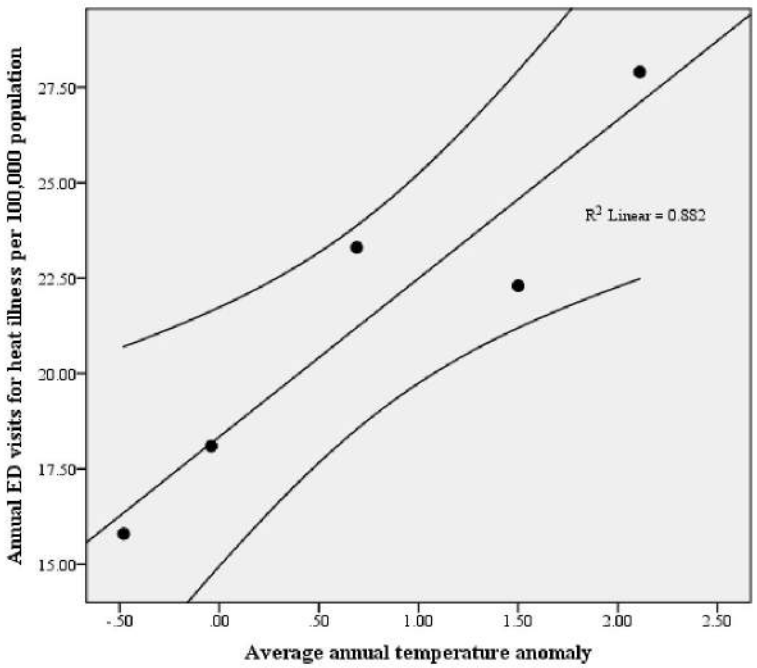
National Estimate Using NEDS 2006-2010

- 65,299 visits/yr May-Sep
- 21.5 visits/100,000/yr
  - 88% treated and released
  - 12% admitted
  - 68% of cases had heat illness as first-listed diagnosis
- 74.7% of cases had heat exhaustion
- 5.4% had heat stroke
- 3.2% nonspecific



Hess J, Saha S, Luber G. Summertime Acute Heat Illness in U.S. Emergency Departments from 2006 through 2010: Analysis o f a Nationally Representative Sample. Env Health Persp 2014

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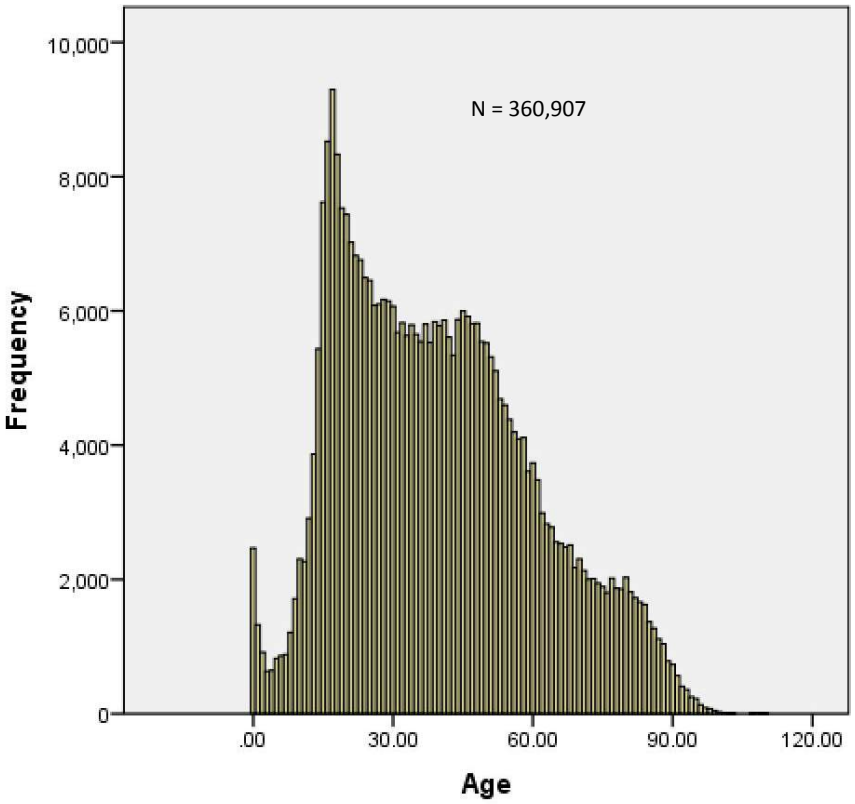
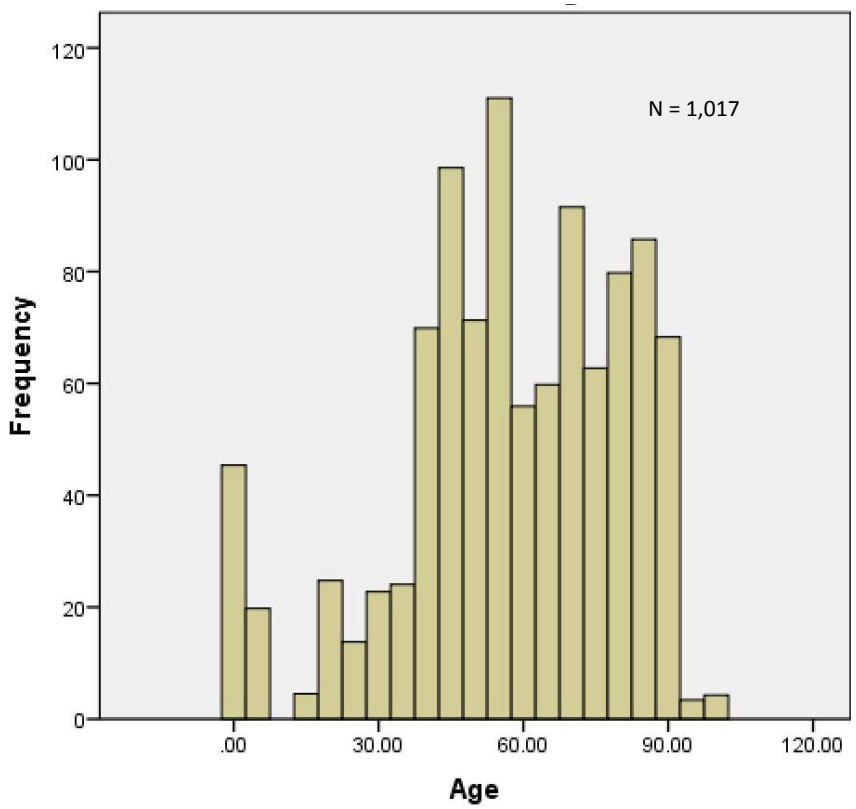
Frequency Distributions All Cases and Deaths





Hess and Saha, in preparation.

Case Fatality Rate (CFR) Heat Stroke Cases

Age Group	CFR (%)
0-1	15.0
2-5	8.7
6-10	3.6
10-20	0.6
21-30	1.7
31-40	2.1
41-50	4.7
51-60	4.0
61-70	3.4
71-80	4.0
>80	4.6

Hess and Saha, in preparation.

Linking ED Visits and Vulnerability

Evaluation of a Heat Vulnerability Index on Abnormally Hot Days: An Environmental Public Health Tracking Study

Colleen E. Reid,[1] Jennifer K. Mann,[1] Ruth Alfasso,[2] Paul B. English,[3] Galatea C. King,[3] Rebecca A. Lincoln,[4] Helene G. Margolis,[5] Dan J. Rubado,[6] Joseph E. Sabato,[2] Nancy L. West,[7] Brian Woods,[8] Kathleen M. Navarro,[1] and John R. Balmes[1,9]

BACKGROUND: Extreme hot weather conditions have been associated with increased morbidity and mortality, but risks are not evenly distributed throughout the population. Previously, a heat vulnerability index (HVI) was created to geographically locate populations with increased vulnerability to heat in metropolitan areas throughout the United States.

OBJECTIVES: We sought to determine whether areas with higher heat vulnerability, as characterized by the HVI, experienced higher rates of morbidity and mortality on abnormally hot days.

METHODS: We used Poisson regression to model the interaction of HVI and deviant days (days whose deviation of maximum temperature from the 30-year normal maximum temperature is at or above the 95th percentile) on hospitalization and mortality counts in five states participating in the Environmental Public Health Tracking Network for the years 2000 through 2007.

RESULTS: The HVI was associated with higher hospitalization and mortality rates in all states on both normal days and deviant days. However, associations were significantly stronger (interaction p-value < 0.05) on deviant days for heat-related illness, acute renal failure, electrolyte imbalance, and nephritis in California, heat-related illness in Washington, all-cause mortality in New Mexico, and respiratory hospitalizations in Massachusetts.

CONCLUSION: Our results suggest that the HVI may be a marker of health vulnerability in general, although it may indicate greater vulnerability to heat in some cases.

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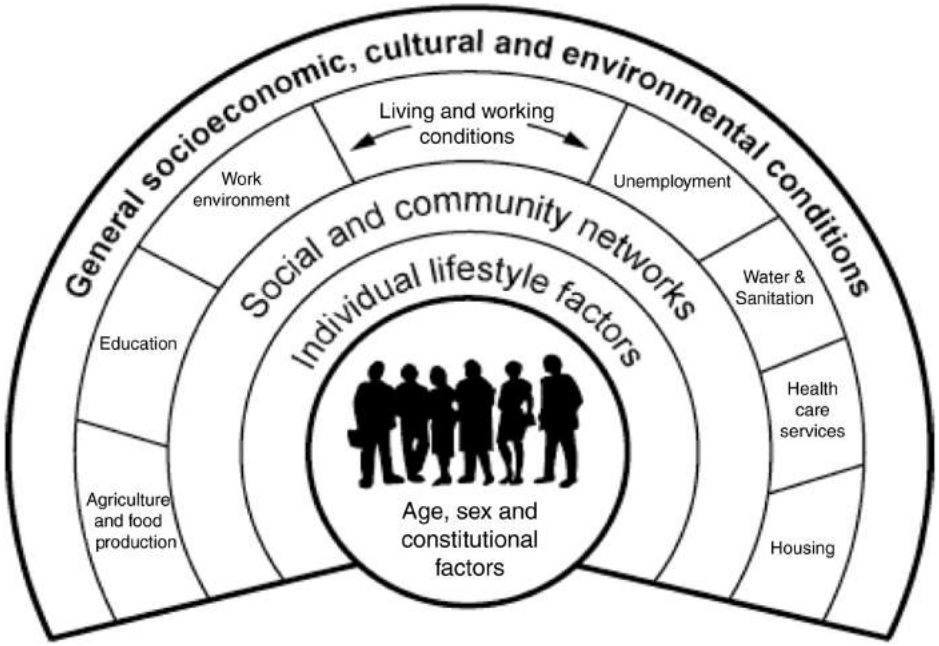

POLICY CONSIDERATIONS

No Perceptible Effect on Operations

SAEM Academic Emergency Medicine
Official Journal of the Society for Academic Emergency Medicine

ORIGINAL RESEARCH CONTRIBUTION

Forecasting Daily Emergency Department Visits Using Calendar Variables and Ambient Temperature Readings

Izabel Marcilio, MD, MSc, Shakoor Hajat, MSc, PhD, and Nelson Gouveia, MD, MSc, PhD

Conclusions: This study indicates that time-series models can be developed to provide forecasts of daily ED patient visits, and forecasting ability was dependent on the type of model employed and the length of the time horizon being predicted. In this setting, GLM and GEE models showed better accuracy than SARIMA models. Including information about ambient temperature in the models did not improve forecasting accuracy. Forecasting models based on calendar variables alone did in general detect patterns of daily variability in ED volume and thus could be used for developing an automated system for better planning of personnel resources.

ACADEMIC EMERGENCY MEDICINE 2013; 20:769–777

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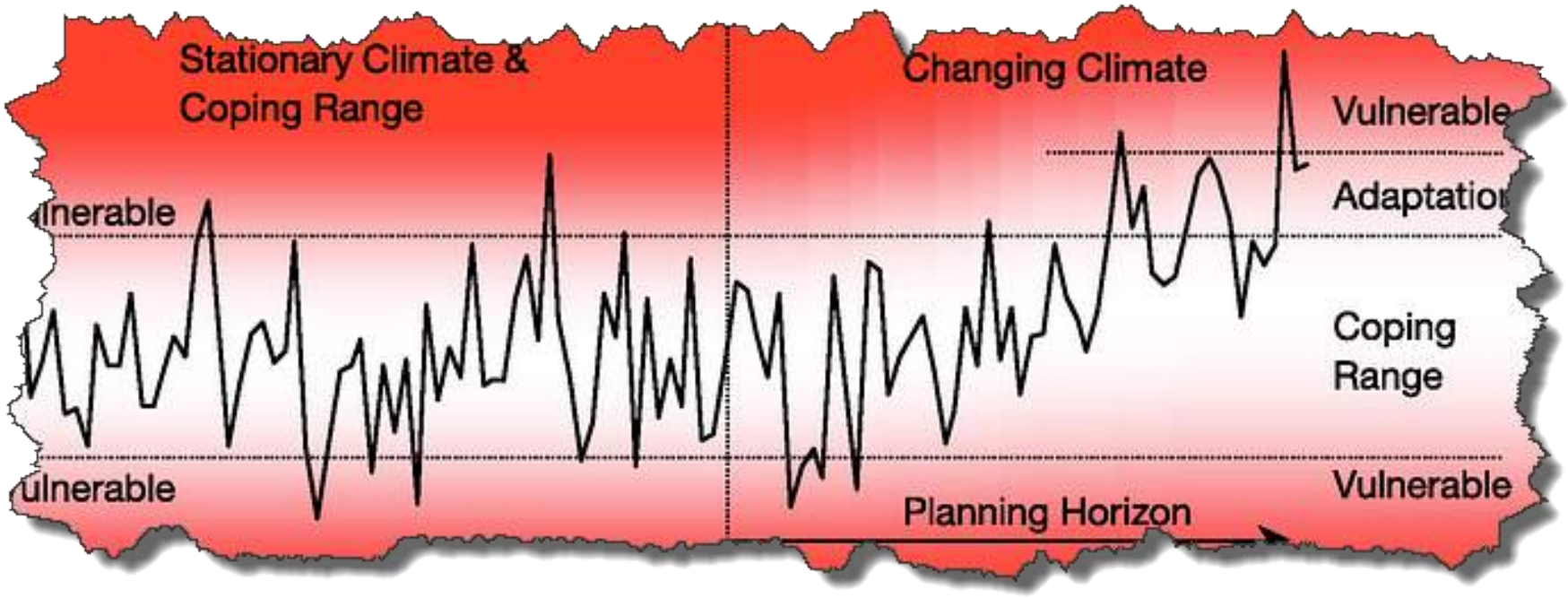
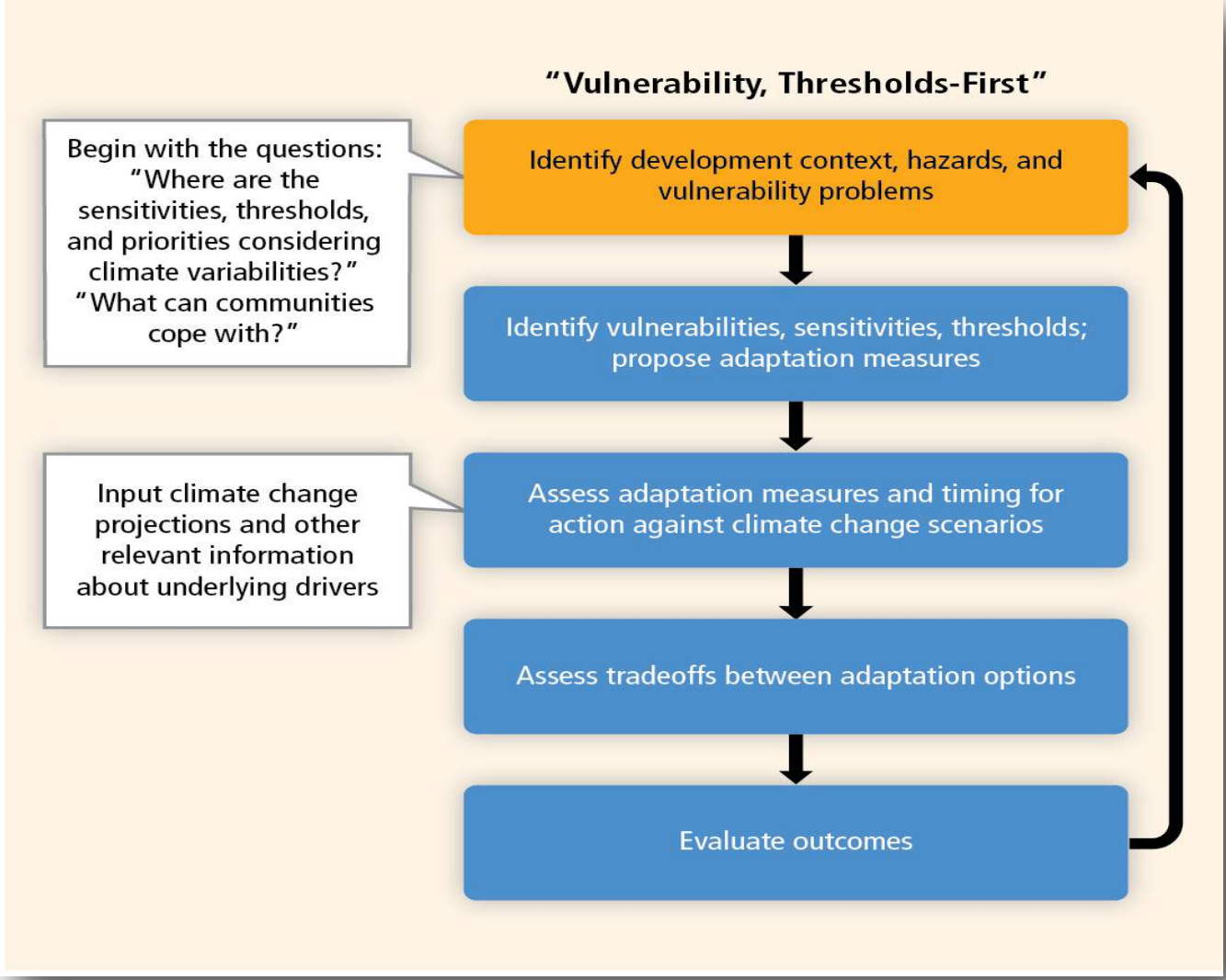
Where Are We Now?



And What Should Come First?



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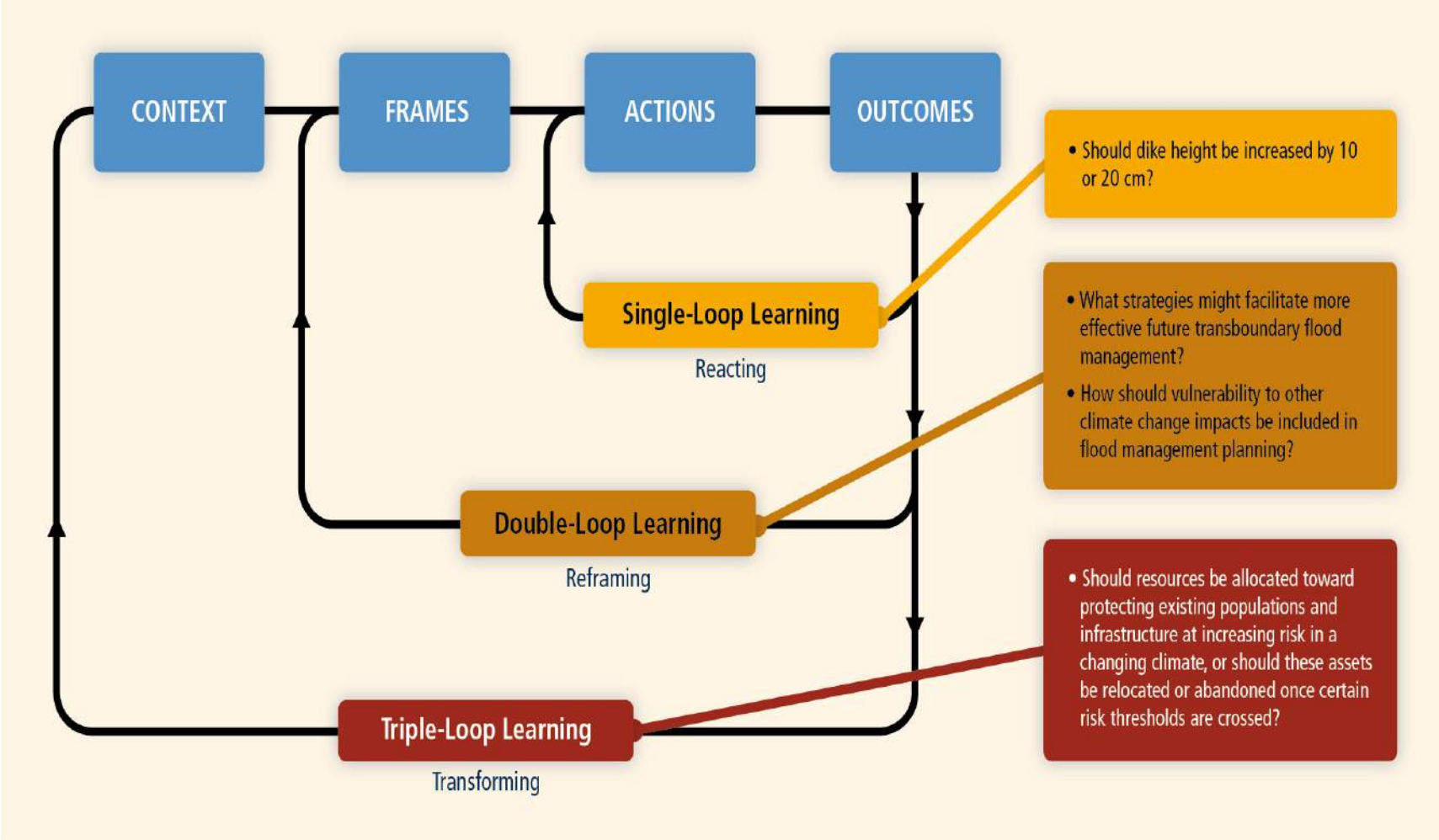
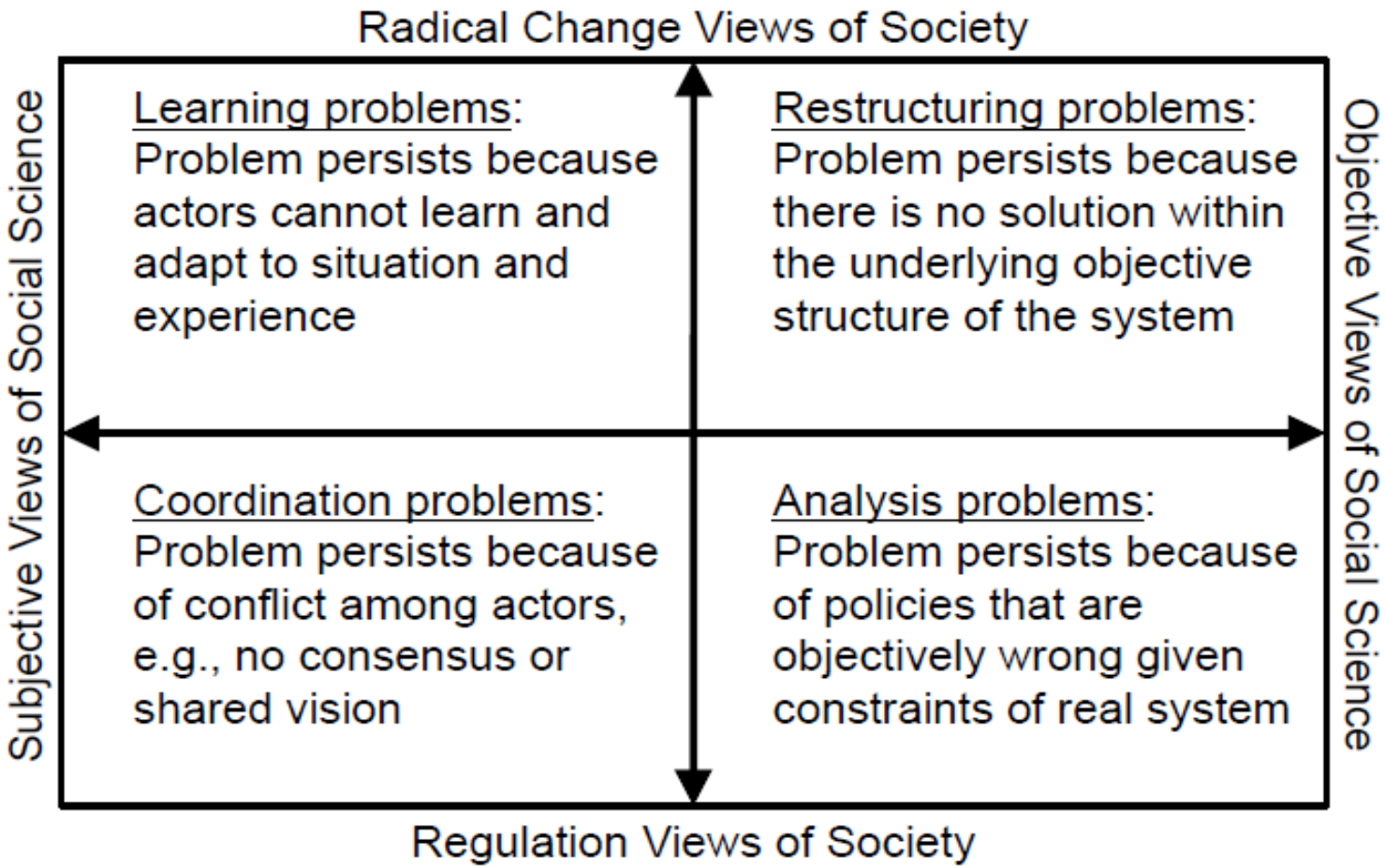
The Role of Learning



IPCC, SREX, 2012

Problem Types



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Experimentation

Contents lists available at SciVerse ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

A survey of urban climate change experiments in 100 cities

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ABSTRACT

Cities are key sites where climate change is being addressed. Previous research has largely overlooked the multiplicity of climate change responses emerging outside formal contexts of decision-making and led by actors other than municipal governments. Moreover, existing research has largely focused on case studies of climate change mitigation in developed economies. The objective of this paper is to uncover the heterogeneous mix of actors, settings, governance arrangements and technologies involved in the governance of climate change in cities in different parts of the world.

The paper focuses on urban climate change governance as a process of experimentation. Climate change experiments are presented here as interventions to try out new ideas and methods in the context of future uncertainties. They serve to understand how interventions work in practice, in new contexts where they are thought of as innovative. To study experimentation, the paper presents evidence from the analysis of a database of 627 urban climate change experiments in a sample of 100 global cities.

The analysis suggests that, since 2005, experimentation is a feature of urban responses to climate change across different world regions and multiple sectors. Although experimentation does not appear to be related to particular kinds of urban economic and social conditions, some of its core features are visible. For example, experimentation tends to focus on energy. Also, both social and technical forms of experimentation are visible, but technical experimentation is more common in urban infrastructure systems. While municipal governments have a critical role in climate change experimentation, they often act alongside other actors and in a variety of forms of partnership. These findings point at experimentation as a key tool to open up new political spaces for governing climate change in the city.

Speaking the Language

Changes in Mortality After Massachusetts Health Care Reform

A Quasi-experimental Study

Benjamin D. Sommers, MD, PhD; Sharon K. Long, PhD; and Katherine Baicker, PhD

Background: The Massachusetts 2006 health care reform has been called a model for the Affordable Care Act. The law attained near-universal insurance coverage and increased access to care. Its effect on population health is less clear.

Objective: To determine whether the Massachusetts reform was associated with changes in all-cause mortality and mortality from causes amenable to health care.

Design: Comparison of mortality rates before and after reform in Massachusetts versus a control group with similar demographics and economic conditions.

Setting: Changes in mortality rates for adults in Massachusetts counties from 2001 to 2005 (prereform) and 2007 to 2010 (post-reform) were compared with changes in a propensity score–defined control group of counties in other states.

Participants: Adults aged 20 to 64 years in Massachusetts and control group counties.

Measurements: Annual county-level all-cause mortality in age-, sex-, and race-specific cells (n = 146 825) from the Centers for Disease Control and Prevention's Compressed Mortality File. Secondary outcomes were deaths from causes amenable to health care, insurance coverage, access to care, and self-reported health.

Results: Reform in Massachusetts was associated with a significant decrease in all-cause mortality compared with the control group (−2.9%; P = 0.003, or an absolute decrease of 8.2 deaths per 100 000 adults). Deaths from causes amenable to health care also significantly decreased (−4.5%; $P < 0.001$). Changes were larger in counties with lower household incomes and higher prereform uninsured rates. Secondary analyses showed significant gains in coverage, access to care, and self-reported health. The number needed to treat was approximately 830 adults gaining health insurance to prevent 1 death per year.

Limitations: Nonrandomized design subject to unmeasured confounders. Massachusetts results may not generalize to other states.

Conclusion: Health reform in Massachusetts was associated with significant reductions in all-cause mortality and deaths from causes amenable to health care.

Primary Funding Source: None.

Ann Intern Med. 2014;160:585-593. www.annals.org
For author affiliations, see end of text.

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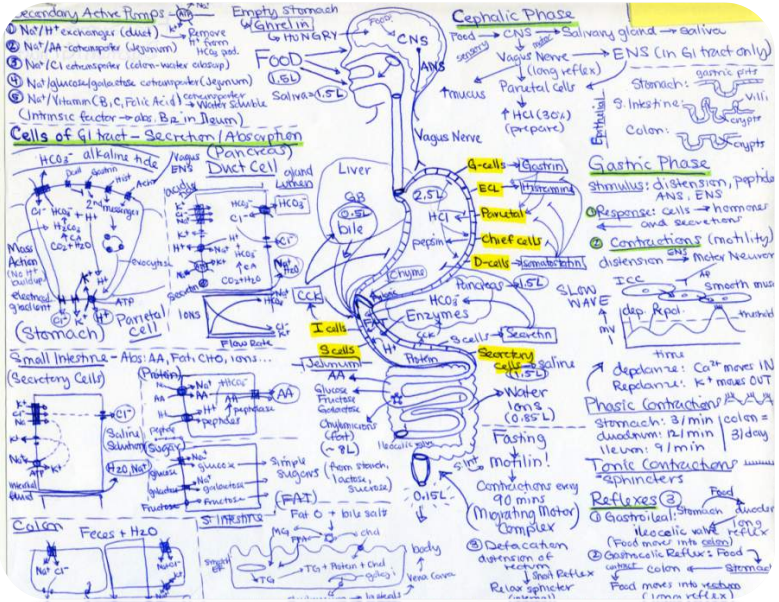
Cephalic Phase
Gastric Phase
Cells of GI tract – Secretion / Absorption
Small Intestine – Abs: AA, Fat, CHO, ions...
Colon
Liver
Pancreas
Fasting
Phasic Contractions
Tonic Contractions
Reflexes

SUMMARY

Conclusions

- There are multiple-climate sensitive health issues active at the urban scale
- Heat is a significant driver of morbidity and mortality and emergency departments are most affected
- While we may have made headway in risk management of heat illness in recent decades, the disease burden is still significant
- We have an opportunity to improve our expression of risk in vulnerable groups
- Stronger evidence for interventions and alternative expressions of effectiveness and efficacy may result in more effective interdisciplinary action and risk management

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