Increasing Heat in China, Mitigation and Adaptation

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- **Over the last three decades, rapid economic growth in China has pulled hundreds of millions of people out of poverty**
  - **Environmental effects** of economic growth are of increasing concern to Chinese people and policy makers
  - **Increases in fossil fuel use** in China have resulted in a steep rise in the emissions of CO_2 that cause global climate change, which has broad consequences for public health

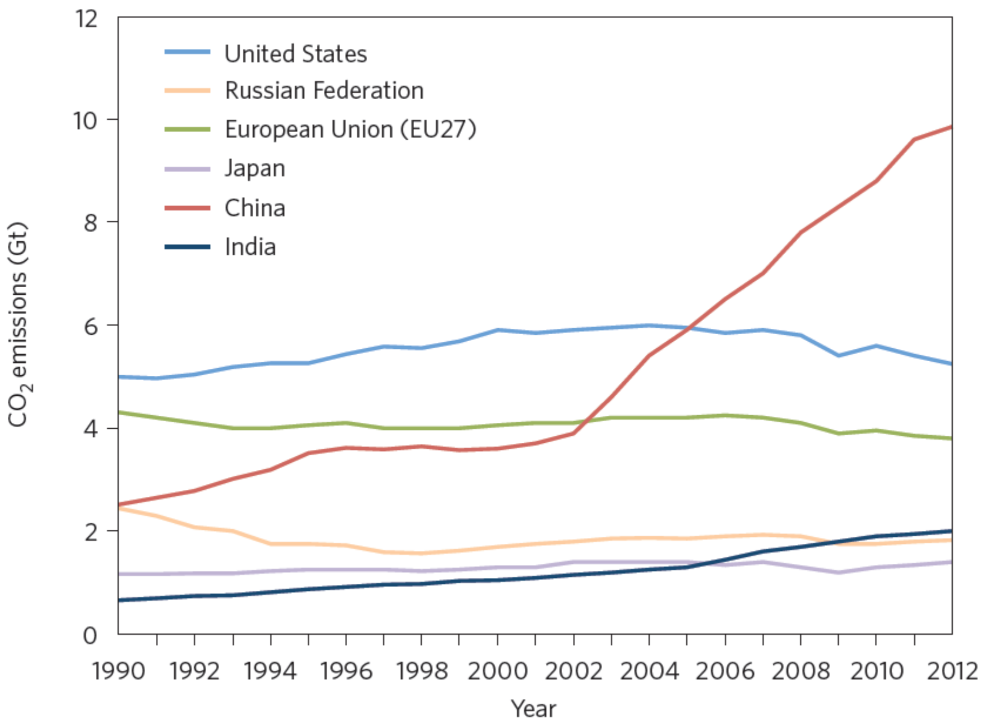
Environmental Health in China

- **China is subject to both traditional and modern environmental risk factors**
  - **Traditional:** unsafe drinking water, poor sanitation
  - **Modern:** industrial waste, air pollution, climate change

- Diseases associated with environmental factors remain a major source of ill health, especially **in poor populations**

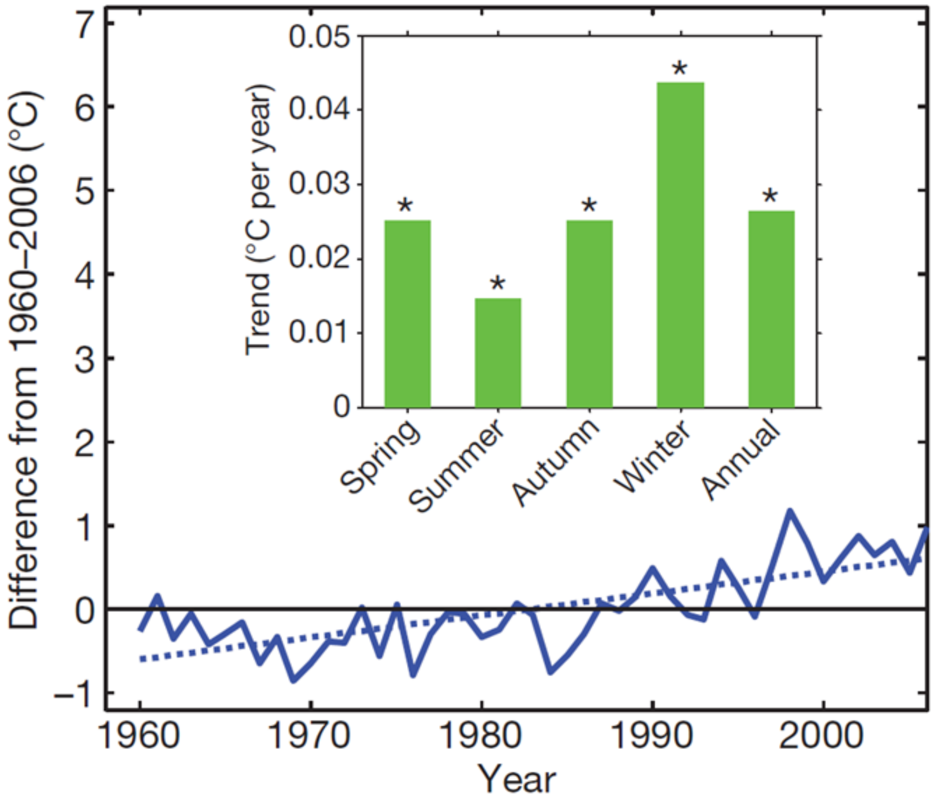
China's GHG emissions

- China's economic growth has been largely driven by combustion of fossil fuels that emit GHGs, which accumulate in the atmosphere and lead to changes in the global climate



In 2012, China's GHG emissions far surpassed those of other major countries

Oliver JGJ, et al., *Trends in Global CO2 Emissions: 2013 Report*



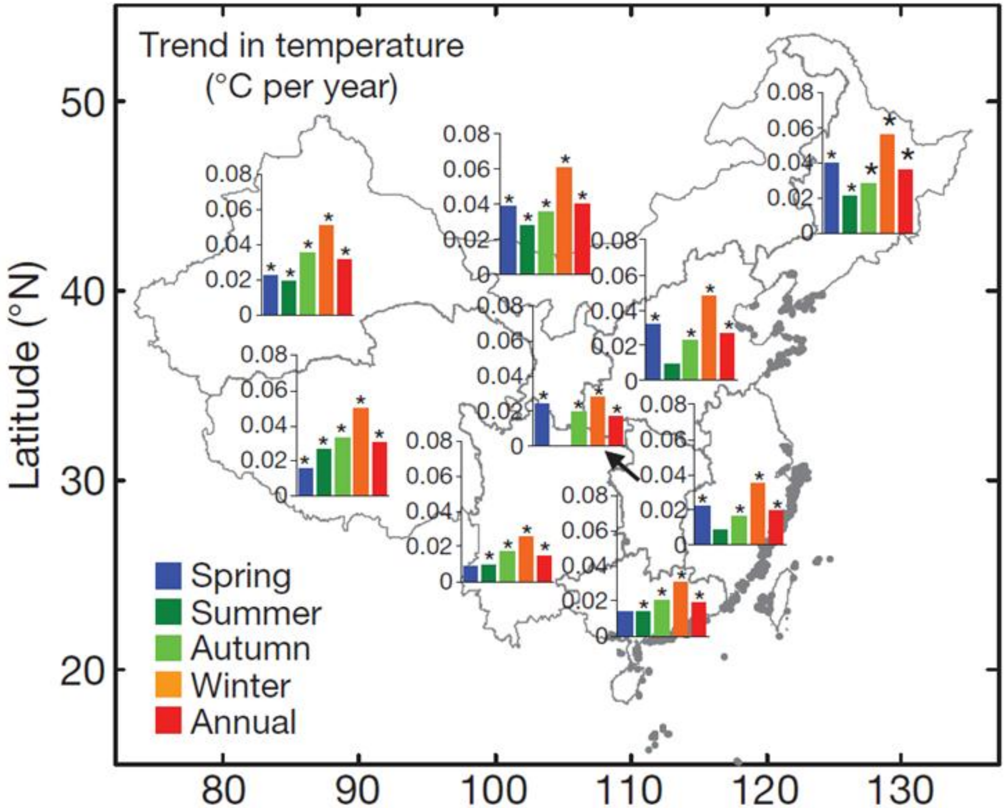
A strong warming of China over the past five decades is observed.
The temperature has increased by 1.2 ℃ since 1960.

Winter warming is about four times the rate of summer warming, and thus the temperature seasonal cycle amplitude has decreased.

Observed mean annual temperature variations between 1960 and 2006 across the country expressed as deviation from the mean during that period (blue line)

The inset shows trends in seasonal temperature during the period 1960–2006

Piao S, et al., *Nature*, 2010. 467(7311):43-51.

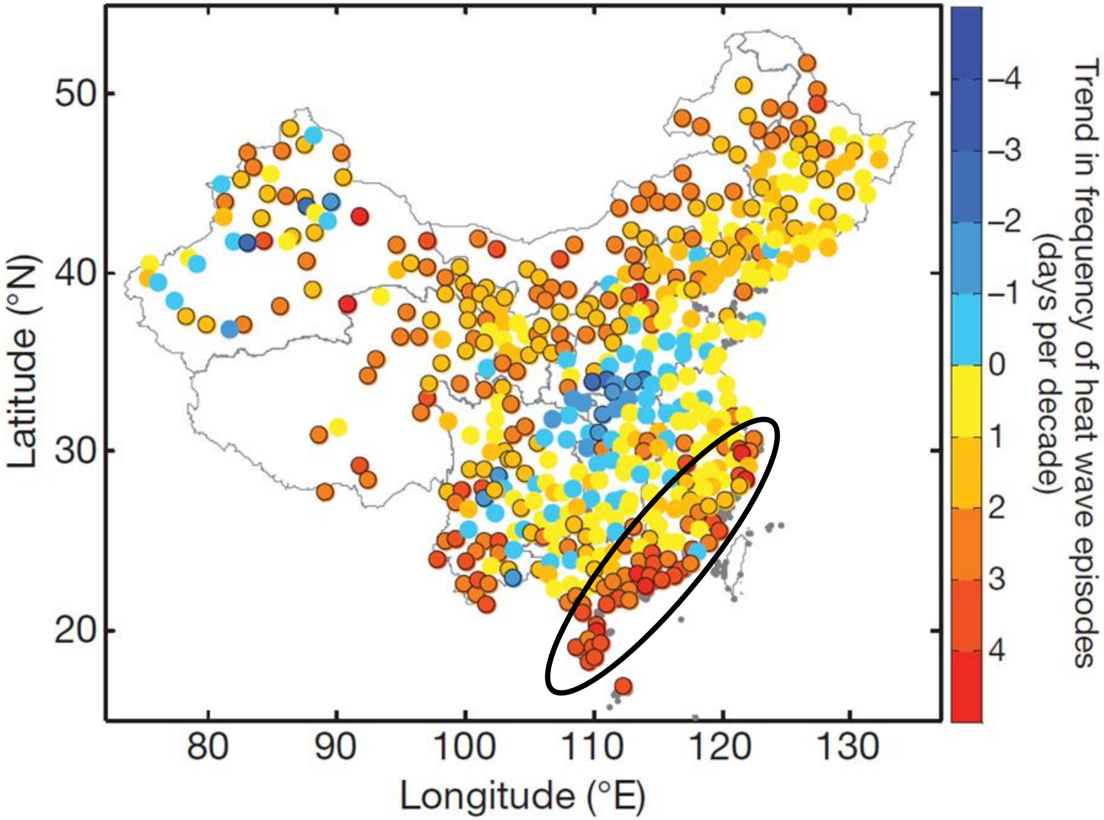


Although China's overall mean annual temperature has significantly increased over the past five decades, there are remarkable regional contrasts.

Northern China is warming faster than southern China.

Spatial patterns of the trend in seasonal temperature (shown as bar graphs) from 1960 to 2006

Piao S, et al., *Nature*, 2010. 467(7311):43-51.



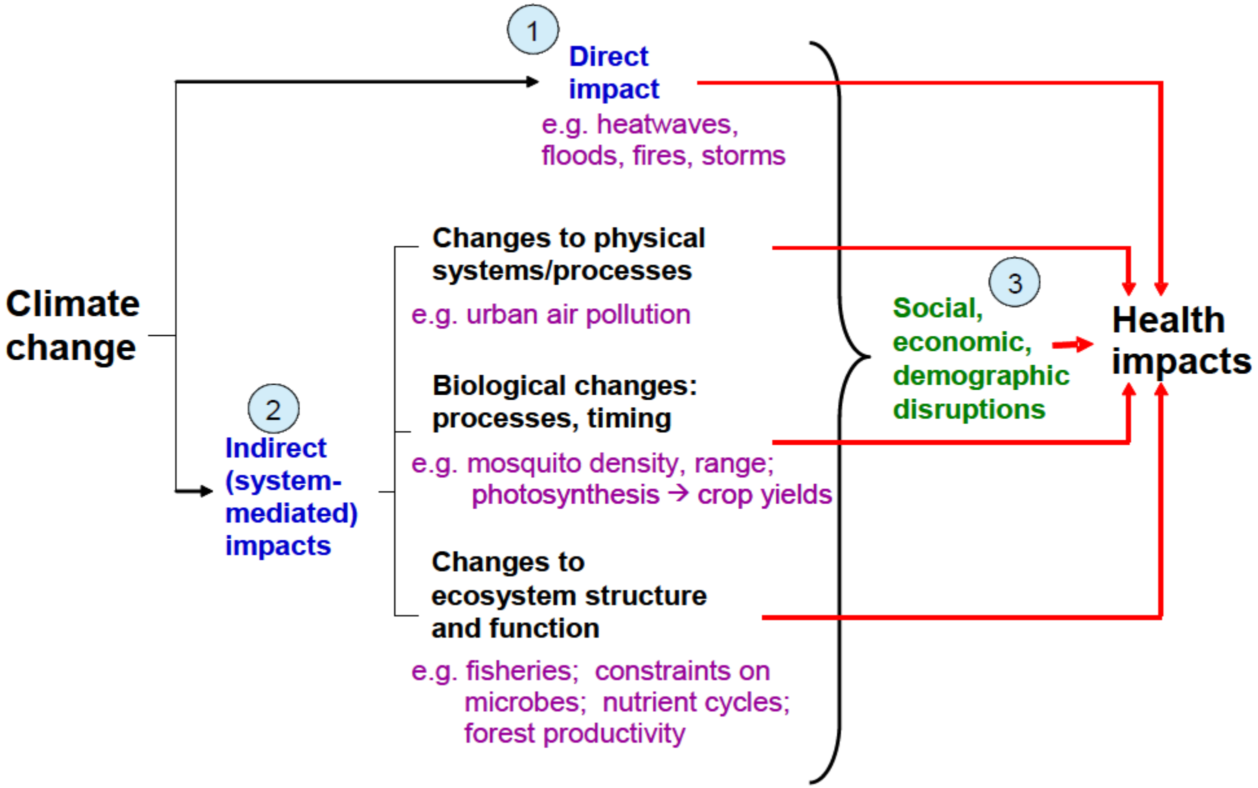
An increase in frequency of heat wave events occurred across most of China.

The coastal regions of southern China show the largest increase in frequency of heat wave events.

Spatial patterns of the trend in frequency of summer heat wave episodes from 1960 to 2006
Heat wave episodes were defined as hot summer (June–August) days with temperatures exceeding the 90th percentile with respect to the reference period (1960–2006)

Piao S, et al., *Nature*, 2010. 467(7311):43-51.

Climate Change and Health: Pathways

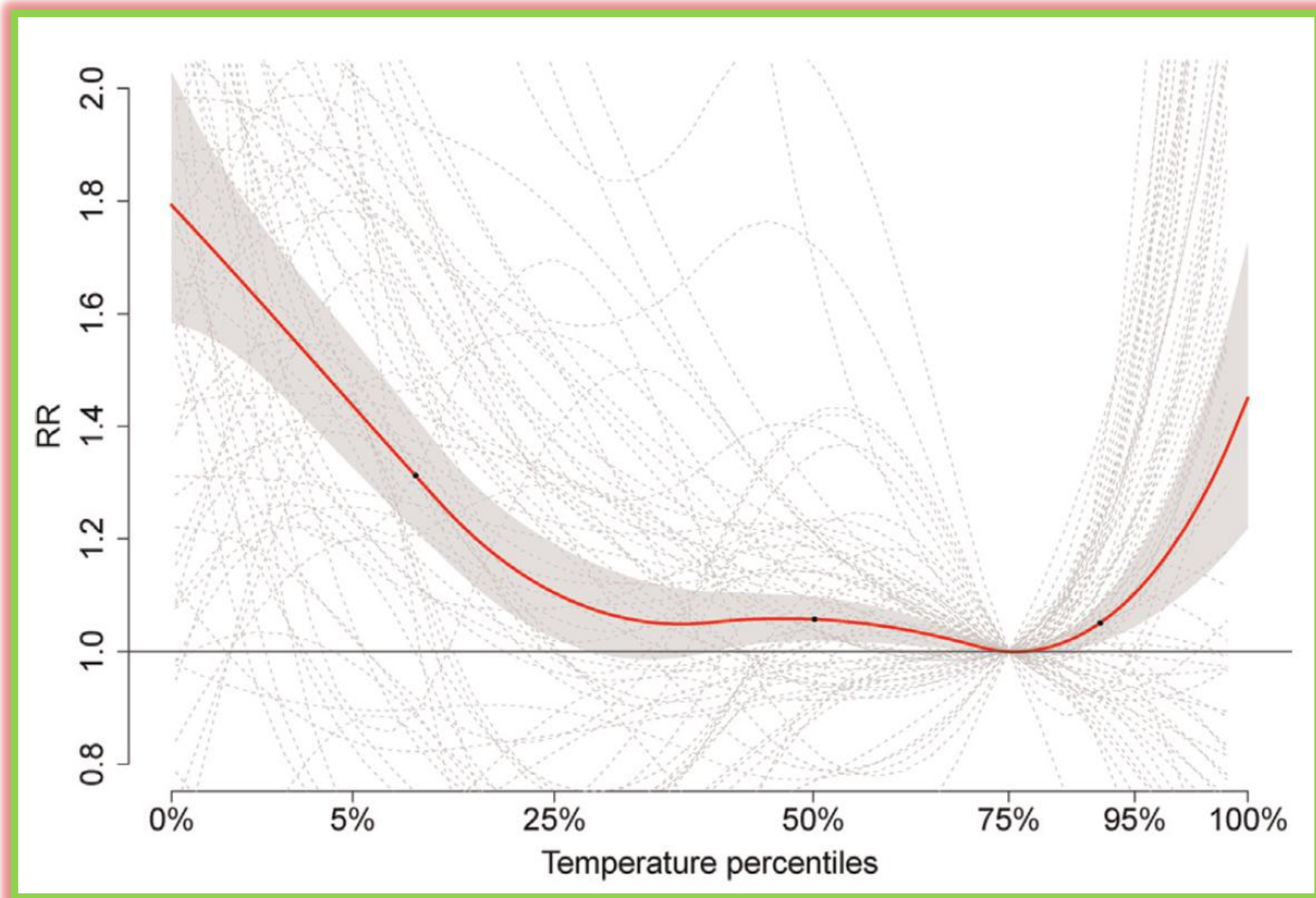


Evidence is mounting that climate change has affected public health in China from **direct** to **indirect** effects, such as extra deaths due to heat waves, increases in the transmission of climate-sensitive infectious diseases, and mental health problems caused by floods, droughts and other weather extremes

Temperature-health epidemiological studies in China

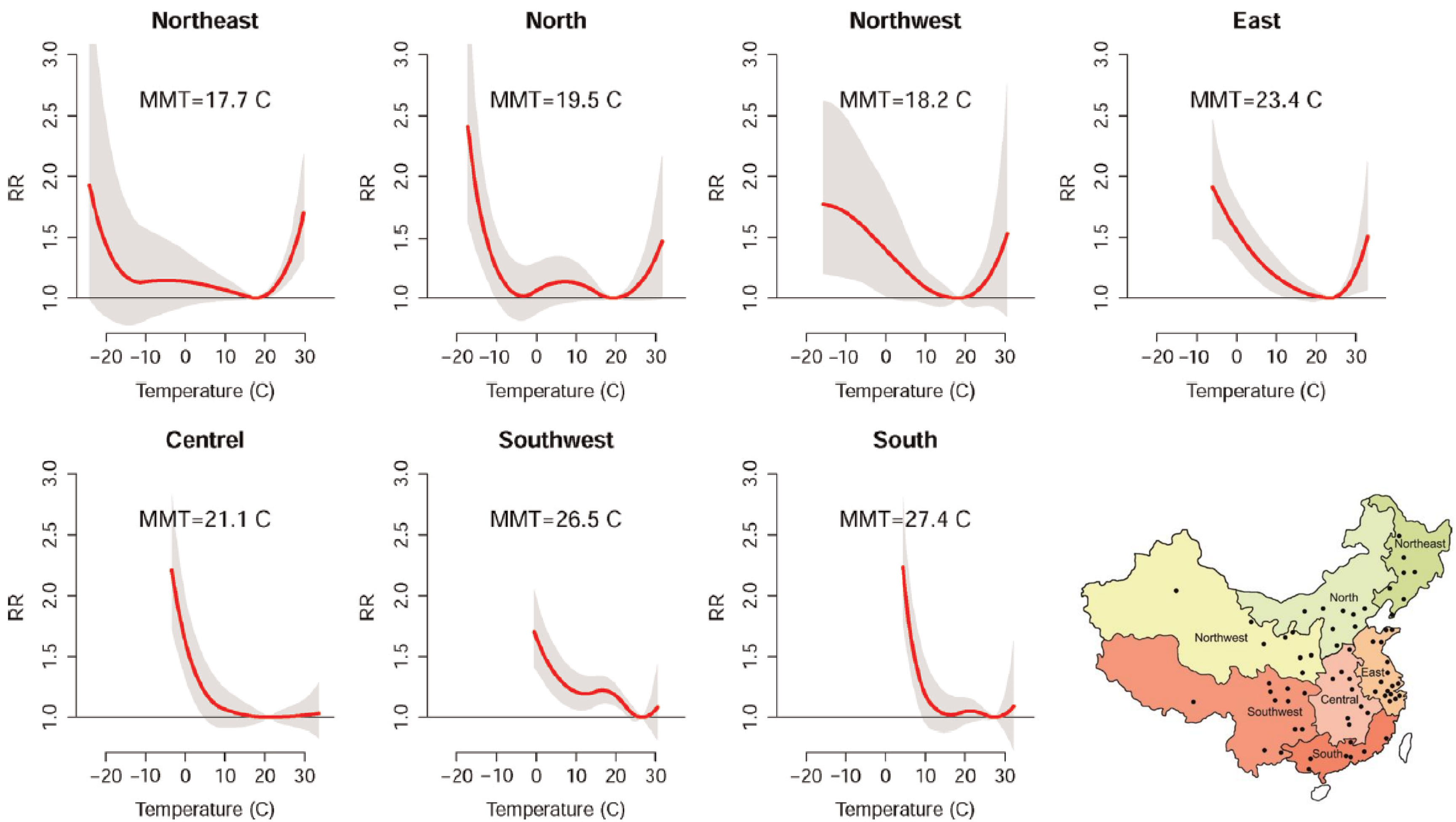
- **Studies have found that extreme temperatures are associated with an increased risk of illness and death**
  - **Mortality:** total non-external deaths and cause-specific diseases
  - **Morbidity:** hospital admissions, emergency room visits

- **The health effects of high temperatures have been estimated using the heat threshold and heat slope**
  - A significant geographic variability has been observed in both heat thresholds and slopes
  - Heat thresholds tend to be higher in warmer locations, suggesting acclimatization



Pooled overall temperature–mortality response curve based on 66 communities across China
The percentiles on the x-axis correspond to the average distribution of temperature across all communities; reference to 75th percentile of community-specific temperature distribution.

Ma W, et al., *Environmental Research*, 2015. 137:72-77.



Ma W, et al., *Environmental Research*, 2015. 137:72-77.

Temperature and morbidity on the roof of the world

Tibet of China, with an average altitude of over 4000m, has experienced noticeable changes in its climate over the last 50 years

Science of the Total Environment 490 (2014) 838–848

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Temperature, hospital admissions and emergency room visits in Lhasa, Tibet: A time-series analysis

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Li Bai [a], Cirendunzhu [b], Alistair Woodward [c], Dawa [b], Zhaxisangmu [b], Bin Chen [a], Qiyong Liu [a,d,e,*]

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[e] Collaborative Innovation Center for Diagnosis and Treatment of Infectious Diseases, Hangzhou 310003, PR China

- **High temperatures are associated with increases in morbidity, to a greater extent than low temperatures**
  - The relative risks of high temperature for total emergency room visits and non-external hospitalizations were 1.17 (95% CI: 1.002–1.349) and 1.16 (95% CI: 1.007–1.339) respectively, for lag 0–14 days
  - Acute heat effects at lag 0 were related with increases of renal and respiratory diseases, whereas immediate cold effects increased admission for digestive diseases
  - Those ≥65 years of age and males were more vulnerable to high temperatures

- Chen et al. (2015) compared the associations between heat waves defined by different heat wave definitions and cause-specific mortality in warm season in Nanjing, China

Heat wave definitions and heat-wave days during 2007–2013 in Nanjing, China

HW	Definition	Heat-wave days
HW01	Daily average temperature >90th percentile (30.6 °C) for ≥2 consecutive days	95
HW02	Daily average temperature >95th percentile (31.9 °C) for ≥2 consecutive days	45
HW03	Daily average temperature >98th percentile (32.7 °C) for ≥2 consecutive days	16
HW04	Daily average temperature >99th percentile (33.5 °C) for ≥2 consecutive days	11
HW05	Daily average temperature >90th percentile (30.6 °C) for ≥3 consecutive days	79
HW06	Daily average temperature >95th percentile (31.9 °C) for ≥3 consecutive days	35
HW07	Daily average temperature >98th percentile (32.7 °C) for ≥3 consecutive days	14
HW08	Daily average temperature >99th percentile (33.5 °C) for ≥3 consecutive days	9
HW09	Daily average temperature >90th percentile (30.6 °C) for ≥4 consecutive days	67
HW10	Daily average temperature >95th percentile (31.9 °C) for ≥4 consecutive days	32
HW11	Daily average temperature >98th percentile (32.7 °C) for ≥4 consecutive days	11
HW12	Daily average temperature >99th percentile (33.5 °C) for ≥4 consecutive days	6
HW13	Daily maximum temperature >95th percentile (36.4 °C) for ≥2 consecutive days	44
HW14	Daily maximum temperature >97.5th percentile (37.3 °C) for ≥3 days, daily maximum temperature >81st percentile (34.0 °C) every day, the average of daily maximum temperature for all consecutive days >97.5th percentile (37.3 °C)	33
HW15	Daily maximum temperature >35 °C for ≥3 consecutive days	84

Chen K, et al., *Science of the Total Environment*, 2015. 506-507:18-25.

China's air pollution shock

- During 2013, air pollution became a major economic and social issue across the country ('**the pollution shock**')
  - In January 2013, thick smog blanketed Beijing and northern China, covering 2.7 million square kilometers and affecting more than 600 million people
  - Although varying with weather and other factors, air pollution remained high in many parts of China throughout 2013
- Many cities, including Beijing and Shanghai, experienced a return of heavy air pollution in 2014

- **Air pollution and climate change influence each other through complex interactions in the atmosphere**
  - The main GHGs and the major air pollutants, to a large extent, come from the same sources
  - Air pollutions, especially ozone and particles, play an important role in the climate system
  - Climate change and air quality are linked through the chemistry of the atmosphere, as some air pollutants influence the lifetimes of GHGs

Due to climate change, the IPCC predicted

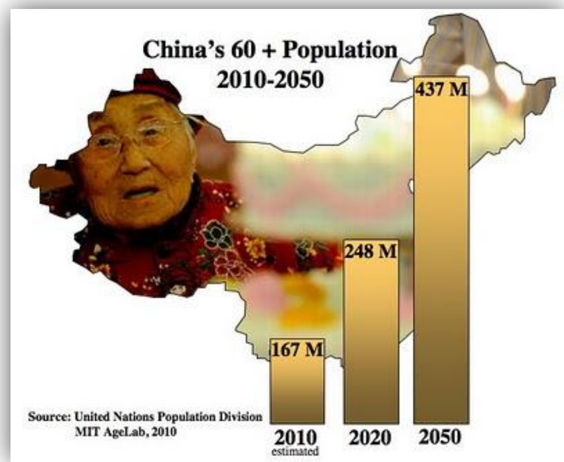
"declining air quality in cities"

Synergetic effects of air pollution and heat

- Epidemiological evidence from Chinese cities has indicated significant mortality risks of ozone associated with increasing temperatures (Zhang et al., 2006)
- Qian et al. (2008) found that high temperatures enhanced the mortality effects of air pollution in the "oven" city of Wuhan, China
- Wu and Zhang (2009) also observed similar synergetic effects in Beijing

HOT WEATHER, CLIMATE CHANGE AND PUBLIC HEALTH

- Heat-related mortality in China is a growing public health concern due to **climate change**, **population ageing** and **increasing urbanization**

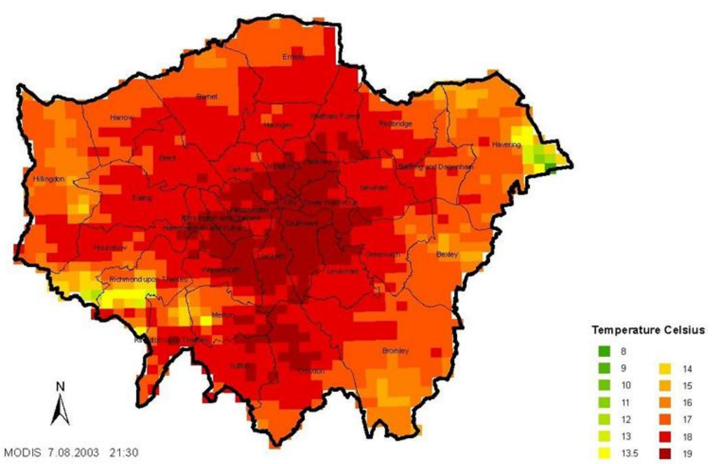


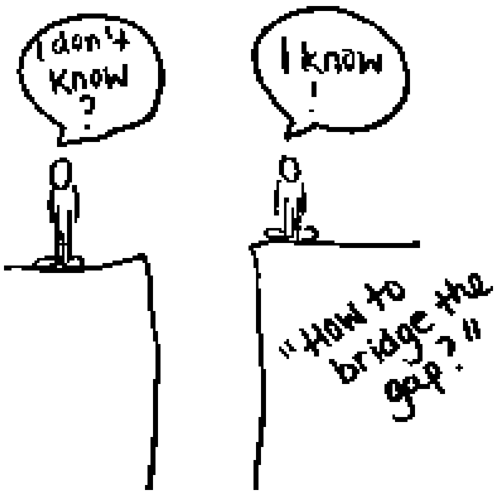
What we have known

- **The quantitative relationship between temperature and mortality**
  - a U- V- or W-shaped, with mortality generally increasing both above and below some temperature threshold
  - the precise shape of this relationship varies across different geographical areas
- **The role of specific individual- and city-level characteristics in modifying this relationship**
  - the elderly and people with pre-existing medical conditions are particularly vulnerable to the effects of temperature
  - higher levels of education in a population are associated with decreased risk of mortality

What are less clear

- **Because most studies take the city as the level of analysis, they are unable to shed sufficient light on these intro-urban inequalities**
  - The temperature distributions within cities are spatially heterogeneous and correlated with inequalities in distribution and access to urban infrastructures, good quality housing and health care services
  - Other spatially differentiated factors: the amount of control that people exert over their adaptation choices, options and policies; people’s perception of their own vulnerability





- **Until now, most studies in China have focused on:**
  - quantifying temperature–health relationships
  - characterizing vulnerable subgroups
  - identifying effect modifiers

- **The structural drivers and mechanisms determining differences in vulnerability within and across populations are less clear**

- **Less research on minimising the health risks of temperature exposure, and long-term strategies to address the health effects of temperature have not been sufficiently considered in public health practice and activities**

PUBLIC HEALTH ADAPTATION TO HEAT EVENTS IN RESPONSE TO CLIMATE CHANGE

- **Public health adaptation:**
  - any short- or long-term strategies that can reduce adverse health effects or enhance resilience in response to climate change and associated weather extremes, as well as exploit any beneficial opportunities

- **Adaptation strategies to deal with heat events:**
  1. **reducing the heat exposure**
  2. **managing the health risks**

1. Reducing the heat exposure

- During extreme heat events, there is limited potential for people to improve their physiological adaptive capacity
- It is important to plan ahead ways to decrease exposure to heat, particularly for susceptible people

a) Access to cooling

b) Building design

c) Urban planning

Access to cooling

- A few hours in a cool environment have been shown to be a strongly protective effect for reducing heat-related illness and deaths

- Some people at risk may not have or use air conditioning
  - failure to recognize the need, or reluctance to use it
- Some researchers caution against the widespread use of air conditioning
  - emit heat during use, increase outdoor temperature
  - further increase GHG emissions and consequently contribute to accelerated climate change and deteriorating local air quality
  - demands for electricity during heat waves can burden power infrastructure, which may even lead to large-scale power failures
- *Government run cooling centers?*
  - reduce risk for the large number of people unable to afford air conditioning
  - rely on people having transportation and recognizing when they should go

Building design

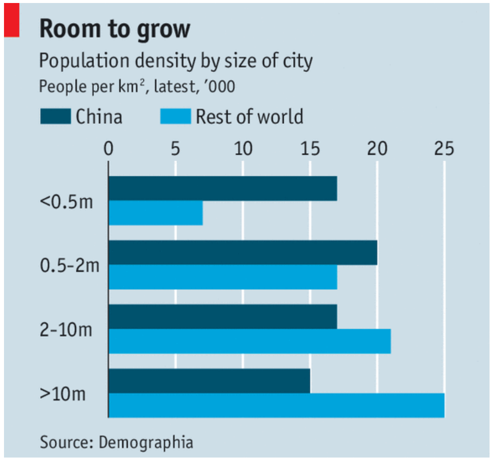
- People spend most of their lives indoors and tend to stay indoors during hot weather
  - adjust indoor temperature through improved building design so that the indoor temperature is more often in a comfortable range

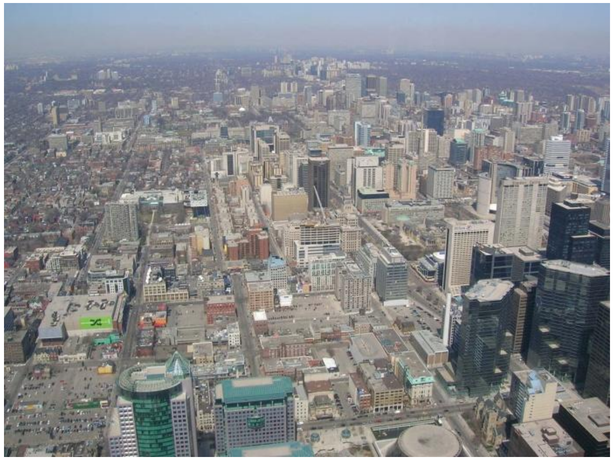
- Building orientation, design and materials can all influence the impact of outdoor heat on indoor temperatures
  - insulation can act as a barrier to hot air and is essential to keep homes warm in winter and cool in summer
  - advocate for improvement of thermal insulation in old and poorly constructed buildings

Urban planning

- Cities are usually warmer than the surrounding countryside, a phenomenon known as **the urban heat island (UHI) effect**
- Many cities have decentralized in recent decades, creating **urban sprawl** with low-density land use and heavy reliance on cars (China's megacities are less dense than equivalents elsewhere in the world)

The UHI and urban sprawl may be an inevitable consequence of development, but appropriate planning can play an important role in reducing vulnerability, building resilience, and promoting health





2. Managing the health risks

- Public health efforts to deal with heat-related health problems require a variety of actions

  a) **data surveillance and early warnings**
  b) **health care system preparedness**
  c) **public health awareness campaigns**

Data surveillance and early warning

- Real-time data surveillance can provide early detection of heat-related health effects by informing decision-makers about abnormal numbers
  - useful health data: deaths, emergency room visits, ambulance calls
  - data need to be available promptly as increases in mortality and morbidity from heat events occur quickly after exposure

- Heat–health warning systems are becoming more widespread
  - the essential elements: identifying locally relevant extreme weather, designing sensitive and specific trigger alerts, monitoring weather forecasts, and putting appropriate response actions in place
  - little research to evaluate the effectiveness of these systems

Health care system preparedness

- The delivery of health care services can be challenging
  - need to maintain a high level of services to help those affected by the heat and support the community in general
  - working in high temperature environments can potentially affect the health and safety of workforces
  - need to put on more staff and with greater rotation during hot weather

- Social factors can also influence vulnerability to heat
  - should be suited to the needs of the most vulnerable groups through coordination between health departments, social services, and other community organizations
  - identify the most feasible and appropriate options based on the structure of local health care and social service systems

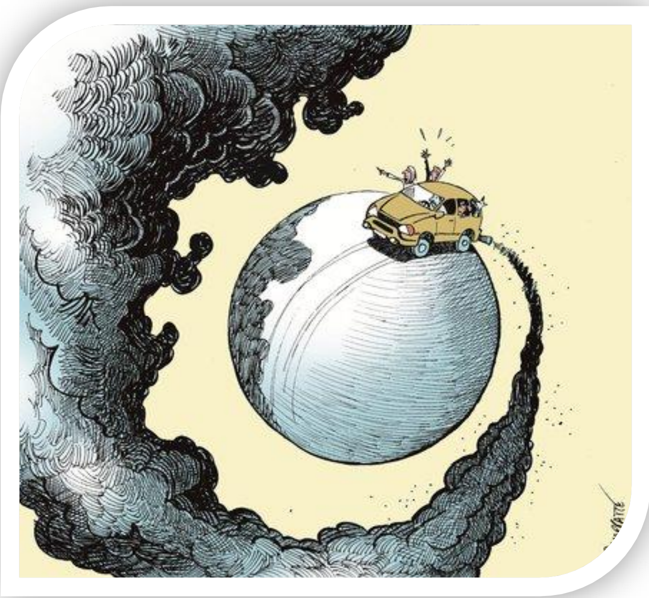
Awareness and education

- Responding effectively to heat events requires individuals to understand what heat events are, what health effects they can have, and what they can do to minimize these effects
  - need to not only create greater awareness of the dangers of heat to inform individuals, but also provide practical tips on how to reduce their risks

- Key messages should be targeted at the public, but also adjusted to the needs of specific vulnerable groups
  - practical tips and important contact details for social and emergency services
  - training programs for doctors, nurses and other health professionals, to enable them to identify heat-related health problems and be familiar with the most appropriate treatments

Global Change and Human Health

- The field of environmental health in China has traditionally focused on analysing the risks associated with **exposure to environmental toxins**: heavy metals, radiation, certain chemicals, etc.



There is an urgent need for **a new field of focus within environmental health** –
a focus on **the emerging health threats associated with large-scale, anthropogenic changes to the natural environment**, including ambient air pollution, global climate change, and altered function of the world's ecosystems.

- **These are difficult to study using traditional approaches**
  - they are **multi-factorial and complex** and often **occur over very large scales** that defy experimental study or even complete characterization

WORLD VIEW *A personal take on events*

China's scientific progress hinges on access to data

It is getting harder for scientists in China to obtain the high-quality public data that they need for important research studies, says **Zheng Wan**.

nature climate change
LETTERS
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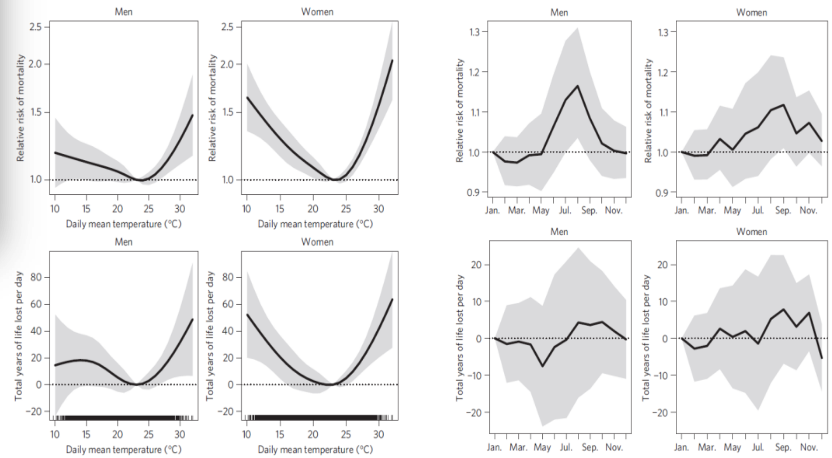
The impact of temperature on years of life lost in Brisbane, Australia

Cunrui Huang[1]*, Adrian G. Barnett[1], Xiaoming Wang[2] and Shilu Tong[1]

Huang C, et al., *Nature Climate Change*, 2012.2:265-270.



		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	1040	424	1648	1032	2466	1850	3510	2894
	Cold days	2461	2038	–423	1633	–828	1255	–1206	914	–1547
	Whole year	3077	3078	1	3281	204	3721	644	4424	1347
Women	Hot days	903	1493	590	2321	1418	3413	2510	4791	3888
	Cold days	2592	1903	–689	1351	–1241	922	–1670	599	–1993
	Whole year	3495	3396	–99	3672	177	4335	840	5390	1895
Total	Hot days	1519	2533	1014	3969	2450	5879	4360	8301	6782
	Cold days	5053	3941	–1112	2984	–2069	2177	–2876	1513	–3540
	Whole year	6572	6474	–98	6953	381	8056	1484	9814	3242

Projecting Future Heat-Related Mortality under Climate Change Scenarios: A Systematic Review

Cunrui Huang,[1] Adrian Gerard Barnett,[1] Xiaoming Wang,[2] Pavla Vaneckova,[1] Gerard FitzGerald,[1] and Shilu Tong[1]

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BACKGROUND: Heat-related mortality is a matter of great public health concern, especially in the light of climate change. Although many studies have found associations between high temperatures and mortality, more research is needed to project the future impacts of climate change on heat-related mortality.

OBJECTIVES: We conducted a systematic review of research and methods for projecting future heat-related mortality under climate change scenarios.

DATA SOURCES AND EXTRACTION: A literature search was conducted in August 2010, using the electronic databases PubMed, Scopus, ScienceDirect, ProQuest, and Web of Science. The search was limited to peer-reviewed journal articles published in English from January 1980 through July 2010.

DATA SYNTHESIS: Fourteen studies fulfilled the inclusion criteria. Most projections showed that climate change would result in a substantial increase in heat-related mortality. Projecting heat-related mortality requires understanding historical temperature–mortality relationships and considering the future changes in climate, population, and acclimatization. Further research is needed to provide a stronger theoretical framework for projections, including a better understanding of socioeconomic development, adaptation strategies, land-use patterns, air pollution, and mortality displacement.

CONCLUSIONS: Scenario-based projection research will meaningfully contribute to assessing and managing the potential impacts of climate change on heat-related mortality.

KEY WORDS: climate change, heat wave, mortality, projection, public health, scenario. *Environ Health Perspect* 119:1681–1690 (2011). http://dx.doi.org/10.1289/ehp.1103456 [Online 4 August 2011]

in mortality and, in some cases, humidity and air pollution (Kovats and Hajat 2008).

The health effects of heat can be estimated using the heat threshold and the heat slope. The temperature–mortality relationship is usually a nonlinear U-, V-, or J-shape. Many studies have quantified cold and heat effects separately, assuming a linear response below and above a threshold temperature (Baccini et al. 2008; Hajat and Kosatsky 2010; McMichael et al. 2008). The heat threshold is the temperature at which the harmful effect of heat begins to occur, and the heat slope measures the size of this effect (Hajat and Kosatsky 2010). A significant geographic variability has been observed in both heat thresholds and slopes. Heat thresholds tend to be higher in warmer locations, suggesting acclimatization (Baccini et al. 2008; Medina-Ramon and Schwartz 2007).

Many studies have found associations between high temperatures and mortality, but

Huang C, et al., *Environmental Health Perspectives*, 2011. 119:1681-1690.

Future collaborations are most welcome!