Potential Applications of Large Ensembles in Assessing Health Impacts of Climate Variability and Change

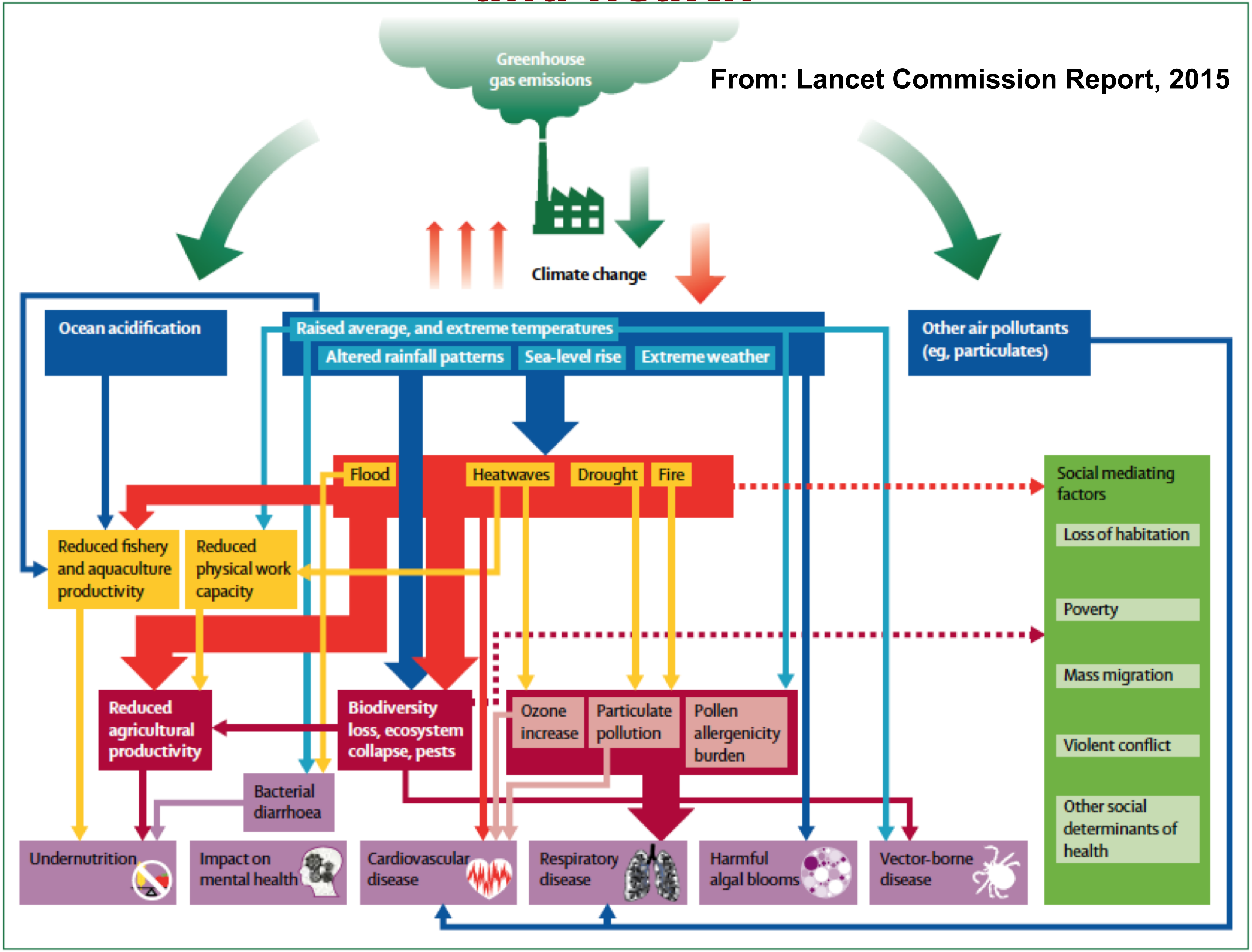
Patrick L. Kinney, Sc.D.

Beverly A Brown Professor of Urban Health, Boston University School of Public Health

pkinney@bu.edu

Illustration of links between emissions, climate, and health

From: Lancet Commission Report, 2015



How can public health research be used to quantify climate impacts?

- Assess the health impacts (or benefits) we might expect in the future from climate change (or its mitigation), in order to
  - Motivate and prioritize climate change mitigation
  - Target adaptation strategies
- Quantify present-day relationships between climate variability and human health
- Document long-term changes in health in response to climate change - attribution

Public Health Approaches

1. ***Epidemiology***

   Study and quantify historical relationships between climate-related exposures and human health outcomes

   …The goal is to identify and quantify "exposure-response" relationships

2. ***Health Impact Assessment***

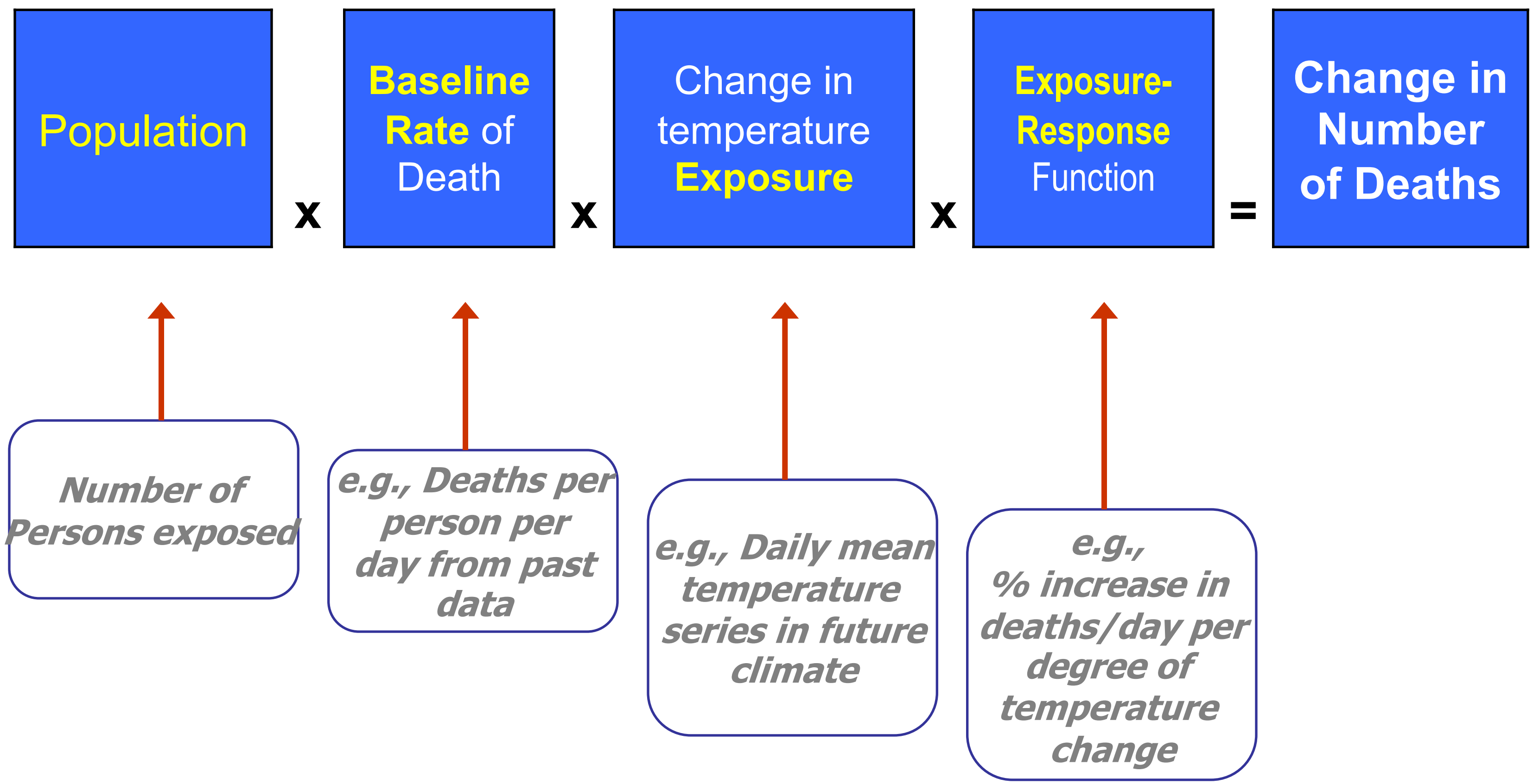
   Project health impacts for hypothetical climate and/or policy scenarios. For example:

   …if climate changes by X amount, what would be the health impacts for a given region?

   …if we adopt Y policy to mitigate climate change, what will be the local health benefits?

Health Impact Assessment:

A method for estimating the change in temperature-related *deaths* that might result from future climate change



How might climate warming affect future temperature-related mortality?

Long-term projections of temperature-related mortality risks for ischemic stroke, hemorrhagic stroke, and acute ischemic heart disease under changing climate in Beijing, China

Tiantian Li[a,*], Radley M. Horton[b], Daniel A. Bader[b], Fangchao Liu[c], Qinghua Sun[a], Patrick L. Kinney[d]

[a] *National Institute of Environmental Health, Chinese Center for Disease Control and Prevention, Beijing, China*
[b] *Center for Climate Systems Research, Columbia University, New York, USA*
[c] *Fuwai Hospital, National Center for Cardiovascular Disease, Chinese Academy of Medical Sciences and Peking Union Medical College,China*
[d] *Department of Environmental Health, Boston University School of Public Health, Boston, USA*

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Data Inputs and Exposure-Response Modeling

- ***Health, environmental and population data***
  - Daily cause-specific death counts and mean daily temperature for Beijing, China obtained from 2008-2013
  - Population held constant at 2010 levels, or allowed to grow based on UN projections

- ***Statistical Modeling***

Distributed lag non-linear Poisson regression model, with lags out to 14 days

Daily mortality ~ natural spline(Temp$_{max_lag}$, 3df) + natural spline(time, 7df) + day of week indicator

Results: Exposure-Response Curve

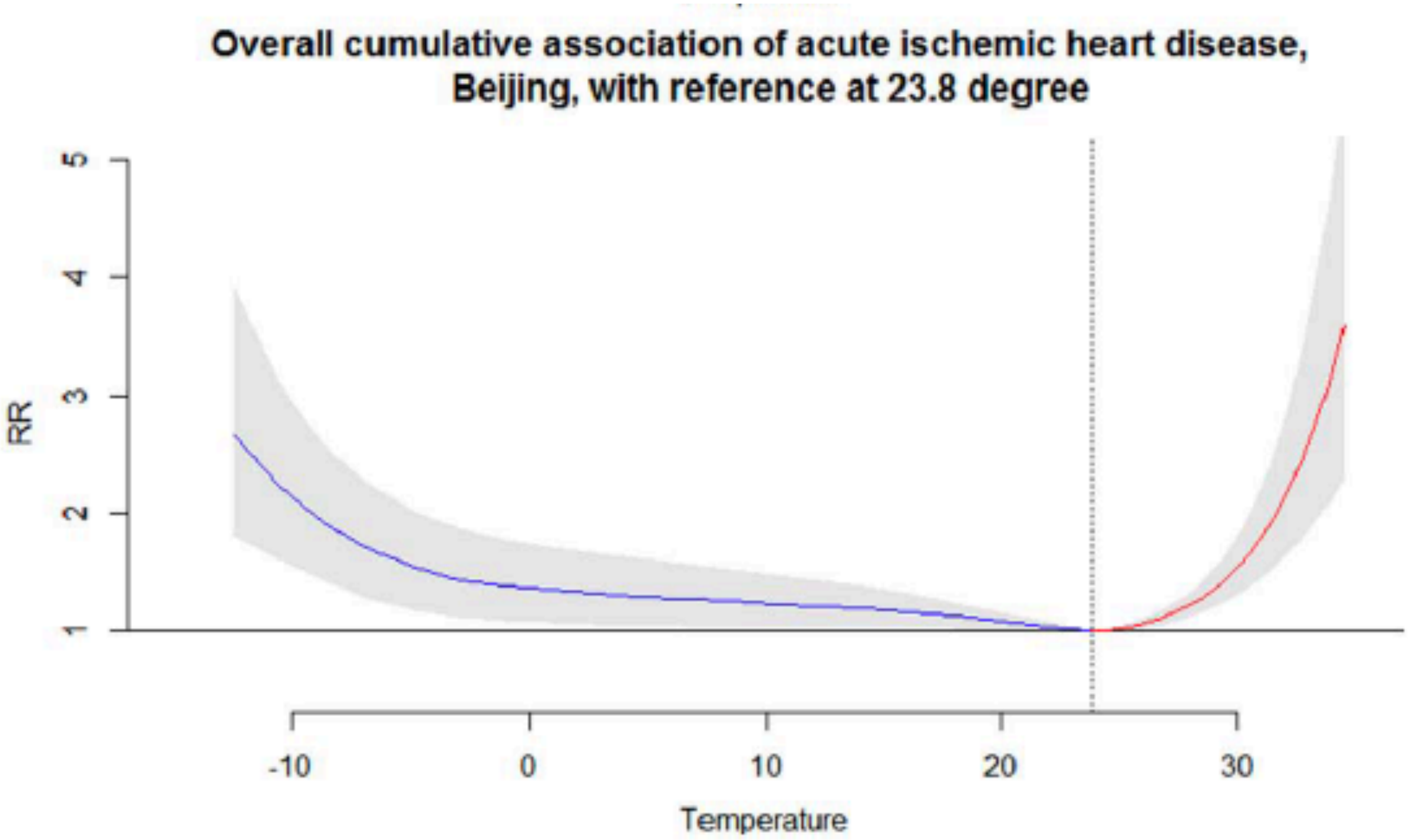


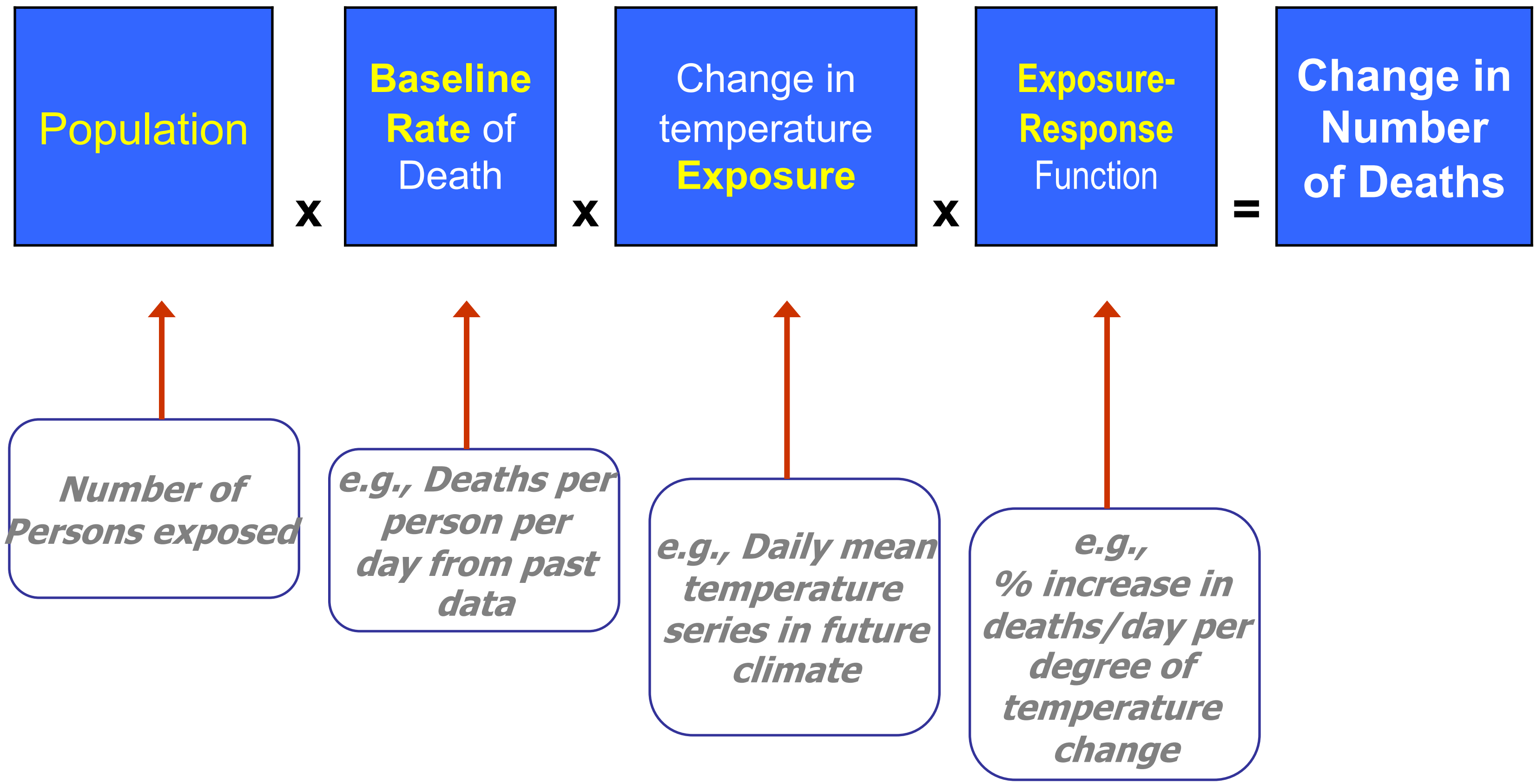
Fig. 1. Exposure-response curves for temperature-related mortality of ischemic stroke, hemorrhagic stroke, and acute ischemic heart disease.

Future temperature modeling:

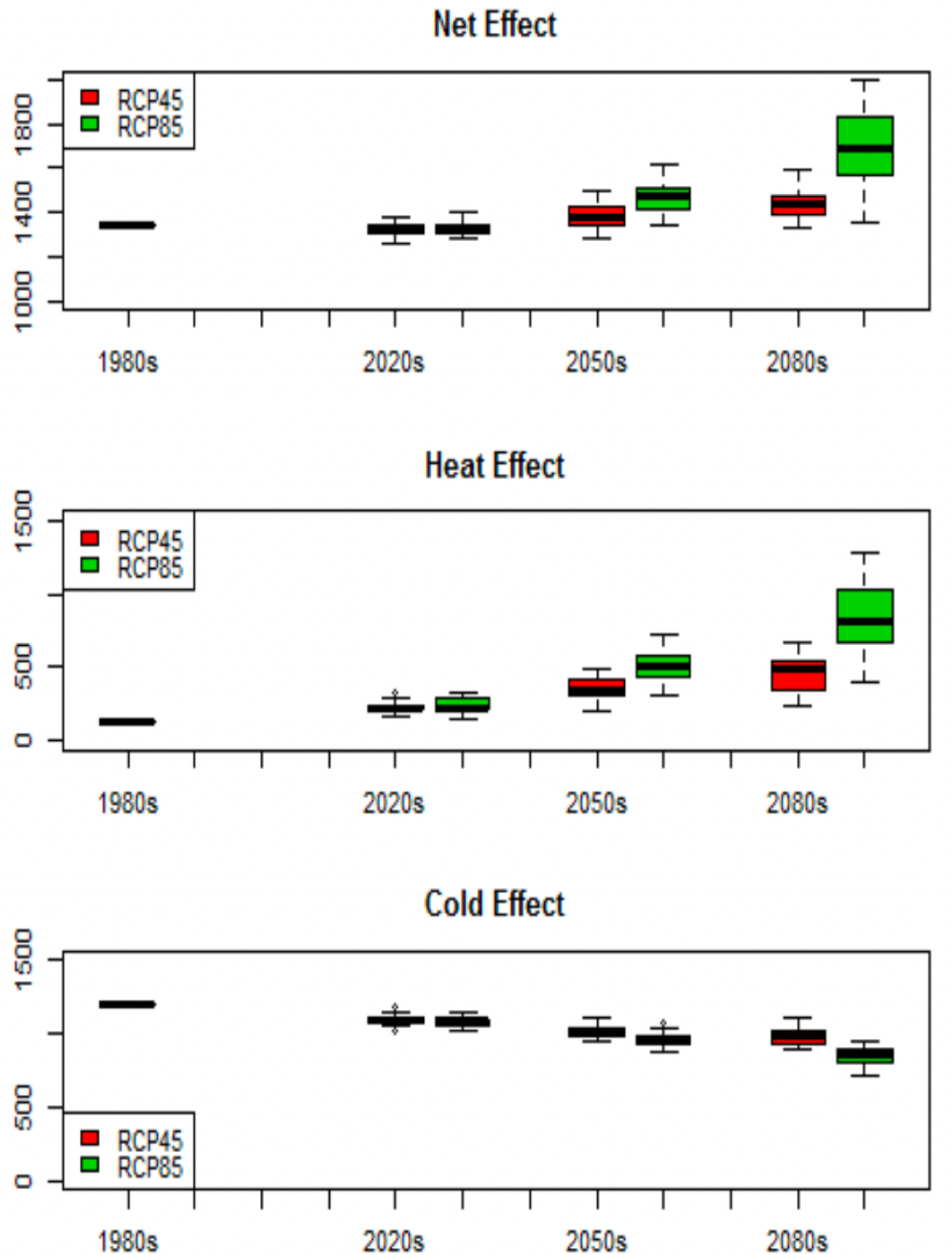
- Obtained future temperature projections down-scaled to Beijing from:
  - ***Two GHG scenarios (RCP4.5 and RCP8.5)***
  - ***31 GCMs from the CMIP5 archive***
- Modeled impacts in 30 year periods centered on the 2020s, 2050s and 2080s. Baseline period is the 30 year climatological baseline of 1970 to 1999 (referred to here as “1980s”)

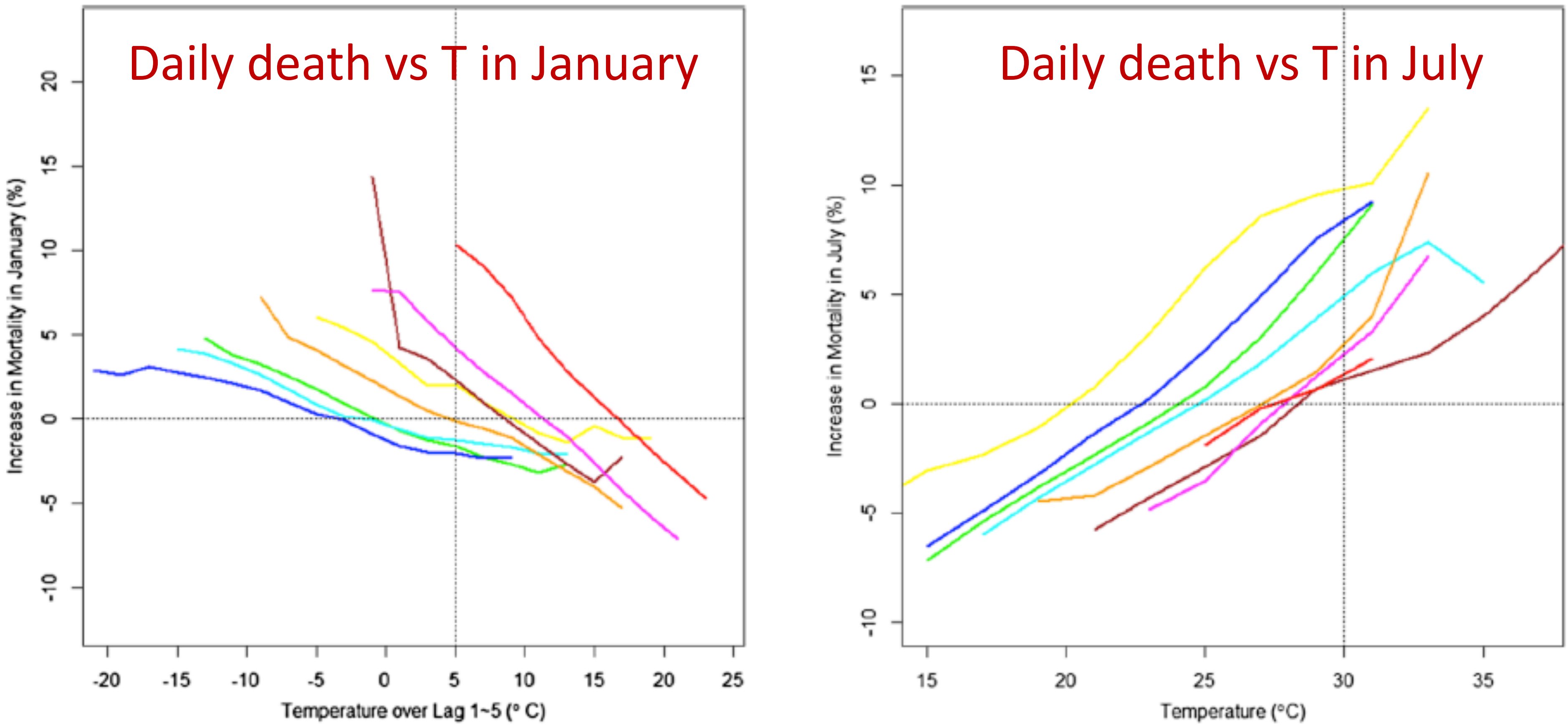
Health Impact Assessment:

A method for estimating the change in temperature-related *deaths* that might result from future climate change



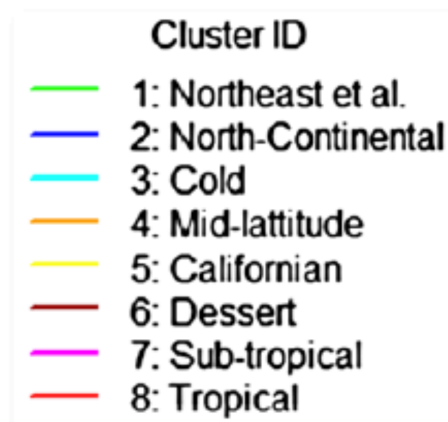
Projected temperature-related deaths due to ischemic heart disease in baseline and future periods





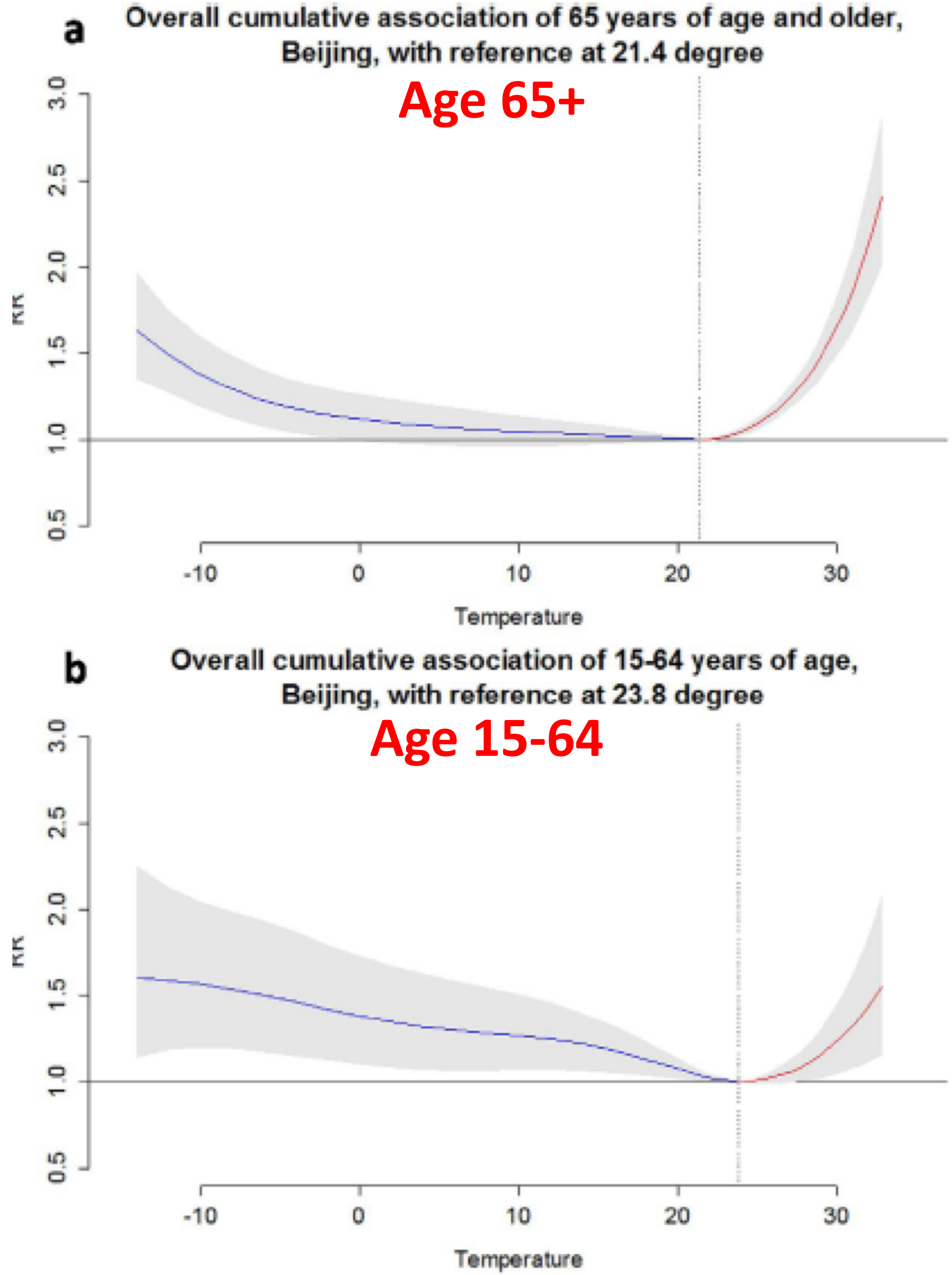
Temperature mortality risk functions in 7 US regions, based on analysis of 209 cities. There are between 8-36 cities/region.

Lee *et al. Environmental Health* 2014, **13**:89
http://www.ehjournal.net/content/13/1/89



Temperature-mortality relationship varies by age in Beijing.

From Li et al., Scientific Reports, 2016



RESEARCH ARTICLE

Future ozone-related acute excess mortality under climate and population change scenarios in China: A modeling study

Kai Chen[1,2], Arlene M. Fiore[3], Renjie Chen[4,5], Leiwen Jiang[6,7], Bryan Jones[8], Alexandra Schneider[2], Annette Peters[2], Jun Bi[1]*, Haidong Kan[4,5]*, Patrick L. Kinney[9]*

1 State Key Laboratory of Pollution Control and Resource Reuse, School of the Environment, Nanjing University, Nanjing, China, **2** Institute of Epidemiology, Helmholtz Zentrum München, Neuherberg, Germany, **3** Department of Earth and Environmental Sciences and Lamont–Doherty Earth Observatory of Columbia University, Palisades, New York, United States of America, **4** Shanghai Key Laboratory of Atmospheric Particle Pollution and Prevention, Shanghai, China, **5** School of Public Health, Key Laboratory of Public Health Safety of the Ministry of Education and Key Laboratory of Health Technology Assessment of the Ministry of Health, Fudan University, Shanghai, China, **6** Asian Demographic Research Institute, School of Sociology and Political Science, Shanghai University, Shanghai, China, **7** National Center for Atmospheric Research, Boulder, Colorado, United States of America, **8** Marxe School of Public and International Affairs, Baruch College, New York, New York, United States of America, **9** Department of Environmental Health, Boston University School of Public Health, Boston, Massachusetts, United States of America

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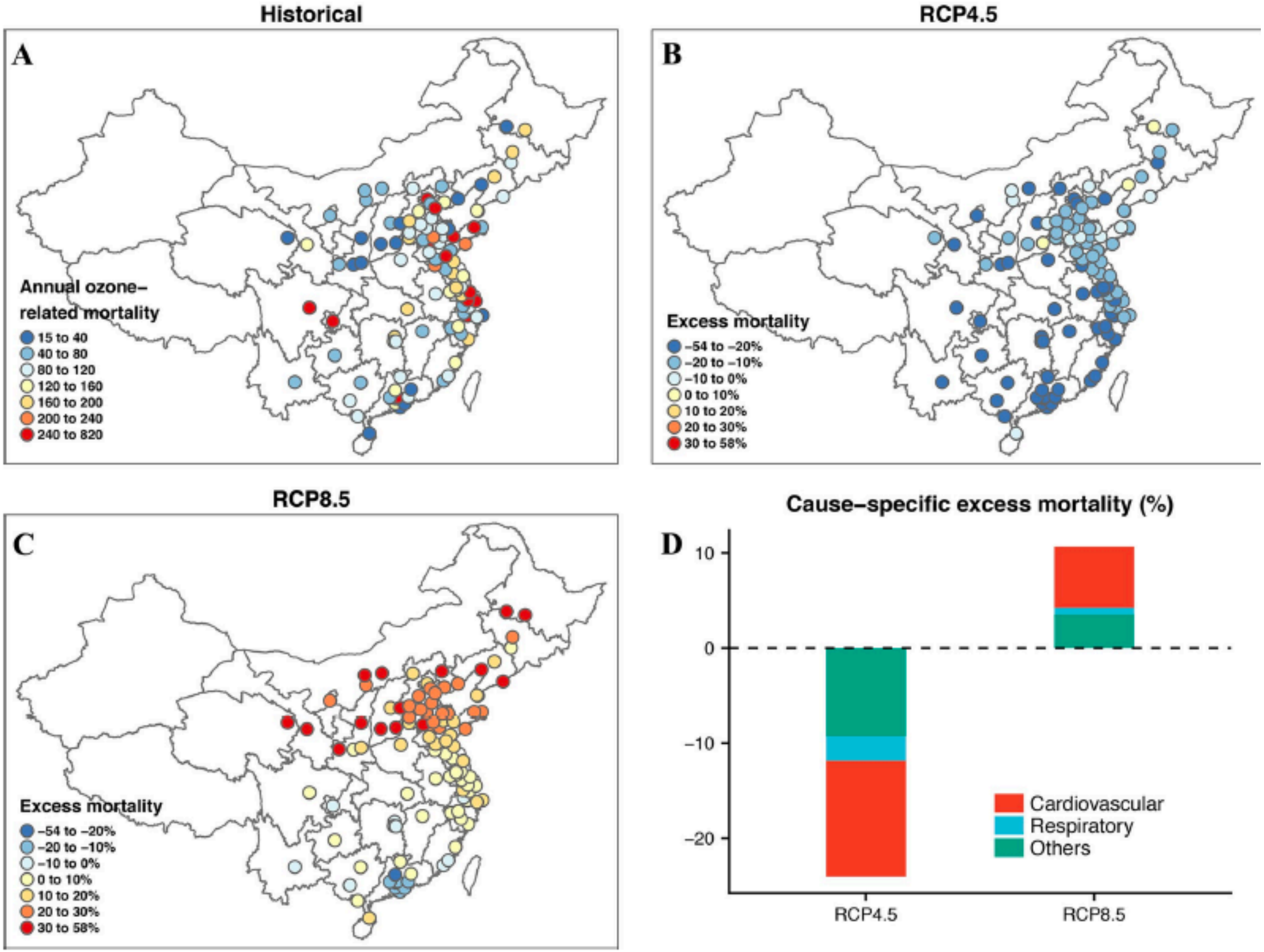
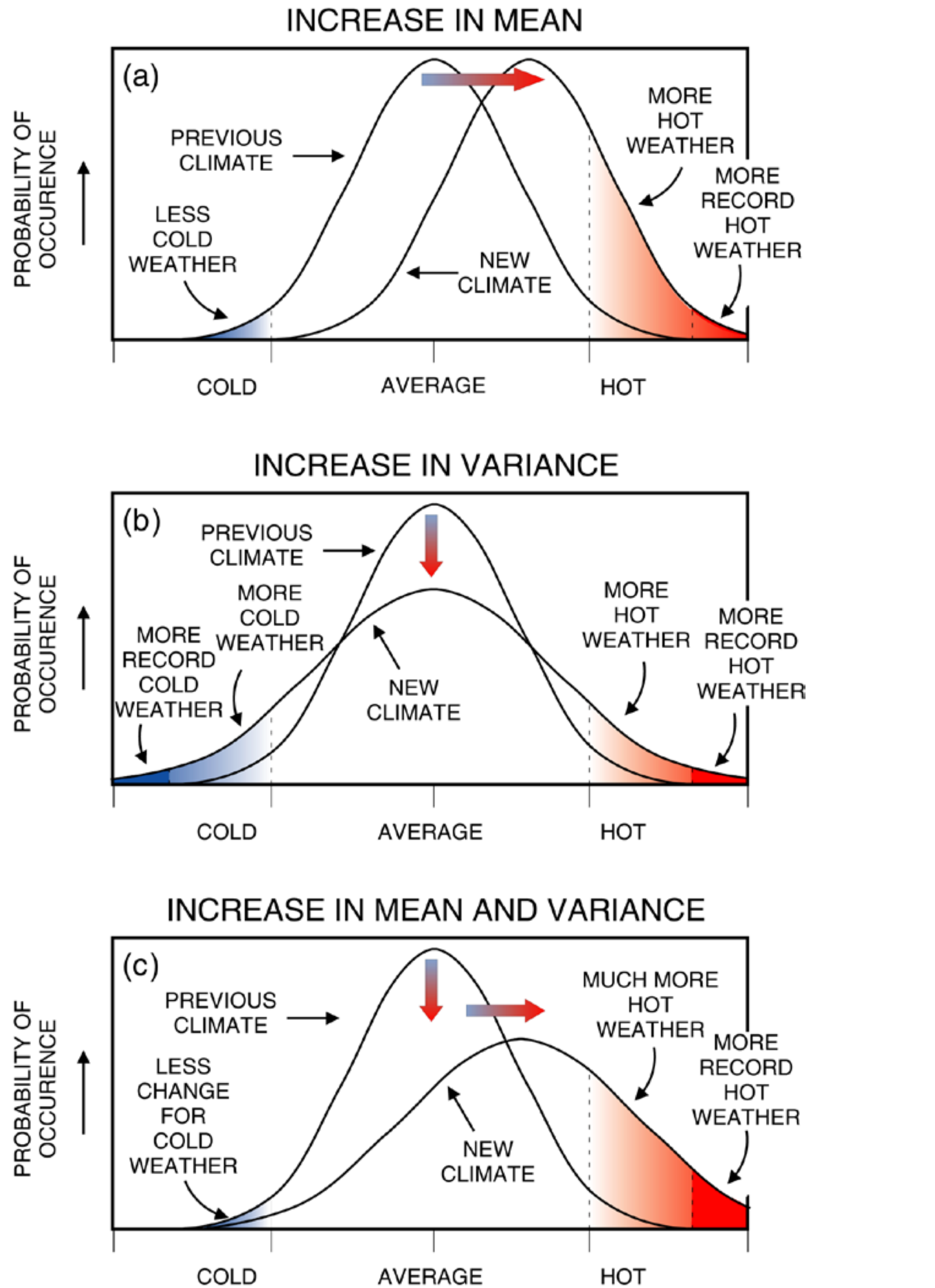


Fig 2. Impact of climate and emission change on ozone-related acute excess mortality. (A) Spatial distribution of historical annual ozone-related mortality in 104 Chinese cities during 2013–2015. (B) Spatial distribution of future changes (%) in annual ozone-related mortality under the RCP4.5 scenario in 104 Chinese cities during 2053–2055 relative to the historical period 2013–2015. (C) Same as (B) but under RCP8.5. (D) Future changes (%) in ozone-related mortality by cause of death (cardiovascular, respiratory, and other causes of non-accidental deaths) under RCP4.5 and RCP8.5. RCP4.5 and RCP8.5 represent moderate and high global warming and emission scenarios, respectively.

Summary and future directions

- Climate-health pathways vary in their complexity, and in our ability to model them.
- To date, health impact studies have rarely taken into account internal variability, and thus variations in exposures, and their health impacts, have been severely underestimated
- The direct temperature effect on mortality seems to be a logical first application of large ensembles
- We need to move away from mean effects and look at upper percentiles – e.g., 95^{th}
- Might LE members falling in the upper 5% for some metric (e.g., days with Tmean > X) be used as boundary conditions to produce statistically or dynamically downscaled ensembles?
- Might decadal LEs initiated with current obs be used for local to regional decadal predictions and heat-health planning?
- Might the joint occurrence of multiple exposures (heat, cold, air pollution) be examined in the LE context?

- The direct effects of climate on health (via heat and precipitation) are driven by extreme values.
- However, health impact studies have been limited in their ability to examine tails of the. exposure distributions.
- We've mostly focused on central tendencies.
- Large ensembles can provide more robust descriptions of tails.



Source: Gettleman and Hack, 2005


Thank You