Direct economic cost of future heat death estimates for India under climate change and population scenarios

AMS100

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PARDEE RAND GRADUATE SCHOOL

Heatwaves

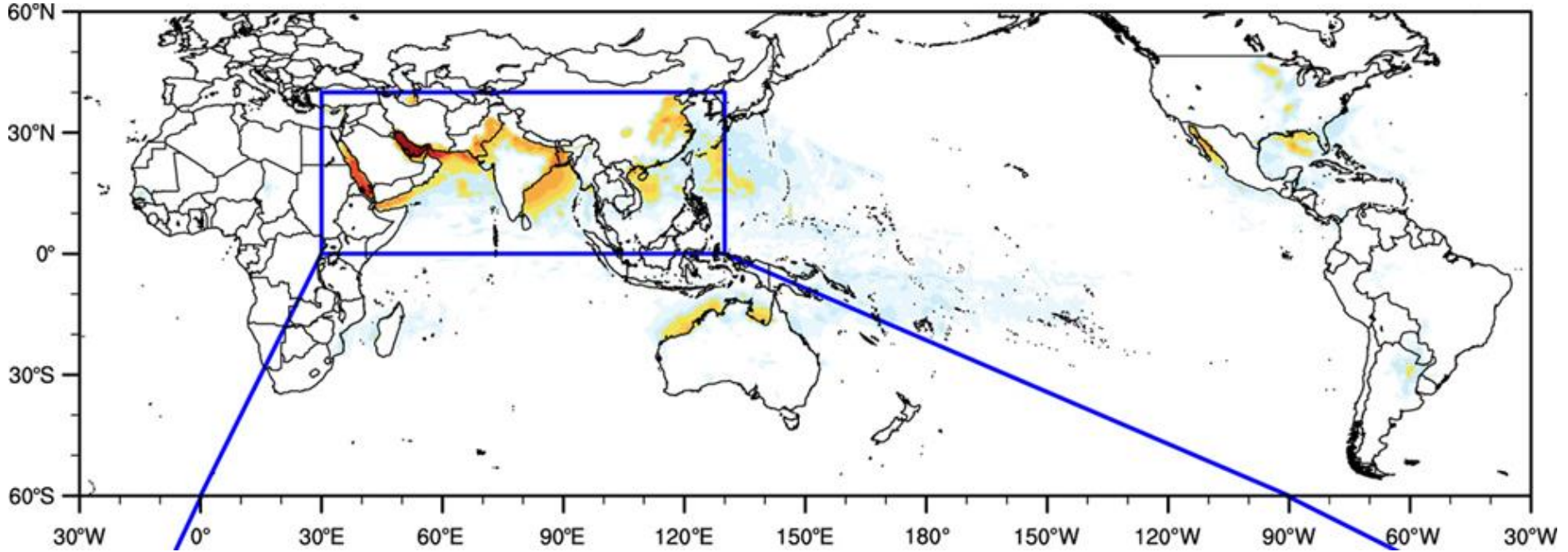
Now

- European (2003) – 70,000 dead
- Russian (2010) – 56,000 dead (?)
- US - several
  - California
  - Chicago
  - LA
  - Others
- India – almost an annual occurrence now

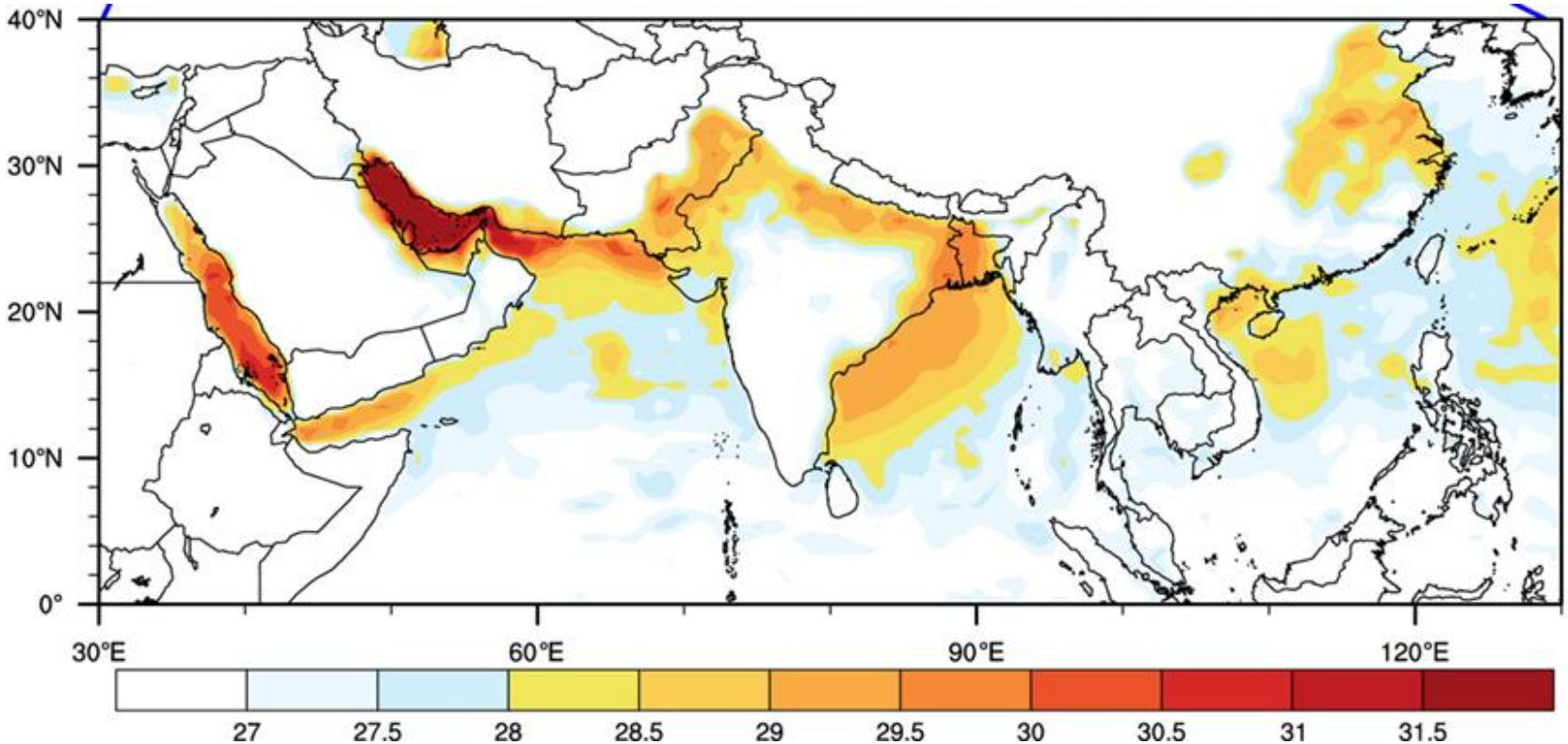
Future

- Future temperatures in SW Asia are projected to exceed threshold for human adaptability
- Heavily populated cities e.g. Delhi could have temperatures > 95º F (35º C) up to 200 days per year
- Likely to increase:
  - Frequency, Intensity, Duration, Deaths

Countries at Risk from Heatwaves



Countries at Risk from Heatwaves



Mortality estimates and costs

Aim1: Estimate future deaths under various climate change scenarios

Aim2: Estimate direct economic costs associated with these deaths

Methods

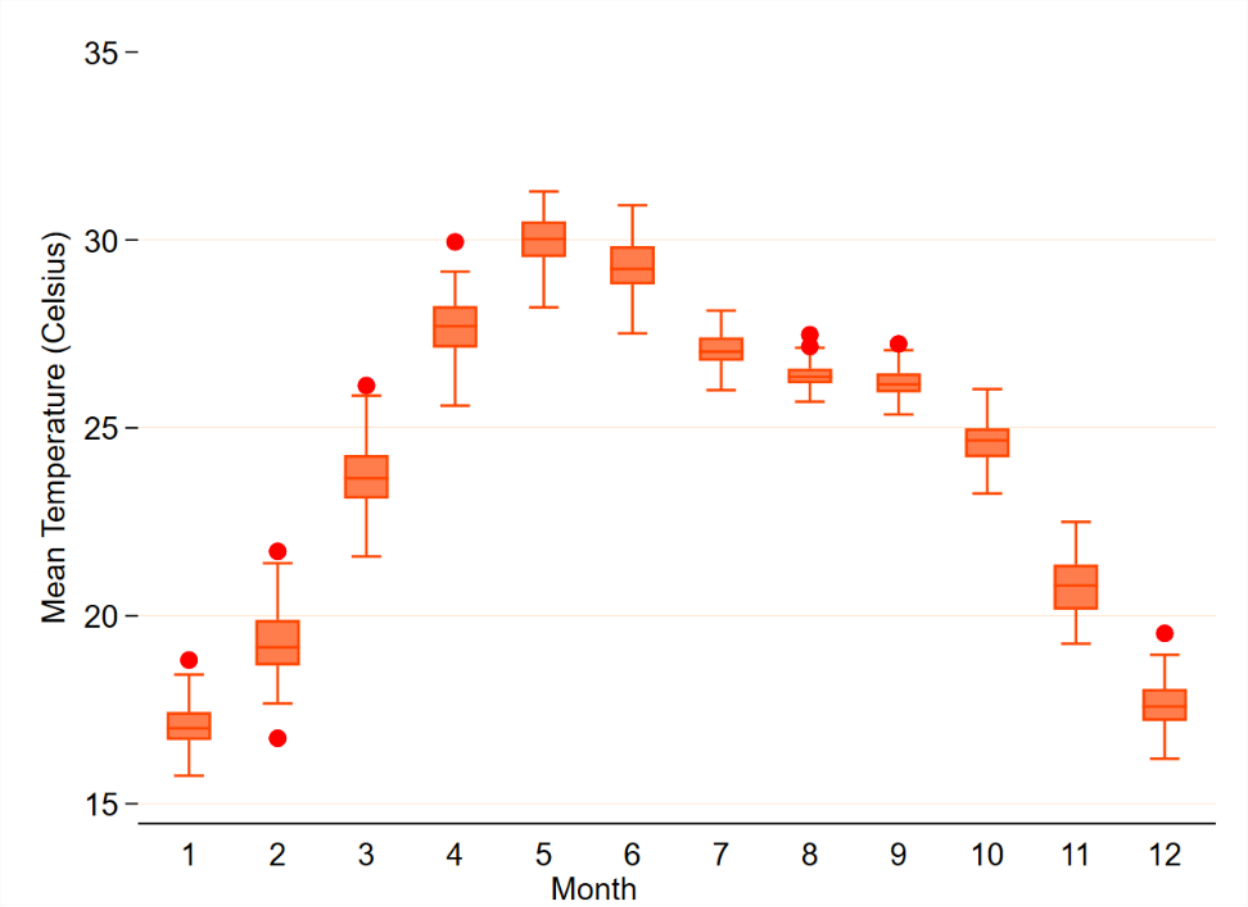
Data

- Deaths:
  - India's NDMA,NCRB, EM-DAT, Articles
  - GBD
- Temperatures – WB Climate data portal
- Population & mortality - United Nation (UN) population projections

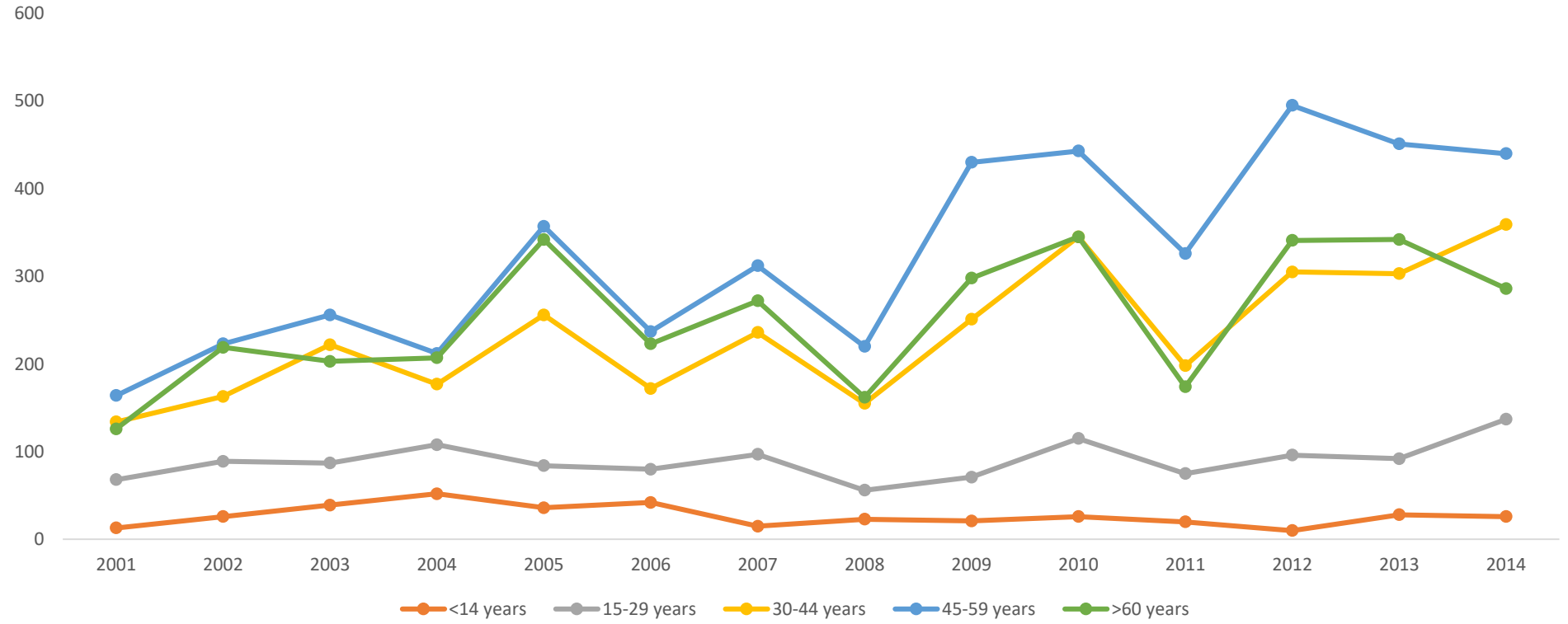
Analysis

- Descriptive & calculated temp indices
- E-R function using Poisson & Neg Bi models
- Deaths (5-yr) in increments
- Array multiplication with temp increases
- Direct economic costs using VSL

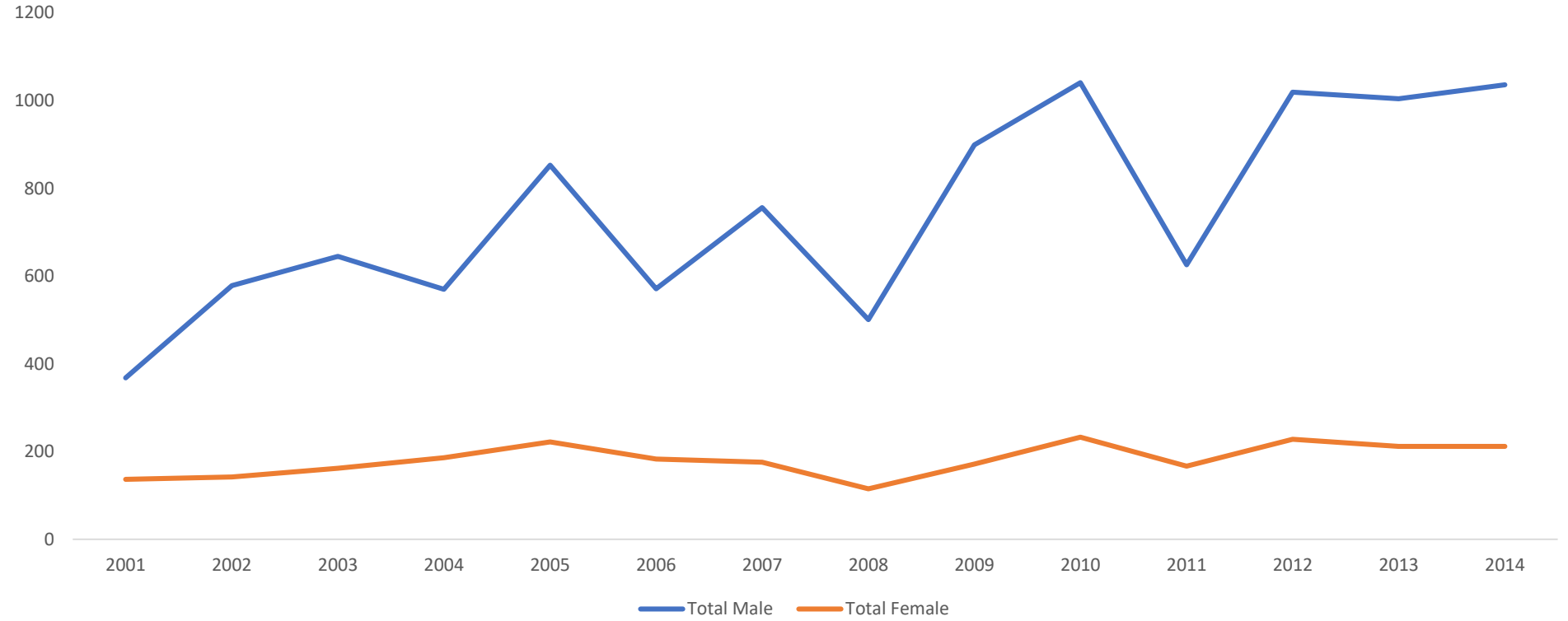
Monthly Temperatures



Annual heat deaths by age-groups



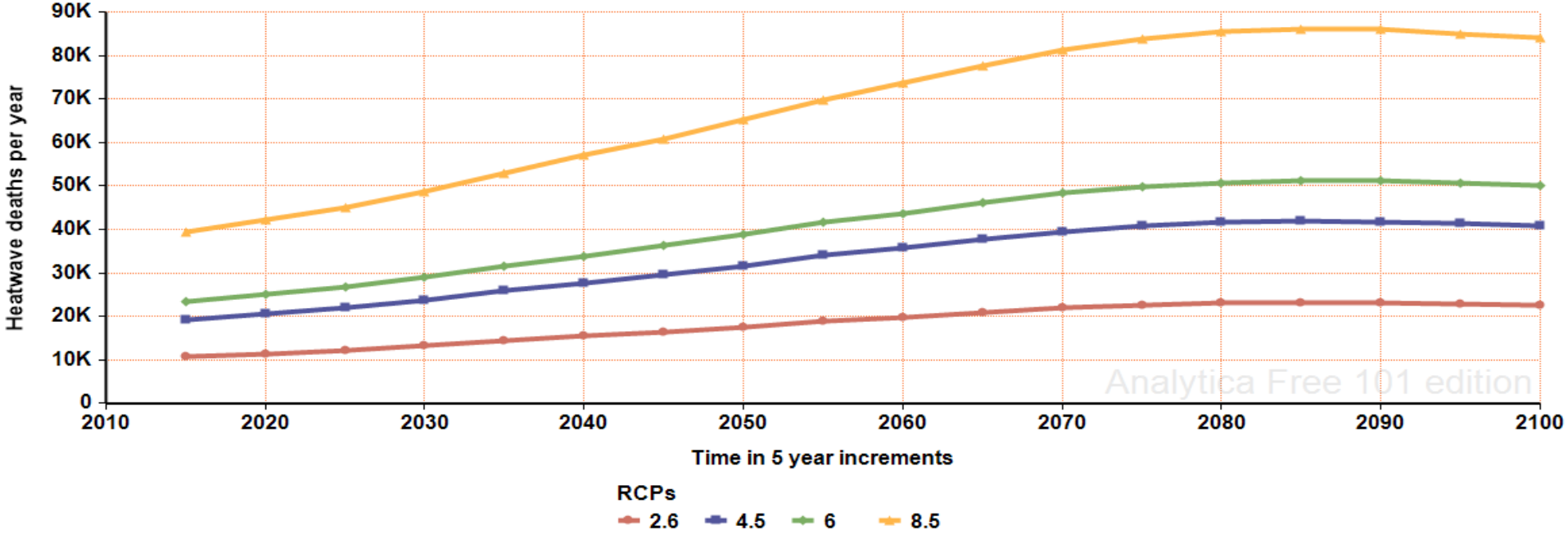
Annual heat deaths by gender



Regression coefficients calculated for excess heat deaths per °C rise in mean summer temperatures

Estimates	OLS		Poisson		Negative Binomial	
	β	SE	β	SE	β	SE
GBD Value	1407.000*	533.04	0.095***	0.00	0.095**	0.03
GBD Upper Limit	1862.477	697.56	0.100***	0.00	0.100**	0.04
GBD Lower Limit	109.200	71.22	0.020***	0.01	0.020	0.01

Projected heat deaths



Projected heat deaths

Population Prediction Intervals (PI) ('000)	Temperature related excess death estimates for RCP 8.5			
	2025	2050	2075	2100
Lower 95 PI	43.55 (30.6 – 56.5)	56.18 (39.48 - 72.88)	61.24 (43.03 - 79.44)	48.76 (34.26 – 63.25)
Lower 80 PI	44.08 (30.98 – 57.19)	59.39 (41.73 – 77.04)	68.55 (48.17 - 88.93)	59.36 (41.71 – 77)
Median	45.03 (31.6 – 58.41)	65.17 (45.8 – 84.55)	83.85 (58.92 - 108.8)	84.04 (59.05 – 109)
Upper 80 PI	45.95 (32.29 – 59.61)	71.18 (50.02 - 92.34)	101.5 (71.34 - 131.7)	114.2 (80.27 - 148.2)
Upper 95 PI	46.41 (32.62 – 60.21)	74.52 (52.37 - 96.68)	112.9 (79.34 - 146.5)	135.9 (95.47 – 176.3)

Projected costs

Mid, later, and end of century temperature related excess death direct cost estimates for five population growth scenarios on RCP 8.5 using US VSL estimates ($9.631 million)

Population Prediction Intervals (PI) ('000)	Temperature related excess death direct cost estimates for RCP 8.5			
	2025	2050	2075	2100
Lower 95 PI	$419,430,050,000	$541,069,580,000	$589,802,440,000	$469,607,560,000
Lower 80 PI	$424,534,480,000	$571,985,090,000	$660,205,050,000	$571,696,160,000
Median	$433,683,930,000	$627,652,270,000	$807,559,350,000	$809,389,240,000
Upper 80 PI	$442,544,450,000	$685,534,580,000	$977,546,500,000	$1,099,860,200,000
Upper 95 PI	$446,974,710,000	$717,702,120,000	$1,087,339,900,000	$1,308,852,900,000

Projected costs

Mid, later, and end of century temperature related excess death direct cost estimates for five population growth scenarios on RCP 8.5 using India VSL estimates ($0.275 million)

Population Prediction Intervals (PI) ('000)	Temperature related excess death direct cost estimates for RCP 8.5			
	2025	2050	2075	2100
Lower 95 PI	$11,976,250,000	$15,449,500,000	$16,841,000,000	$13,409,000,000
Lower 80 PI	$12,122,000,000	$16,332,250,000	$18,851,250,000	$16,324,000,000
Median	$12,383,250,000	$17,921,750,000	$23,058,750,000	$23,111,000,000
Upper 80 PI	$12,636,250,000	$19,574,500,000	$27,912,500,000	$31,405,000,000
Upper 95 PI	$12,762,750,000	$20,493,000,000	$31,047,500,000	$37,372,500,000

Discussion

- Greater increase in min & mean temp than max temp
- Decreasing temp range
- No respite at night
- People unable to control their thermal environment are more vulnerable

- 9.5% rise in mortality / ºC temp
- ~84,000 end-century excess deaths (median pop and RCP 8.5)
- $13 to $23 billion direct economic costs
- Considerable range

Challenges

- Steady state assumption: that the future is an extension of the past
- Possible non-linear relationship
- Absence of district-level, day-wise heatwave deaths (by age and gender) to be correlated with temperature data
- Difficultly in characterizing human adaptation to elevating temp

Policy Implications

Where & when to focus

- Some parts of the country will be affected more than others
- Rural and urban poor have unique exposure and vulnerabilities
- Males in the working age groups are dying more
- Deaths will increase in the future and plateau out by the end of the century

What to do

- Reduce human & economic impacts
- Adaptation requires a combination of strategies
- Subgroups needs special focused measures
- Bottom up ethnographic research needed

Policy Implications

- We calculated direct economic impacts using Value of Statistical Life measures.
- These deaths to the order of billions of dollars.
- With additional indirect costs included, overall impacts are likely to be much higher.
- There would be impacts on families, migration, etc.
- How our societies internalize these costs and deal with the consequences remains to be seen and investigated

Acknowledgements

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- **Horowitz Foundation Dissertation Award**

Questions?!

Heatwaves:

“Silent and invisible killer of silenced and invisible people.” ~ Eric Klinenberg

Image © Outlook India magazine

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Be the answer

“Heat waves receive little public attention not only because they fail to generate the massive property damage and fantastic images produced by other weather-related disasters, but also because their victims are primarily social outcasts—the elderly, the poor, and the isolated—from whom we customarily turn away.”

— Eric Klinenberg, Heat Wave: A Social Autopsy of Disaster in Chicago