

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

AMS100

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Heatwaves

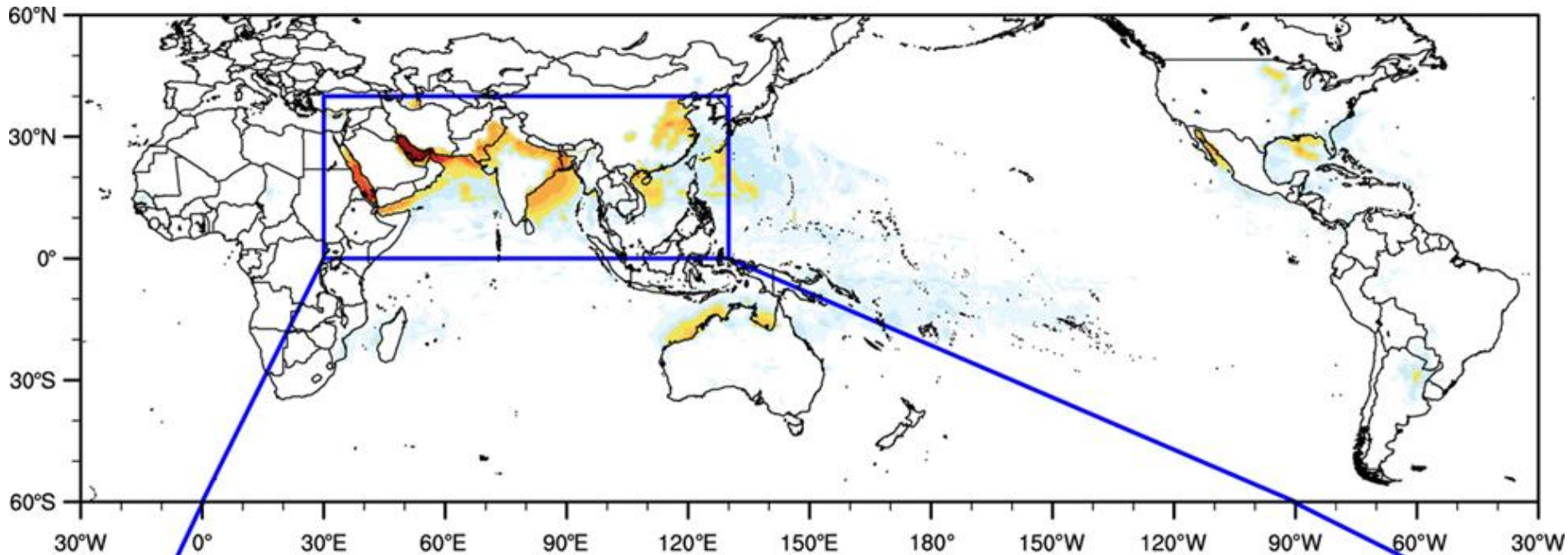
Now

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

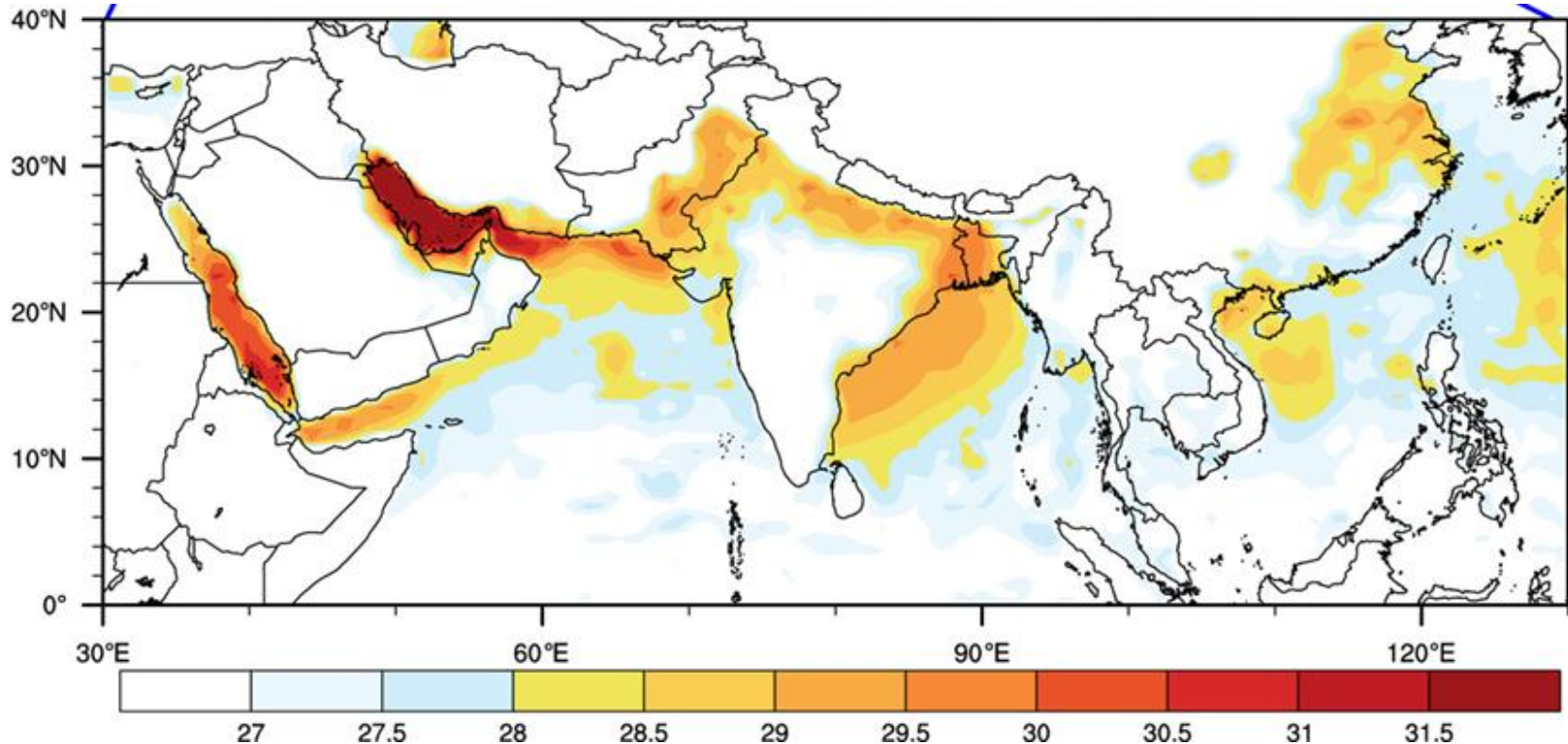
Future

- Future temperatures in SW Asia are projected to exceed threshold for human adaptability
- Heavily populated cities e.g. Delhi could have temperatures $> 95^{\circ}$ F (35° 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

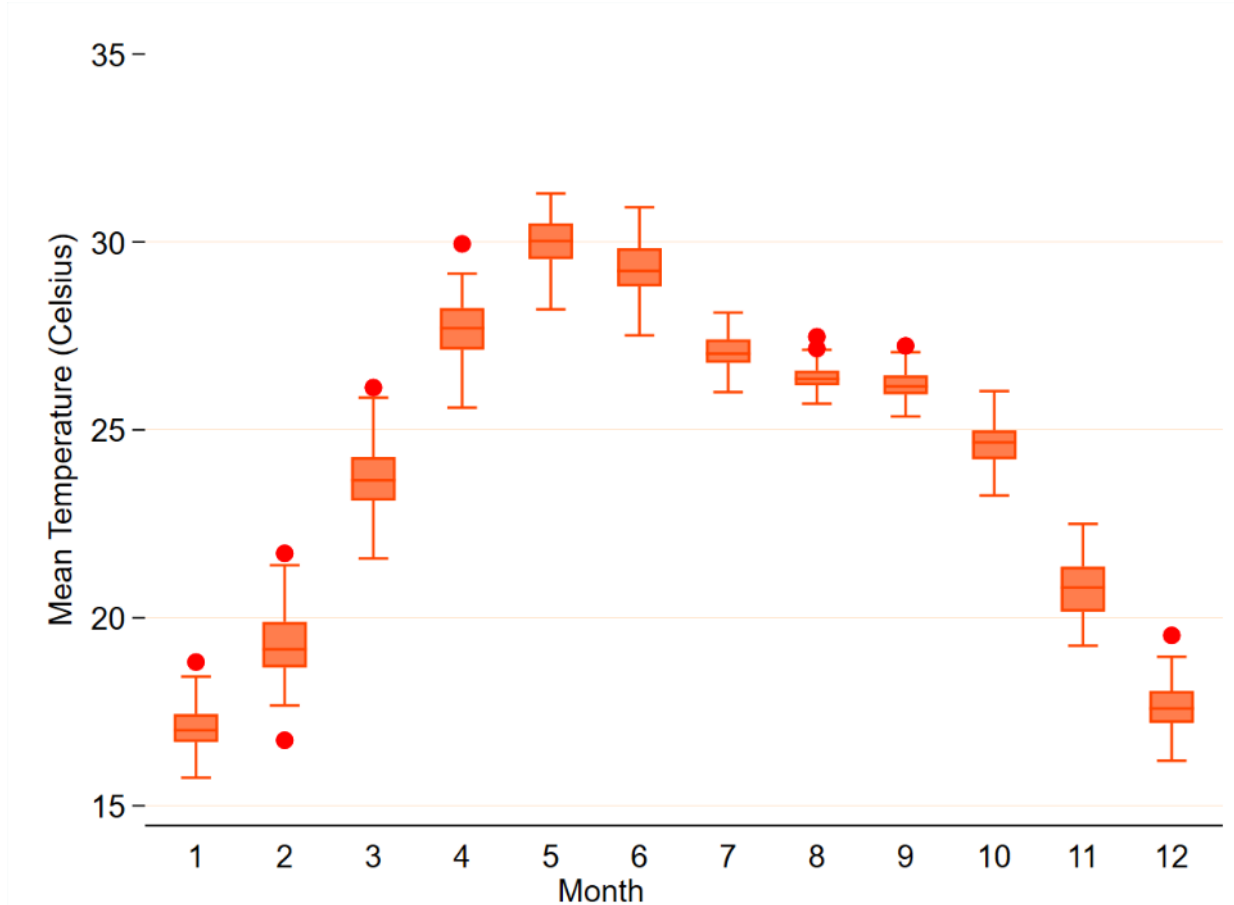
Data

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

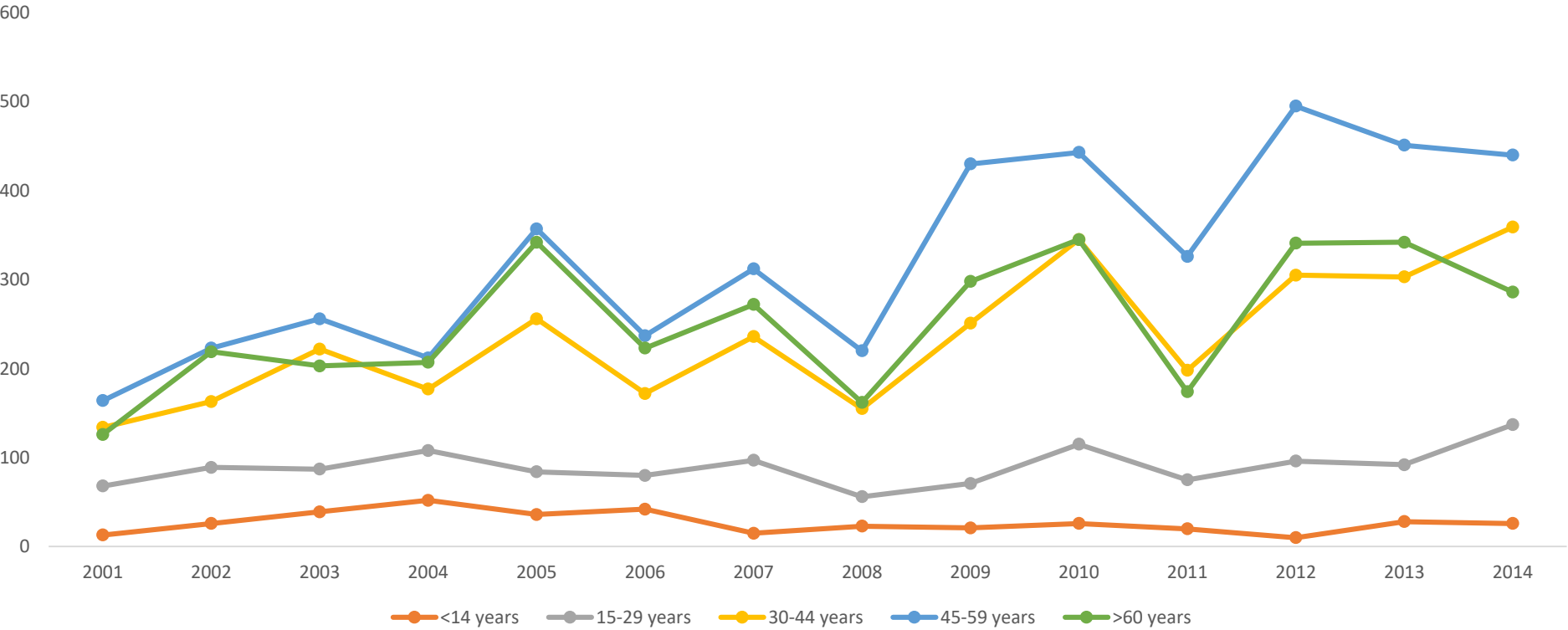
Analysis

- 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

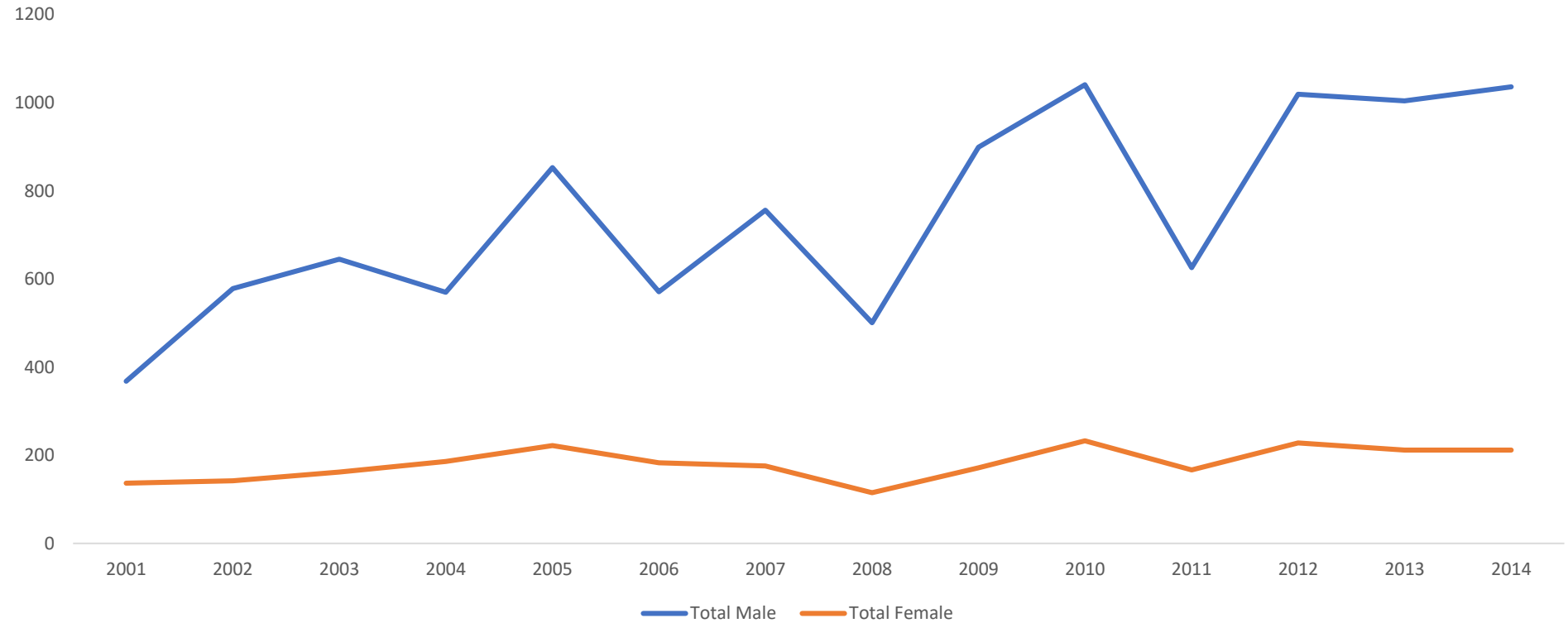
Monthly Temperatures



Annual heat deaths by age-groups



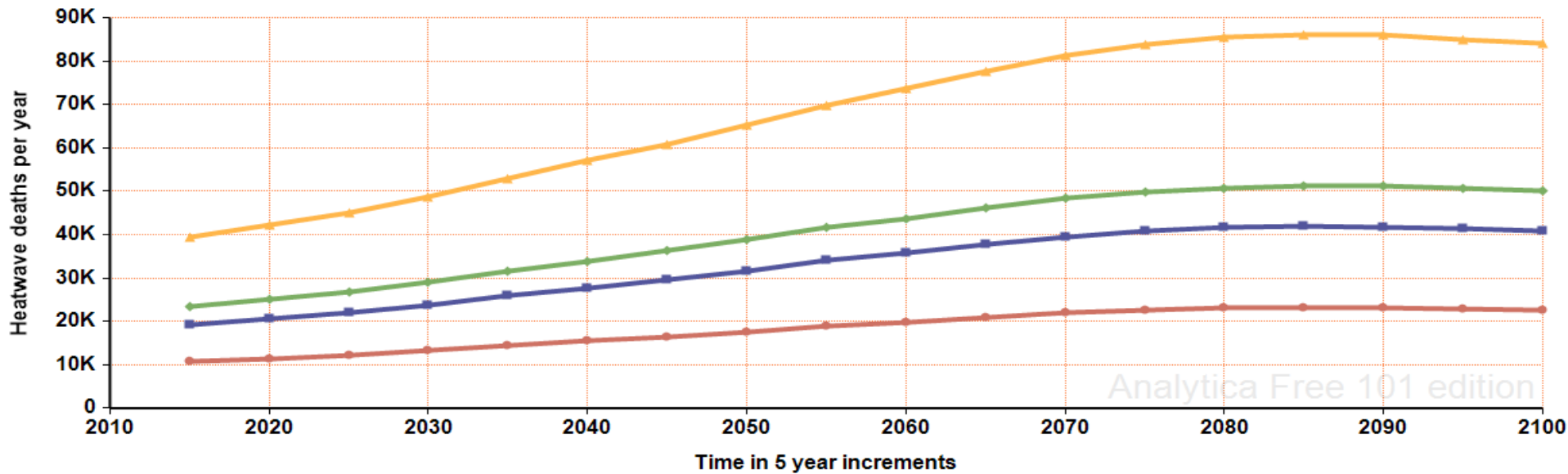
Annual heat deaths by gender



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



Analytica Free 101 edition

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)

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

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 / °C 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
- Difficulty 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

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Questions?!

Heatwaves:

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



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Image © Outlook India magazine

“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*

