



Impact of Heat Waves on All-Cause Mortality in India

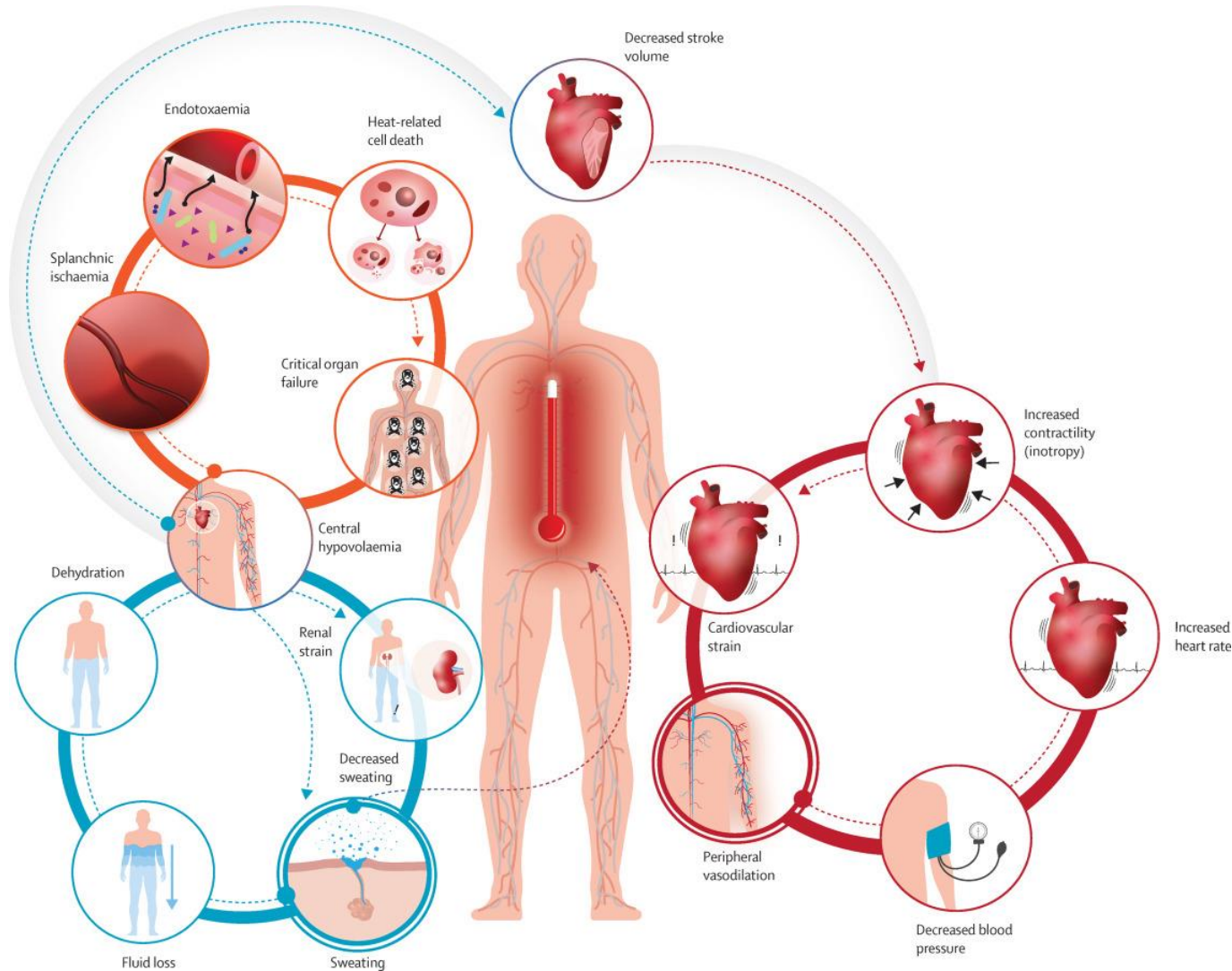
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The health impacts of Heat



Affects:
Cardiovascular health
Respiratory health
Cerebrovascular health

Mechanistic factors:
Physiological
Behavioral

Interaction with other
environmental exposures:
Particulate matter
Ozone

To evaluate the association between high temperatures and heatwaves and daily mortality in India



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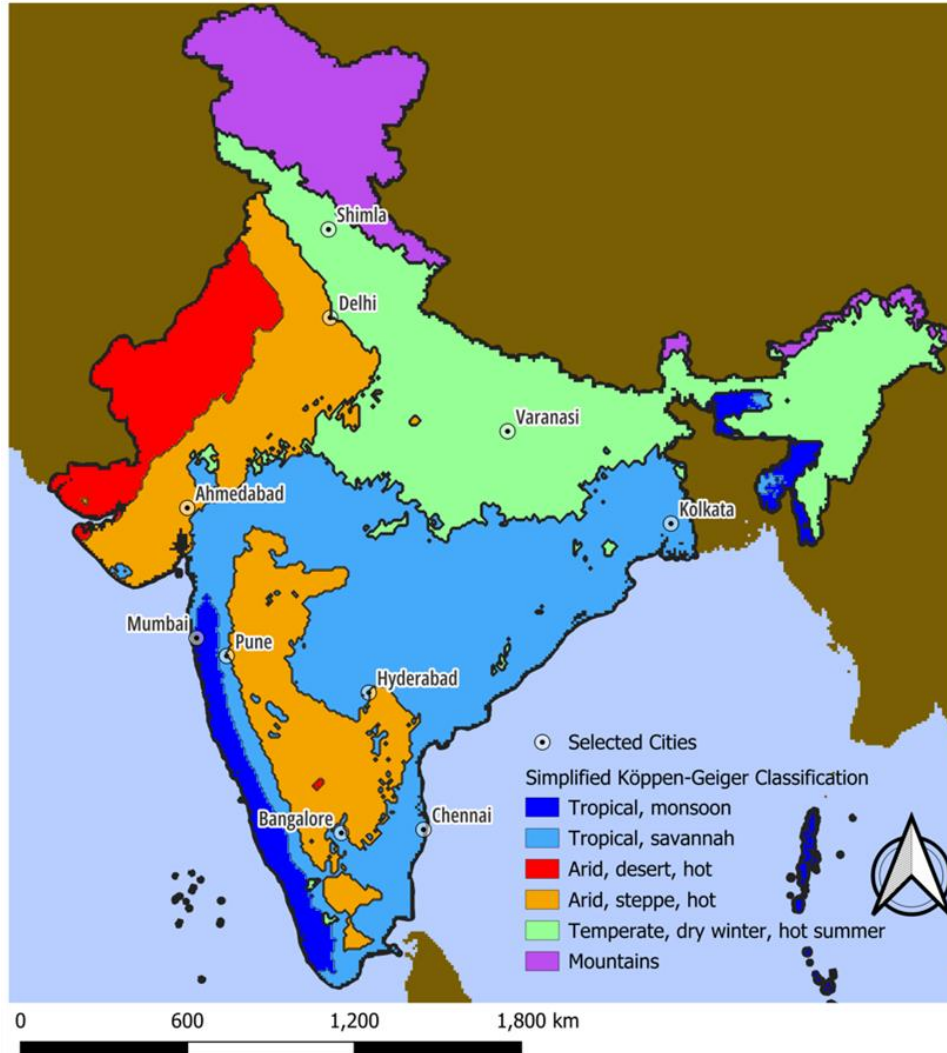
Full length article

Impact of heatwaves on all-cause mortality in India: A comprehensive multi-city study

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de Bont, Jeroen, et al. "Impact of heatwaves on all-cause mortality in India: a comprehensive multi-city study." *Environment International* (2024): 108461.

Data population – time series analysis



City	Population (2011)	Time period	Mortality [N° (daily mean)]
Ahmedabad	6,550,084	2008 - June 2019	510217 (122)
Bangalore	7,552,321	2008 - 2012	220521 (121)
Chennai	7,139,630	2010 - 2019	592336 (164)
Delhi	16,349,831	2011 - 2018	830280 (284)
Hyderabad	7,677,018	2008 - June 2011	99006 (78)
Kolkata	4,496,694	2010 - 2019	625213 (172)
Mumbai	20,185,064	2009 – Nov. 2015	548592 (251)
Pune	6,451,618	2008 - 2012	121961 (68)
Shimla	171,817	2008 – Aug. 2012	7623 (5)
Varanasi	1,746,467	2008 – Nov 2018*	81413 (223)

- Daily mean temperatures were obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) at a resolution of 28 km × 28 km resolution (0.25 ° × 0.25 °).

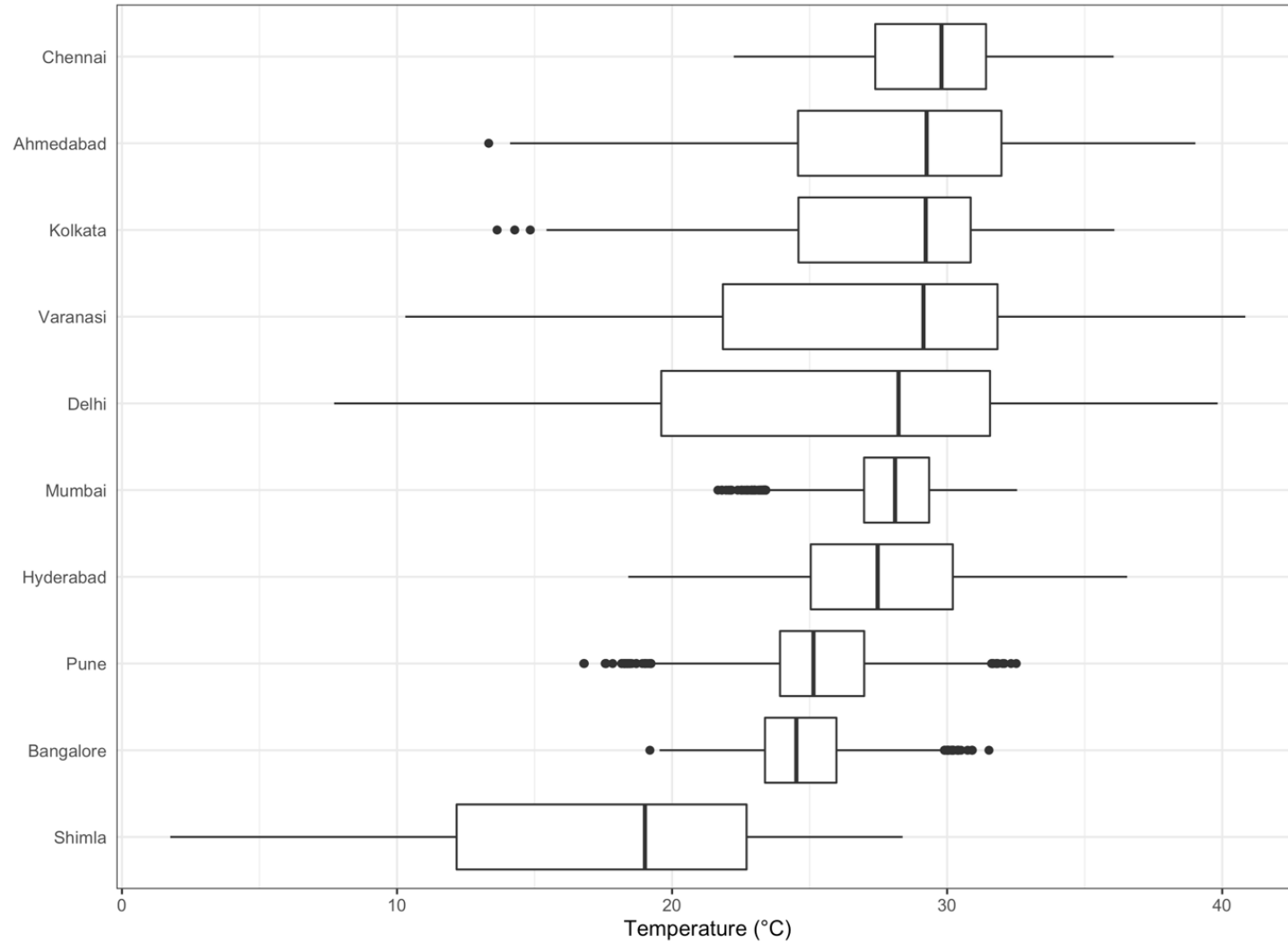
High temperatures

Statistical analysis

We followed a **two-stage analytic protocol** similar: city-specific associations and meta-analyses.

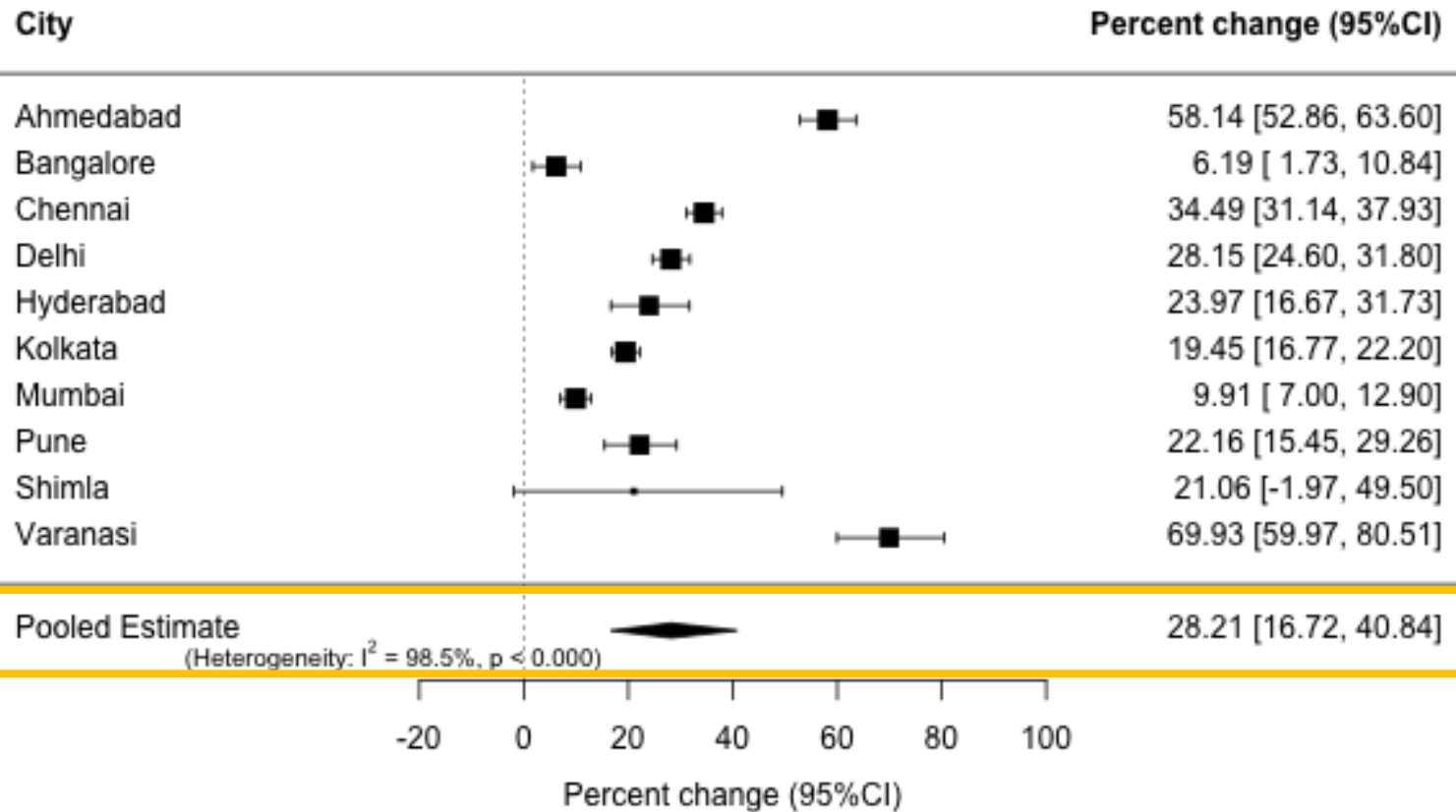
- We used a **5-day average temperature** of current and previous 4-day exposure (**lag04**) to estimate the effect on daily **mortality** (comparing minimum temperature mortality vs 99th percentile)
- Interaction with air pollution: we evaluated the association between temperature and mortality corresponding to low, medium, and high air pollution values

Temperatures across India



Associations between temperatures and mortality

A) High temperature



Heatwave

Statistical analysis

We followed a **two-stage analytic protocol** similar: city-specific associations and meta-analyses.

Heatwave analyses:

- Our **main heatwave definition** was defined as **two consecutive** days with an **intensity** above the **97th annual percentile**.
- **We further identified heatwaves as 1, 2, 3 and 5** consecutive days with an intensity above the **95th, 97th and 99th** annual temperature percentile.
- **Attributable fraction for each heatwave definition**

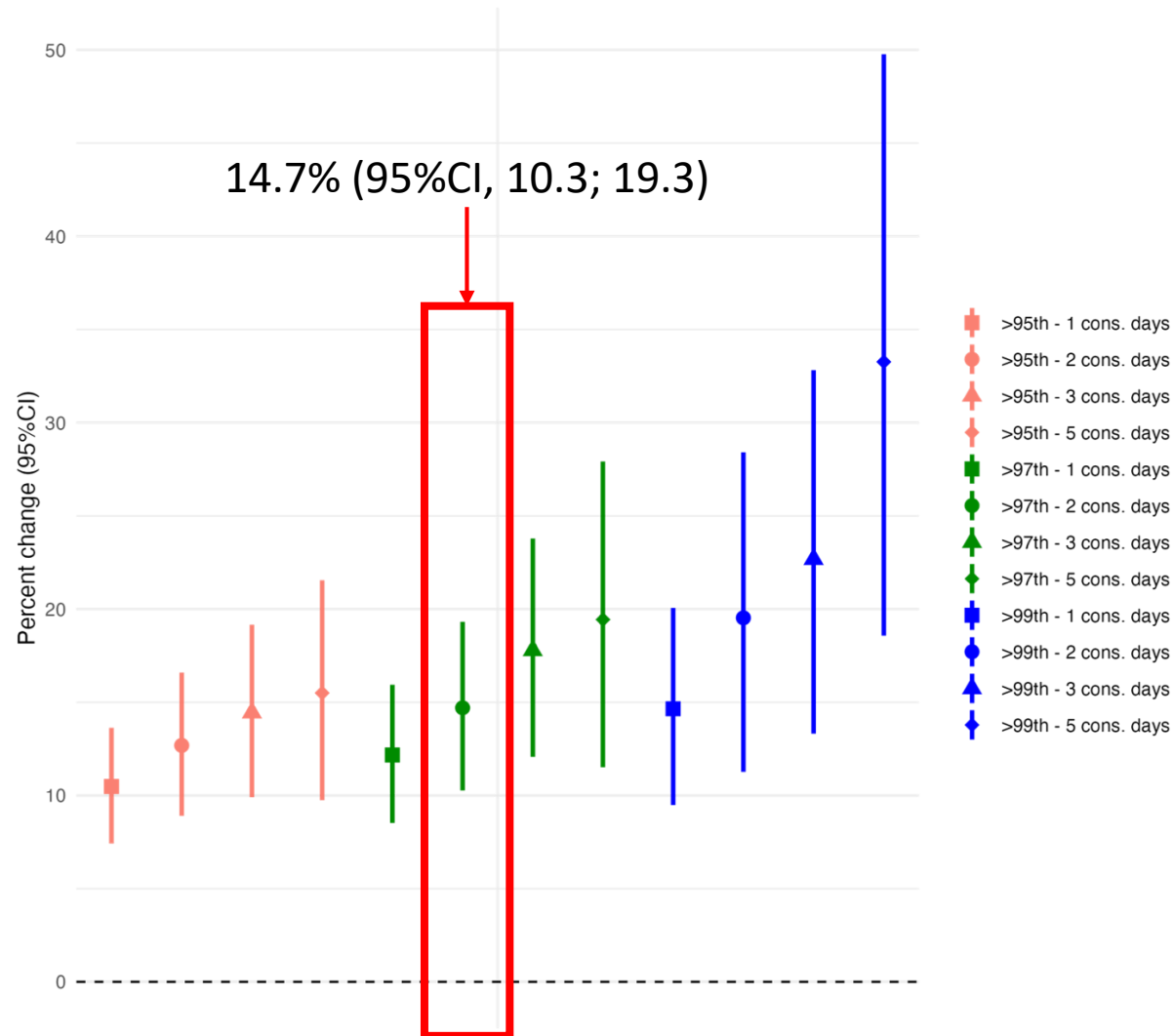
$$D_a = \frac{N_{HW}^c}{year} \times D_e^c \times \left(\frac{RR_{HW}^c - 1}{RR_{HW}^c} \right)$$

N_{HW}^c /year = Number of heatwave days per year, varies by heatwave definition (HW) and city c ; D_e^c = average number of expected daily deaths for city c ((annual mortality rate * city population)/365*24 days); RR_{HW}^c = city-specific heatwave relative risk.

Heatwave characteristics

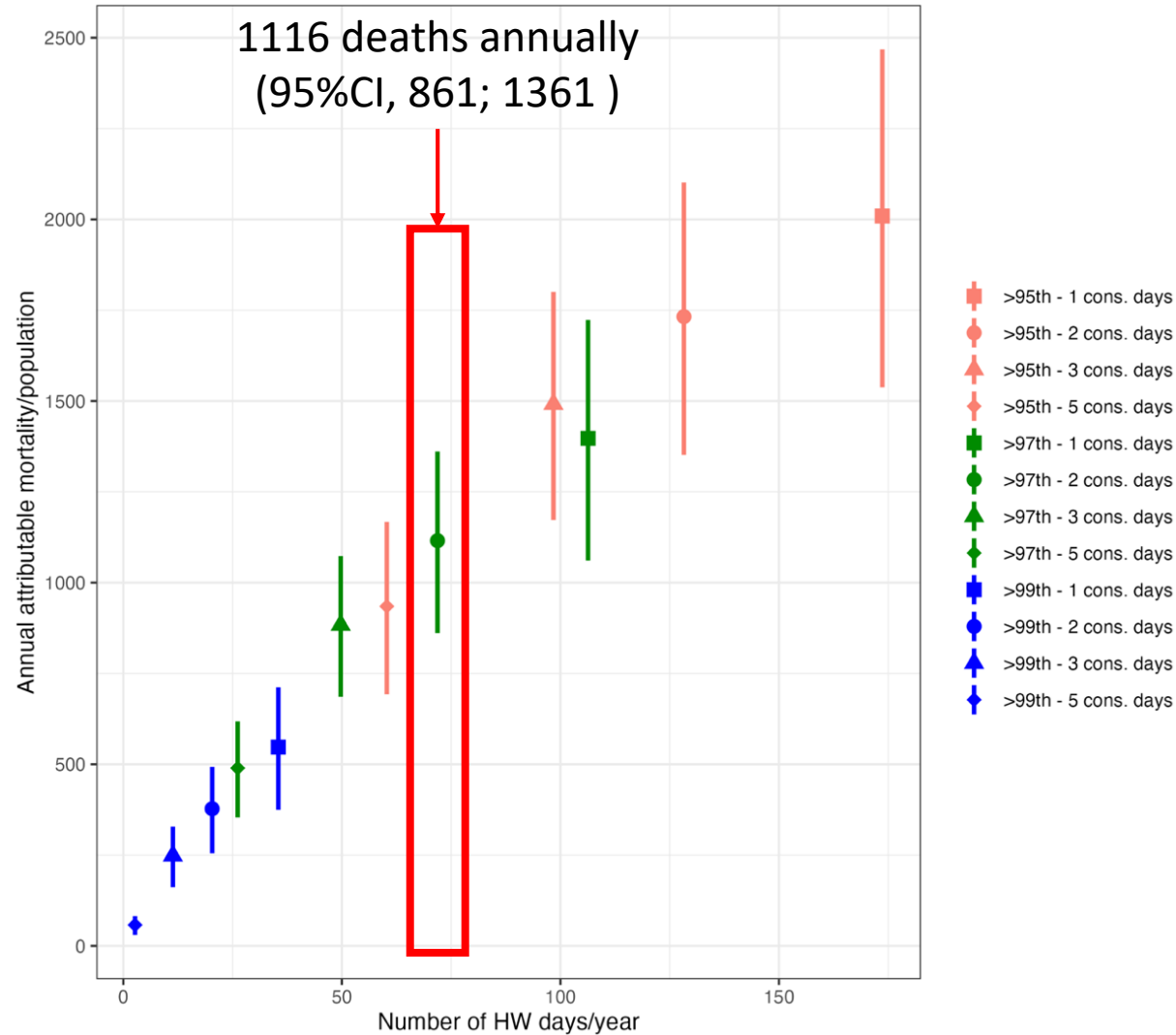
City	No. of heatwaves	Average HW per year	Day in the season from Jan 1st	Average length of HW (days)	Intensity HW in °C (%) [#]
Ahmedabad	28	3.1	83.1	4.1	36.8 (2.4)
Bangalore	13	3.2	45.2	3.8	29.8 (1.9)
Chennai	18	2.2	91.7	5.4	34.2 (1.5)
Delhi	19	2.7	66.9	3.9	37.7 (3.0)
Hyderabad	8	4.0	69.6	4.9	35.2 (1.4)
Kolkata	21	3.0	74.0	4.2	34.2 (1.8)
Mumbai	19	3.6	98.7	3.7	31.5 (1.1)
Pune	13	4.3	51.2	3.8	31.3 (2.4)
Shimla	10	2.5	100.7	4.8	26.5 (3.8)
Varanasi	20	2.2	61.5	4.8	37.6 (2.1)
Overall	168	2.9	75.2	4.3	34.2 (2.1)

Heatwave and mortality



↑ Effect size estimates for daily mortality using heatwave definitions with successively higher percentiles as cut-offs and longer duration

Comparison attributable deaths



↓ number of attributable deaths related to heatwaves when using longer duration and heatwave definition using higher percentile threshold

Conclusions

- We observed associations between **high temperatures** and **heatwaves**, and **daily mortality** across multiple cities in India.
- We observed that **longer** and more **intense heatwaves** are linked to an **increased mortality** risk, whereas using **shorter** and **less intense** definitions of heatwaves **resulted** in a **higher burden** of heatwave-related deaths.
- **Both definitions** of heatwaves and the **burden associated** with each definition should be **incorporated** into **planning** and decision-making processes for **policymakers** to effectively prioritize public health interventions that address the present and future health risks associated with heatwaves in India.



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Dr. Abhiyant Suresh Tiwari, Dr. Mavalankar, Dr. R K Mall & Dr. Amit Garg