XLV Jornadas de Economía de la Salud

Datos, evidencia, decisiones: generando valor para la gestión y las políticas sanitarias

Sevilla, 17 al 19 de junio de 2026

Assessing the economic burden of temperature-attributable mortality in five European settings with heterogeneous climatic contexts, and the impact of high pollution days

Work in progress

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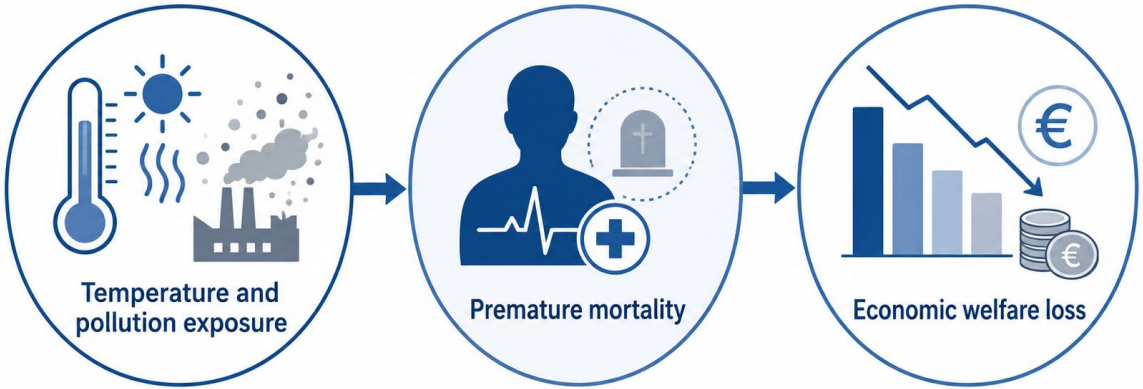
Part of the TRIGGER (SoluTions foR mItiGatinG climate-induced hEalth thReats) European project

Motivation



- Extreme temperatures are an increasing public-health concern (IPCC, 2023)
- Mortality impacts vary across populations and climatic contexts
- Economic valuation:
  - Value of a Statistical Life (OECD, 2025) → Amount a person is willing to pay to avoid a small death risk divided by that risk size; equal valuation for every death
  - Value of a Life Year (CE Delft, 2024) → Valuation is relative to the remaining life expectancy, thus to age at death

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Study design

Contributions:

- Full year considered; influence of both heat and cold
- Homogeneous modelisation for heterogeneous areas
- Control for humidity, holidays, and COVID lockdown
- Pollution control, and interaction with temperature

Main data used:

- Daily mortality 2020-23:
  - All-cause
  - Men / women
  - 0-14 / 15-64 / +65 age groups
  - Cardiovascular / respiratory
- Temperature and humidity from ERA5-Land
- Pollution (O3 and PM2.5) from CAMS
- Population weighting from Eurostat 2021

AES
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Descriptives

Climate:

Augsburg & Geneva → **Oceanic**

Bologna → **Subtropical**

Heraklion → **Mediterranean**

Oulu → **Continental**

Population (1st Jan 2021):

Bologna (city) → **391,686**

Geneva (NUTS3 region) → **506,343**

Heraklion (NUTS3 region) → **306,587**

Oulu (NUTS3 region) → **413,830**

Augsburg (hospital) → Population denominator not applicable

Setting	Mean daily temperature	p5–p95 temperature	Mean daily deaths	Total deaths
Augsburg	9.6°C	−1.5 to 20.9°C	6.0	8,807
Bologna	15.3°C	3.4 to 28.1°C	11.4	16,607
Geneva	11.0°C	−0.2 to 23.2°C	10.4	15,264
Heraklion	18.0°C	9.1 to 27.4°C	8.8	12,866
Oulu	3.9°C	−11.7 to 18.7°C	10.5	15,298

Daily mean temperature and all-cause mortality over time

Within-site standardised daily values; thick lines are centred 14-day moving averages

Analytical framework

Workflow:

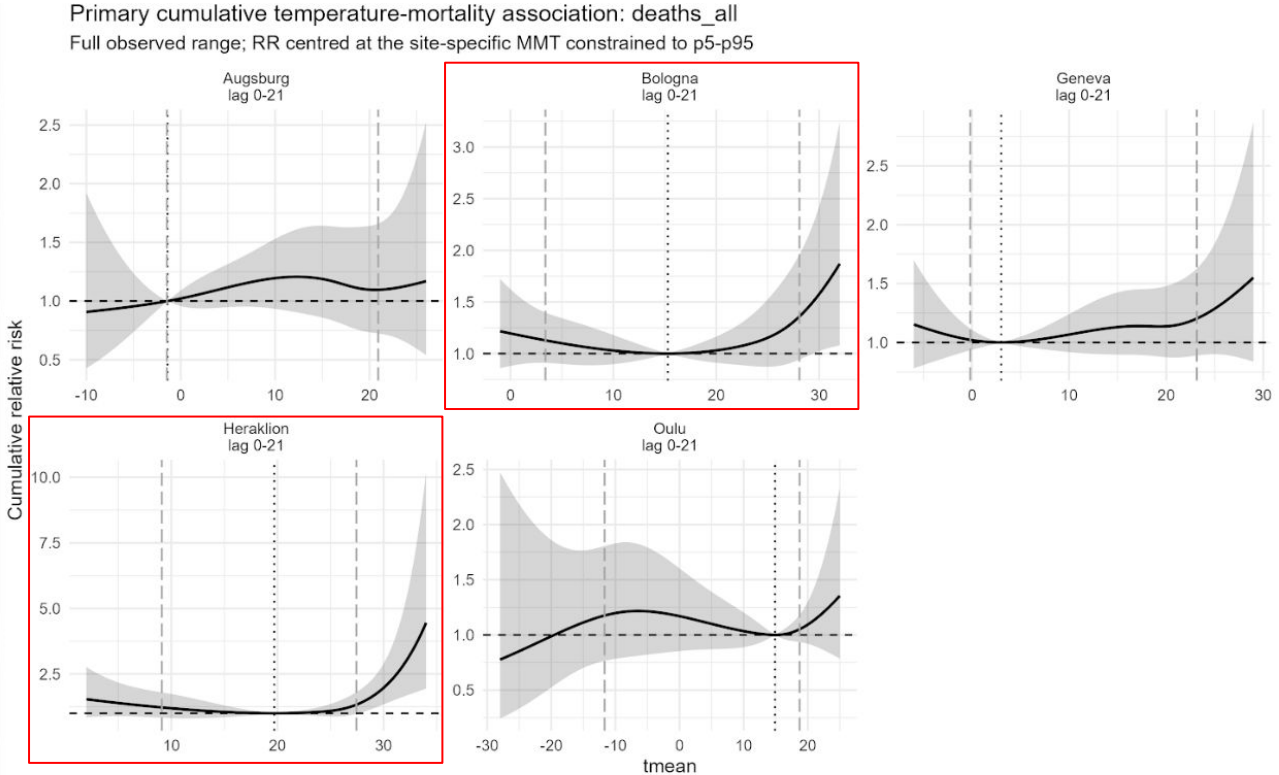
1. **Average temperature DLNM** (Gasparrini et al., 2010)

$$Deaths_t \sim quasi\text{-}Poisson$$

$$DLNM(Tmean,\ lag\ 0\text{–}21) + time + day\ of\ week + humidity + holidays + lockdown$$

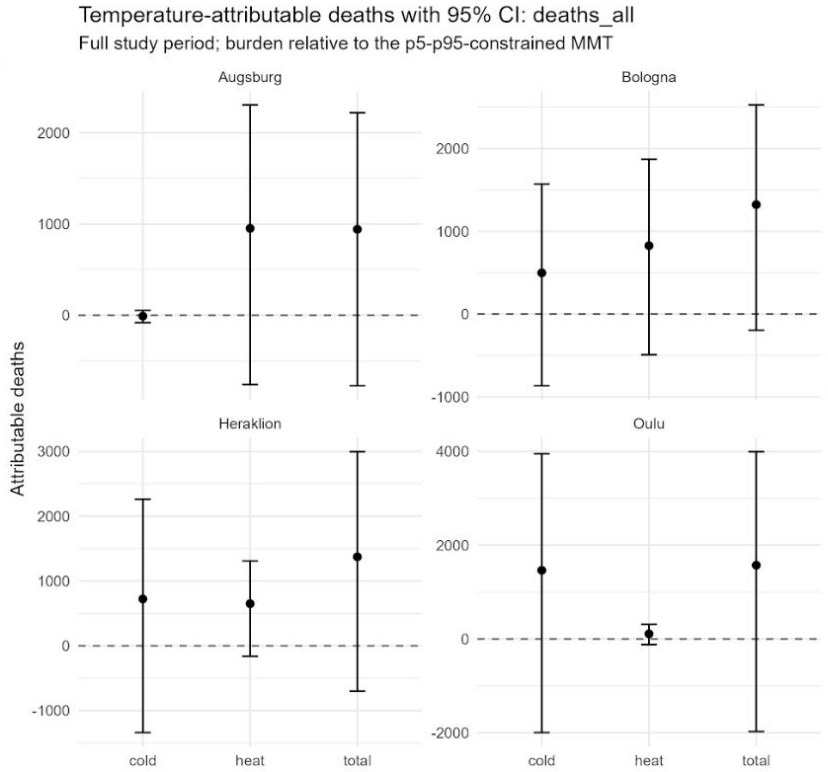
2. **Attributable deaths**
3. **VSL and VoLY valuation**
4. **Pollution-adjusted models**
5. **Temperature x pollution models**
6. Bayesian temporal model (negative binomial) for sparse outcomes
7. Temperature sensitivities (maximum, minimum, UTCI)
8. Augsburg sensitivities (cells or observatories closest to the hospital)

Temperature-mortality curves



95% CI; dotted line: constrained MMT; grey long-dashed lines: p5-p95 search bounds. Values below 1 outside these bounds indicate that the constrained MMT is not the global minimum.

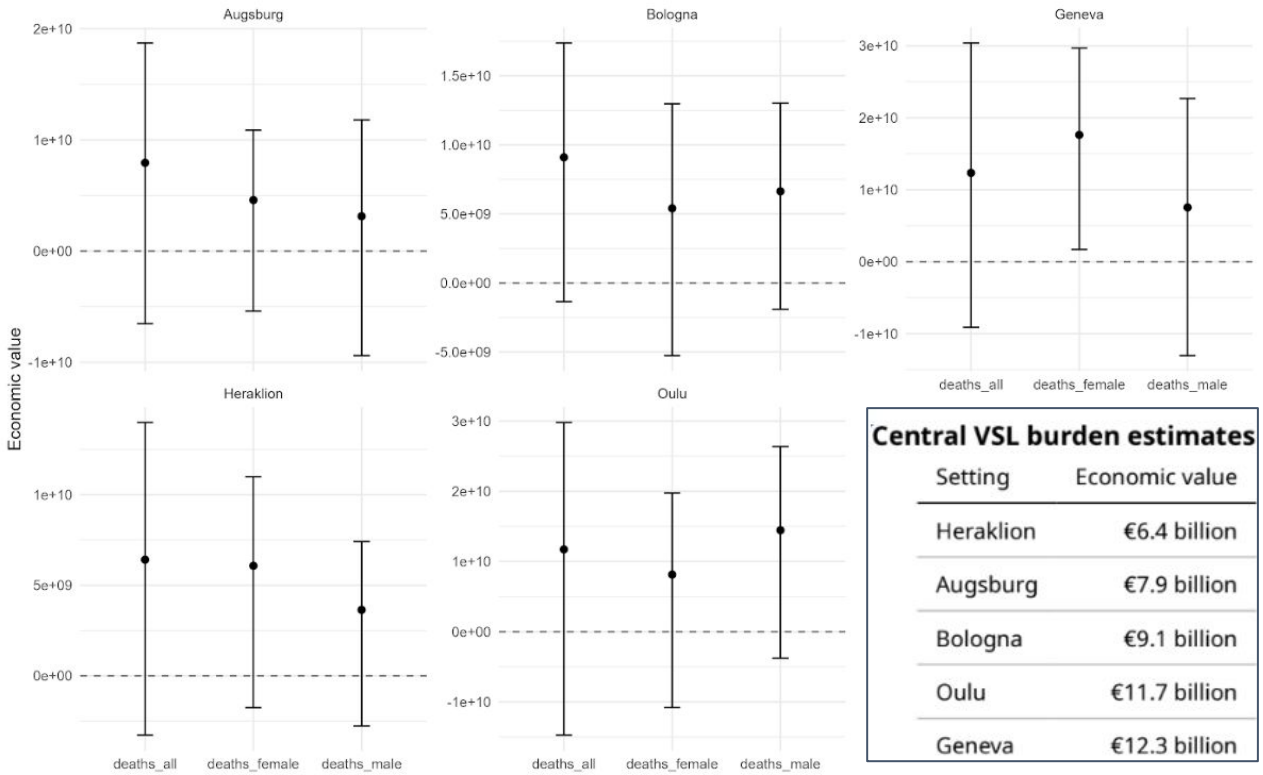
Attributable deaths



Setting	Total attributable deaths	95% CI
Augsburg	942	−773 to 2,220
Bologna	1,323	−196 to 2,527
Geneva	1,087	−802 to 2,675
Heraklion	1,372	−701 to 2,994
Oulu	1,572	−1,974 to 3,994

Economic valuation - VSL

$$VSL_i = VSL_{\text{ref}} \left(\frac{GDPpc_i}{GDPpc_{\text{ref}}} \right)^{\beta_{VSL}}$$

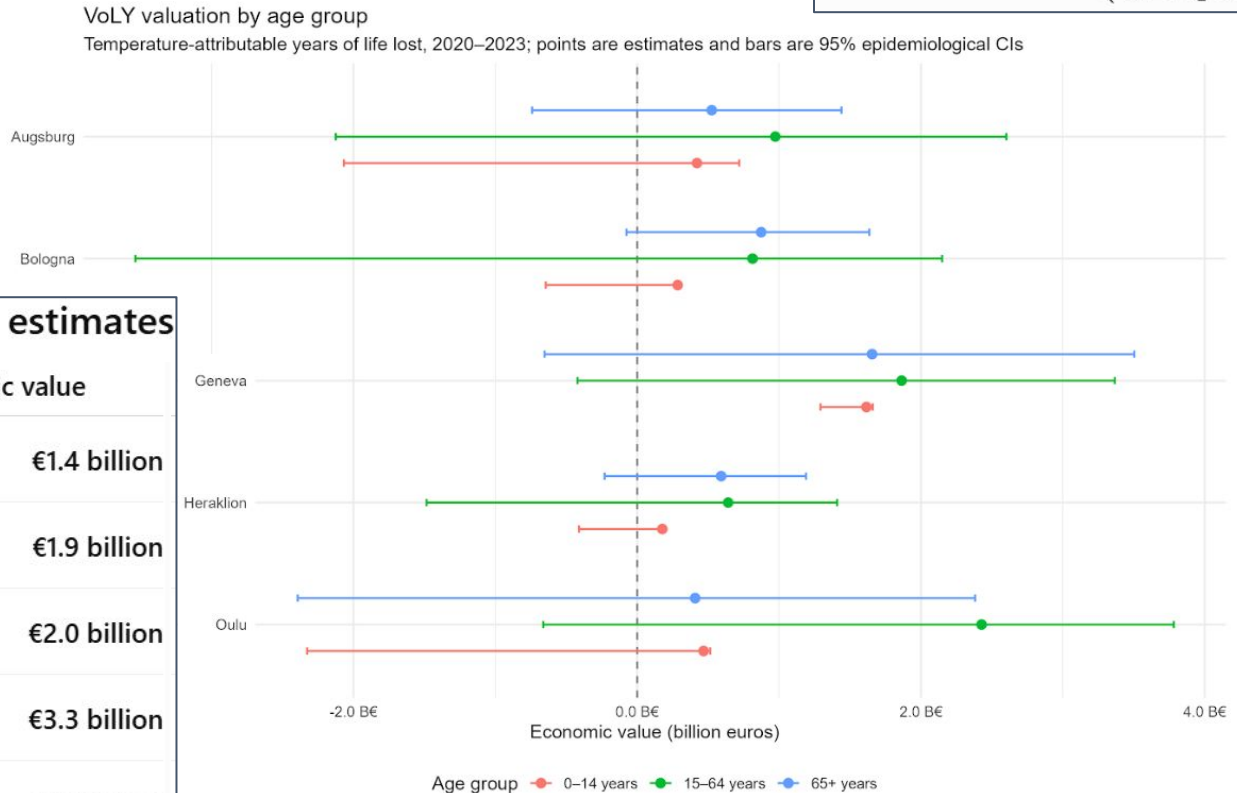


Central VSL burden estimates

Setting	Economic value
Heraklion	€6.4 billion
Augsburg	€7.9 billion
Bologna	€9.1 billion
Oulu	€11.7 billion
Geneva	€12.3 billion

Economic valuation - VoLY

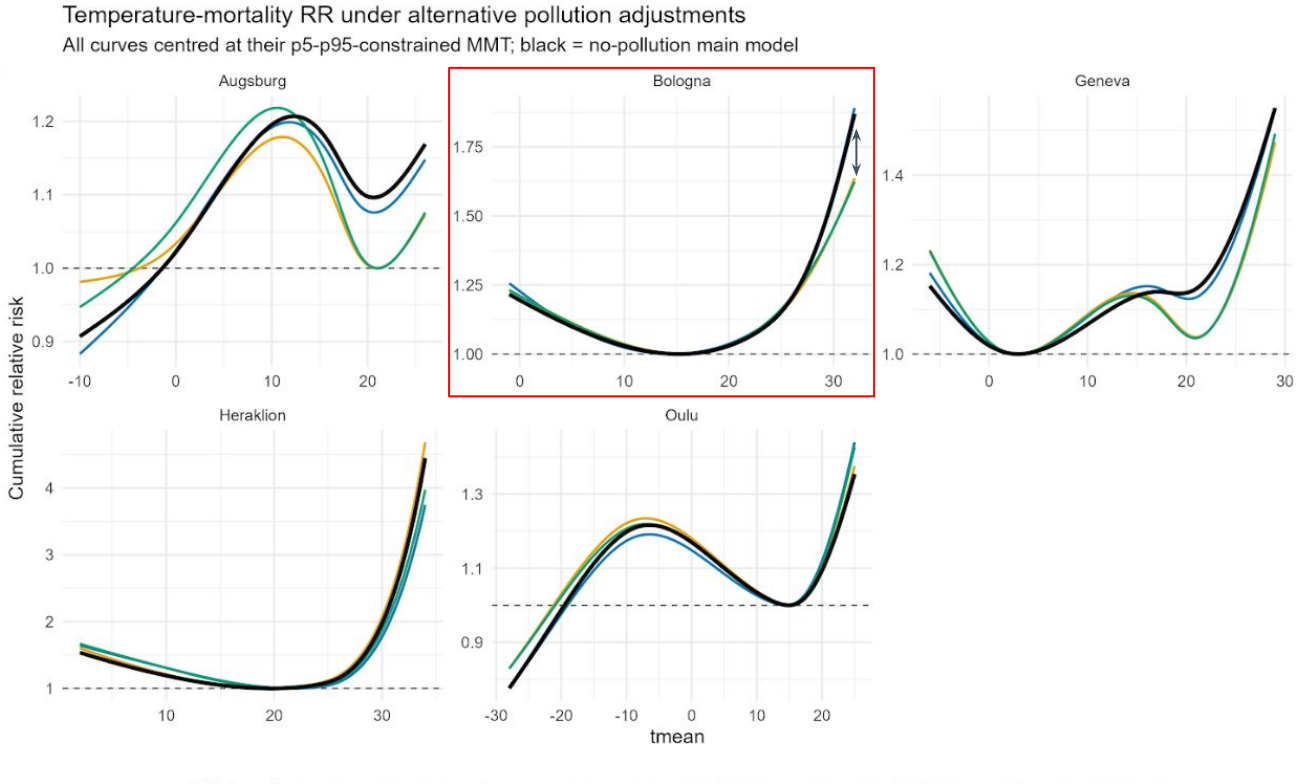
$$VoLY_i = VoLY_{\text{ref}} \left(\frac{GDPpc_i}{GDPpc_{\text{ref}}} \right)^{\beta_{VoLY}}$$



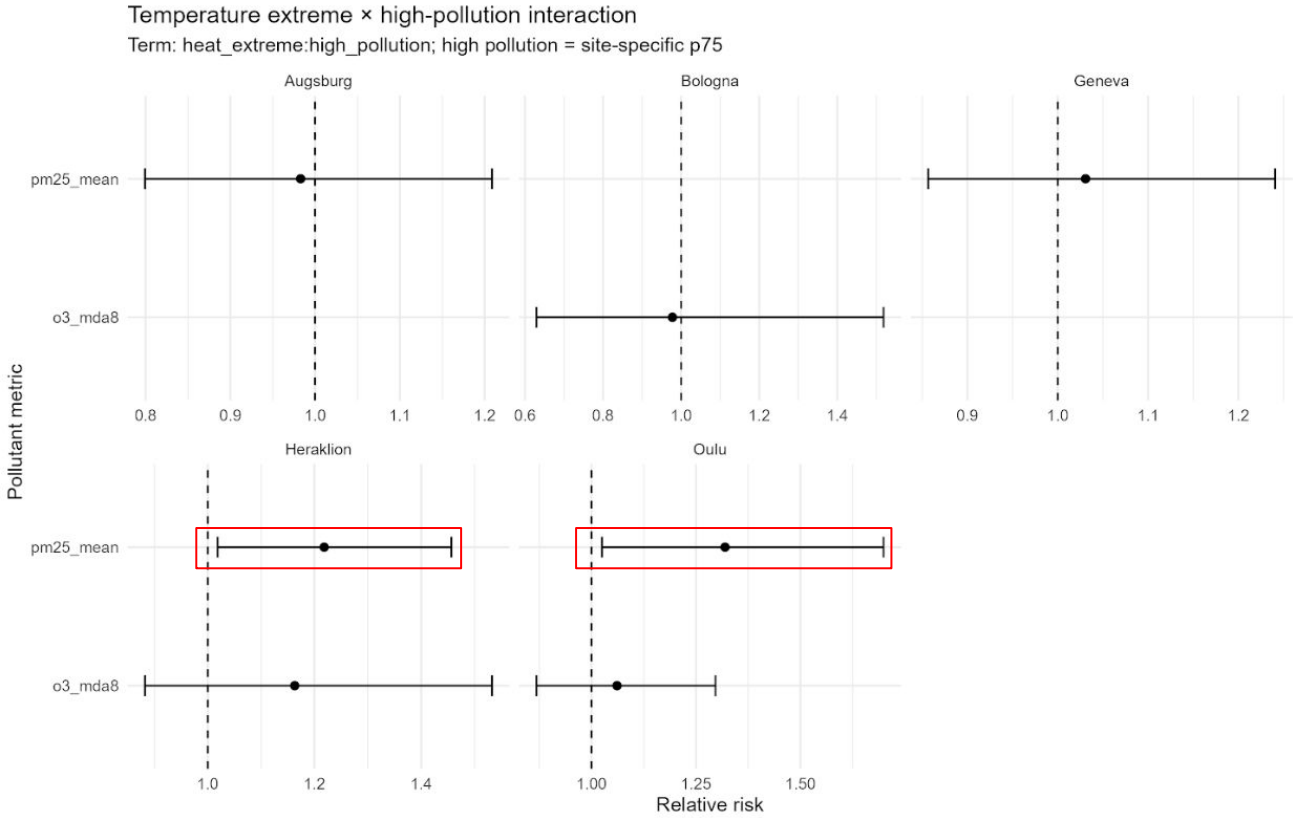
Central VoLY burden estimates

Setting	Economic value
Heraklion	€1.4 billion
Augsburg	€1.9 billion
Bologna	€2.0 billion
Oulu	€3.3 billion
Geneva	€5.1 billion

Effect of pollution



Effect of pollution



Conclusions

- Extreme heat was associated with higher mortality in Bologna and Heraklion
- Point estimates of attributable mortality were substantial but highly uncertain
- High PM2.5 amplified the extreme-heat association in Heraklion and Oulu
- Economic burden estimates reached several billion euros, but inherited the epidemiological uncertainty

Next steps:

- Analyse how to improve the model (site-specific adjustments…)
- Sensitivity with different time windows (summer months, winter months)
- Sensitivity with different temperature measures (max, min, UTCI)
- Sensitivity with different definitions of Augsburg
- Assess lag-window sensitivity (Yang et al., 2012)
- Bayesian temporal modelisation for sparse strata (youngest group…)

THANK YOU!