


Heatwaves & mortality/morbidity

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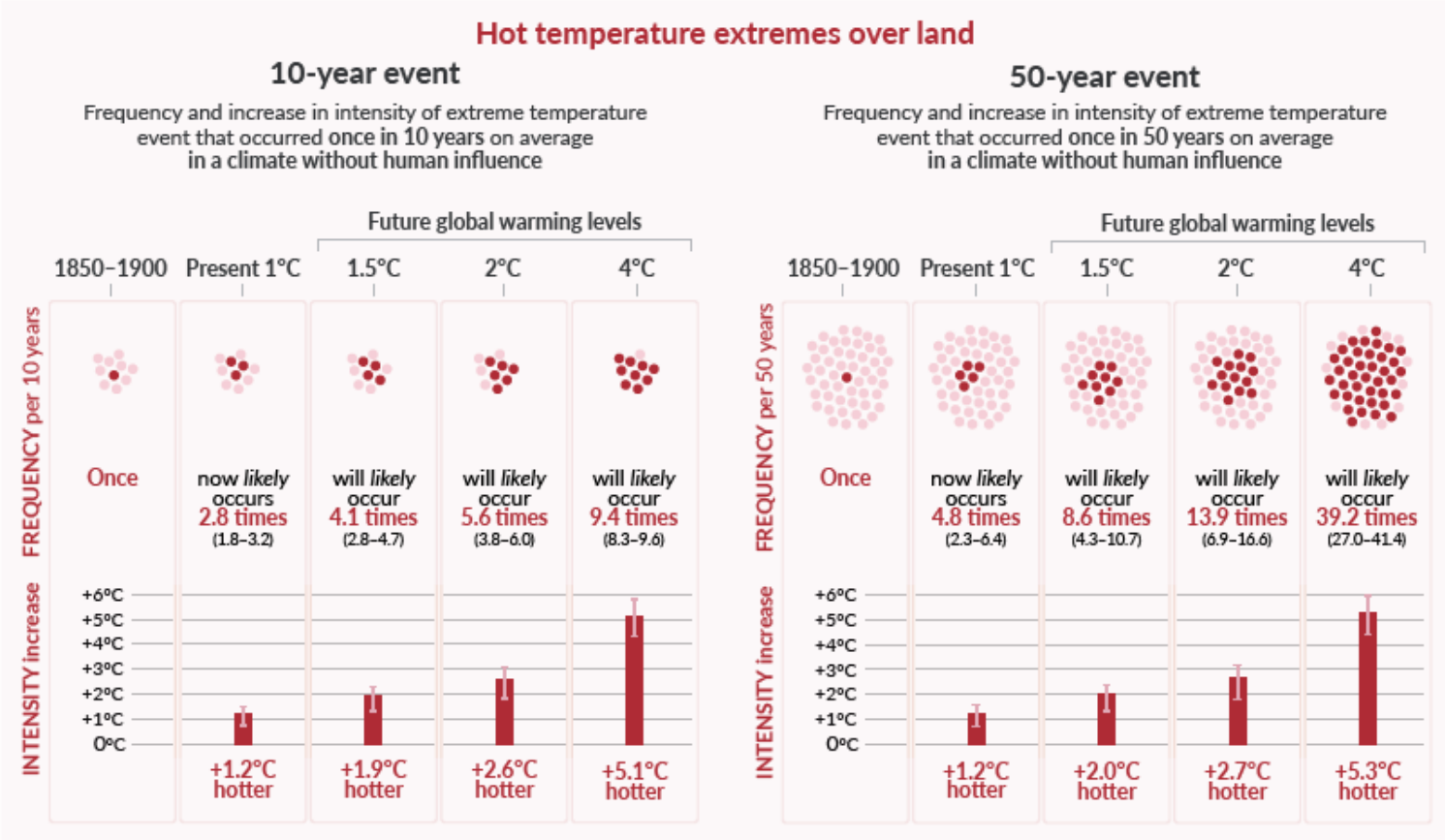
With many thanks to Rémy Slama (PARSEC, INSEM – ENS-PSL)

CC and heatwaves



Nous entrons dans l'ère des canicules FLIP :

- **+ Fréquentes**
- **+ Longues**
- **+ Intenses**
- **+ Précoces**

We are facing heatwaves made :

- **Earlier**
- **Longer**
- **More Intense**
- **+ Frequent**

IPCC – AR6 – WGI, 2021

The impact of heat on the body

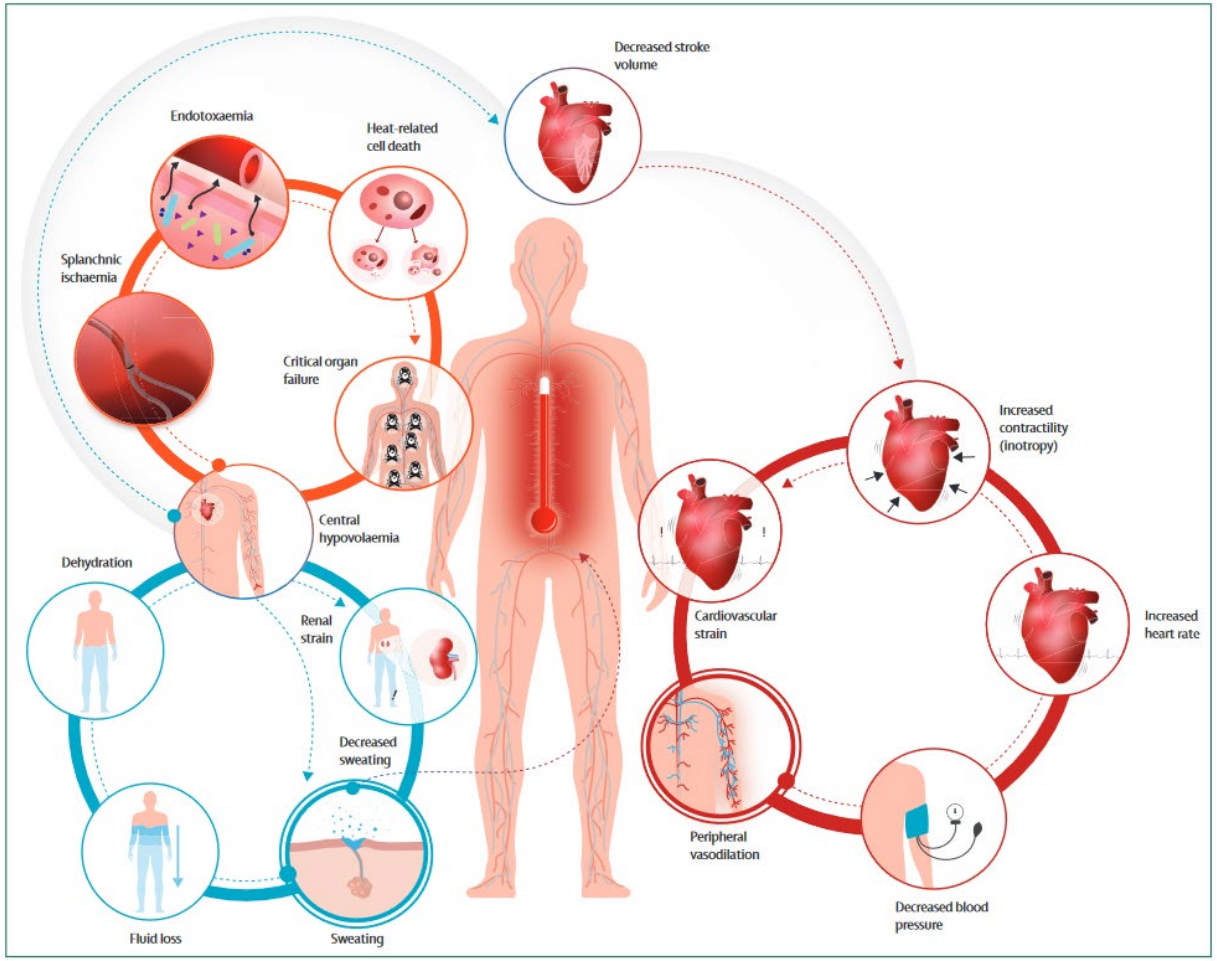
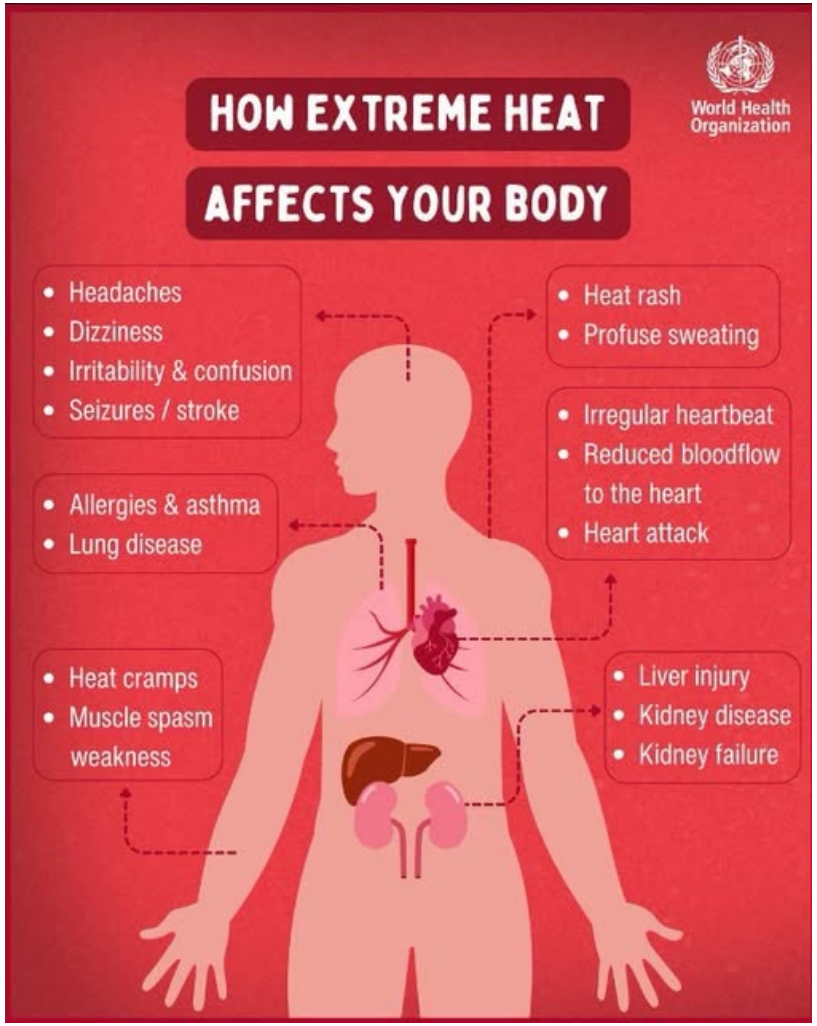


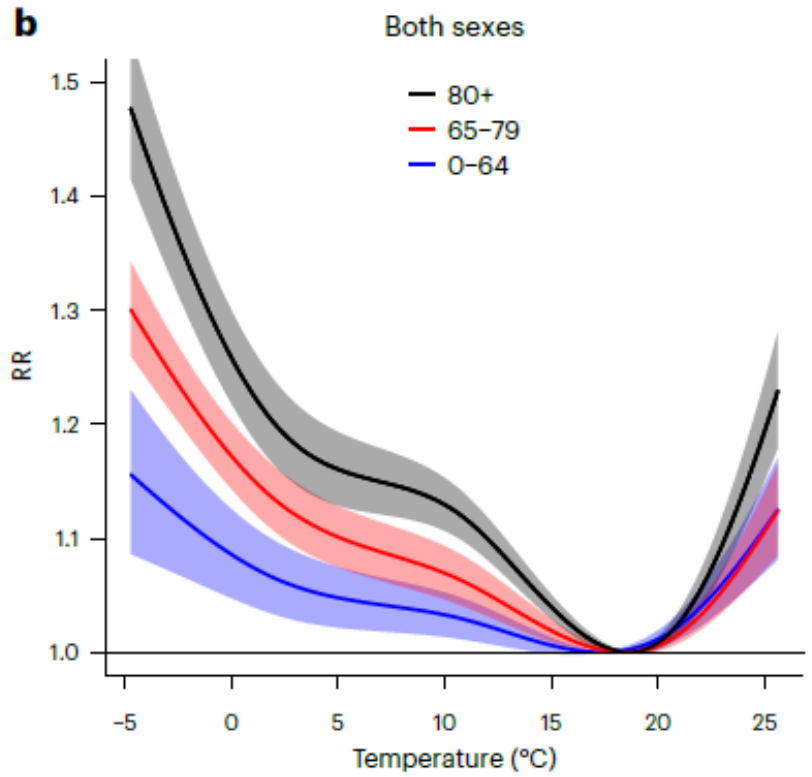
Figure: Illustration of the physiological pathways of human heat strain



Ebi et al, *Lancet* 2021

Mortality effects of heat

Ambiant temperatures and mortality



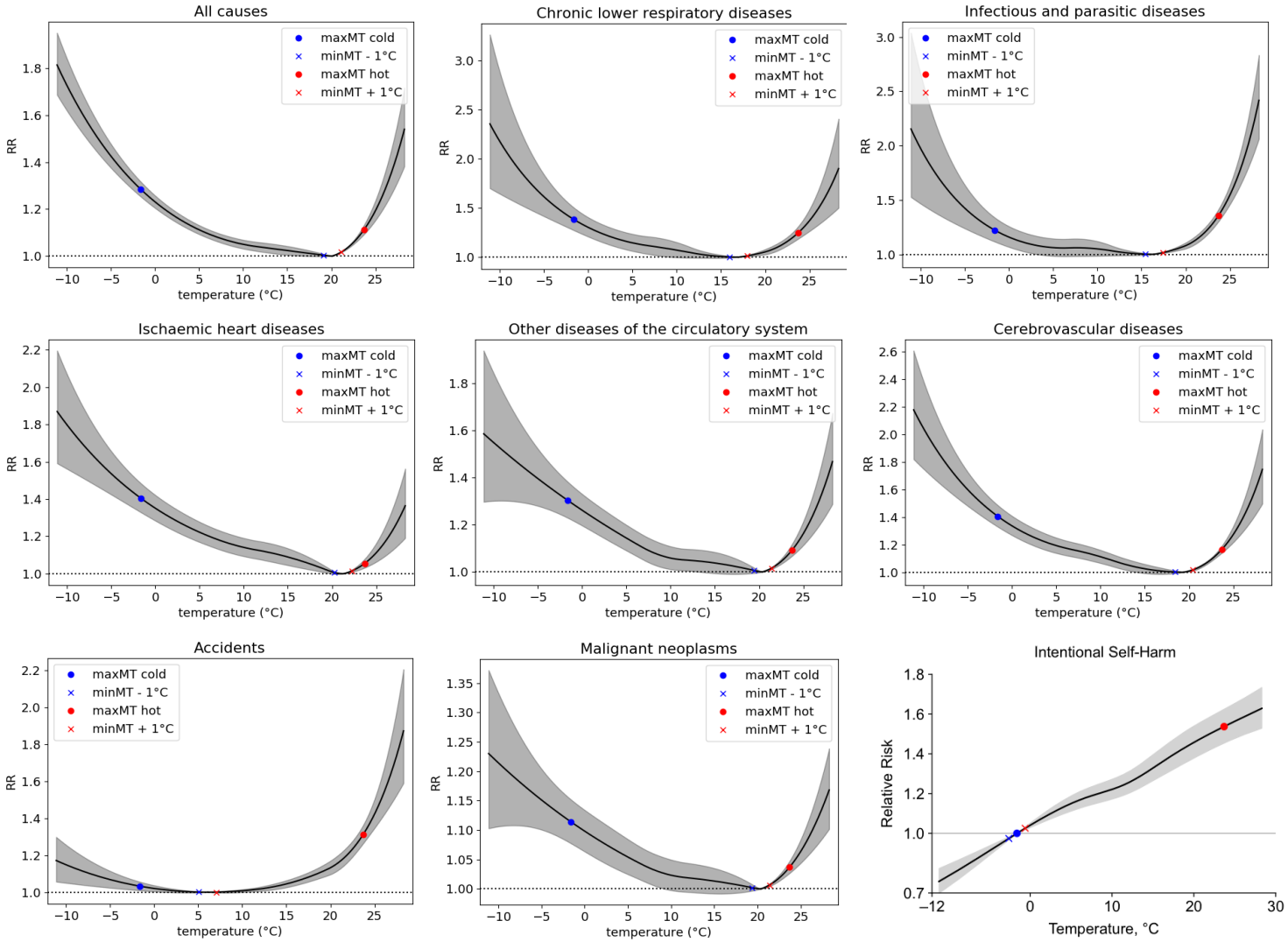
Ballester et al, *Nature Med* 2023

Physiological factors associated with increased risk of death during heatwaves

- **Age**
- Cardiovascular disease
- Respiratory disease
- Cerebrovascular disease
- Kidney disease
- Diabetes
- Mental health illness or disorder
- Substance use
- Loneliness

Ebi et al, *Lancet* 2021

Ambiant temperature and causes of deaths



Lehmann et al, *Am. J. Epi* 2022

Health impact of heatwaves in Europe

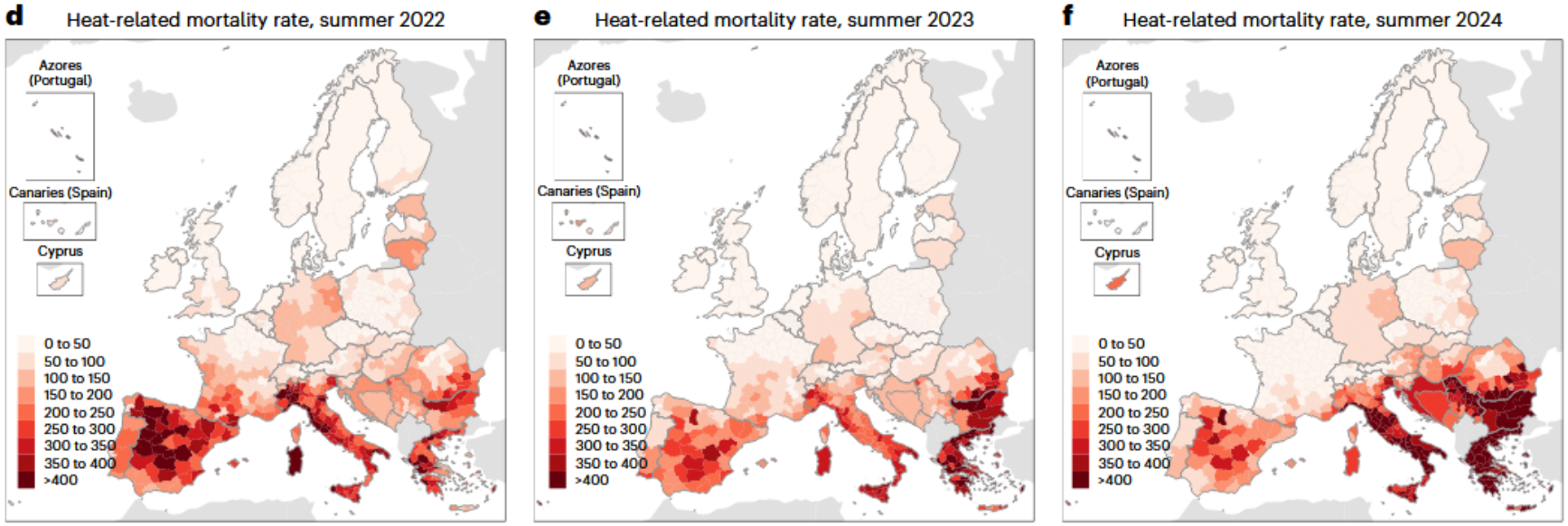
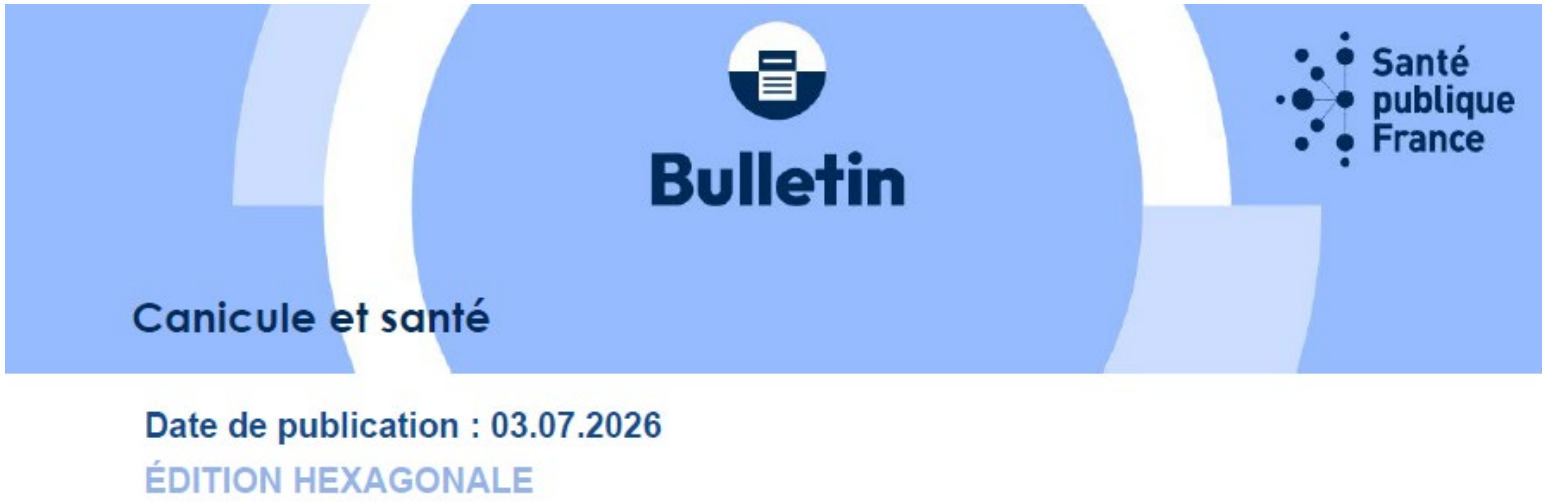


Fig. 2 | Regional temperature anomalies and heat-related mortality rates during the summers of 2022–2024. a–c, Regional temperature anomalies (°C) averaged over the summers of 2022 (**a**), 2023 (**b**) and 2024 (**c**). **d–f**, Regional heat-related mortality rates (summer deaths per million) for the whole population aggregated over the summers of 2022 (**d**), 2023 (**e**) and 2024 (**f**). Summer refers to the period between 1 June and 30 September.

2022	2023	2024
68 000 deaths (95% CI: 38-92)	51 000 deaths (95% CI: 29-69)	63 000 deaths (95% CI: 37-84)

Janos et al, *Nat Med* 2025

What about 2026 (so far) ?



- "*This is an exceptionally severe heatwave, which intensity exceeds that of August 2003*"
- 2,025 more deaths (+25%) observed btw. June 22-28 as compared to June 15-21
- Mostly people aged 45+

Evidence of an harvesting effect ?

Int Arch Occup Environ Health (2006) 80: 16–24
DOI 10.1007/s00420-006-0089-4

ORIGINAL ARTICLE

A. Fouillet · G. Rey · F. Laurent · G. Pavillon
S. Bellec · C. Guihenneuc-Jouyaux · J. Clavel
E. Jougla · Denis Hémon

Excess mortality related to the August 2003 heat wave in France

Received: 17 October 2005 / Accepted: 9 February 2006 / Published online: 8 March 2006

They show that a harvesting effect was limited (Braga et al. 2002; Dessai 2002; Hajat et al. 2005; Kalkstein and Smoyer 1993; Sartor et al. 1995) or even non-existent (Huynen et al. 2001; Rooney et al. 1998). In the present study, no harvesting effect was observed; the excess mortality of the August 2003 heat wave was not followed by a less-than-expected number of deaths until the end of 2003. Moreover, the excess mortality in the first 20 days of August 2003 was not followed, from August 21st to November 30th, 2003, by persistent excess mortality.

Future projections

SSP1-2.6 SSP2-4.5 SSP3-7.0

Table 1 | Excess death rates (per 100,000 person years) in each country, region and at the European level for the periods 2050–2054 and 2095–2099 under the SSP3-7.0 and no adaptation to heat scenarios

	2050–2054			2095–2099		
	Cold	Heat	Net effect	Cold	Heat	Net effect
Netherlands	−16.1 (−36.7 to −1.1)	17.6 (2.2 to 62.2)	1.4 (−20.3 to 33.1)	−25.7 (−45.2 to −9.5)	44.4 (8.6 to 117.2)	18.7 (−21.3 to 81.7)
Germany	−16.4 (−35.8 to −2.9)	22.8 (1.8 to 64.2)	6.5 (−11.0 to 39.4)	−26.6 (−43.4 to −11.7)	63.6 (12.7 to 138.9)	36.9 (−8.1 to 103.8)
Belgium	−15.9 (−34.7 to −2.1)	17.7 (1.8 to 58.6)	1.8 (−17.2 to 30.3)	−27.0 (−44.5 to −11.1)	49.6 (10.6 to 117.2)	22.6 (−17.1 to 80.9)
Luxembourg	−11.3 (−26.2 to −2.3)	16.2 (0.9 to 51.3)	4.9 (−10.3 to 34.4)	−22.2 (−39.1 to −9.4)	54.8 (8.7 to 129.7)	32.6 (−10.3 to 105.1)
Austria	−15.3 (−33.2 to −2.8)	27.2 (3.8 to 73.6)	11.8 (−10.4 to 52.8)	−27.5 (−44.9 to −13.0)	91.0 (26.0 to 212.7)	63.5 (4.7 to 176.2)
France	−17.9 (−35.8 to −5.8)	27.2 (8.4 to 60.2)	9.3 (−11.4 to 40.8)	−28.4 (−44.2 to −15.5)	66.4 (15.2 to 134.8)	38.0 (−8.0 to 101.2)
Switzerland	−13.6 (−35.4 to −1.8)	25.0 (4.7 to 70.5)	11.4 (−8.1 to 51.3)	−24.0 (−40.8 to −11.1)	77.9 (18.6 to 169.2)	53.9 (−0.6 to 140.8)
Western	**−16.7 (−35.1 to −3.9)**	**23.9 (5.7 to 61.7)**	**7.1 (−9.8 to 35.3)**	**−27.2 (−42.6 to −13.9)**	**63.2 (18.4 to 132.7)**	**36.0 (−3.9 to 98.5)**

Morbidity effects of heat

Evidence regarding morbidity impact

- **Pregnancy**
  - Mothers : obstetric complication
  - Children : stillbirth, preterm birth, low birth weigth

Chersich et al, *BMJ* 2020

Lakhoo et al, *Nat Med* 2025

- **Occupationnal health**
  - Occupationnal injuries (construction, farm workers, catering)

Vielma et al, *Env Int* 2025

- **Mental health**
  - Mood disorder, mental disorder, anxiety, schizophrenia

Liu et al, *Env Int* 2021

- **Violence**
  - Car crashes
  - Inter-personnal violences (assault, homicides)
  - Gender-based violence

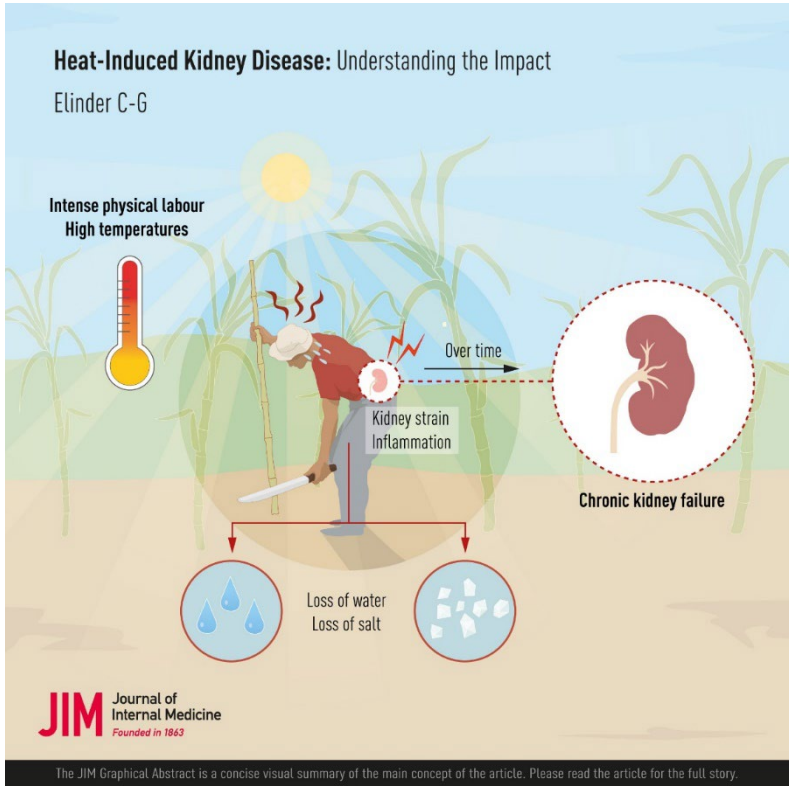
Basagaña et al, *EHP* 2015

Choi et al, *EHP* 2024

Zhu et al, *JAMA Psy* 2023

- **Impacts are often higher in low socio-economic groups**

Chronic/repeated exposure and heat-induced Kidney Disease



"Associations between exposure and kidney damage are strong, consistent, and specific, occur after acute and chronic exposure *[…].*

Improving working conditions by providing hydration, rest, and shade to heat-stress-exposed workers is beneficial.

Continued global warming *will increase the number of people at risk for dangerous heat exposure and* ***kidney disease****."*

Elinder et al, *J Int Med* 2024

Heat prevention plans

Heat action plans and their impact

Am Pub Health Asso : Enhance Readiness for Extreme Heat

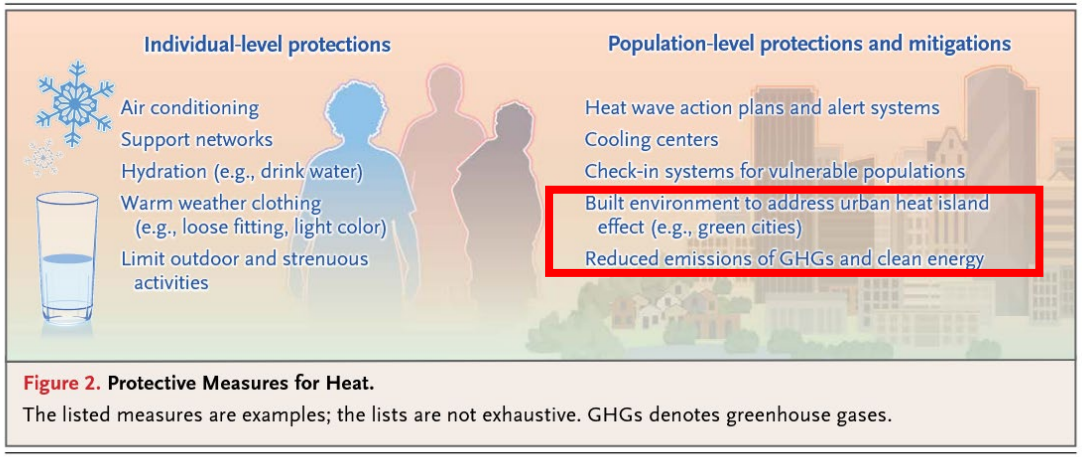
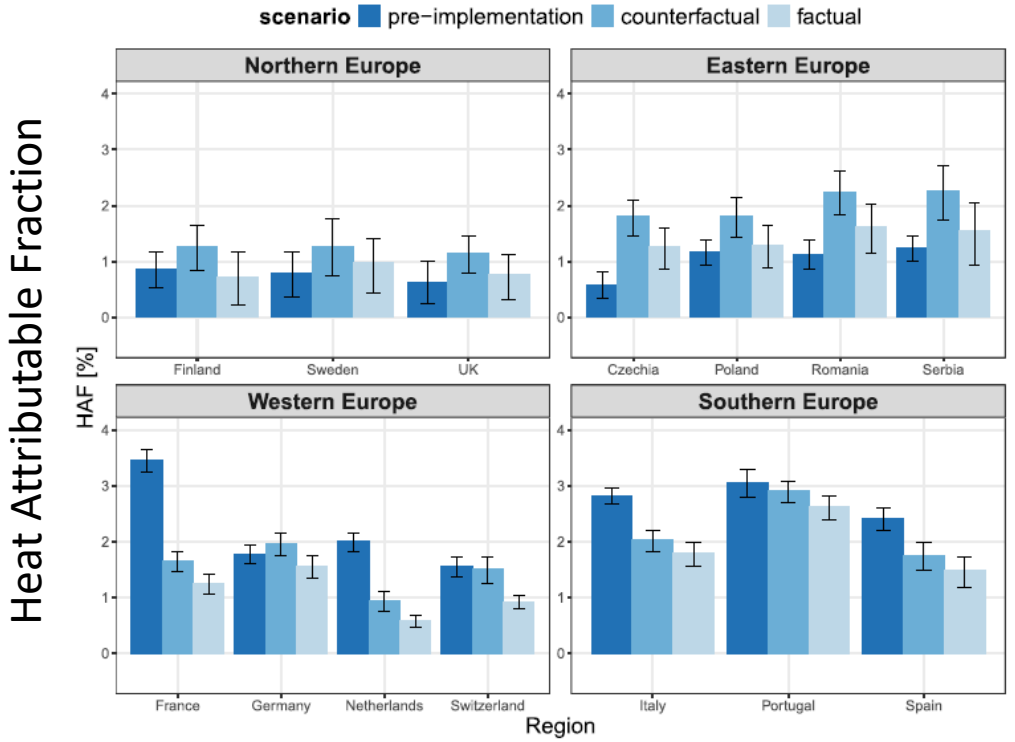


Figure 2. Protective Measures for Heat.
The listed measures are examples; the lists are not exhaustive. GHGs denotes greenhouse gases.

Bell et al, *NEJM* 2024



HPP [Heat Prevention Plans] implementation ***was associated with a 25.2% [95% CI: 19.8% to 31.9%] reduction in excess deaths*** *attributable to extreme heat*

Urban et al, *Env Res Letters* 2025

Mitigation is also the opportunity for healthier and more robust societies

Preventable mortality fraction through air quality, increased physical activity and improved diet, **within net-zero emission scenarios**

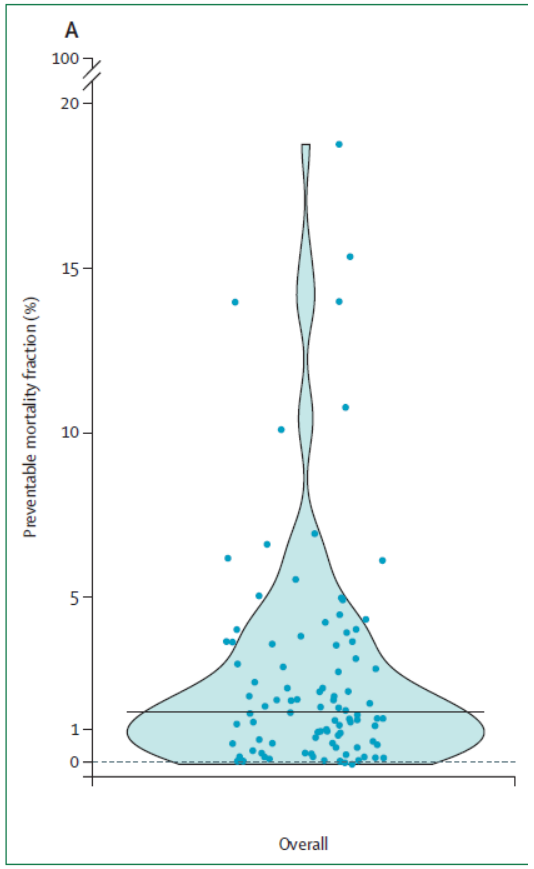


Figure 6: Preventable mortality fraction in various net-zero scenar

Moutet et al, *Lancet Planetary Health* 2025

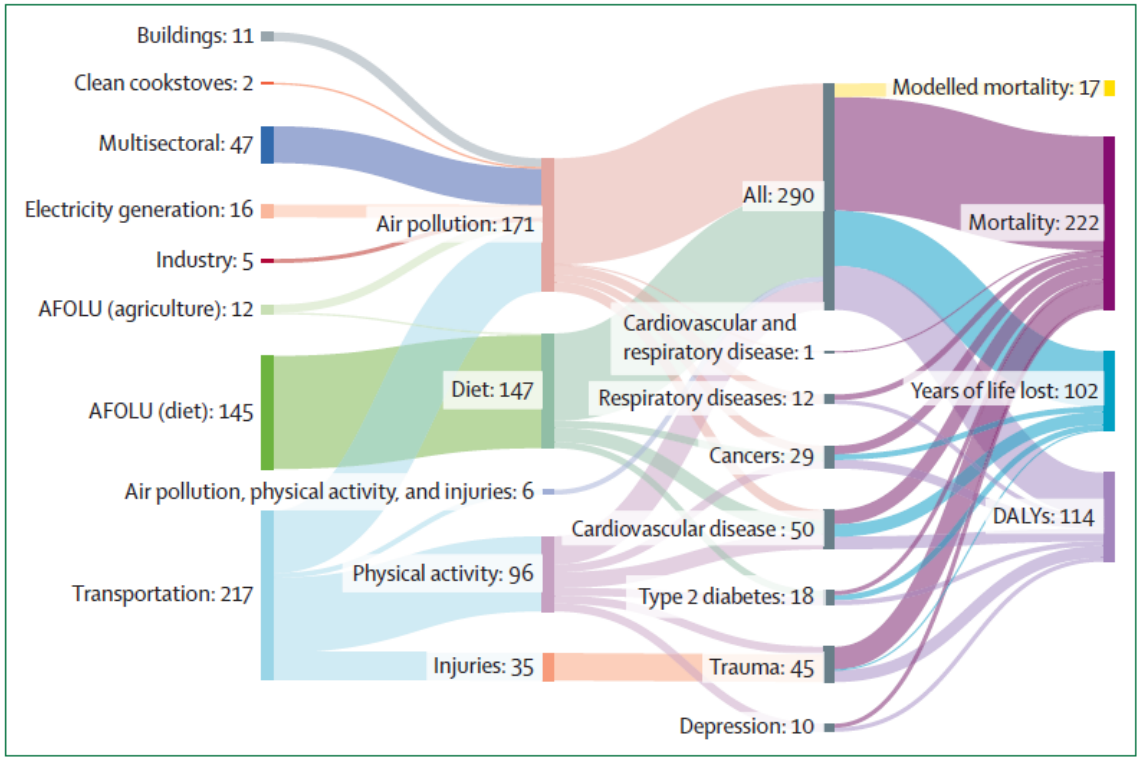


Figure 4: Mitigation actions across sectors and their associated pathways to health outcomes

Whitmee et al, *Lancet* 2024

Merci pour votre attention

Warm thanks to **Rémy Slama**
(PARSEC - Inserm, ENS-PSL)

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À NOTRE santé!

(Ed. Payot, 2026, 220p.)

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