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Linking Indoor Overheating and Mortality: A Risk-Based Assessment of Heatwave Impacts on Buildings and Occupants

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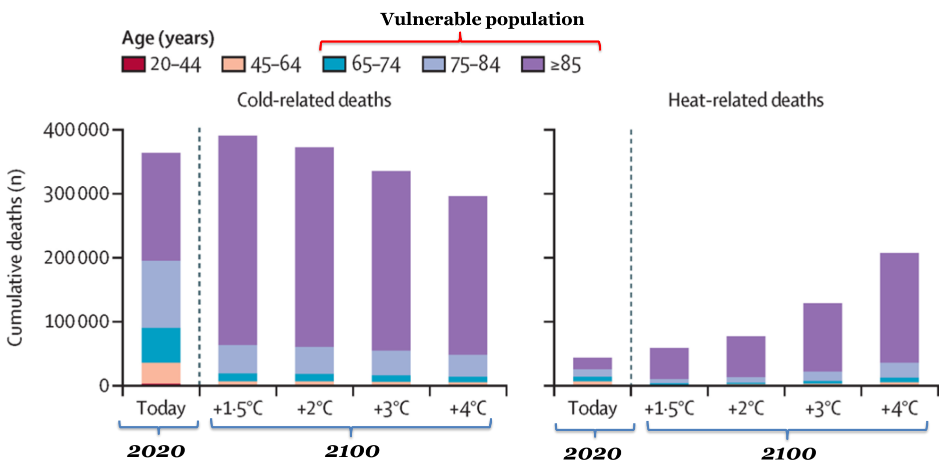
Outline

1. **General Context**
2. Proposed Risk-Based Assessment Framework
3. Example for Impact: Heat-related Mortality Identification in France
4. Summary and Future Work Pathway

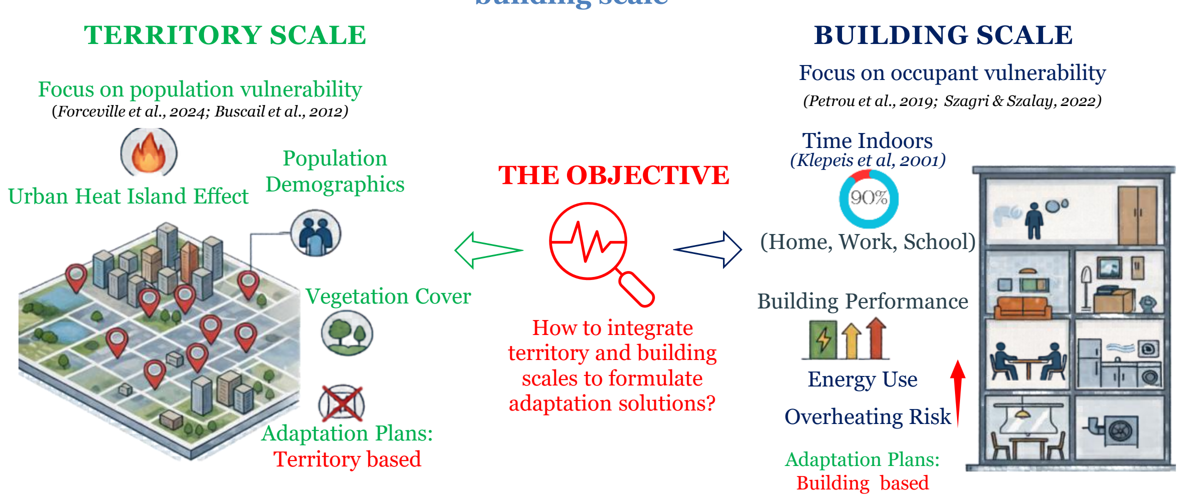
The Problem: From Discomfort to a Public Health Emergency

- Climate change is increasing the frequency and severity of heatwaves, thereby increasing heat related mortality (***García-León et al., 2024***).



extracted from García-León et al., 2024

The Research Gap: Integrated approaches at territory and building scale



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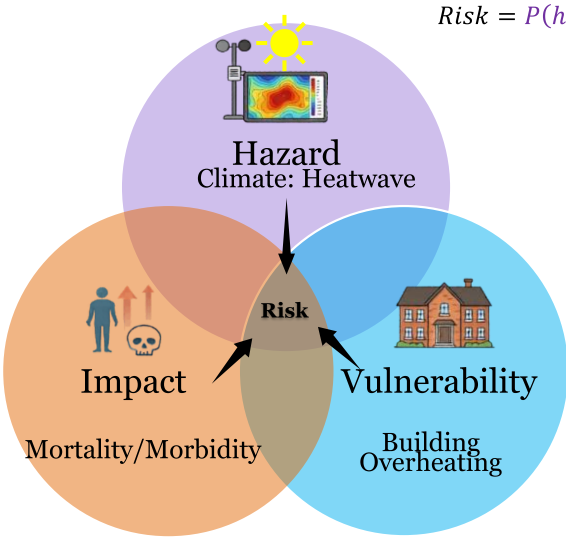
Framework for Assessing Heat Mortality risk

$$Risk = P(hazard) \times P(vulnerability|hazard) \times impact|hazard$$



Hazard is the extreme event (heatwave) e.g exceedance of 95 percentile of historical temperatures (30yrs).

Vulnerability is the ability of building to keep indoor temperature below the health thresholds.

Impact is the magnitude of consequences of the heatwave (mortality or morbidity).

Outline

Impact : Heat mortality risk in France (2019-2024)

Impact

Mortality

$AF = \frac{RR-1}{RR}$

(Gasparrini & Leone, 2014)

Input

Daily Average temperature, Daily all cause death count

Method

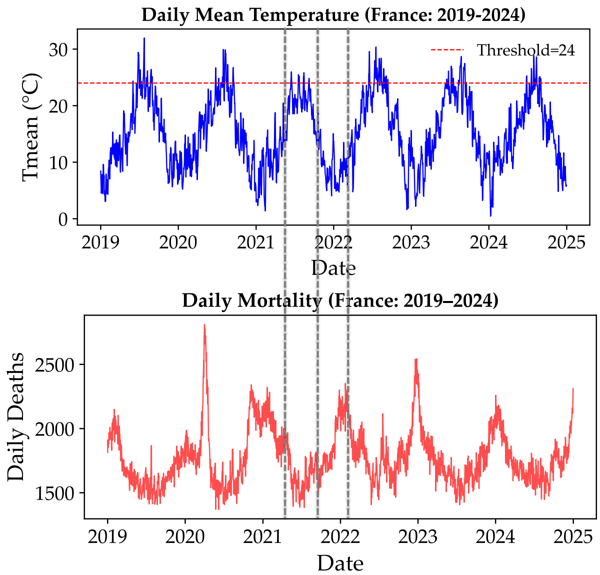
Distributed Lag Non-linear Model using quasi-poisson regression method to account for overdispersion *(Gasparrini, 2011):*

$$ln(\gamma_t) = \beta_0 + cb(T, lag) + ns(t, df) + DOW_t$$

Output

- Minimum Mortality Temperature **(MMT-°*C*):** least deaths point
- Relative Risk **(RR):** ratio of risk at any temperature as to **MMT**
- Attributable fraction **(AF-%):** share death due to the event
- Heat Attributable Mortality: excess deaths due to the event

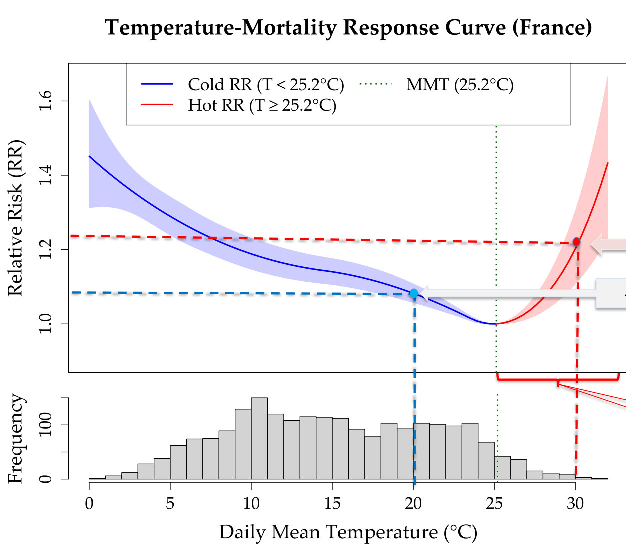
Dataset



Daily average temperature for France (2019-2024) ***(Source: Meteo France).***

Daily all cause mortality for France (2019-2024) ***(Source: INSEE France).***

France temperature-mortality response curve for 2019-2024



Minimum Mortality Temperature (MMT): 25.2 °C.

- Hot days less frequent but higher impact than cold days.

+5°C (30°C) RR of ***1.23 (23%)***

-5°C (20°C) RR of ***1.09 (9%)***

4.7% heat related mortality (8086 deaths)

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Summary and Future Work

The Core Problem & Forward Step

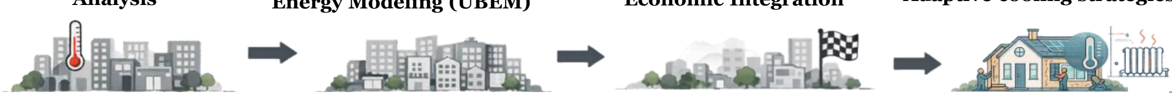
- High risk of extreme heat with climate change
- Quantifying building vulnerability where people spend most time
- Risk based adaptation framework for climate resilient buildings
  Active and passive cooling strategies

Health Impact

- The regression model have been useful in identifying heat related mortality and the lagging effects of temperature.
- **4.7%** of heat related mortality (8086 deaths)
- **+23%** Mortality Risk on 5 °C increase (25°C to 30°C)

The Future Work Pathway

Phase 1: Typology Analysis → **Phase 2: Urban Building Energy Modeling (UBEM)** → **Phase 3: Socio-Economic Integration** → **Phase 4: Risk-based Adaptive cooling strategies**



Acknowledgements

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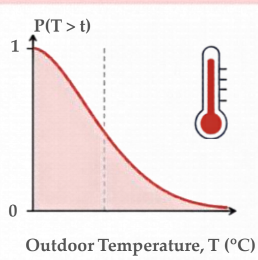
Appendix: Broad method approach

1. Outdoor Temperature Hazard Curve



Probability of exceeding outdoor temperature T within the heatwave threshold

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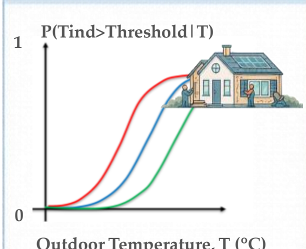
2. Vulnerability of Buildings (Fragility Curve)



Conditional probability of exceeding a health damaging state, given the outdoor temperature T.

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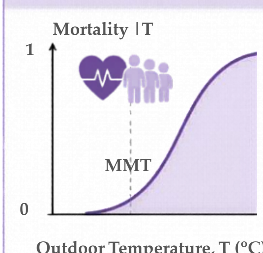
3. Heat-Attributable Mortality



Heat-attributable mortality given the outdoor temperature T.

Common Intensity Measure: Outdoor Temperature, T (°C) | **Common Reference Time Period:** 2019-2024

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Appendix: Lagged effects of temperature