

Modeling Heat-Related Mortality and Adaptation in Switzerland under Climate Change

Introduction

As climate change intensifies, Switzerland is experiencing increasingly frequent, prolonged, and severe heatwaves. Despite public awareness and the implementation of Heat-Health Action Plans (HHAPs) in many regions, excess mortality during these events remains persistently high. The situation is particularly critical for elderly individuals, people with chronic illnesses, and low-income or socially isolated groups—populations whose vulnerability is compounded by both biological sensitivity and inadequate adaptive capacity. This modeling challenge invites to examine why heat-related mortality remains so resilient to current policy interventions and to explore which adaptive measures could meaningfully reduce future deaths.

The aim is to develop a policy-relevant, dynamic model that captures the interactions among climatic hazards, demographic trends, housing quality, and policy responses over the coming decades.

Modeling Objective

The purpose of the model is to simulate heat-related mortality under different scenarios of climate change and policy intervention, with the goal of identifying effective strategies to protect vulnerable populations. The model should represent how mortality risk evolves across population groups, and how interventions—such as improved housing, increased access to cooling systems, or more robust early warning systems—could mitigate this risk over time.

To do so, the modeler will need to construct a robust stock-and-flow structure that captures the population dynamics of heat vulnerability across different age, income, and housing categories.

Model Structure and Core Dynamics

The population will be disaggregated across three dimensions: age group (e.g., young (0-14 years old), adult (15-64), elderly (65+)), socio-economic status (e.g., low-, middle-, and high-income), and housing adequacy (whether or not residences have effective cooling). Each group differs in terms of its vulnerability (exposure to heat, biological or social sensitivity, and adaptive capacity). For instance, elderly individuals in poorly insulated homes and with limited financial means face disproportionately higher mortality risks during heatwaves.

The model should include demographic chains that account for aging and inflows into vulnerable states (e.g., the development of chronic illness or the onset of social isolation). Mortality risk should be modeled as a function of heat exposure and sensitivity, offset by available adaptation resources.

Key mechanisms include the rising frequency and intensity of heatwaves, projected changes in population aging, and disparities in the implementation and effectiveness of adaptation policies across Swiss cantons. Infrastructural, behavioral, and institutional factors all play a role in shaping both exposure and resilience.

Modeling Steps

The modeling process begins with building a demographic structure that distinguishes population groups by age, income level, and housing adequacy. This forms the backbone of the model. Next, heat exposure should be calculated as a function of climate data and housing conditions. Mortality can then be computed by combining exposure with sensitivity and subtracting adaptive capacity—a formulation consistent with heat vulnerability indices in the literature.

Once the base population-risk structure is in place, adaptation interventions can be introduced. These might include the diffusion of cooling technologies, the expansion of HHAP coverage (e.g., Early Warning Systems, public awareness campaigns), etc. The effectiveness of each intervention can be simulated over time.

Finally, modelers may choose to extend the model to include feedback loops—for instance, rising mortality leading to increased policy urgency, or widespread public attention driving behavioral change. However, the priority is to establish a solid and interpretable stock-and-flow framework that reflects current data and policy challenges.

Use and Relevance

This model is intended as a tool for public health planners, policymakers, and researchers seeking to understand and address heat-related mortality in a changing climate. By enabling simulation of long-term adaptation scenarios, it can help identify leverage points for reducing systemic vulnerability. The time horizon of the simulation is set from 2025 to 2055, capturing both short-term adaptation responses and long-term demographic and climatic shifts.

Commented [HR1]: Overall pretty good problem definition with clear model boundary for the task at hand.

Commented [MA2]: as they have distinct physiological vulnerabilities (e.g. immature thermoregulation, dependency on caregivers)

Commented [HR2R2]: I think housing adequacy is highly correlated with socio-economic status, so you could combine the two into one, and perhaps use socio-economic status as primary dimension and getting housing adequacy from that.

Commented [HR3]: Make sure you have a flexible, subscript based formulation for aging chain so that you can change the resolution as needed without changing the stock and flow structure too much.

Commented [MA4]: However, I think it might be hard to find data on this

Commented [HR4R2]: That's ok. If it is an important distinction conceptually, you want it in the model even if you don't have data on it.

Commented [MA5]: How would the stocks looks like? Something like non-vulnerable and vulnerable?

Commented [HR5R2]: So you would have people move along age groups as simple aging model, and socio-economic categories could be fixed, or include switching between categories as a function of economic growth, social safety nets, etc (as a second iteration).

Commented [MA6]: This seems very complicated atm

Commented [HR6R2]: Yes; for now I wouldn't go into change in vulnerability state beyond socio-economic status, at least not in the stock and flow structure. The probability that a low income family is receiving protective measures can be modeled separately.

Commented [MA7]: Again, seems too complicated to me atm

Commented [HR7R2]: Too complicated for the model for this class. Relevant for the next steps perhaps, beyond class scope.

Commented [HR8]: Probably not needed, see above

Commented [HR9]: This all makes good sense; key to use the most standard formulations in the literature; if you already know those, great, if not, LLMs may be helpful for identifying standard formulations.

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