

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 us 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 and socio-economic 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+)) and socio-economic status (e.g., low-, middle-, and high-income), and housing adequacy. In Switzerland, the majority of housing doesn't have effective cooling (due to a combination of factors including building design focusing on heat retention for winter, regulations around air conditioning installation, and a historical lack of need for cooling due to milder summers).

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 a subscript-based aging chain structure, allowing resolution to be modified without substantial structural changes. People should move through age groups in a standard aging chain. Socio-economic categories can initially be fixed, with the possibility of modeling transitions between them in a second iteration as a function of economic growth and social safety nets.

Mortality risk should be modeled as a function of heat exposure and sensitivity, offset by available adaptation resources. Changes in vulnerability state beyond socio-economic status will not be modeled within the core stock-and-flow structure. Instead, the probability that a low-income household receives protective measures (e.g., access to cooling or early warning systems) can be modelled separately.

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.

Modeling Steps

The modeling process begins with building a demographic structure that distinguishes population groups by age and socio-economic status. This forms the backbone of the model. Next, heat exposure should be calculated using standard formulations from the public health and climate change literature, incorporating climate data and housing conditions as a function of socio-economic status. Mortality can 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.

The model can later be extended 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.

MIT OpenCourseWare
<https://ocw.mit.edu/>

15.879 Building Serious System Dynamics Models from Scratch
Spring 2025

For information about citing these materials or our Terms of Use, visit: <https://ocw.mit.edu/terms>.