Understanding the Impacts of Climate Change on Human Health and Well-being

Introduction

The traditional approach to understanding the human health impacts of climate change is to list a series of health outcomes that can be directly attributed to shifting weather baselines and intensified storms. This chapter aims to develop a more holistic conceptual model for how climate change impacts health and well-being. Specifically, to capture both direct, more acute health impacts and the delayed and persistent indirect impacts of climate change on health that are mediated by factors like social and institutional inequities; housing, transportation networks, social ties, functioning ecosystems and access to care; and intangible determinants of well-being such as self-determination and influence. The objective of creating such a model is to provide a useful structure for answering questions such as "who is impacted", "how are they impacted" and "what can be done about it".

Direct Impacts



Figure 1. Direct health impacts of climate change.

Previous summaries of health impacts of climate change can be found in the U.S. Global Change Research Program's 2023 Fifth National Climate Assessment[1], Vermont Emergency Management's 2023 State Hazard Mitigation Plan[2], UVM's 2021 Vermont Climate Assessment[3] the Vermont Department of Health's Health Risks of Climate Change website[4]. These

summaries and others generally focus on how climate change is increasing health risks associated with the direct impacts of climate change:

- Heat-related impacts – e.g. heat-related illness and death that occurs during hot weather
- Air pollution – e.g. elevated ozone concentration due to increased temperatures or particulate concentrations during a wildfire smoke event
- Extreme weather events – e.g. deaths and injuries directly attributable to storms or floods made more intense by climate change
- Mosquito and tick-borne disease – i.e. introduction of new or exacerbation of existing mosquito or tick-borne diseases

This focus on direct impacts means that current conceptual frameworks do not sufficiently capture the health and well-being implications of things like 1) the economic hardships, daily indignities, grief and loss experienced by individuals and communities after catastrophic events like Tropical Storm Irene or repeat flooding, or 2) the loss of a sense of place, routines, or customs that results from long-term incremental environmental or ecological changes, such as diminishing opportunities for outdoor recreation due to tick or mosquito-borne disease risks, or winter recreation due to lack of snow or ice. Understanding direct health impacts continues to be essential to climate change work; however, to adapt and respond to climate change, we need a holistic conceptual model that more faithfully captures the indirect impacts of climate on health and well-being.

Indirect Impacts

"In the summer it's really, really a challenge because a lot of people don't have the clothes. The clothing. They have to carry everything with them. So they may have a sleeping bag, a blanket, maybe they're in a tent. I don't know if you've ever been in a nylon tent with the sun beating on it. It's really hard. So you know you end up outside and when you're outside in the night you're vulnerable, things happen. You're really at the mercy of the environment, and all they're trying to do is survive."

– Worker at Vermont homeless shelter, 2023

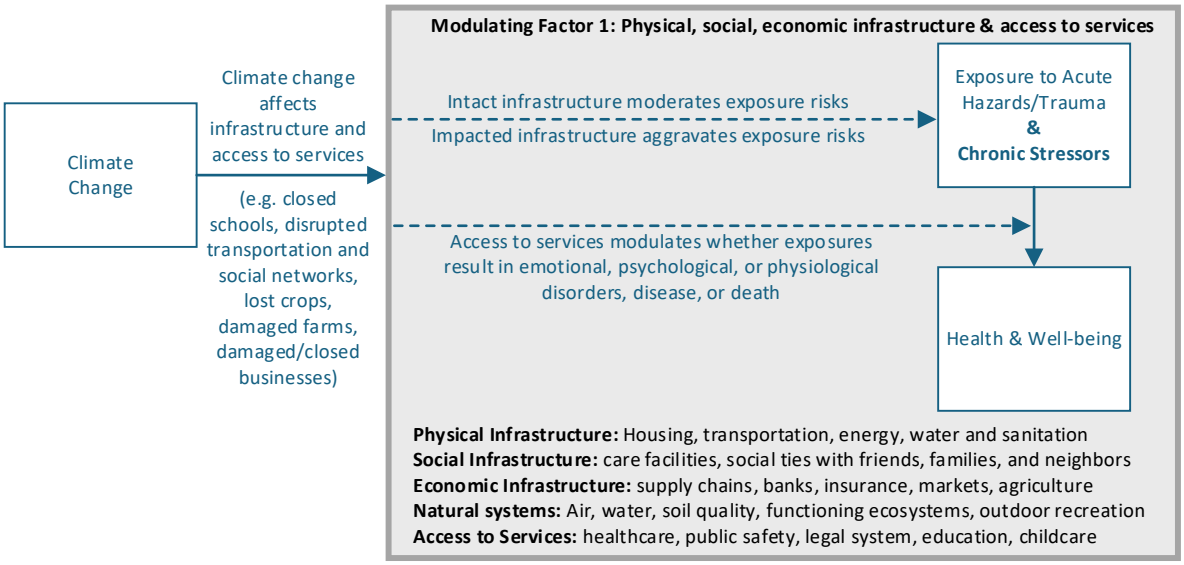


Figure 2. Indirect health impacts of climate change, moderated or exacerbated by physical, social, and economic infrastructure, and access to functioning natural systems and essential services.

Climate change can affect human health indirectly through its upstream impacts on the physical, economic, and social conditions that provide the foundation for human health and well-being. By degrading the conditions in which a person lives, climate change can 'load-the-dice', reducing the likelihood that an individual will be healthy. This degradation can occur gradually, for example through the disappearance of recreational options due to hotter weather, avoidance of tick-bites, or cyanobacteria blooms or suddenly, due to destruction caused by floods, landslides, or wildfire. The effects of gradual changes and sudden social and economic disruption can also have a cumulative effect, such as when a family living in an area impacted by repeated weather events made more extreme by climate change has to pay more for homeowner's insurance, groceries, air conditioning, or storm repairs[5]. With less time or money available to spend on food, housing, recreation, or healthcare, that family is likely to be less healthy than they would have been absent from the effects of climate change.

> *"Because of the floods, there are less investments happening in regular paving projects. Because of the floods, there are less investments happening in public safety. Because of the floods, there is less investment happening in water and wastewater infrastructure."*
>
> -**Ted Brady**, Executive Director, Vermont League of Cities and Towns[6]

The same is true for towns and for the state as a whole. Some towns' outstanding debts from road and infrastructure repair from 2023 and 2024 flooding exceed their annual budgets. [7] Funds that are required for repairing roads and essential infrastructure after a flooding event can't be otherwise invested in walkable/bikeable roads, Police/Fire/EMS services, libraries, parks and recreation, drinking or wastewater infrastructure maintenance or improvements, or other infrastructure investments that lay the foundation for sanitation and good health. These community-wide impacts affect property values, the tax-base[8], and the labor market[9].

Chronic stressors are the stresses from everyday life that impact our well-being, for example, job loss, losing a loved one, worrying about how to pay rent or buy food, or a divorce. Daily or chronic stressors such as poverty, overcrowded or inadequate housing, lack of access to clean water, heat or sanitation, lack of access to education and employment, discrimination, and stigma are equally strong or stronger predictors of PTSD as direct prior exposure to violence and trauma.[10] Explicitly including chronic stressors in the model highlights the importance of identifying and mitigating the continuous chronic stressors in the lives of people recovering from a natural disaster as a means of increasing their ability to cope in the short term and protecting their psychological (and physical[11]) well-being long-term.[12] It also raises the questions of which class of impacts, immediate/acute or long-term/chronic, has a larger impact on human health and well-being. One study that attempted to address this question found that the number of deaths attributable to the long-term (15 years post-storm) effects of tropical cyclones (hurricanes) in the continental United States was 300 to 480 times greater than the average of 24 deaths that occurred in the immediate aftermath of the storm.[13]

A partial list of health outcomes affected by climate change impacts on infrastructure and access to services includes:

- Malnutrition, due to increased cost of nutritious foods, having less money available to buy food, and decreased nutrient content due to CO_2 fertilization[14]
- Mold-related illness, due to flood damage
- Compromised chronic disease management
- Gastrointestinal and diarrheal disease, from food and water contamination
- Poor birth outcomes, due to heat or chronic stress

- Cardiovascular disease, due to air pollution such as wildfire smoke
- Addiction and drug overdose, due to lack of access to healthcare or housing insecurity
- Mental Health: Anxiety, Depression, PTSD, Suicide
- Stress-related illness: Hypertension, Heart Disease, Stroke

Baseline Wellbeing and Health Status Modify Exposure and Resilience

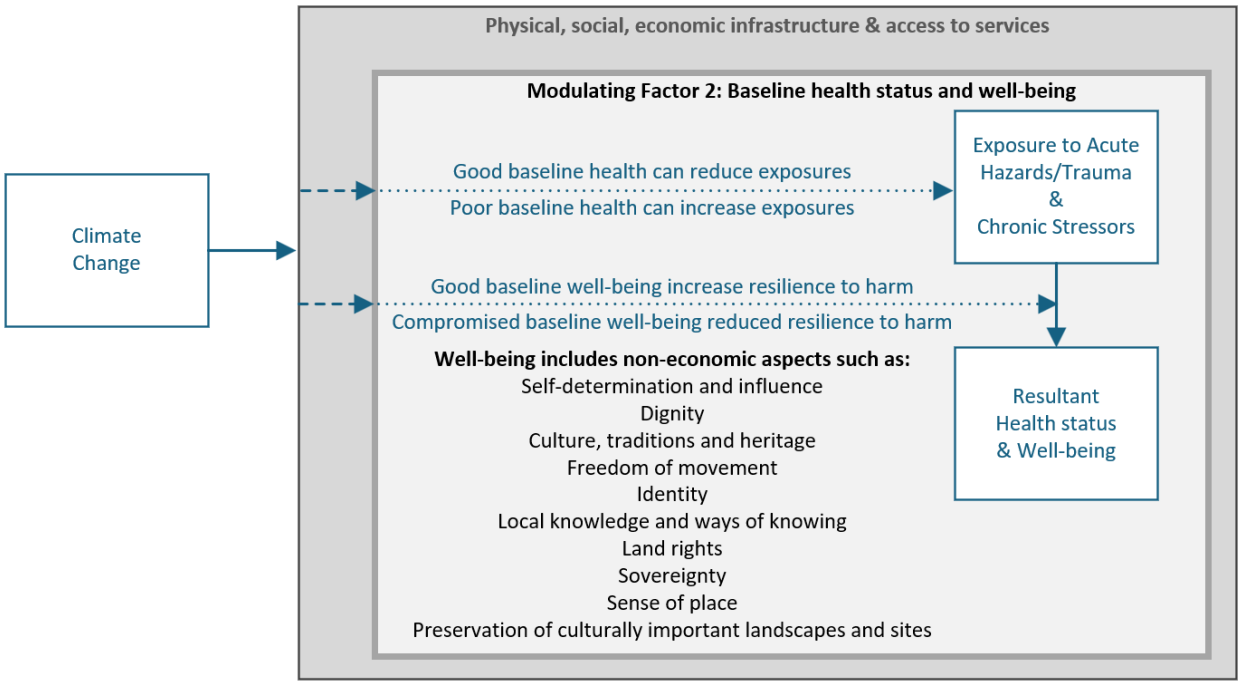


Figure 3. Non-economic values are a) aspects of well-being (e.g., lack freedom of movement or a sense of identity directly harms a person's well-being) and b) can modulate the indirect effects of climate impacts (lack of freedom of movement can result in exposure to acute hazards, job loss or displacement can result loss of one's sense of identity).

[Need to update this paragraph to parallel the figure, now that this modulating factor is baseline health and well-being status. So it more the personal infrastructure that helps to 1.) avoid or minimize exposure and 2.) modulates reactivity to prevent or promote the translation of exposure into harm]

Focusing solely on physiological health impacts can have the effect of flattening the human experience of climate change into a column of statistics that does not adequately capture the depth, complexity, or extent of human experience. There are other determinants of well-being beyond health[15] that can help to protect against exposure to acute hazards and chronic stressors

when preserved, or conversely, that can aggravate harmful exposures when compromised. Another name for these intangible values is noneconomic commodities[16], and some are listed in Figure 3. They can be impacted directly by climate change, for example when someone is displaced from a place with cultural or spiritual significance. And they can modulate whether or not someone is exposed to a hazard, e.g. when someone without freedom of movement is confined to their home during a heatwave or flood, or when someone with local knowledge of what a cyanobacteria bloom looks like can avoid it. When these values are preserved, they can be protective against the daily stressors and insults that can lead to stress-related illness, substance use, intimate partner violence, post-traumatic stress disorder, anxiety, depression, and suicidal ideation.

Narratives that encompass dimensions of well-being beyond just physiological health convey the impacts of living in a changing climate with a clarity that can be missing in graphs of disease, injury, and mortality rates. For example:

"My parents got divorced. I think definitely [. . .] the flood had something to do with it because it really stressed the whole family out."

-Resident of Rochester, Vermont three years after Tropical Storm Irene[17]

"It's hard for my husband to talk about. He still wears it very close. On rainy days he's looking out the window and checking the river levels. A nervous wreck. And he knows that it's not going to happen. And I have to remind him it was a freak storm."

- Resident of Waterbury, Vermont seven years after Tropical Storm Irene[18]

"*I find that when you can't get out so much … you tend to do more things. Some people use addictions more, whatever that may be. It may be drinking, or drugging … that's' increasing"*

- North American health worker, describing the impacts of people not being able to go out on the ice[19]

"*I was suicidal in January and February. Emotionally the worst period of my life … I feel very isolated … I'm running out of resilience to keep taking the blows and keep moving on … I carry the hurt inside"*

- Australian man describing the impacts of extended drought[20]

"I have lost interest in my house … it's not home anymore … I knew that the thing that really finished me (loss of personal possessions and craft work) … because I cannot get my motivation back to do things … I think 'why bother …"

- English flood survivor[21]

Societal and Institutional Inequities

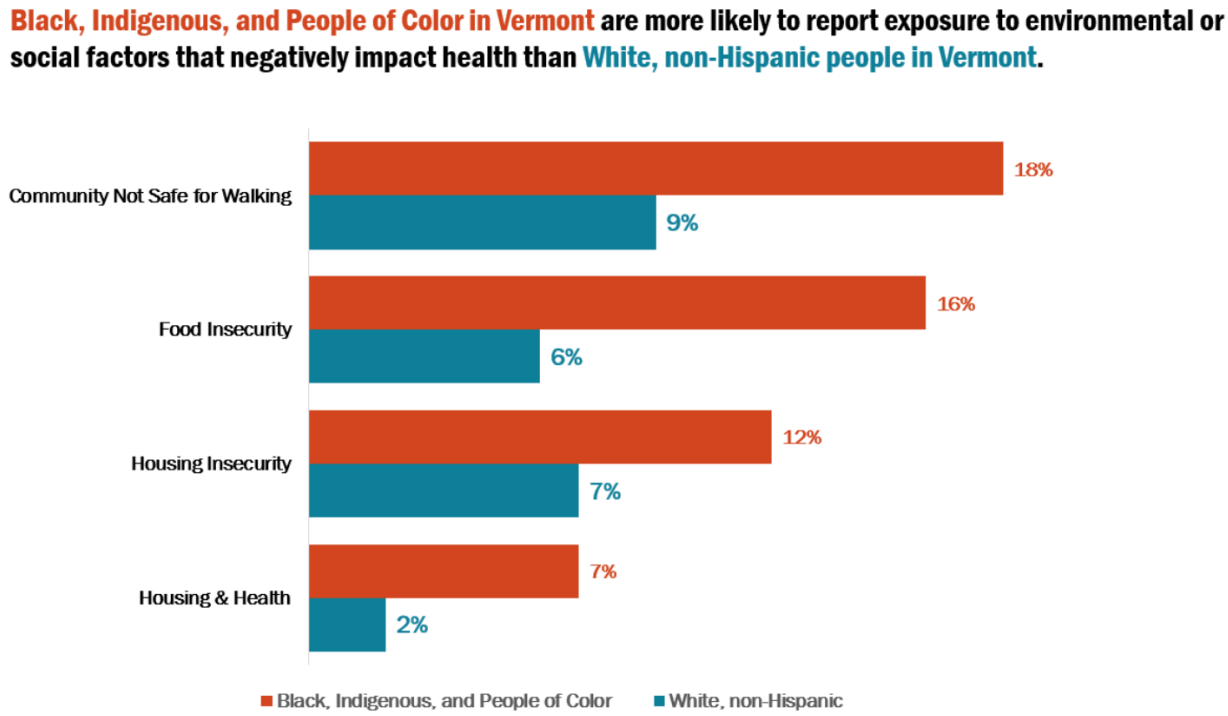


Figure 4. Black, Indigenous, and People of Color (BIPOC) Vermonter are more likely to report that environmental or social factors negatively impact their health.[22]

Because climate change extracts resources from individuals and communities, the impacts of climate change are most severe for segments of the population who have historically had the least social, political, and economic power and capital, which is another way of saying that they are subject to social and institutional inequities.

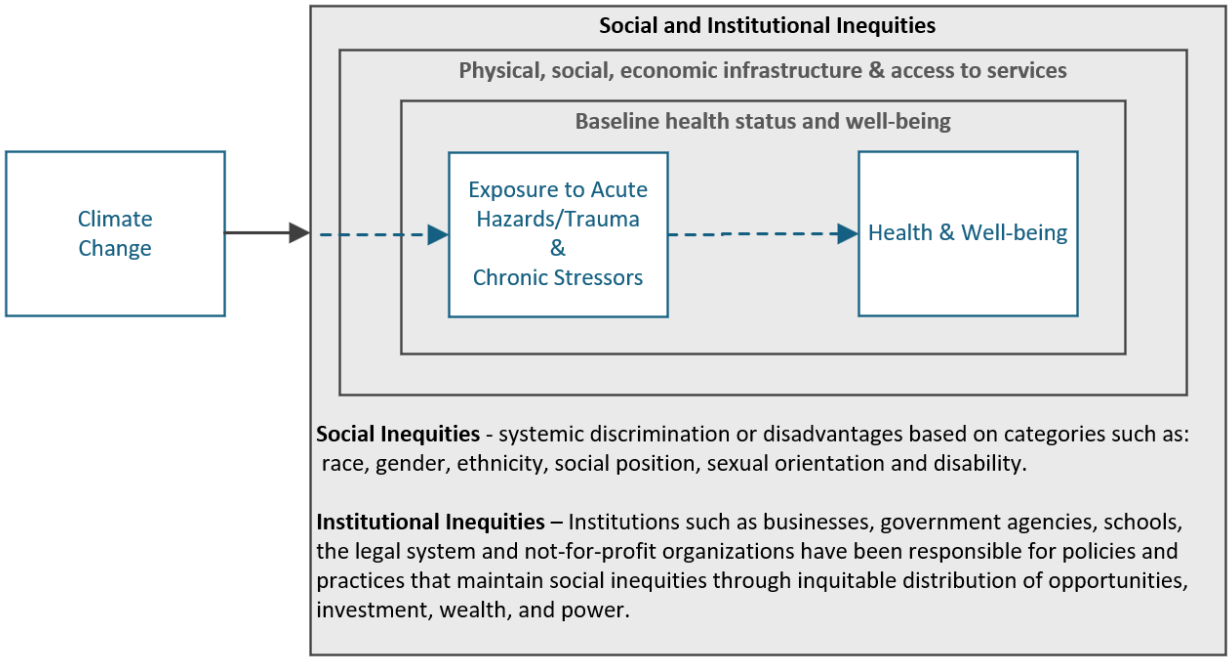


Figure 5. Social and institutional inequities can be exacerbated by climate impacts such as drought or resource scarcity. Social and institutional inequities cause some groups to experience a disproportionate degree of trauma, stress, and harm due to a climate hazard.

Disproportionately impacted groups, are also described as "impacted and frontline communities" in the Just Transitions Chapter of the 2021 Climate Action Plan, or "environmental justice focus populations" in the Vermont Environmental Justice Law (Act 154 of 2022). Some of the groups that are disproportionately impacted by climate change include:

- Low-income Vermonters
- Black, Indigenous, and People of Color
- Immigrants, Refugees, Asylees, and Asylum-Seekers
- Farmworkers
- People with disabilities
- Veterans
- People with limited English proficiency
- Elderly people living on fixed incomes
- People living in manufactured housing
- Renters
- People who live in rural settings
- People with chronic illnesses or poor health
- People with substance use disorder
- People experiencing homelessness
- Children
- People who are incarcerated

- Members of the LGBTQ+ community
- People who work outdoors

The groups that have the least social, political, and economic capital to draw upon often live closest to the edge, whether on a literal edge like a riverbank, or on the figurative edge of instable access to housing, employment, child care, food, health care, and family support. As a result, those groups with the smallest buffer between them and an acute hazard are most likely to experience the greatest cumulative impacts of a climate disaster and its aftermath.[23] Because they have previously experienced harm or loss, or because of their lack of social, political, and economic capital, these groups are also subject to increased exposure to the chronic stressors described earlier, which contribute to their mental and physical health burden. These disproportionate impacts are not unique to climate hazards. These groups are also the first and worst impacted during natural disasters, infectious disease pandemics, economic recessions, and other societal disruptions.

Not only are these groups subject to greater exposure, but that exposure is more likely to translate into disease or injury. The concept of *allostatic load*, the 'wear-and-tear' on the body that results from adapting to stress, provides a model for understanding how exposure to a stressor does or does not translate into disease.[24] In addition, the amount of exposure to the stressor, the magnitude of reactivity, the rate of recovery, and the ability for resource restoration (through rest and sleep) determine the physiological burden of stress.

Sources of Climate-related Stress

The link in the causal chain between erosion of social, economic, and physical infrastructure, and the resultant human health impacts are intermediate societal outcomes. These are non-health metrics that impact an individual's daily experience of stress.

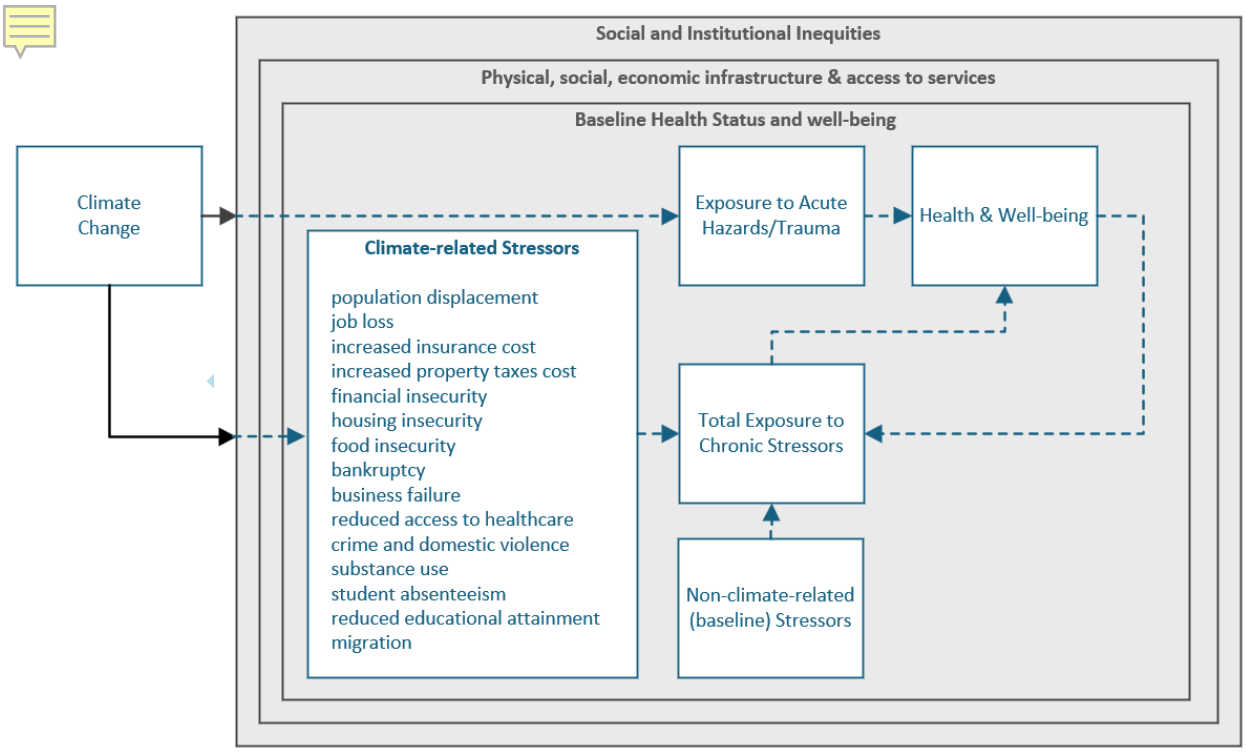


Figure 6. Sources of climate-related stress. This framework also acknowledges that people's baseline stress differs and contributes to their cumulative stress. Also acknowledged is the fact that poor health and well-being also contribute to chronic stress.

The economics chapter of the Fifth National Climate Assessment[25], provides examples of societal stressors that are affected by climate disruption, as shown in figure X. Through their impacts on chronic stress, all of these outcomes (including crime and domestic violence[26], substance use[27], student absenteeism[28]) can impact physical and mental well-being. Total exposure to chronic stressors is a function of the amount of exposure, and the net effect of protective factors and exacerbating factors.

It is important to note that, setting aside climate impacts, the baseline level of stress is not the same among all groups[29]. Groups that are likely to be disproportionately impacted by climate change are also more likely to be impacted by other societal stressors. Figure 7 provides an example of disparities related to food security. So, climate-related social, economic, or physical disruption that negatively affects these groups adds to a metaphorical "stress cup" that is already closer to capacity.

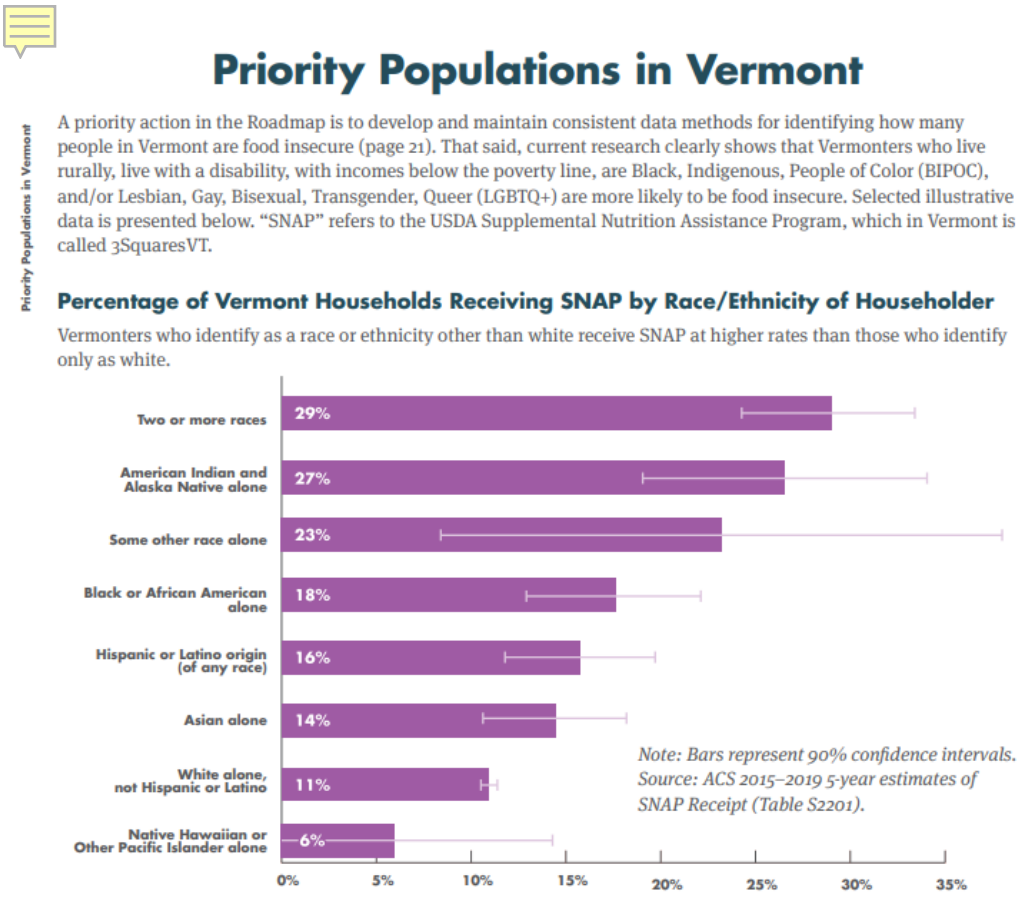


Figure 7. Figure from Farm to Plate's Food Security in Vermont: Roadmap to 2035.

The charts below show how the incidence of some of the intermediate outcomes related to climate-related societal stressors have changed over time.

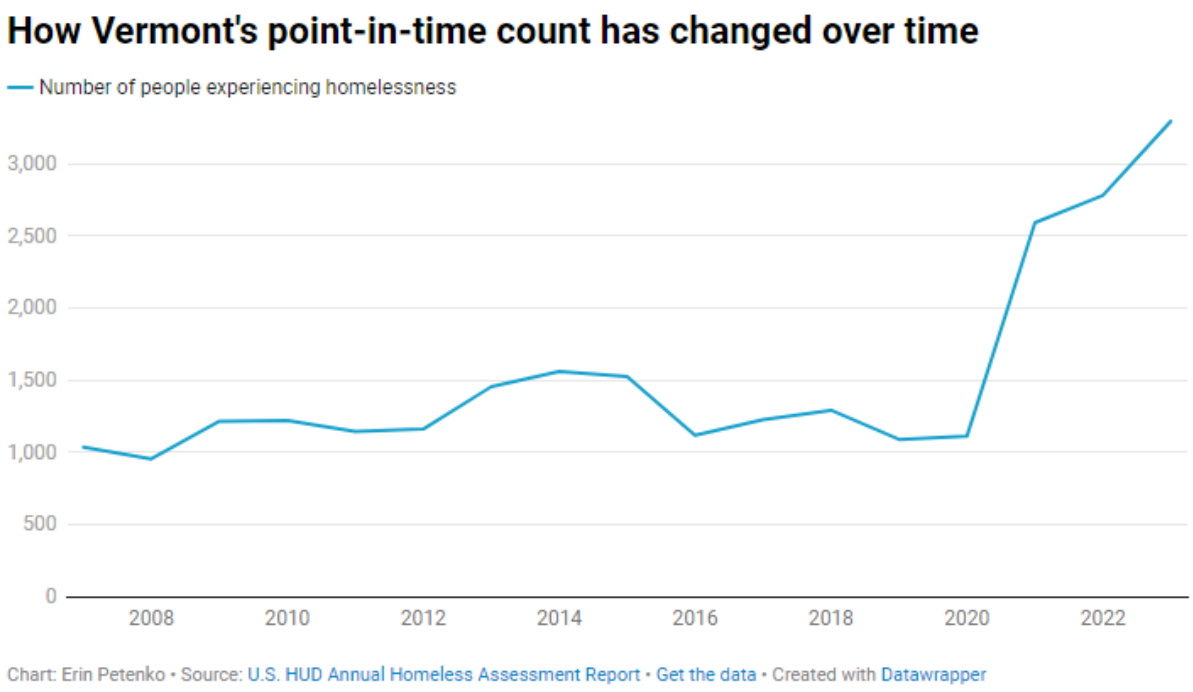


Figure X. Houselessness by Year Source: Vermont's rates of homelessness are still among the worst in the nation | Vermont Public

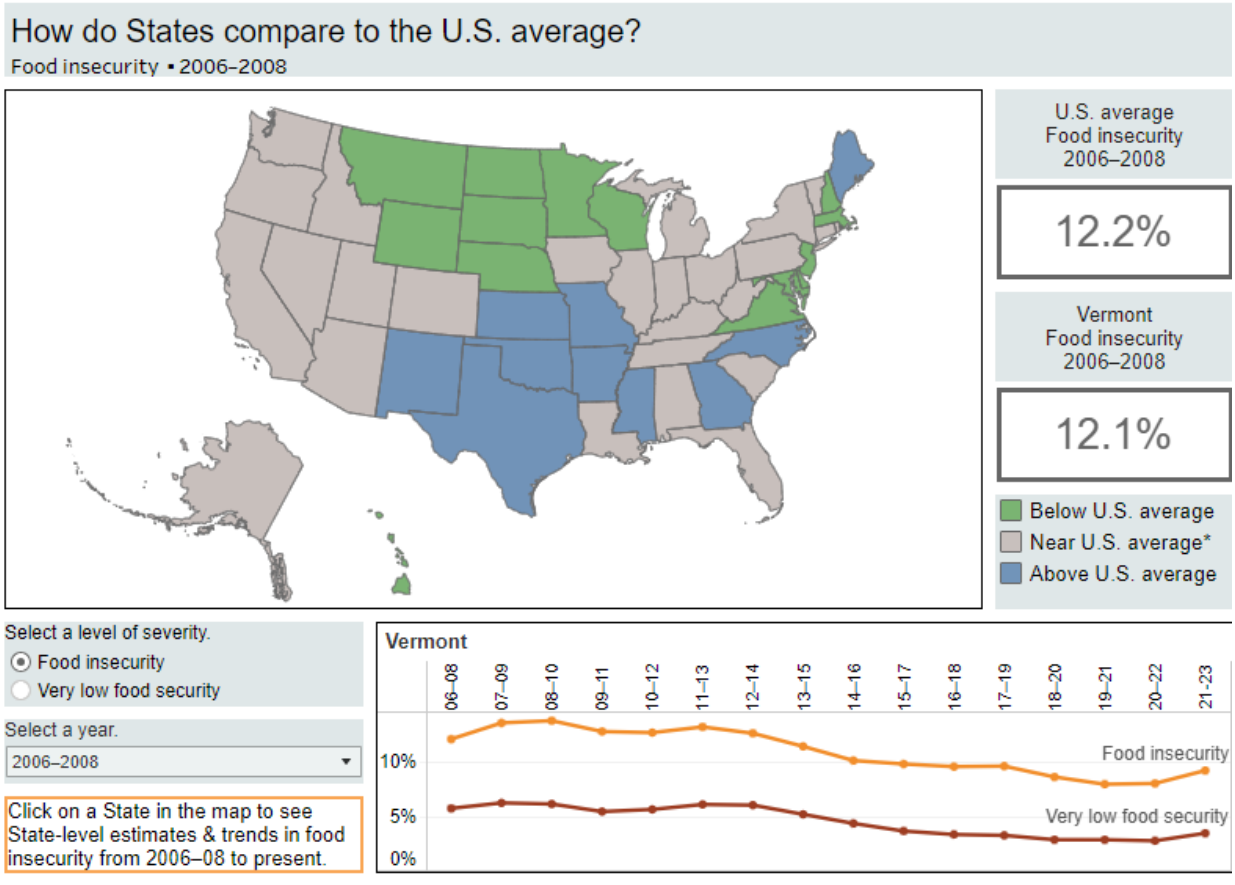


Figure X. Food Insecurity. Source: [Food Security in the United States: How Do States Compare? | Tableau Public]

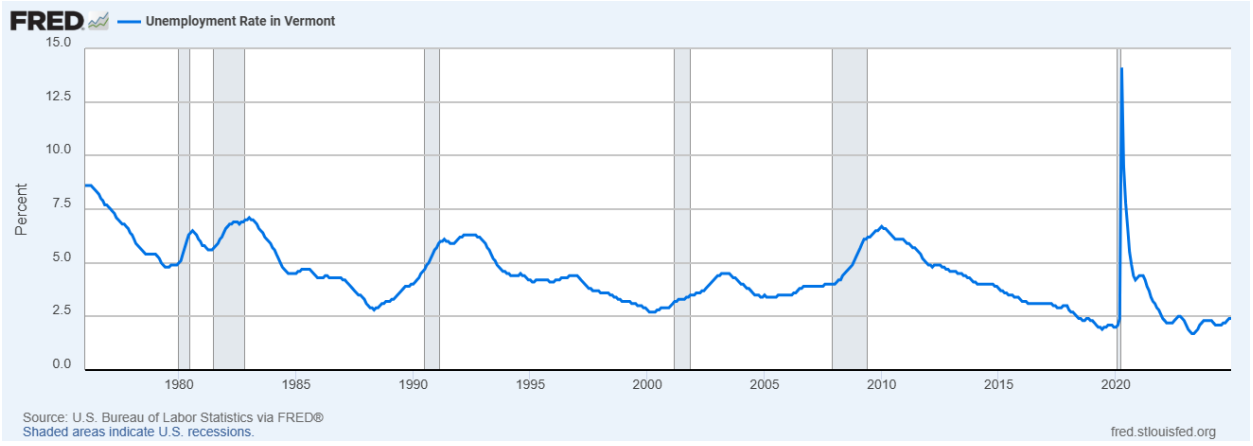


Figure X. Unemployment Rate. Source: [Unemployment Rate in Vermont (VTUR) | FRED | St. Louis Fed]

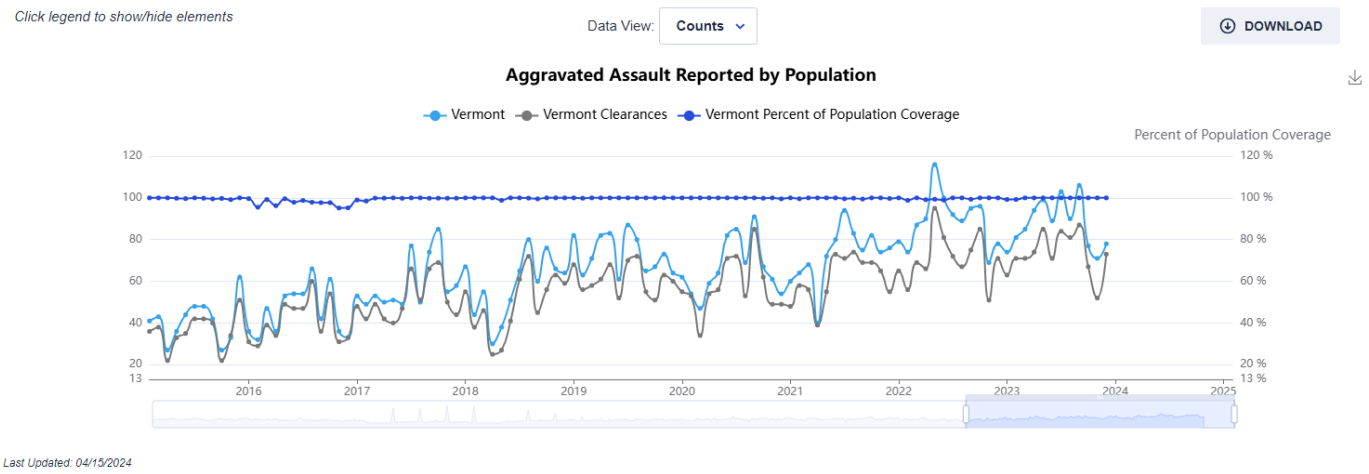


Figure X. Violent Crimes/Aggravated Assault. Source: https://cde.ucr.cjis.gov/LATEST/webapp/#/pages/explorer/crime/crime-trend

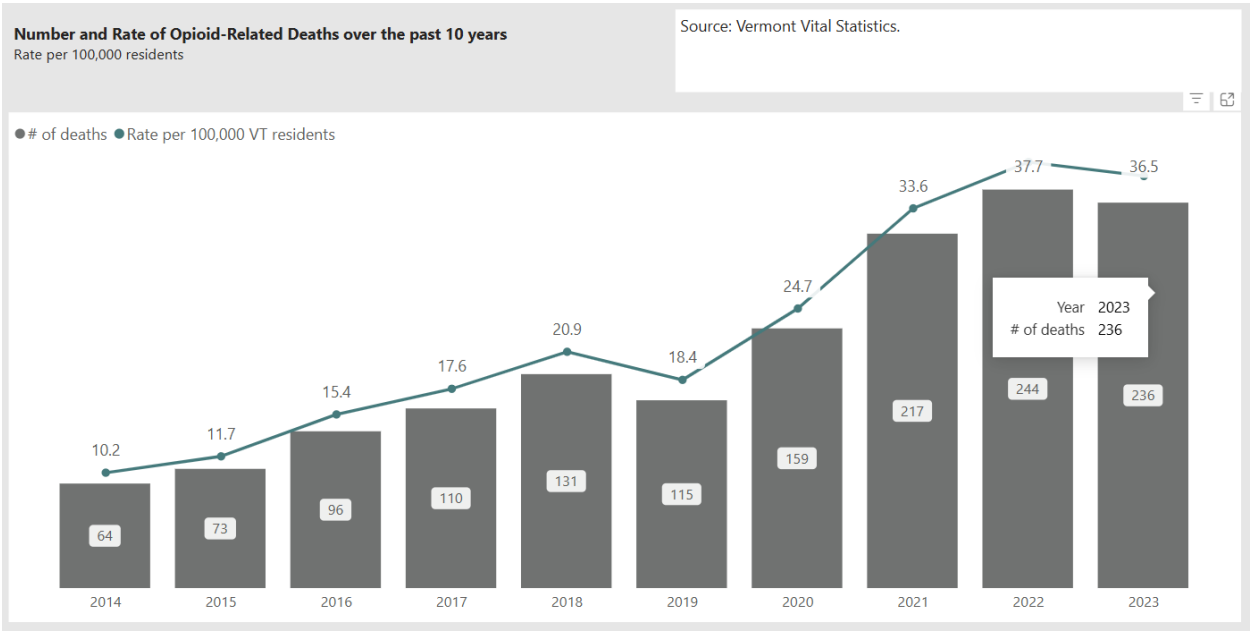


Figure X. Opiod-related fatal overdoses in Vermont over the past 10 years.[30] Source: Substance Use Dashboard | Vermont Department of Health

What actions are being taken to reduce the health risks of climate change in Vermont?

By taking such a broad view of the factors that contribute to the health impacts of climate change, we can see that most, if not all of the actions included in the Climate Action Plan, the

State Hazard Mitigation Plan, and the Resilience Implementation Framework contribute to the protection of human health and well-being. However, the only state entity explicitly charged with directly addressing the health impacts of climate change is the Health Department's CDC-funded Climate and Health program. This program supports the integration of public health considerations into climate action policy across state agencies and coordinates public outreach and support for regional, municipal, and community partners during hot weather events, episodes of wildfire smoke, and other climate emergencies. The program is also working to integrate climate preparedness and community resilience across all Divisions and business units of the health department.[31] Other program accomplishments include:

- a collaboration with the National Weather Service Burlington office to reduce the heat index threshold for issuing Heat Advisories from 100°F to 95°F, which supports the communication of critical heat safety messaging to Vermonters during periods of dangerous hot weather.
- development of guidance and a template for municipalities to plan for responding to hot weather emergencies, including providing training to every Regional Planning Commission (RPCs) and Local Health Office to assist municipalities with plan development, leading to development of 30 municipal hot weather response plans.
- development of an online map tool to inventory and share information about places that the public could go to cool off during periods of hot weather. The cooling sites webpage received over 10,000 visits in 2024.
- Synthesizing scientific evidence about the health benefits of providing home weatherization services to low-income households and used this evidence to estimate monetizable health benefits related to increased thermal safety, improved indoor and outdoor air quality, and fuel savings.

Strengths and Limitations

Strengths

1. Counting intermediate outcomes in climate impacted areas can be used as a proxy for climate impacts on health when those outcomes are harder to count

2. Every arrow is an opportunity – Each "modulating factor" arrow is an opportunity to either reduce or increase risk of exposure and harm. Therefore the design of every adaptation action, mitigation action, and public health intervention should ensure that it addresses 1) social and institutional inequities 2) physical, social, and economic infrastructure 3) baseline inequities in health and wellbeing, in order to minimize adverse health outcomes and maximize health co-benefits.

3. Not about us without us – Make room for marginalized voices to lead and advocate for their needs. Impossible to know what sources of stress and injury are unless affected groups are meaningfully involved.

This chapter has endeavored to develop a conceptual model that is rich enough that it can better support efforts to develop, monitor, and assess the climate adaptation and climate mitigation actions. The resulting model, developed from a public health perspective, centers on the human experience of climate change, and reflects the interests and biases of the authors and the limitations of their perspectives. Our hope is that this limitation will be addressed in part by the public review process. A second important limitation is that this chapter does not examine the societal or health implications of positive feedback cycles, tipping points, or abrupt climate change. We assume that climate changes will occur in a gradual or incremental manner, not in an abrupt or step-change manner, which is unlikely under higher emissions or "business-as-usual" emissions scenarios.[32]

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