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

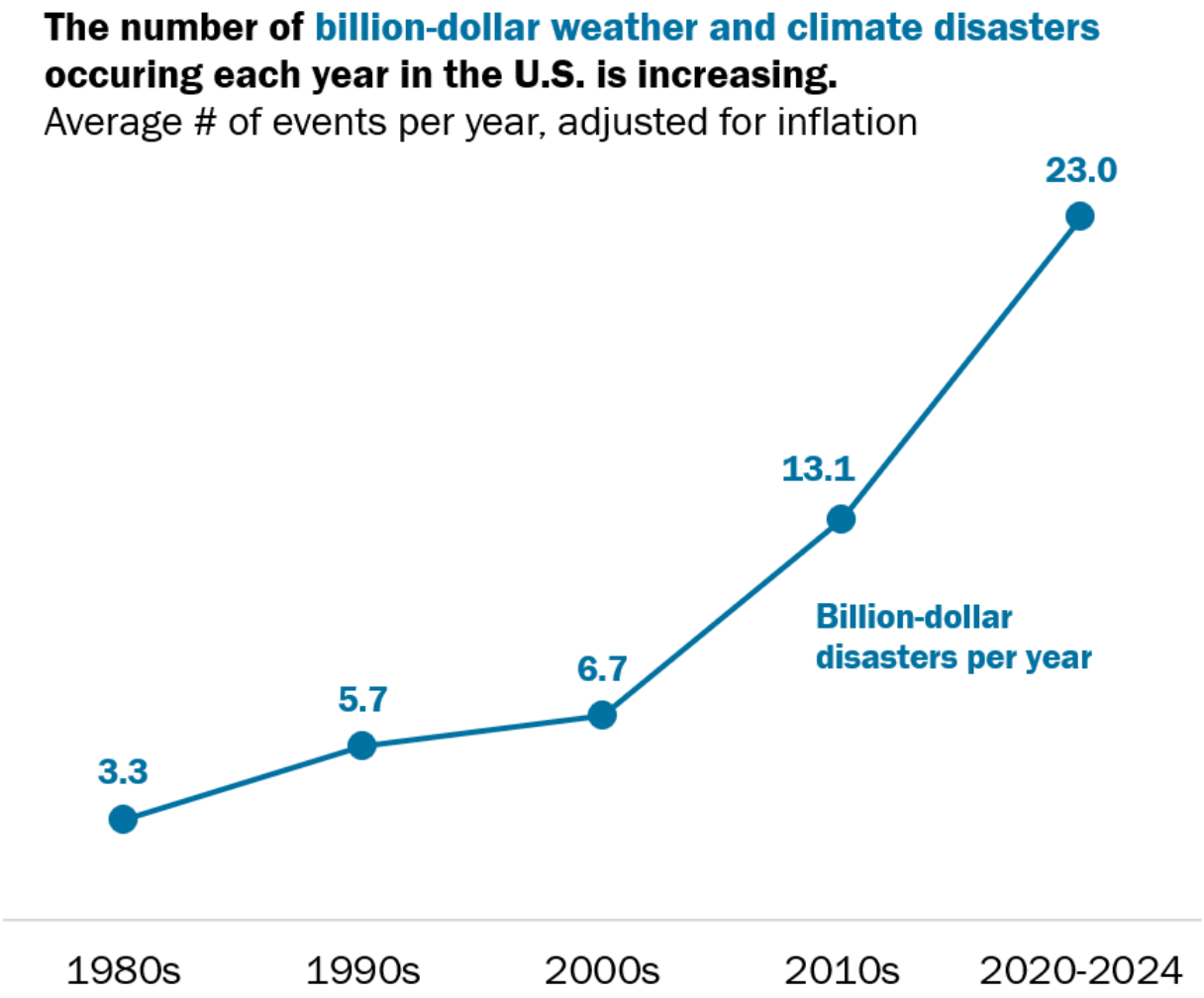

Figure 4. The average number of weather and climate disasters with overall damages/costs exceeding one billion dollars occurring in the United States each year, grouped by decade.[1]

Introduction

The desire to protect human health from the impacts of climate change was one of the central motivations for reducing emissions of planet-warming gases cited by the Vermont's Global

Warming Solutions Act, "[a] climate emergency threatens our communities, State, and region and poses a significant threat to human health and safety, infrastructure, biodiversity, our common environment, and our economy."[2] Deepening our understanding of how the climate emergency threatens human health can help direct the prioritization of actions as part of the Climate Action Plan.

In 2021, over 200 medical and health journals, led by The Lancet and the New England Journal of Medicine, released a joint statement declaring climate change the "greatest threat to global public health."[3] This threat includes both direct, acute impacts on health such as illness caused by extreme heat, wildfire smoke, vector-borne diseases, as well as delayed and persistent indirect effects exacerbated by chronic stress, economic hardship, and damage to housing and other critical infrastructure. To date, efforts to reduce health impacts caused by climate change in Vermont have focused primarily on direct health impacts. The long-term impacts on Vermonters' health and well-being of the catastrophic flooding that occurred in 2011, 2023 and 2024, especially the physical and mental health toll of the clean-up and recovery phase, have not been central to discussion of the climate impacts on health. The aim of this chapter is to improve our understanding of these kinds of indirect health impacts so that we can do a better job preventing, measuring, and managing them in the future.

Direct Impacts

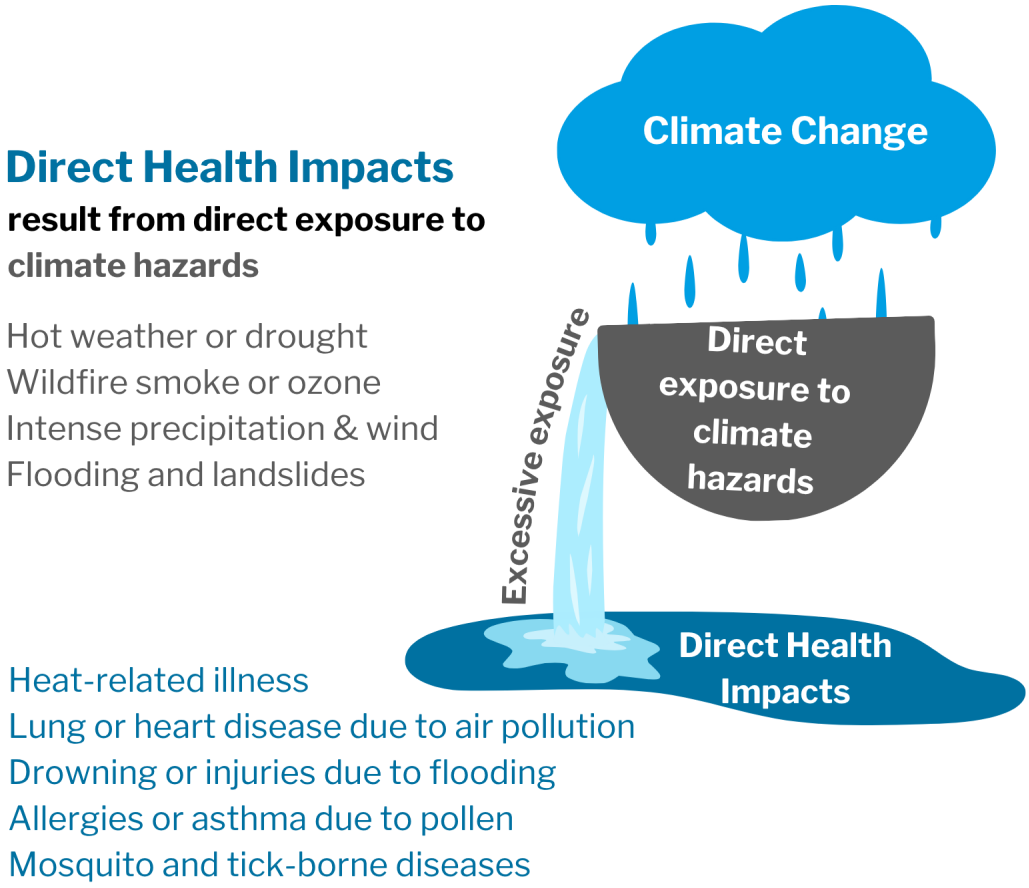

Figure 5. Direct health impacts of climate change.

Prior summaries of the health impacts of climate change in Vermont[4,5,6] and nationally[7] primarily focus on the health risks directly associated with climate change. Direct impacts include illnesses, injuries or deaths that can be directly attributed to changing temperatures or weather patterns or weather disasters made more intense by climate change.

Efforts to quantifying and prevent direct health impacts[8] are essential; however we also need to be able to identify, measure, and address those health impacts associated with economic

hardship, grief, stress, damaged homes and infrastructure, displacement and loss of connection that can result from flooding, landslides, drought, or incremental climate change.

Indirect Impacts

Key Message 1: The impacts of climate on health can be sudden and direct, or more gradual and indirect, as environmental changes undermine the conditions that support our health, including our physical surroundings, economic stability, and social support systems.

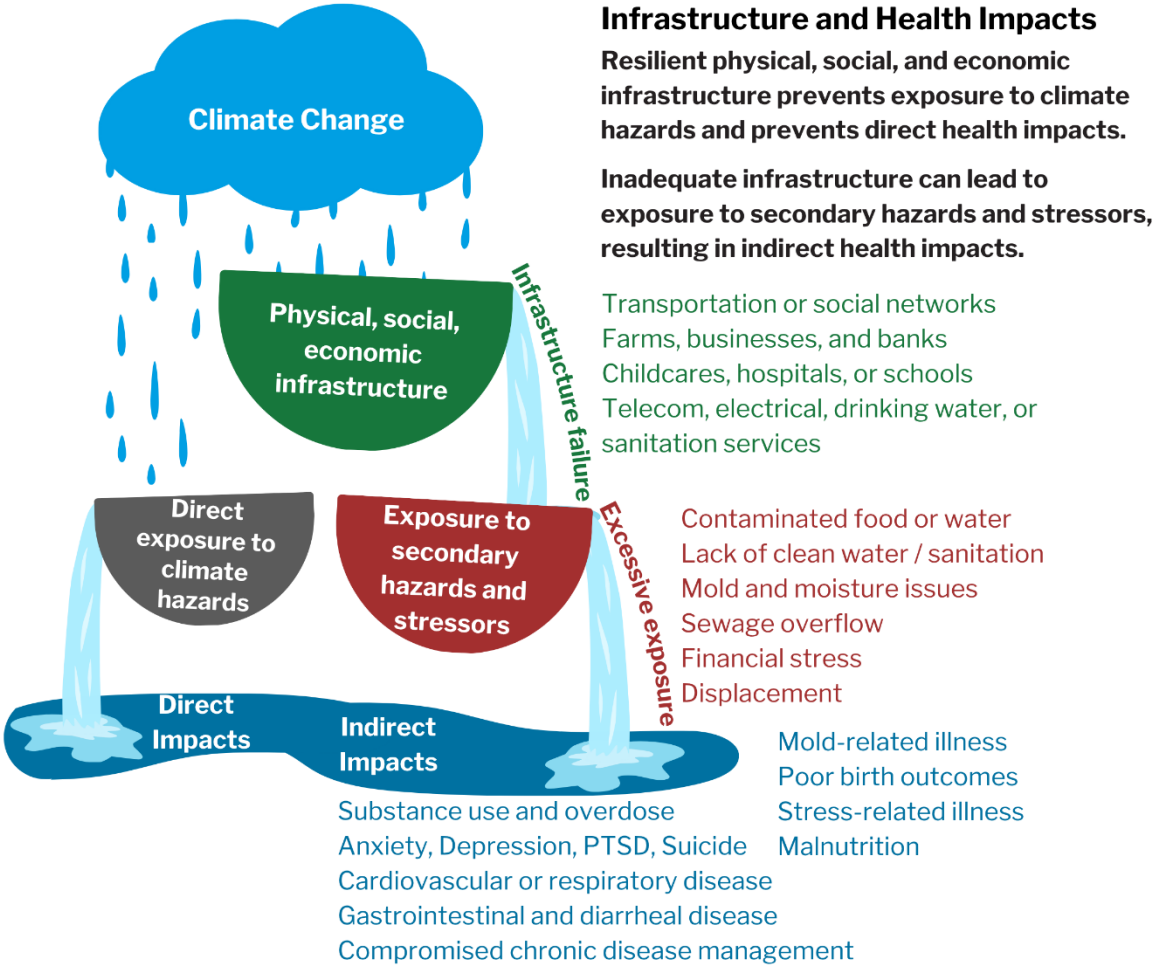

Figure 6. Indirect health impacts result from climate-related damage to physical, social, and economic infrastructure, natural systems or essential services.

Climate change affects human health indirectly through its 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 'loads-the-dice', reducing the likelihood that an individual will be healthy. This degradation can occur gradually, for example when we restrict outdoor activities due to a lack of snow or ice, or to limit tick or mosquito-borne disease risks. The conditions in which we live can also degrade suddenly, due to destruction caused by floods, landslides, or wildfire. While not specific to Vermont, one study that examined the relative size and importance of indirect impacts found that the number of deaths attributable to the longer-term social and economic effects of hurricanes during the 15 years after a storm was 300 to 480 times greater than the number of deaths that occurred in the immediate aftermath of the storm.[9]

Indirect impacts also include opportunity costs. For example, when a family living in an area impacted by repeated extreme weather events has to pay more for homeowner's insurance, groceries, air conditioning, or storm repairs,[10] they have less money available to spend on food, housing, recreation, and healthcare. Climate change can have similar effect on the expenses of towns or the state as a whole.

> *"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[11]

Funds that are required to repair roads and essential infrastructure cannot be invested in infrastructure for walkers, cyclists or public transportation, police, fire, and EMS services, libraries, parks and recreation, drinking or wastewater infrastructure. Some towns' debts from road and infrastructure repair from the flooding that occurred in 2023 and 2024 exceeded their annual budgets.[12] These community-wide impacts affect property values, the tax-base[13], and

the labor market.[14] Agriculture provides another example of infrastructure damage mediating health impacts: In 2023, flooding events and severe weather in Vermont caused more than $16 million in losses across 27,000 acres of farmland.[15] Apart from the economic losses and resulting stress and anguish for farmers, crop and livestock losses may affect the availability of local food options for consumers who live nearby.

Baseline Wellbeing and Health Status Modify Exposure and Resilience

Key Message 2: Compromised health or well-being increases the risk of exposure to climate hazards and the likelihood that those exposures will result in negative impacts such as illness, death, or the loss of values that contribute to well-being, like sense of identity, self-determination, influence, or dignity.

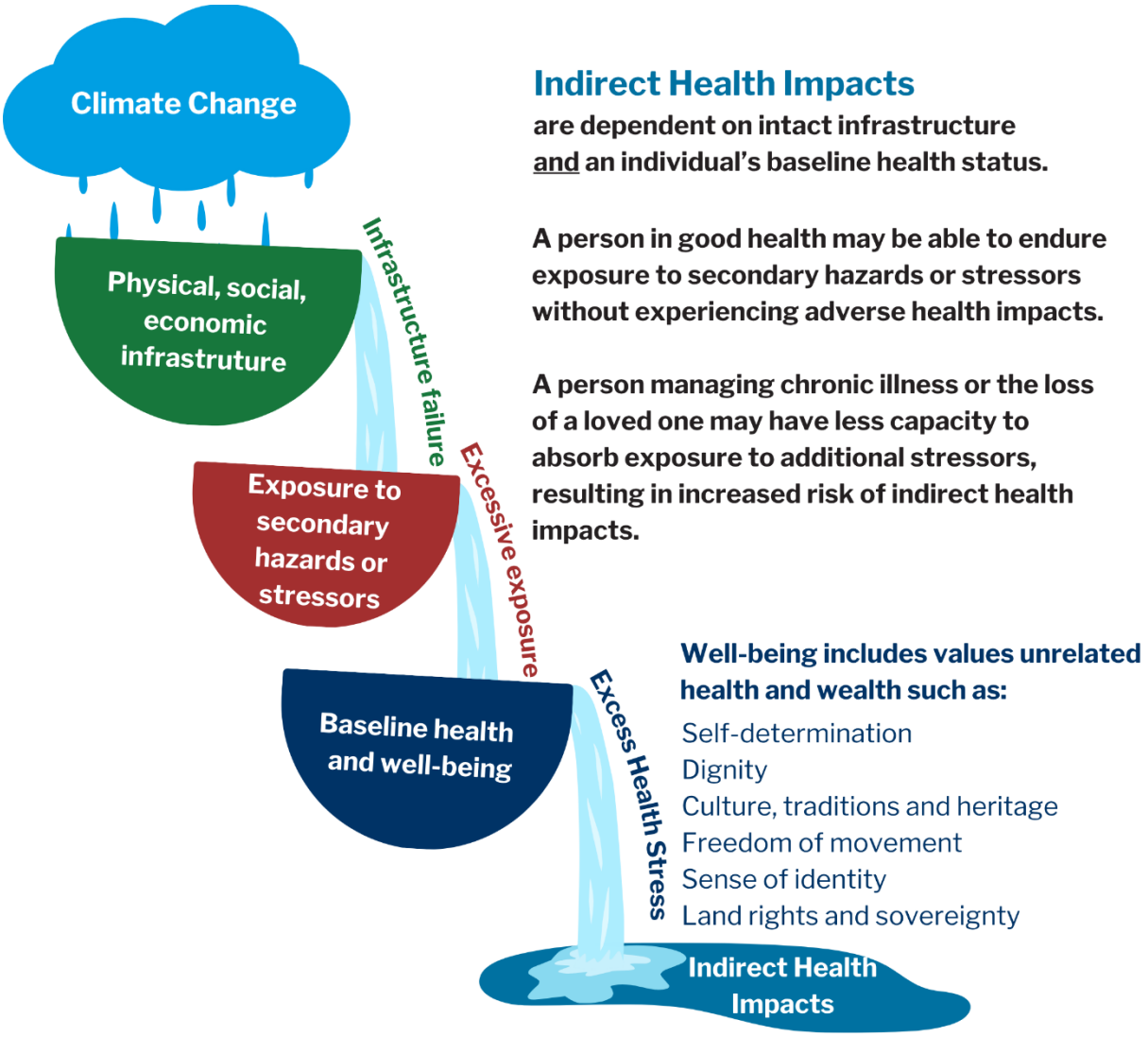

Figure 7. People's baseline health and well-being impacts their resilience to harm when exposed to secondary climate hazards stressors like contaminated food or water, financial stress, or loss of their home.

Poor health can affect a person's exposure to climate hazards. Someone in poor health might not be able to evacuate without assistance during a flooding event and may have more difficulty finding adequate housing if their home is uninhabitable. Someone who relies on medical devices like an oxygen concentrator or dialysis machine will be exposed to greater risk during a power outage. It may also take someone in poor health longer to recover from a climate disaster, and that exposure may, in turn, prolong their illness. Similarly, a person's baseline health can affect whether exposure to a climate hazard will result in health impacts

and the severity of those impacts. For example, someone experiencing anxiety or depression may find that their symptoms worsen during a heatwave. A road closure or disruption in mail service may be life-threatening for someone dependent on medication or daily therapies such as dialysis to manage a chronic illness.

Determinants of well-being beyond money and health can also be impacted by climate change[16] and can reinforce or undermine a person's resilience. Examples of 'non-economic values' that influence well-being are listed in Figure 7. When values such as dignity, influence, and self-determination are preserved, they can help insulate people from the stresses associated with living in an area affected by a natural disaster, like lack of access to clean water, sanitation, or having to live as guest in a shelter or someone else's home. Alternatively, repeated exposure to daily stress increases the risks of substance use, intimate partner violence, post-traumatic stress disorder, anxiety, depression, suicidal ideation, and stress-related illness such as cardiovascular disease. First-person narratives are helpful to convey impacts on non-economic values in ways that maps of disease and injury rates cannot.

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

- Vermont resident 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."

- Vermont resident 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."*

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

"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…"

- Flood survivor[20]

"*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"*

- Individual describing the impact of extended drought[21]

Societal and Institutional Inequities

Key Message 3: Individuals or communities with the least economic, social, or political resources tend to experience the greatest risks and impacts associated with climate change hazards.

The impacts of climate change are most severe for segments of the population that have historically had the least social, political, and economic power and capital. These groups often live closest to the edge, whether on a literal edge like a floodplain, or on the figurative edge of losing access to housing, employment, childcare, food, health care, and family support. As a result, 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.[22] Groups that are impacted 'first and worst' by climate change may also be at the greatest risk during non-climate natural disasters such as infectious disease pandemics, economic recessions, or other societal disruptions. Because they are more likely to have experienced prior loss or trauma, and because of disparities in social, political, and economic capital, these groups are subject to increased exposure to chronic stress[23], which contributes to their baseline mental and physical health burden.

Examples of groups at increased risk of exposure due to physical, social or economic infrastructure

- People who work outdoors, including farmworkers
- People experiencing homelessness
- People who are incarcerated
- People living in flood plains
- People living on upper stories of buildings in urban areas (due to heat risk)
- People living at home alone with few social ties

Examples of groups at increased risk of harm due to baseline health or well-being

- People with disabilities
- People with poor mental health, prior trauma, or adverse childhood experiences
- People with substance use disorder/s
- People at greater risk due to age (e.g. the elderly, babies, and children)
- People with a chronic or pre-existing medical condition
- People on medications that increase the risk of harm in hot weather

Examples of groups at increased risk due to social and institutional inequities

- People with lower-income or few assets
- Black, Indigenous, and People of Color
- Veterans
- Immigrants, Refugees, Asylees, and Asylum-Seekers
- People who live in rural settings
- People with limited English proficiency
- Members of the LGBTQ+ community
- Renters

Figure 8. Examples of groups that may be disproportionately affected by climate change impacts on individual health and community resilience.

Sources of Climate-related Stress

Key Message 4: Climate-related impacts on the health of a community, like increased cost of living, unemployment and housing insecurity, act as chronic stressors at the individual-level, undermining physical and mental well-being.

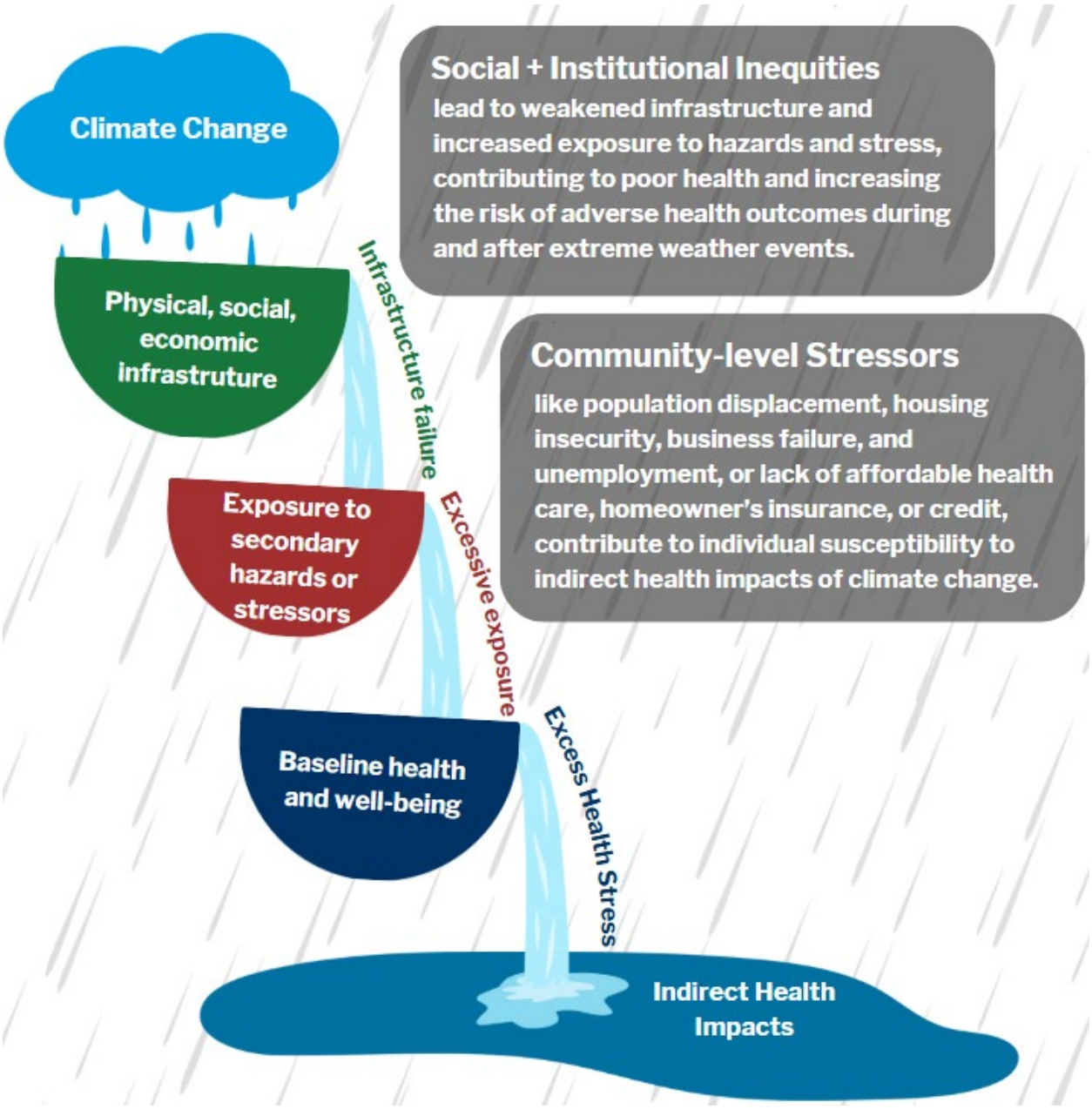

Figure 9. Climate-related hazards and stressors add to a person's cumulative exposure to chronic stress. Repeated climate disasters exacerbate social and institutional inequities and community-level stressors, reducing individual and community resilience during subsequent emergencies.

Under normal conditions, sources of chronic stress could include job loss, losing a loved one, worrying about how to pay rent or buy food, or a divorce. In the aftermath of a disaster, chronic

stress could include things like overcrowded or inadequate housing, lack of access to clean water, heat or sanitation, discrimination, stigma, or lack of access to education and employment. The Fifth National Climate Assessment,[24] provides examples of elements of community resilience that that are affected by climate disruption, shown in **Figure 6**. Through their impacts on chronic stress, these indicators of community resilience (including rates of crime and domestic violence,[25] substance use,[26] and student absenteeism[27]) can impact individual physical and mental well-being.

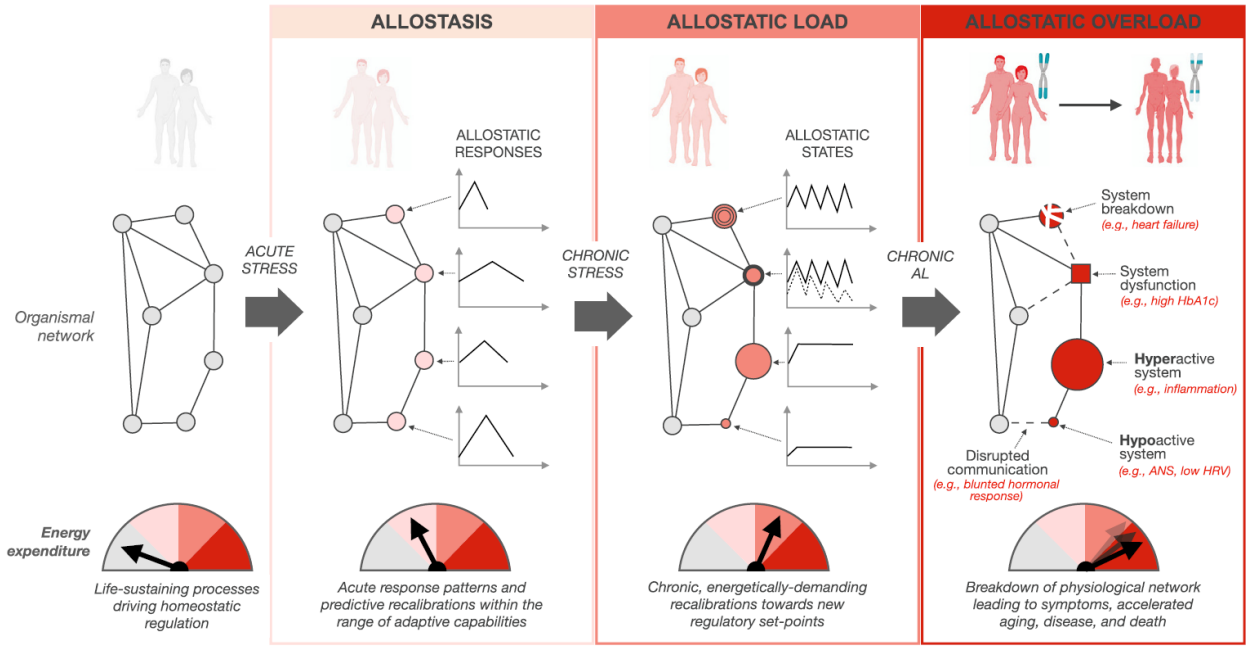

Figure 10. The Allostatic Load model for how stress leads to disease.[28]

Allostatic load is 'wear-and-tear' on the body that results from (energy-consuming and potentially unhealthy) cellular, physiological, or behavioral adaptations to stress[29], for example the thickening of arterial walls in response to chronically elevated blood pressure. Allostatic load provides a model for understanding how chronic stress can translate into pathology. Similarly, the physical or financial stress of responding to natural disasters or climate change contributes to 'wear-and-tear' (i.e. indirect impacts) for affected individuals and communities, in part because the time, energy, and dollars expended could have been put to more productive use.

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

By incorporating indirect impacts into our understanding of how climate impacts health, it becomes clearer how actions that aim to prevent damage to physical, social, or economic infrastructure contribute to the protection of health and well-being. The Climate Action Plan, the State Hazard Mitigation Plan, the Resilience Implementation Strategy, and the State Health Improvement Plan, all include actions that help insulate people's health from climate impacts by shoring up infrastructure and/or essential services. Federal, state, or non-profit programs designed to provide financial assistance to impacted individuals, farms, or other businesses, can help reduce the indirect health impacts associated with financial stress. Finally, efforts that are specifically targeted to address health risks include the Department of Mental Health's flood recovery outreach program Starting Over Strong, Farm First Vermont's flooding and disaster relief services, and the Vermont Department of Health's efforts to provide guidance and support to municipalities, schools, child cares, residential care facilities, and homeless shelters to develop hot weather response plans and increase hot weather preparedness.

Conclusion

In order for our understanding of the health impacts of climate change to reflect Vermonters' experience with repeated climate disasters during the last 15 years, it must include both direct impacts and indirect impacts that result from damage to physical, social, and economic infrastructure. Since most indirect health impacts of climate change do not result in a visit to the emergency room or admission to the hospital, they need to be accounted for in other ways, for example by monitoring how flooding events impact housing, food, and economic security. An improved understanding of indirect health impacts, paired with the capacity to measure them, can help to ensure that climate adaptation and response actions do a better job protecting human health and well-being in the future.

[1] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2025). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73

[2] Global Warming Solutions Act, 2020, Vermont State Legislature, Act 153, Sec 2.1, Page 1. https://legislature.vermont.gov/Documents/2020/Docs/ACTS/ACT153/ACT153%20As%20Enacted.pdf

[3] Atwoli, Lukoye, Abdullah H. Baqui, Thomas Benfield, Raffaella Bosurgi, Fiona Godlee, Stephen Hancocks, Richard Horton et al. "Call for emergency action to limit global temperature increases, restore biodiversity, and protect health." The Lancet 398, no. 10304 (2021): 939-941. https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(21)01915-2.pdf

[4] Vermont State Hazard Mitigation Plan, 2023, Vermont Emergency Management. https://vem.vermont.gov/sites/demhs/files/documents/2023%20SHMP_Adopted%20Draft%20Jan2024.pdf

[5] Clement, S., Mezzacapo, M., 2021. Human Health. In Galford, G.L., Faulkner, J. et al. (Eds), The Vermont Climate Assessment 2021. Burlington, Vermont: Gund Institute for Environment at the University of Vermont. DOI: 10.18125/kowgvg.

[6] VT Dept. Health. (accessed Feb 26 2025). Health Risks of Climate Change. *Climate and Health Program*. https://www.healthvermont.gov/environment/climate-health/health-risks-climate-change

[7] Hayden, M.H. *et al.*, 2023: Ch. 15. Human health. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH15

[8] VT Dept. Health. (accessed May 23 2025). Health Risks of Climate Change.

[9] Young, Rachel, and Solomon Hsiang. "Mortality caused by tropical cyclones in the United States." *Nature* 635, no. 8037 (2024): 121-128. https://www.nature.com/articles/s41586-024-07945-5

[10] Hsiang, S. *et al.*, 2023: Ch. 19. Economics. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH19

[11] Peter Hirschfeld, “FEMA's plodding bureaucracy exacts financial toll on Vermont towns” *Vermont Public*, September 23, 2024. https://www.vermontpublic.org/local-news/2024-09-23/fema-plodding-bureaucracy-puts-small-rural-vermont-towns-debt

[12] Kevin O’Conner, “Flooding long past, many Vermont municipalities are still swimming in red ink” *VTDigger*, February 27 2025. https://vtdigger.org/2025/02/26/flooding-long-past-many-vermont-municipalities-are-still-swimming-in-red-ink/

[13] Hsiang, S. *et al.*, 2023: Ch. 19. Economics. In: Fifth National Climate Assessment. USGCRP.

[14] Coulombe, Raphaelle G., and Akhil Rao. "Fires and local labor markets." *Journal of Environmental Economics and Management* 130 (2025): 103109.

[15] VT Agency of Agriculture Food and Markets. (accessed March 22 2025). 2023 Extreme Weather Impact & Recovery Report. https://agriculture.vermont.gov/severe-weather-and-flooding-agricultural-impacts-survey-2024

[16] Tschakert, Petra, Neville R. Ellis, Christopher Anderson, Adam Kelly, and James Obeng. "One thousand ways to experience loss: A systematic analysis of climate-related intangible harm from around the world." *Global Environmental Change* 55 (2019): 58-72.

[17] Buschman, V., Fernandes, C., Guth, S., Mullen, A., Rosales-Underbrink, P. “Tropical Storm Irene: A Retrospective on Mental and Emotional Impacts on Vermont Communities, Three Years Later” *Middlebury College Community Engaged Practicum*, Fall 2014B. https://drive.google.com/drive/folders/1KOYE7fyJZ1Fbryol5LbUXG_Kxrfy9Yw0?usp=sharing

[18] Carmichael, C., Danks, C., Vatovec, C. “Health Impacts of Climate Change: Perspectives from Waterbury, Vermont” *Presentation at Northeast Vermont Regional Hospital*, Feb 14, 2019.

[19] Tschakert, Petra *et al. Global Environmental Change* 55 (2019): 58-72.

[20] Tapsell, S.M., Tunstall, S.M., 2008. “I wish I’d never heard of Banbury”: the relationship between ‘place’ and the health impacts from flooding. Heal. Place 14, 133–154. https://doi.org/10.1016/j.healthplace.2007.05.006.

[21] Tschakert, Petra *et al. Global Environmental Change* 55 (2019): 58-72.

[22] McKee, M., Reeves, A., Clair, A. *et al.* Living on the edge: precariousness and why it matters for health. *Arch Public Health* **75**, 13 (2017). https://doi.org/10.1186/s13690-017-0183-y

[23] Geronimus A.T., “Weathering: The Extraordinary Stress of Ordinary Life in an Unjust Society”, *Hachette Book Group*, 2023. https://www.hachettebookgroup.com/titles/dr-arline-t-geronimus/weathering/9780316257978/

[24] Hsiang, S. *et al.*, 2023: Ch. 19. Economics. In: Fifth National Climate Assessment. USGCRP.

[25] Le Masson, V., 2022. Disasters, climate change, and violence against women and girls. In *Oxford Research Encyclopedia of Natural Hazard Science*. https://doi.org/10.1093/acrefore/9780199389407.013.393

[26] Vergunst, F., Berry, H. L., Minor, K., & Chadi, N. (2023). Climate Change and Substance-Use Behaviors: A Risk-Pathways Framework. *Perspectives on Psychological Science*, *18*(4), 936-954. https://doi.org/10.1177/17456916221132739

[27] United Nations Office for Disaster Risk Reduction. The invisible toll of disasters. *UNDRR* https://www.undrr.org/explainer/the-invisible-toll-of-disasters-2022 (2022).

[28] Bobba-Alves, Natalia, Robert-Paul Juster, and Martin Picard. "The energetic cost of allostasis and allostatic load." Psychoneuroendocrinology 146 (2022): 105951. https://www.sciencedirect.com/science/article/pii/S030645302200292X

[29] Juster, Robert-Paul, Bruce S. McEwen, and Sonia J. Lupien. "Allostatic load biomarkers of chronic stress and impact on health and cognition." *Neuroscience & Biobehavioral Reviews* 35, no. 1 (2010): 2-16. https://www.ebtconnect.net/science/biomarkers_juster.pdf