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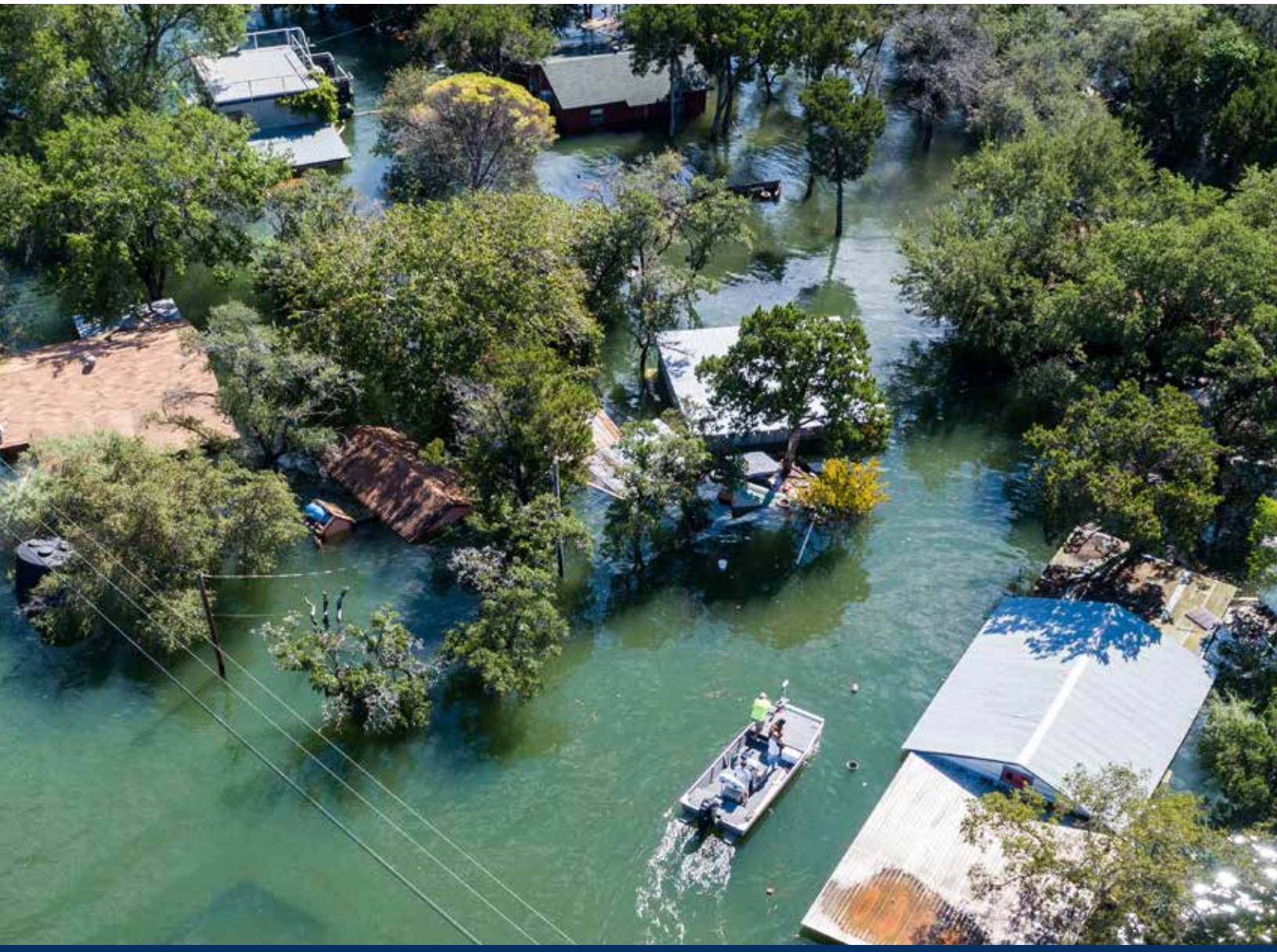

Building a Climate-Resilient Healthcare System

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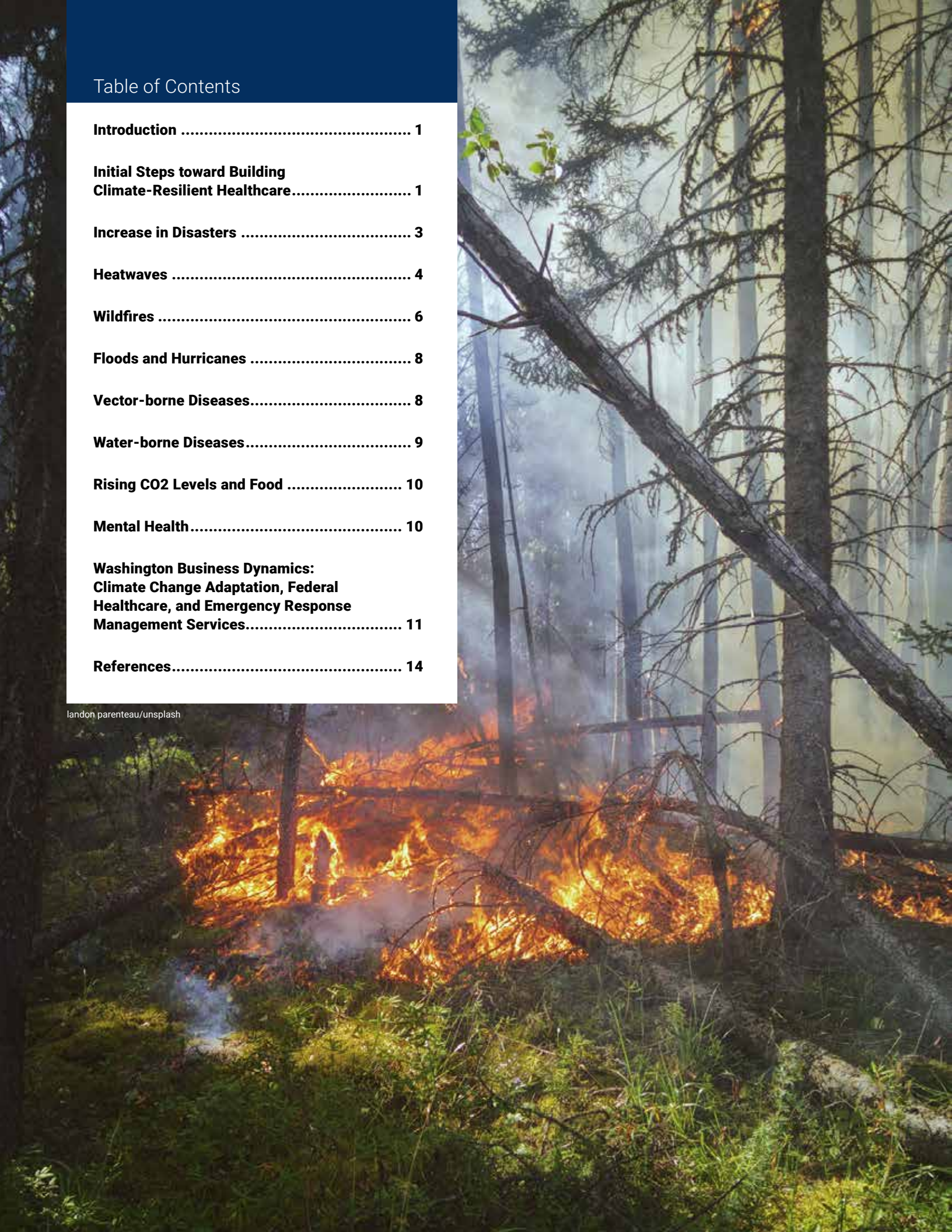
Table of Contents



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Introduction

Each year, environmental factors due to anthropogenic climate change kill at least 13 million people worldwide, and casualties are predicted to rise significantly over the coming decade.[1] The World Health Organization (WHO) finds that climate change is the single biggest health threat facing humanity. The Earth is now 1.8° F (1.1° C) warmer than pre-industrial times and is predicted to get even warmer by 2050. As a result, more severe heatwaves, floods, droughts, wildfires, diseases, and storms are causing **poorer health and increased death rates in record numbers.** The 2022 Intergovernmental Panel on Climate Change (ICPP) states, with *very high confidence*, that climate-related illnesses, premature deaths, malnutrition, and threats to mental health will continue to increase in the near and long term.[2]

Even though global warming is expected to continue at the world's current and predicted rate of greenhouse gas (GHG) emissions, investing in policies to reduce greenhouse gases and implementing adaptation measures could reduce the most severe impacts of climate change. Concurrently, the United States must invest more in **developing a coordinated, climate-resilient health system that could prepare for and quickly respond to related disasters to mitigate the health risks and deaths caused by extreme weather events.** To date, U.S. government and non-government healthcare entities incorporate conjoint climate change and health factors in a disconnected manner, often leaving out health outcomes in climate change adaptation preparedness altogether.[3] But **by integrating climate change and health impacts in a coordinated healthcare and emergency response system** — beginning with a nationwide vulnerability assessment that identifies hazards and prepares adaptation and mitigation measures by a designated lead entity — **the U.S. can build a climate-resilient healthcare system that will reduce risks and save lives in the near and long-term.**[4]

Elements of a climate-resilient healthcare system should include:[5]

- Increased adaptive capacity
- Advanced supply chains developed to respond to extreme weather events
- Improved health service capacity and resources that address vector-borne and water-borne diseases
- Increase funding of cross-disciplinary research that links meteorology, climatology, and disaster risk management with health
- Improved early warning systems that communicate health risks and preparedness during extreme weather events (e.g., heatwaves)
- Advanced surveillance systems to monitor vector- and water-borne diseases
- Linked climate change adaptation measures with disaster response and healthcare systems

Initial Steps toward Building Climate-Resilient Healthcare

In 2021, the U.S. federal government began to acknowledge the risk climate change poses on its healthcare systems and is starting to seek ways to mitigate certain risks. The U.S. House Ways and Means Committee in 2022 identified the impact of climate change on U.S. healthcare systems, noting that GHG emissions in the sector account for 10 percent of GHG emissions nationwide.[6] The Committee sent a Request for Information on March 24, 2022, to hospitals and other healthcare systems and providers asking how climate change has affected the health sector and what they are doing to reduce emissions.[7] The Committee also noted other initial steps the U.S. government has taken in considering the impact of climate change on its healthcare system, including:

- President Biden signed an Executive Order on Tackling the Climate Crisis at Home and Abroad in January 2021
- The Department of Health and Human Services (HHS) established the Office of Climate Change and Health Equity at the Department of Health and Human August 2021
- HHS published a Request for Information on the health consequences of climate change and ways to mitigate, adapt, and prepare for climate change impacts in May 2022

Local communities should adopt climate-resilient plans that include preparing and coordinating their health and emergency systems to respond to extreme weather-related events. Plans should begin with Environmental Protection Agency (EPA) conducting a vulnerability assessment to identify hazards; then implement adaptation measures with continuous monitoring and reassessment. Specifically, a plan should address frontline communities — where residents experience the worse consequences of climate change at higher levels. Low-income communities and communities of color frequently lack the basic infrastructure to support them during climate-related impacts such as floods or extreme heat events, such as the Lower 9th Ward in New Orleans during Hurricane Katrina in 2005.

> "Currently, efforts to address climate within the health sector are piecemeal and vary by organization and region. This RFI is an important effort to elevate the climate dialogue to a national level to ensure a robust, coordinated effort that can provide needed assistance to health care organizations as they tackle these challenging issues." — Press Release, **House Ways and Means Committee, March 24, 2022**

Federal policies that integrate climate change risks and adaptation measures into coordinated U.S. healthcare and disaster risk management systems will create a better-equipped

healthcare and emergency response workforce by improving tools to respond to extreme weather-related events, such as early warning systems.[8] Healthcare officials will also acquire the acumen to build climate-resilient measures into their systems. Given the large GHG footprint of the healthcare sector, an informed workforce can begin to implement adaptation and mitigation measures to reduce GHG emissions. Integrating climate change into **healthcare and disaster response systems should begin with a nationwide vulnerability assessment with vulnerability index maps for all hazards and implement adaptation measures.**[9] Increased coordination between the healthcare community and disaster response entities around climate change risks will strengthen climate change adaptation and mitigation measures that save lives during extreme weather events.

Further, a designated climate change and health entity should quantify climate change health outcomes' current magnitude and costs and develop future risk scenarios. Determining the health co-benefits and cost savings of adaptation and mitigation policies should drive future policy.

> "[S]ome climate-related hazards, like extreme heat, fall outside of the official or perceived domains of responsibility for professional disaster management agencies or are approached through a distributed governance model with no designated lead entity. The key policy levers for health-sector decision makers are climate change adaptation, GHG mitigation, and disaster risk management. To date, cross-sector adaptation efforts have been largely incremental, adjusting existing systems while maintaining their core structure and function." — Kristie Ebi et al. "Extreme Weather and Climate Change: Population Health and Health System Implications," *Annual Review of Public Health*, April 2021.

The connection between climate change and health is still in its infancy in the United States. Several federal agencies, including the **EPA and the Centers for Disease Control (CDC), are taking initial steps to "advance the dialogue in connecting climate change and human health."**[10] However, a robust and coordinated system that integrates climate change indicators (e.g., GHG levels, rising temperatures, sea level rise) into weather-related **health pathways** (e.g., floods, wildfires, disease-carrying vectors) and **health outcomes** is lacking.[11]

The statutory foundation for action exists. Congress mandated the Global Climate Change Research Act of 1990 to "develop and coordinate a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change."[12] One of the program's legal requirements is to "Improve cooperation among Federal agencies and departments with respect to global change research activities."[13] The U.S. Global Change Research Program emerged from this act, and it publishes the National Climate Assessment. The latest assessment, the Fourth National Assessment 2018, *described* the health risks due to climate change, but a key finding established that:

> "While mitigation and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades." — The Fourth National Climate Assessment, Volume II: Impacts, Risks, and Adaptations in the United States

In January 2021, President Biden established the Office of Climate and Health Equity (OCCHE) in HHS. The office attempts to support a "whole of government approach" and Biden Administration initiatives on the climate change impacts of extreme heat.[14] Although it lacks congressionally appropriated funds to incorporate climate change into the nation's healthcare system, the OCCHE can use HHS regulatory and statutory powers to address climate change impacts on frontline communities. The office also works alongside state, local, community-based, academic, and non-government organizations to address health disparities due to climate change and improve community resilience and can offer training to healthcare workers and community-based organizations. Yet in October 2022, HHS's senior advisor to OCCHE, Arsenio Mataka, told the non-profit foundation The Commonwealth Fund, "We're just scratching the surface of what's possible."[15]

Because Americans are dying now in higher numbers from more frequent and intense extreme weather events, they cannot wait for the federal government to begin the conversation toward nationwide adaptation measures. Absent a designated entity to integrate climate change into a national healthcare and emergency response systems, in 2022, the biotechnology firm Biogen is funding the non-government organization Americares and Harvard University's Center for Climate, Health, and the Global Environment at Harvard T.H. Chan School of Public Health to build a "Climate Resilience for Frontline Clinics Toolkit." The toolkit targets free clinics and federally qualified health centers because, "These clinics have gotten the least amount of attention and the least amount of investment in preparedness but see the patients who are most vulnerable to the impacts of the climate crisis," states Kristin Stevens, Americares' director of climate and disaster resilience.[16]

Increase in Disasters

A total of 432 catastrophic natural disasters occurred worldwide in 2021 — a marked increase from the annual average of 357 recorded in 2001–2020.[17] Most were floods, followed by drought and storms. Asia experienced the brunt of these weather-related events, 40 percent, accounting for 49 percent of the total number of deaths. In the United States that year, 20 different billion-dollar-plus weather-related disasters cost more than a billion dollars each; altogether they totaled $145 billion in damages. More than 688 people died in 2021 because of weather-related disasters, the most since 2011 and more than double of the previous year. The National Oceanic and Atmospheric Administration (NOAA) reports a new record for 5-year costs in weather-related disaster events — $764.9 billion from 2017 to 2021.[18]

Record-setting weather and climate-related disasters in 2021 that each resulted on more than $1 billion in damages:

- One winter storm/cold wave event
- One wildfire event
- One drought/heatwave event
- Two flood events
- Three tornado outbreaks
- Four tropical cyclones
- Eight severe weather events

Source: NOAA

Officials from NOAA state that the costliest events in 2021 were Hurricane Ida ($75 billion), the February winter storm and cold wave ($24 billion), and the wildfires in the Western states ($10.9 billion).[19]

> "It is concerning that 2021 was another year in a series of years where we had a high frequency, a high cost, and large diversity of extreme events that affect people's lives and livelihoods—concerning because it hints that the extremely high activity of recent years is becoming the new normal." — NOAA, January 2022

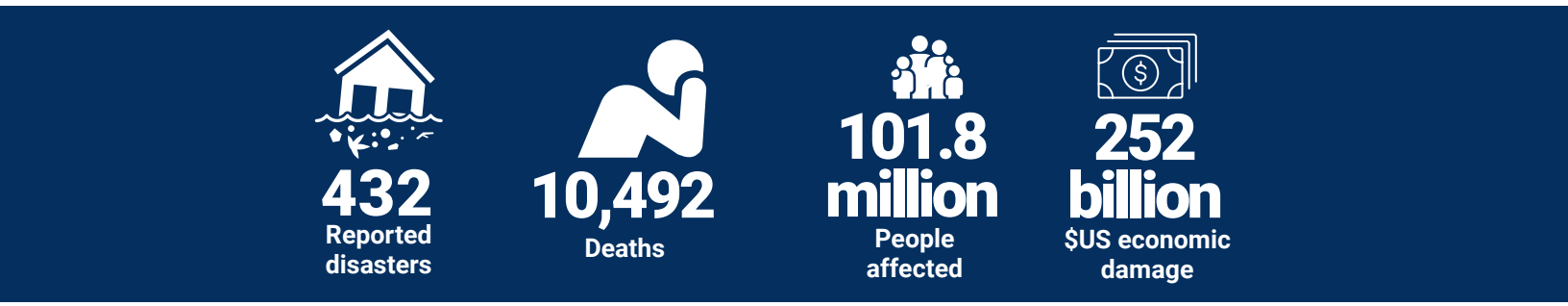
In addition to the immense health risks and adverse outcomes that will increase over the next few decades, the financial costs of a changing climate justify the increased investment. For the first time, in April 2022, the Office of Management Bureau (OMB) predicted that under current U.S. policies,

> "[C]limate change could reduce U.S. GDP by 3 to 10 percent by the end of this century. The new Budget analyses found that, at the upper end of that range, climate change could lead to an annual Federal revenue loss at the end of the century of 7.1 percent, which in today's dollars would equal $2 trillion per year. Furthermore, the analyses found that, the Federal Government could spend between an additional $25 billion to $128 billion annually on just six types of Federal expenditure: coastal disaster relief, flood insurance, crop insurance, healthcare insurance, wildland fire suppression, and flooding at Federal facilities."[20]

The IRA is an encouraging step in the right direction to reduce emissions. Still, the federal government has yet to invest in American health outcomes caused by climate change with equal urgency. **The evidence is clear that the costs in human lives, climate-related illnesses and diseases, injuries, and premature deaths must be the federal government's next right step.**

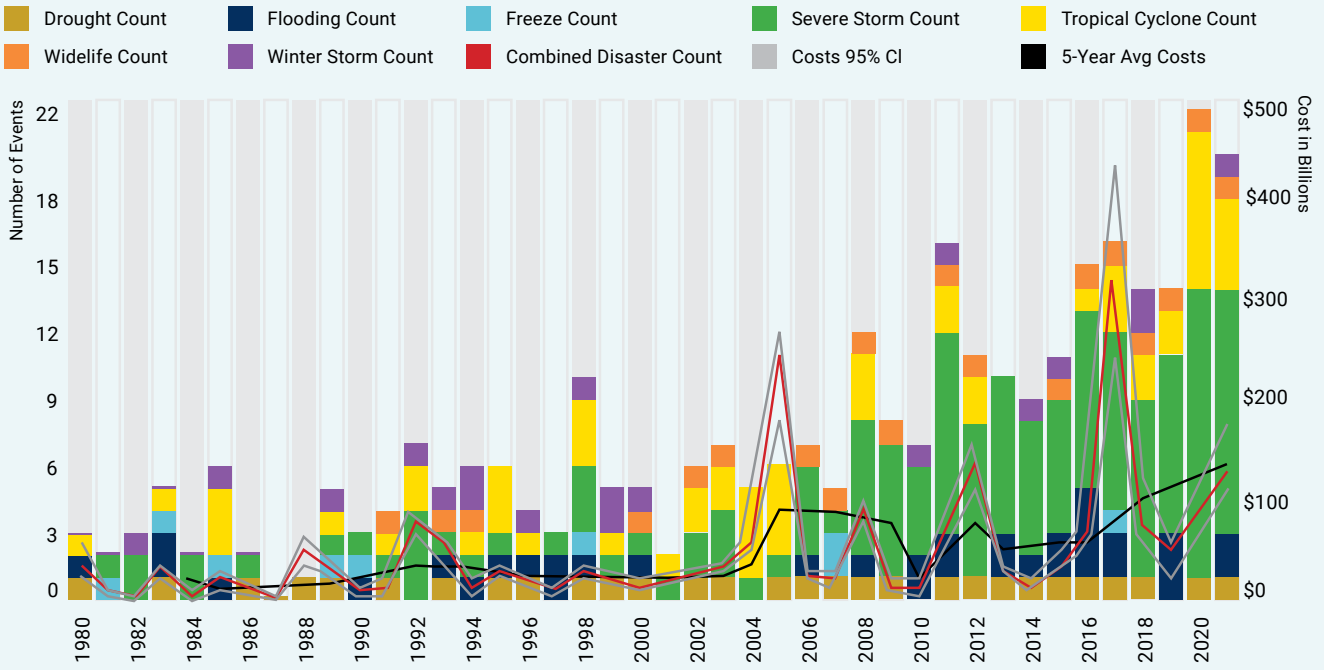
The frequency and intensity of weather-related disasters caused by climate change across the U.S. will increase in the coming decades. Below is what to expect and how the nation must prepare and adapt to the new climate normal.

Worldwide Catastrophic Natural Disasters in 2021



Source: Centre for Research on the Epidemiology of Disasters and USAID. April 2022.[21]

United States Billion-Dollar Disaster Events 1980-2021 (CPI-Adjusted)



Source: NOAA, 2022

Heatwaves

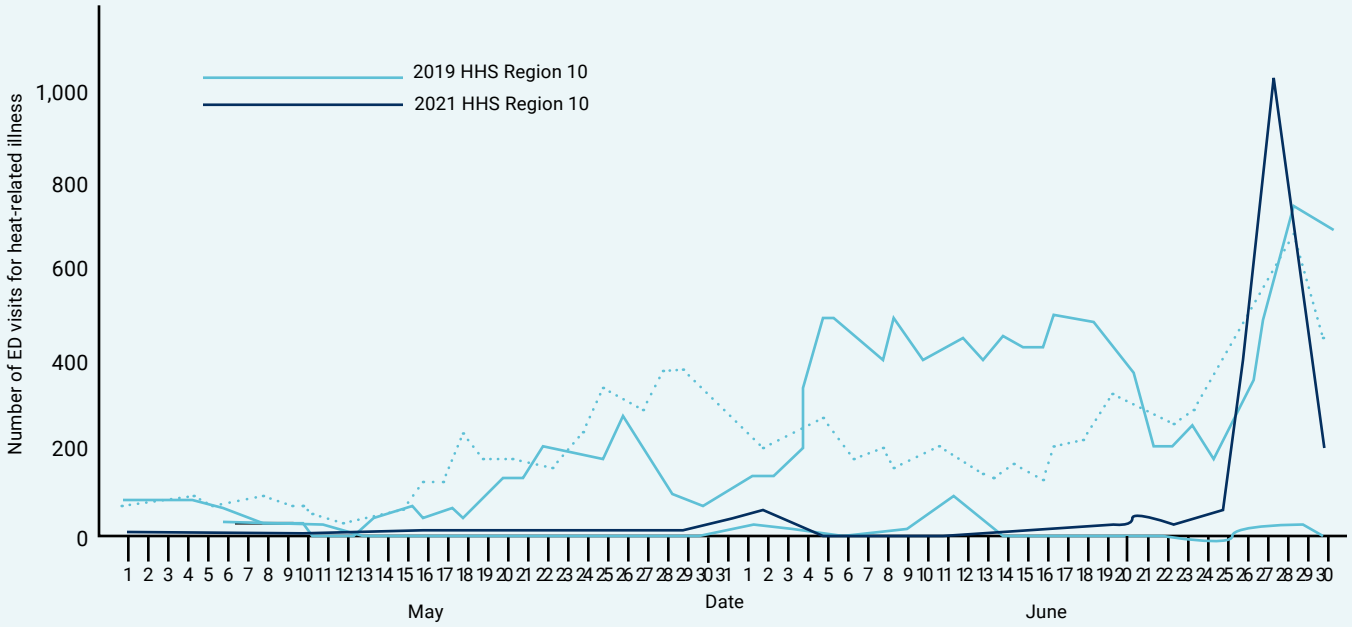
Heatwaves are the deadliest of all extreme weather events in the United States. In late June 2021, a record heatwave in Oregon and Washington state killed more than 400 people in one week.[22] Add British Columbia, and the number rises to 800.[23] Recent studies concluded that heat deaths are severely undercounted in the U.S. "with some studies putting the actual total at thousands each year."[24] As record highs caused by anthropomorphic climate change become more frequent and more extreme, so will heat-related illnesses that can lead to heatstroke, the most serious of several heat-related illnesses. When people suffer from heatstroke, they cannot cool their body down (the ability to sweat fails), and their temperature rises rapidly. Heatstroke can cause a person's temperature to reach 106° F within 10 –15 minutes.[25] Without emergency treatment, heatstroke can result in permanent disability or death.

Outdoor laborers, the elderly, and persons with high blood pressure are susceptible to heat exhaustion because of profuse sweating and excessive loss of water and salt. Other heat-related illnesses include rhabdomyolysis, "a medical condition associated with heat stress and prolonged physical exertion," according to the CDC.[26] This condition causes muscle tissue to breakdown and release electrolytes and large proteins into the bloodstream, causing irregular heart rhythms, seizures, and kidney damage. Other heat-related illnesses can include fainting, heat cramps, and heat rash.

A coordinated disaster and healthcare systems plan must include an early warning and response system that quickly reaches the most vulnerable members of local communities in advance of a heatwave. Local governments with services for people living with disabilities, the elderly, and child and family services can contact vulnerable populations quickly. Faith-based, volunteer, and community organizations, especially homeless shelters and food banks, should coordinate with local government officials and be equipped to provide heatwave protective behaviors and strategies to vulnerable populations.

Such early warning systems save lives. Currently, the CDC offers a "passive" surveillance system that tracks heat and emergency room visits after the fact.[27] The U.S. needs to improve meteorological technologies to predict heatwaves and its communication protocols. The 2021 heatwave in the Pacific Northwest caught some climate scientists "off

Heat-Related Emergency Department Visits During the June 2021 Northwestern Heat Wave



SOURCE: Morbidity and Mortality Weekly Report, CDC, July 23, 2021

guard," one scientist told *Scientific American*. "Even a lot of our climate models that project out how frequent extreme heat will be in the future wouldn't have necessarily predicted this level of heat for that part of the country," said Kristina Dahl, a senior climate scientist at the Union of Concerned Scientists.[28]

Emergency management services and Seattle Mayor, Jenny Durkin, received communication from National Weather Services Seattle in "very strong language" about the magnitude of the heatwave. Yet as the Medical Director of Seattle's Harborview Medical Center Emergency Department put it, "We didn't really understand what the regional impacts were going to be with this type of heat, because none of us had ever come close to experiencing this before." In hindsight, Seattle hospitals, emergency management services, or the Seattle Mayor's Office could have declared a *mass casualty incident* once hospitals became overwhelmed and an additional 450 deaths and heat-related illnesses occurred in Washington state over 2-3 days.[29] A mass casualty incident (MCI) is an event that "overwhelms the local healthcare system, where the number of casualties vastly exceeds the local resources and capabilities in a short period of time."[30] By declaring an MCI, public safety agencies can engage "immediate, early action" from emergency services and tell hospitals to prepare for heat-related emergency room visits. Yet an MCI was not declared, even though the CDC found that "A clear peak was detected on June 28, with 1,090 heat-related illness ED [emergency department] visits."[31] After correcting for changes in reporting to facilitate comparison with 2019, the analysis found that **1,038 heat-related illness ED visits occurred on June 28, 2021, compared with 9 heat-related illness ED visits on the same date in 2019.** By definition, that amounts to an MCI.

Here is what a coordinated climate-resilient healthcare and emergency response system should invest in and support:

1. Improve heatwave early warning systems and public alert systems.
2. Increase preparedness in hospital emergency rooms and health clinics.
3. Create resilient infrastructure (e.g., long-term urban planning).
4. Support local heat action plans, including the ability to declare an MCI, by public health officials and emergency services:
   - Develop a public awareness campaign on protective behaviors, including passive cooling strategies, hydration, and when to leave hot residences for air-conditioned public locations.
   - Build public cooling centers — essential for the homeless.
   - Mobilize public services and community partners to conduct wellness checks on vulnerable persons (outdoor workers, homeless, elderly).
   - Distribute water.

A recent peer-reviewed study by First Foundation predicts that 8.8 million people in 50 U.S. counties will experience temperatures above 125° F in 2023.[32] By 2053, temperatures are expected to be even higher, broiling 107.6 million Americans in an emerging region the Foundation calls the "Extreme Heat Belt" — stretching from northern Texas and Louisiana and through the Southern Plains to the Midwest — reaching Illinois, Indiana, and parts of Wisconsin.

More than 125°F.

Demand for air conditioning is expected to rise over the next few decades, contributing to global warming. Air conditioners use hydrofluorocarbons (HFCs), a potent greenhouse gas that increases global warming thousands more times than carbon dioxide. Commercial air-conditioners also strain the electrical grid — to the point that they can trigger blackouts or brownouts during a heatwave. In September 2022, the U.S. Senate ratified the 2016 Kigali Amendment of the Montreal Protocol on Substances that Deplete the Ozone Layer and joined 137 countries to gradually reduce HFCs over the next few decades.[33]

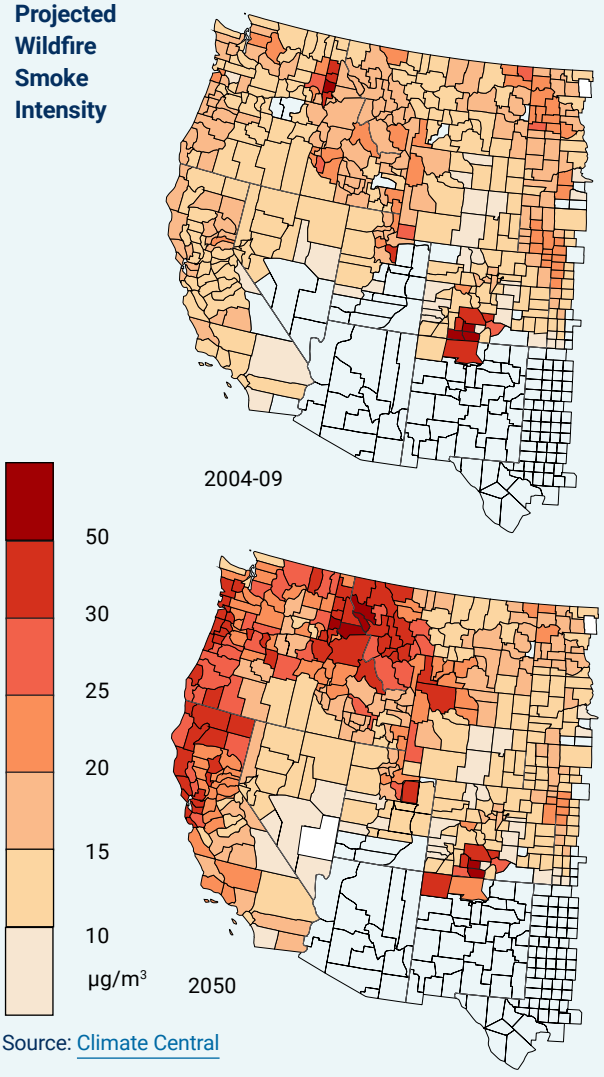
On the other hand, passive cooling strategies can lower the temperature in homes and apartments, reducing the environmental impact.[34] Because heat-related illness and death are associated with racial and socioeconomic disparities in the U.S., passive cooling strategies are critical for those who cannot afford air conditioning.[35] Exterior blinds or other exterior window coverings, increased vegetation and trees in the neighborhoods to provide shade, especially in urban areas and at-risk communities, and cross ventilation during the night are just some examples of passive cooling. Future building designs, including rooftop vegetation and trees nearby, are essential to decrease reliance on air conditioners.

"Running an air conditioner is just trying to solve a problem that it is also worsening," Alexandra Rempel, Assistant Professor of Environmental Design at the University of Oregon told *The Washington Post* following the deadly Pacific Northwest heatwave in 2021. She argues that "passive cooling offers a way to handle heat that doesn't risk raising temperatures further." [36]

Wildfires

Hotter temperatures lead to increased wildfires. Because of anthropogenic climate change, wildfire season has increased the amount of time, frequency, and acreage burned in the American West.[37] Wildfire smoke emits chemicals and small pieces of solid and liquid particles, called particulate matter, or PM, that become suspended in the air.[38] When inhaled, the large pieces, called PM10, cause throat and eye irritation, while the fine particles, known as PM2.5, go straight into the lungs and bloodstream.

"Understanding the populations that are most affected by wildfire smoke exposure is important for targeting public health adaptations to increased wildfires under a changing climate …Very few studies have investigated differential impacts of wildfire smoke by race, ethnicity, or socioeconomic status (SES), but there is some evidence of stronger associations between wildfire smoke and visits to the emergency department and hospitalizations in lower-SES neighborhoods." Source: Kristi Ebi et al. in "Extreme Weather and Climate Change: Population Health and Health System Implication."



Source: Climate Central

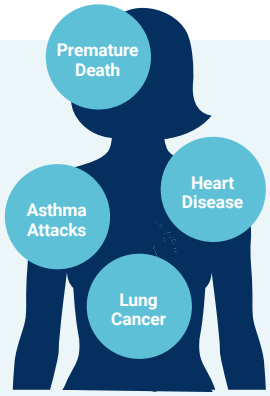
The effects of PM2.5 on human health are severe. The elderly, pregnant women, children, outdoor workers, people of lower socioeconomic status, and people with heart, lung, and even kidney diseases are particularly vulnerable to the effects of wildfire smoke.[39] According to the CDC, particulate pollution can lead to lung cancer, increased heart attack risk, low birth weight in babies, and eye, nose, and throat irritation. The EPA reports that wildfire smoke can cause "reduced lung function, pulmonary inflammation, bronchitis, exacerbation of asthma and other lung diseases, exacerbation of cardiovascular diseases, such as heart failure, and even premature death."[40] Recent studies also associate wildfire smoke with adverse mental health and a surge in emergency department visits to treat respiratory illnesses.[41]

How Climate Change Increases Health Risks

"One way that climate change endangers health is by worsening air quality. Heat waves and wildfires, exacerbated by climate change, can worsen air pollution. Ground-level ozone pollution (aka smog) forms more easily in hotter temperatures and stagnant air, and wildfire smoke contributes to particle pollution. These two pollutants can have serious health effects – including asthma attacks, heart attacks, and even early death."

Source: American Lung Association
See also: A Health Professionals' Declaration on Climate Change

Effects of PM2.5 from Wildfires on Human Health



Heatwaves often accompany extreme wildfires causing a "compound event."[42] Extreme temperatures increase the amount of airborne particulate matter from wildfire smoke, necessitating multiple public health interventions, including emergency room and hospital preparedness. A climate resilience adaptation plan is essential to prepare communities and public health services for an increasing number of compound events. Recommendations, especially for vulnerable populations, include:

- Stay indoors.
- Limit physical activity.
- Reduce indoor air pollution sources.
- Use air filters or cleaners (e.g., high-efficiency heating, ventilation, and air conditioning filters or room air cleaners).
- Wear appropriate N95 or P100 particulate air respirators (important for people with pre-existing health conditions e.g., asthma).
- Close schools and public events.

Source: Climate Central

Like the 2021 Seattle heatwave crisis, another missed opportunity comes from the U.S. Forest Service. The Forest Service created an Interagency Wildland Fire Air Quality Response Program in 2019 to deploy Air Resource Advisors to wildfire events.[43] Yet the program needs climate change indicators in its wildfire modeling system. The advisors analyze, predict, monitor, and communicate smoke impacts on the public and firefighters using specialized technologies, such as smoke monitors that measure PM2.5 particulates. The advisors also use satellite-based technologies to provide real-time data to EPA's AirNow website.

AirNow is an excellent opportunity to integrate into a unified climate-resilient health system that invests more in:

- Climate and health research
- Coordinated local, state, and federal communication around climate-event emergency preparedness
- Sustainable technologies (e.g., satellite weather monitoring)
- Climate-resilient health infrastructure and services, such as building health facilities in locations prone to current and future climate-related weather events

Integrating climate change with health and emergency response systems could save more lives from wildfires and other extreme weather events.

Floods and Hurricanes

Extreme rainfall followed by severe flooding is expected to increase across all regions of the U.S. due to anthropomorphic climate change. Injuries from flooding are a common risk, as well as the trauma from losing homes and livelihoods. As in wildfires, the loss of healthcare workers and the ability to access hospitals and healthcare centers also pose a risk factor. The CDC reports that floods are the second-deadliest extreme weather event in the United States, right behind heatwaves.[44] Flash flooding and floods resulting from hurricanes account for the most fatalities, primarily from drowning as a direct impact during the event. **Yet indirect deaths, sometimes weeks after the event, can be just as high.** After seven hurricanes pummeled Florida in 2004–05, the chairman of the Florida Medical Examiners Commission stated, "The vast majority [of fatalities in those storms] are the indirect deaths that come after the storm, [the number increased]…by people who have pre-existing conditions exacerbated by the stress or strain of the storm."[44]

A comprehensive study found that 44 percent of all fatalities from U.S. hurricanes over the last 50 years were due to indirect deaths.[45] Hurricane Katrina, for example, caused 520 direct deaths and 565 indirect deaths.[46]

Most of the immediate indirect causalities stem from a loss of electrical power, including:

- Carbon monoxide poisoning (especially from misuse of generators)
- Hypothermia
- Medical equipment failure
- Electrocution
- House fires (from open flames, such as candles)

Heart attacks and cardiovascular events account for nearly one-third of all indirect deaths and are often the most difficult to attribute to a weather event. For example, an additional 307 fatal cardiovascular events following Katrina could not be determined as direct or indirect deaths.[47]

Up to ten days following an event, health risks include skin and wound infection, pneumonia, viral respiratory infection, and gastroenteritis.[48] After ten days, bacterial and viral infections can appear, including diseases from mosquitos thriving in standing water and Hepatitis A or E viral infections. Depression and PTSD are common mental health risks following a flood that can last a year or longer, as well as managing chronic disease.[49]

Linking climate change adaptation and disaster risk management to healthcare are the building blocks for creating a climate-resilient healthcare system. The results will be **a better-prepared healthcare workforce to respond to the short-, medium-, and long-term health outcomes from floods, such as surveillance and monitoring for vector-borne diseases and improved early warning systems and disaster response.** A recent study concludes that "little is known about how disaster risk reduction and climate change adaptation should be linked in health."[50] Now is the time to **prioritize government-funded research on making these linkages under a designated climate change and health entity.**

> "The overall health burden of climate change is severely underestimated. What we see today is just the tip of the iceberg." — Kai Chen, Yale School of Public Health's Department of Environmental Health Sciences.

Vector-borne Diseases

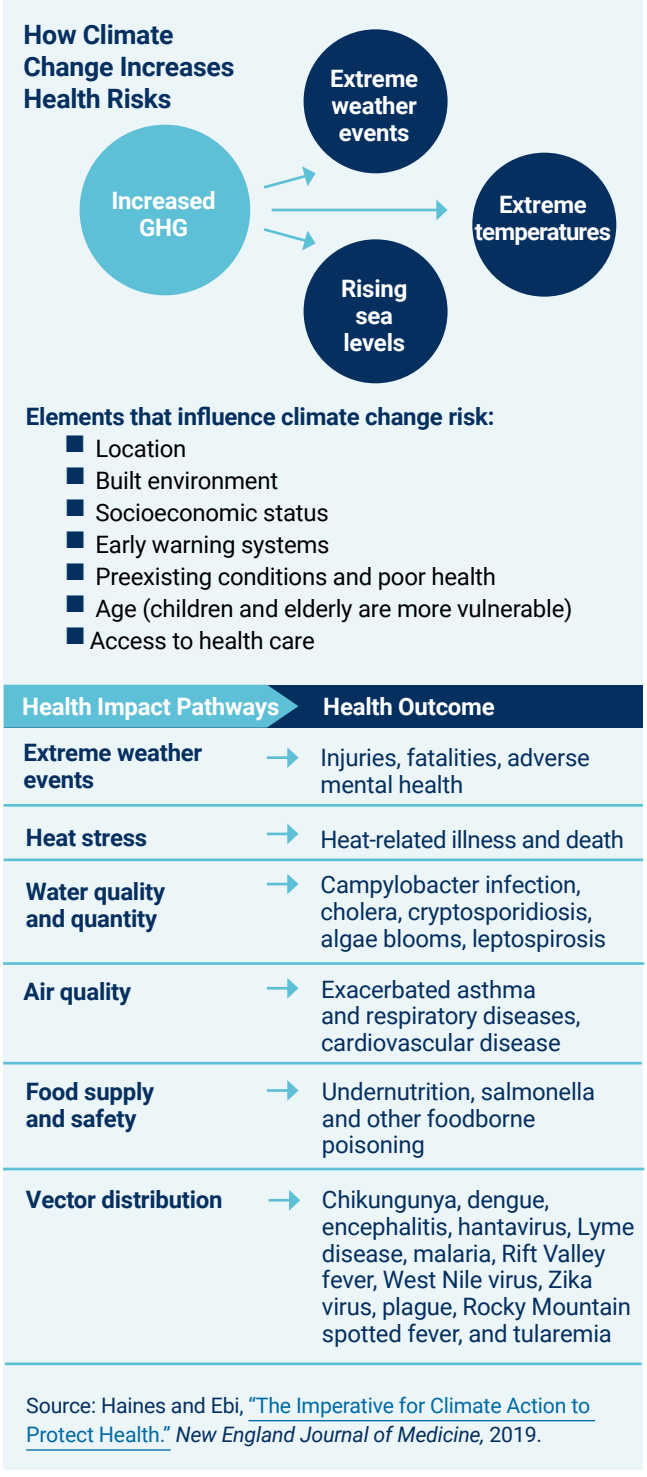
Increased temperatures, rainfall, and floods caused by human-induced climate change create an increased risk for humans to contract vector-borne diseases. A *vector* is an organism that can transmit a disease from one host to another. Mosquitoes, ticks, flies, and fleas spread diseases to humans, such as Lyme disease. Hotter temperatures, increased humidity, and longer summer seasons allow disease-carrying vectors to multiply faster and expand their territory.

The CDC states that Americans are now at risk from the following vector-borne diseases: Lyme, dengue fever, West Nile virus disease, Rocky Mountain spotted fever, plague, and tularemia. Future threats from vector-borne diseases that are yet to arrive include chikungunya, Chagas disease, and Rift Valley fever viruses.[51]

In September 2021, Dr. Eric Rubin, editor-in-chief of the *New England Journal of Medicine*, told National Public Radio, "We've seen a complete change in where the insects that carry diseases are spread. Lots of them were confined to tropical areas, and as the Earth gets warmer, they've been migrating further northward. And so the mosquitoes that carry a lot of the major diseases that affect Central and South America are here in the U.S. right now."[52]

Epidemiologists in the U.S. say there is a "significant gap" in disease forecasting in this epoch of global warming.[53] **Climate change indicators could improve the ability to predict and pinpoint when and where a vector-borne disease might emerge.** A coordinated climate change and vector-borne disease tracking and assessment program, with adaptation strategies for high-impact, climate-sensitive diseases, could serve as an *active* surveillance system to inform state, local, and population health officials of *upcoming* risks.

Early communication could then allow public health officials to *prepare* communities on ways to decrease disease exposure. An early warning to avoid specific areas and a widespread public health recommendation to use insect repellent, to name but two examples, could decrease the health risks of contracting vector-borne illnesses.



Source: Haines and Ebi, "The Imperative for Climate Action to Protect Health." *New England Journal of Medicine,* 2019.

Water-borne Diseases

The CDC estimates that water-borne pathogens (bacteria, viruses, and protozoa) cause 7,000 deaths, 120,000 hospitalizations, 7 million illnesses, and $3 billion in healthcare costs in the U.S. every year.[54] **These figures are expected to increase due to a changing climate.** The most common water-borne pathogens in the U.S. are associated with bacteria in human and animal fecal waste, such as *E. coli*.[55] Others occur naturally in waterbodies and coastal systems in the U.S., such as the bacteria *Legionella*. Increased temperatures, rainfall and water runoff, floods, and hurricanes increase the risk of contracting water-borne diseases.

Humans contract water-borne diseases through drinking contaminated water, swimming in outdoor waterbodies, and ingesting contaminated food. **Cascading events from excessive rainfall and flooding can cause fecal matter on the land (animal sources in saturated pastures and fields) to overwhelm water treatment facilities, then enter drinking water distribution systems, leading to a water-borne outbreak.**[56] Floods can cause downstream sewer treatment facilities to overflow, releasing raw sewage into nearby rivers and streams. Floods damage sewer plants, contaminate wells and even pollute aquafers. EPA has identified 772 U.S. cities with a "combined sewer system" where surface water runoff from streets and drainage pipes is combined with domestic sewage and industrial wastewater and transported to the treatment facility.[57] During heavy rainfall, a combined sewer system is designed to directly discharge excess wastewater — raw human sewage and industrial waste — in nearby waterbodies.

Increased temperature allows certain water-borne bacteria and protozoa pathogens to grow and thrive, although not viruses. Warmer water, for example, causes increased growth and survival in the naturally occurring waterborne pathogen *Naegleria fowleri*, an ameba found in lakes, rivers, and hot springs that causes a fatal brain infection when water goes up the nose.[58] The bacteria *Vibrio* can contaminate shellfish in warm coastal waters with low salinity, such as the Chesapeake Bay. The CDC estimates that 100 deaths and 80,000 illnesses from *Vibrio* infections each year are caused by eating undercooked and raw shellfish.[59]

A recent study concluded **that human-caused climate change is responsible for increased *Vibrio* infections in the Baltic Sea, and further *Vibrio* infections will increase in the coming decades due to climate change.**[60]

By using active surveillance meteorological technology to monitor and predict climate conditions that surpass a certain threshold for a water-borne disease outbreak, the **U.S.**

could develop a national early warning system to communicate to public health officials when and where to anticipate a disease outbreak. Healthcare officials could provide health alerts and begin early screening *before* a widespread outbreak. The European Centre for Disease Prevention and Control has established such a system with its *Vibrio* Map Viewer.[61] Currently, the U.S. uses a passive surveillance system that reports disease outbreak *after* it occurs.[62]

Rising CO2 Levels and Food

Climate change is also affecting the global food system, including the United States, presenting new challenges to food safety, access, and nutritional value.[63] In certain parts of the world, especially the Horn of Africa, countries are experiencing a "raging food catastrophe" linked to drought and floods and the war in Ukraine.[64] "Changing weather patterns, droughts and storms are disrupting crop cycles and fisheries," United Nations Secretary-General António Guterres told the G20 in November 2022.[65] In the U.S., the National Institutes of Health (NIH) warn that rising temperatures, droughts, and floods increase the risk of foodborne illness by increasing the "distribution and survivability of pathogens that cause foodborne illnesses."[66]

Rising CO2 levels decrease the nutritional *quality* of staple crops (known as C3 crops), including wheat, rice, and soybeans. Increased CO2 might promote plant growth through its photosynthesis mechanism, but it also increases the plant's carbohydrate content, meaning **less protein, micronutrients, and B vitamins available.** Globally, humans obtain 63 percent of their protein from plant sources, as well as 81 percent of their iron and 68 percent of their zinc.[67] **Decreasing the nutritional quality of staple crops will have a devasting global impact on the 2 billion people already deficient in one or more of these vital nutrients.** Current research in Nature Climate Change predicts that by 2050, an additional 175 million people will become zinc-deficient, an additional 122 million people will become protein-deficient, and an additional 1.4 billion children worldwide and women of childbearing age will develop anemia from iron deficiency.[68]

In addition, anthropogenic climate change at its current projected rate increases the need for greater amounts and frequency of pesticides due to:

- More pests, diseases, and weeds
- Leaching and runoff from increased rainfall
- Faster pesticide degradation due to higher temperatures

Increased use will then lead to increased pesticide resistance in a negative feedback loop. Moreover, a recent study in the *International Journal of Environmental Research and Public Health* concluded that "due to climate change, the increasing use of insecticides and pesticides increases exposure and human health risks from pesticide pollution."[69]

The NIH warns that rising temperatures, droughts, and floods increase the risk of foodborne illness by increasing the "distribution and survivability of pathogens that cause foodborne illnesses."[70] Also at risk is the supply chain and nutritional integrity of livestock due to more pathogens, increased use of pesticides in animal feed, and decreased nutritional quality of crops.[71] And during a Kansas heatwave in June 2022, thousands of cattle died from the heat.[72]

> "Global warming and its associated changes in mean climate variables and climate variability affect feed and water resources as well as animal health and production. Climate change also has implications for the processing, storage, transport, retailing and consumption of livestock products. The ability of current livestock systems to support livelihoods and meet the increasing demand for livestock products is thus threatened." — "Impacts of climate change on the livestock food supply chain; a review of the evidence," *Global Food Security*, March 2021.

Both the NIH and the U.S. Department of Agriculture (USDA) advocate for more research to assess the effects of climate change on food production, availability, and contamination, and measures to protect food safety from rising temperatures, drought, and flooding.[73] A critical research priority for the United States is to develop adaptation measures to protect the nutritional quality of staple crops through novel genetic or agricultural practices.

Increasing CO2 Threatens Human Nutrition

Research led by Sam Myers, Director of the Planetary Health Alliance at the Harvard Chan School of Public Health, found that when food crops like wheat, corn, rice and soy are exposed to CO2 at levels predicted for 2050, the plants lose as much as 10% of their zinc, 5% of their iron, and 8% of their protein content.

Mental Health

Extreme weather events due to anthropogenic climate change can cause stress, anxiety, depression, post-traumatic stress disorder (PTSD), and exacerbate existing mental health conditions.[74] Severe weather events can also lead to financial difficulties, loss of property, and displacement, further contributing to mental health problems. Some populations and communities in the U.S. bear weather disasters differently. People most vulnerable to mental health challenges are those who already experience health inequities based on socioeconomic status, race (non-Caucasian, non-white), and other social and environmental determinants of health.[75] Children, the elderly, first responders, persons with disabilities and pre-existing health conditions, the homeless, outdoor laborers, and refugees are especially at risk of negative mental health impacts following a weather disaster.[76]

In addition, some people experience "ecological grief," the intense feeling of grief due to the impacts of anthropogenic climate change, including the loss of species, biodiversity, ecosystems, and terrain.[77] The psychiatric community developed a new concept, *solastalgia,* to illustrate the "eco-anxiety" some people experience due to distress and a sense of powerlessness brought on by environmental change.[78]

> "The lesser known, and often overlooked, health impact of climate change is the mental health implications from our changing climate. Often, this oversight is due to the general lack of attention to mental health within broader conceptualizations of health, and also to the challenges of monitoring, assessing, and predicting the mental health implications from climate change-related hazards."
> — Katie Hayes and Black Poland, International Journal of Environmental Research and Public Health, September 2018.

Mental health impacts are rarely associated with climate change due to scarce research. Addressing this issue through government-funded research should be a priority. A vulnerability assessment that identifies hazards and prepares adaptation and mitigation measures on a national scale must include mental health indicators. Healthcare and disaster response systems should prepare for increased mental health services alongside physical health illnesses, especially where services are lost or diminished following a disaster. Heathcare systems must anticipate mental health impacts in the short and long term, as the treatment and support might be required for years. Children, especially, are susceptible to long-term, trauma-related symptoms following a disaster and require continued monitoring.[79] Improving mental health literacy and making mental health resources available following an event will help decrease the mental health disorders that increasingly affect the American public.[80]

Washington Business Dynamics: Climate Change Adaptation, Federal Healthcare, and Emergency Response Management Services

Here at Washington Business Dynamics (WBD), our healthcare experts, certified climate change professionals, scientists, engineers, and economists implement climate change adaptation and mitigation strategies for our clients. We support the Veterans Health Administration, the Department of Health and Human Services at the National Institutes of Health, the Department of Homeland Security at the Federal Emergency Management Administration (FEMA), and the U.S. Agency for International Development (USAID), among many other federal, state, and private sector entities. We implement elements of President Biden's Executive Order on Tackling the Climate Crisis at Home and Abroad in our current projects. We are poised to support clients as they apply GHG mitigation through the Administration's Inflation Reduction Act (IRA) of 2022.

As part of our strategic advisory services, WBD has developed a holistic, four-step approach to help local U.S. communities develop and implement a Climate Resilience Plan.

We recommend actions that do more than reduce the concentration of greenhouse gasses and climate change mitigation; instead, we assist in reducing the impact of climate change — climate change *adaptation*. That includes collaborating with local public health officials, hospitals, and emergency response teams as an integrated system that supports a community's climate resilience plan.

For our federal clients, WBD's IT experts develop applications that elevate data-driven decision-making processes and facilitate organization-wide collaboration. For example, WBD identified and implemented goals for our DHS client to support the FEMA IT Strategic Plan for Fiscal Years 2020-2024. Our team created the Strategic Implementation Plan as a guide to making the strategic goals a reality. Each strategic goal has specific objectives and initiatives that clearly define success through metrics and timeframes. In addition, our strategic risk experts have implemented closed-loop management to control risk and value at FEMA.

At our own firm, WBD follows a rigorous standard for environmental responsibility through our Greenhouse Gas Management Statement and Methodology.

Lack of investment in climate change and health is the greatest public health challenge the U.S. must overcome to save lives and reduce health costs. The U.S. has structures in place but needs to adequately fund them. For example, the Office of Climate Change and Health Equity did not receive funding for more than a year after President Biden established it in January 2021.[83] The National Institutes of Health, the largest government funder of health research, allocates between 0.1 and 0.5 percent of its total annual funding to climate change and natural disaster-related research.[84] Although the emphasis is not human health, the passage of IRA in 2022 will accelerate the transition to clean energy in the United States — *if they are implemented* at the scale the Act proposes. The health benefits that might result from the IRA include:[85]

- Appropriate $20 million to EPA through 2031 to monitor and address methane emissions, a deadly GHG 21 times more potent than carbon dioxide.
- Increase GHG and methane monitoring in poor and disadvantaged communities and funds to mitigate the health-related impacts of emissions.
- Finance for the Forest Service to enhance wildfire mitigation projects that will reduce wildfire smoke and remove hazardous waste material on public land.[86]

But the numbers dedicated to climate change and health are insufficient to offset health costs, save lives, and reduce premature death.

Based on WBD's analysis, the U.S. federal government needs to develop a **national adaptation plan to the health impacts from climate change**. A designated entity could be established at HSS through a new office or, perhaps, in an expanded charge in the Office of Climate Change and Health Equity (OCCHE). In its interagency capacity, the OCCHE belongs to the Extreme Heat Interagency Working Group with the Departments of Labor, Homeland Security, Agriculture, EPA, and NOAA. The six federal agencies regularly meet to discuss how the federal government could coordinate and communicate heat-related risks to Americans and build extreme heat resiliency measures.[87]

In addition, HHS supports the U.S. Global Change Research Program (USGCRP), primarily through emerging CDC- and NIH-funded research on linkages between climate change and health and the effectiveness of various public health adaptation strategies to reduce climate vulnerability. The Department of Health and Human Services translates scientific advances into tools for public health professionals, monitors climate change health outcomes, and engages the public health community in two-way communication about climate change.[88]

What the ICPP states is currently happening due to climate change:[81]

- Climate change has adversely affected physical health of people globally (*very high confidence*) and mental health of people in the assessed regions (*very high confidence*).
- In all regions extreme heat events have resulted in human mortality and morbidity (*very high confidence*).
- The occurrence of climate-related food-borne and water-borne diseases has increased (*very high confidence*).
- The incidence of vector-borne diseases has increased from range expansion and/or increased reproduction of disease vectors (*high confidence*).
- Animal and human diseases, including zoonoses, are emerging in new areas (*high confidence*).
- Water and food-borne disease risks have increased regionally from climate-sensitive aquatic pathogens, including *Vibrio* spp (*high confidence*).
- Increased exposure to wildfire smoke, atmospheric dust, and aeroallergens have been associated with climate-sensitive cardiovascular and respiratory distress (*high confidence*).
- Health services have been disrupted by extreme events such as floods (*high confidence*).

Impacts the ICPP predicts in the mid- to long-term, 2041 to 2100:[82]

- Climate change and related extreme events will significantly increase ill health and premature deaths (*very high confidence*).
- Climate change will increasingly put pressure on food production and access, especially in vulnerable regions, undermining food security and nutrition (*high confidence*).
- Globally, population exposure to heatwaves will continue to increase with additional warming, with strong geographical differences in heat-related mortality without additional adaptation (*very high confidence*).
- Climate-sensitive food-borne, water-borne, and vector-borne disease risks are projected to increase under all levels of warming without additional adaptation (*high confidence*).
- Mental health challenges, including anxiety and stress, are expected to increase under further global warming in all assessed regions, particularly for children, adolescents, elderly, and those with underlying health conditions (*very high confidence*).

A future designated entity at HHS could establish a data trust that includes NOAA, USGCRP, the CDC, EPA, FEMA, USDA, and other stakeholders such as academia and the private sector. The U.S. produces great quantities of data, but it is often siloed rather than shared among relevant entities, resulting in missed opportunities and inadequate decision-making. **A data trust is a legal framework to manage shared data among all parties on a secure, single platform.** For example, the Department of Transportation uses a data trust among its stakeholders to collaboratively improve railroad safety that would be "difficult for individual railroads to achieve on their own."[89] With a data trust, researchers and other stakeholders can access high-quality, accurate, and previously unavailable data to conceptualize new insights. A data trust is scalable and can offer tools or dashboards for researchers to quickly analyze the right data, producing better information to inform decision-making and create better solutions.

The University of Maryland's CATT Lab is the logical choice to provide its data trust design services to a designated entity at HHS. Multiple federal agencies already rely on the CATT lab for its data management capabilities, including the HHS, DHS, NOAA, FEMA, U.S. Senate, National Security Agency (NSA), and the U.S. Treasury, among many others.

The designated entity could use a data trust to link meteorology, climatology, and disaster risk management with health. Through a coordinated and interdisciplinary effort, the designated entity could offer better solutions to improve climate-related health supply chains and early warning and surveillance systems at scale.

To drive this initiative, WBD has identified several science-based consultancies to serve as data architects. WBD's organizational strategies have long provided the federal government with large-scale transformations and built resilient operating models. Together, the two firms can leverage their friendly relationships with U.S. members of Congress and propose a detailed plan for constructing and managing an interagency Climate Change and Health designated entity within the U.S. Federal Government. We are prepared to respond to a future HHS Request for Information on supporting a new Office of Climate Change and Health.

From enabling response teams when disaster strikes at FEMA to providing emerging healthcare solutions and technologies for our nation's veterans at the VHA, WBD is committed to advancing our partners' missions. Whatever your climate resilience needs, WBD can help our partners make better decisions.

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WBD Analysis

Adaptation measures the U.S. needs to take now to build a climate-resilient healthcare system:

1. Link disaster response and climate change into the healthcare system via a designated entity.
2. Protect vulnerable and high-risk populations against exposure to climate hazards.
3. Improve early warning and response systems and heat action plans for heatwaves.
4. Strengthen surveillance systems to monitor vector- and water-borne diseases.
5. Improve access to potable water and reduce water treatment and distribution systems' contamination due to flooding. Provide early warning to communities.
6. Initiate mental health surveillance due to the impact of extreme weather and climate events and improve access to mental health care.
7. Integrate health adaptation measures into food, infrastructure, water, and sanitation policies.
8. Advance meteorological and climate technologies into better tools to predict and pinpoint extreme weather events and enhance early warning systems, disaster response, and healthcare preparedness.
9. Improve supply chains to respond to extreme weather events.
10. Increase funding of cross-disciplinary research that links meteorology, climatology, and disaster risk management with health.

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References

1. World Health Organization and World Meteorological Organization, *ClimaHealth*.

2. Climate Change 2022: Impacts, Adaptation, and Vulnerability. ICPP 6th Assessment.

3. "Topic Collection: Climate Change and Healthcare System Considerations." Department of Health and Human Services, 2022, and "FEMA Resources for Climate Resilience." Department of Homeland Security, Federal Emergency Management Agency, December 2021.

4. Banwell, N., Rutherford, S., Mackey, B., and Chu, C. "Towards Improved Linkage of Disaster Risk Reduction and Climate Change Adaptation in Health: A Review." *International Journal of Environmental Research and Public Health*. 2018 Apr 18;15(4):793.

5. Mayhew, S., Van Belle, S., and Hammer, M. "Are we ready to build health systems that consider the climate?" *Journal of Health Services & Research Policy.* 2014 Apr;19(2):124-7.

6. Southwick, R., "House Committee Chairman asks hospitals what they're doing on climate crisis." *Chief Executive Healthcare,* March 25, 2022. Unfortunately, the incoming Congress in January 2023 deleted all past press releases and details of the RFI on the Ways and Means Committee website.

7. "House Unveils Report, Holds Hearing on Health Care Sector and Climate Events." Association of American Medical Colleges.

8. Ebi, K.L., *et al.* "Extreme Weather and Climate Change: Population Health and Health System Implications." *Annual Review of Public Health.* 2021 Apr 1;42:293-315.

9. Yu, J., Castellani, K., Forysinski, K. *et al.* "Geospatial indicators of exposure, sensitivity, and adaptive capacity to assess neighbourhood variation in vulnerability to climate change-related health hazards." *Environ Health* 2021; 20(31).

10. Understanding the Connections Between Climate Change and Health. Environmental Protection Agency.

11. USGCRP Indicator Platform. U.S. Global Change Research Program.

12. Legal Mandate. U.S. Global Change Research Program.

13. Ibid.

14. Fact Sheet: Biden Administration Mobilizes to Protect Workers and Communities from Extreme Heat. White House. September 20, 2021.

15. "How Health Care Organizations Are Preparing for Climate Shocks and Protecting Vulnerable Patients." The Commonwealth Fund. October 20, 2022.

16. "How Health Care Organizations Are Preparing for Climate Shocks and Protecting Vulnerable Patients." The Commonwealth Fund. October 20, 2022.

17. Ibid.

18. Smith, A., "2021 U.S. billion-dollar weather and climate disasters in historical context." National Oceanic and Atmospheric Administration.

19. Ibid.

20. "Quantifying Risks to the Federal Budget from Climate Change." White House. April 2022.

21. Centre for Research on the Epidemiology of Disasters and USAID. Cred Crunch Newsletter, 2022;April; 66.

22. Todd, G., Ryan, J,. "Heat wave killed far more people in Washington state than reported." National Public Radio, August 13, 2021.

23. Boon, R. "Dangerous Pacific Northwest heatwave suspected in 7 deaths." *AP News*, July 30, 2022.

24. Brown, A., "Public Health Agencies Lack Money to Combat Climate Threats." Pew Charitable Trusts. August 12, 2022.

25. Heat stress and heat-related illness. Centers for Disease Control and Prevention.

26.Ibid.

27. Heat and Health Tracker. Centers for Disease Control and Prevention.

28. Lewis, T., "Why Extreme Heat Is So Deadly." *Scientific American,* July 22, 2021.

29. Popovich, N., Choi-Schagrin, W., "Hidden Toll of the Northwest Heat Wave: Hundreds of Extra Deaths," *New York Times,* August 11, 2021.

30. DeNolf, R., Kahwaji, C,. "EMS Mass Causality Management." *StatPearls,* October 10, 2022.

31. "Heat-Related Emergency Department Visits During the Northwestern Heat Wave." Morbidity and Mortality Weekly Report, Centers for Disease Control and Prevention, July 16, 2021.

32. Emerging "Extreme Heat Belt" will Impact Over 107 Million Americans by 2053. First Street Foundation, August 15, 2022.

33. "U.S. Ratification of the Kigali Amendment." U.S. Department of State, September 21, 2022.

34. "Passive cooling designs to improve heat resilience of homes in vulnerable communities." Department of Energy, Energy Technologies Area, December 2021.

35. Gronlund, C., "Racial and socioeconomic disparities in heat-related health effects and their mechanisms: a review." *Current Epidemiological Report.* 2014 Sep 1;1(3):165-173.

36. Kaplan, S., "How to cool your home without relying on air-conditioning." *The Washington Post,* July 26, 2021.

37. "Climate Change Indicators — Wildfires." Environmental Protection Agency.

38. "Particle Pollution." Centers for Disease Control and Prevention.

39. Hampton, T., "Exposure to Wildfire Smoke Linked to Higher Death Rates in Patients with Kidney Failure." *Journal of the American Society of Nephrology,* July 16, 2020.

40. "Wildfire Smoke: A Guide for Public Health Officials 2019." Environmental Protection Agency and "Mortality risk attributable to wildfire-related PM2·5 pollution: a global time series study in 749 locations." *The Lancet Planetary Health,* 2021;5(9).

41. Brown, M., *et al.* "After the Fort McMurray wildfire there are significant increases in mental health symptoms in grade 7-12 students compared to controls." *BMC Psychiatry.* 2019 Jan 10;19(1):18 and Dohrenwend PB, *et al.* "The impact on emergency department visits for respiratory illness during the Southern California wildfires." *Western Journal of Emergency Medicine.* 2013 Mar;14(2):79-84.

42. Zscheischler, J. et al. "Future climate risk from compound events." *Nature Climate Change.* 2018;8:469–477

43. Interagency Wildland Fire Air Quality Response Program

44. Precipitation Extremes: Heavy Rainfall, Flooding, and Droughts. Centers for Disease Control and Protection.

45. Rappaport, E., Blanchard, W., "Fatalities in the United States Indirectly Associated with Atlantic Tropical Cyclones." *Bulletin of the American Meteorological Society,* 2016 July 1 97;7.

46. Ibid.

47. Ibid.

48. Paterson, D., *et al.* "Health Risks of Flood Disasters." *Clinical Infectious Diseases,* 2018 Nov 1, 67; 9, pp 1450–1454.

49. Racker, E., "Lessons from Hurricane Katrina for predicting the indirect health consequences of the COVID-19 pandemic." 2020 May 18.

50. Banwell, N., *et al.* "Towards Improved Linkage of Disaster Risk Reduction and Climate Change Adaptation in Health: A Review." *International Journal of Environmental Research and Public Health.* 2018 Apr 18;15(4):793.

51. Diseases Carried by Vectors. Centers for Disease Control and Prevention.

52. "Climate Change Is The Greatest Threat To Public Health." National Public Radio. September 7, 2021.

53. Coalson, J., *et al.* "The Complex Epidemiological Relationship between Flooding Events and Human Outbreaks of Mosquito-Borne Diseases: A Scoping Review." *Environmental Health Perspectives,* 2021 Sep. 28;129(9).

54. Waterborne Disease. Centers for Disease Control and Prevention.

55. Water Quality Topics: Pathogens. Centers for Disease Control and Protection.

56. Semenza, J., "Cascading risks of waterborne diseases from climate change." *Nature Immunology.* 2020;21:484-487.

57. What are Combined Sewer Overflows (CSOs)? Environmental Protection Agency.

58. Water Quality Topics: Pathogens. Centers for Disease Control and Prevention and Naegleria fowleri — Primary Amebic Meningoencephalitis (PAM) — Amebic Encephalitis. Centers for Disease Control and Prevention.

59. *Vibrio* Species Causing Vibriosis. Centers for Disease Control and Prevention.

60. Semenza, J., *et al.* "Environmental Suitability of *Vibrio* Infections in a Warming Climate: An Early Warning System." 2017 Oct 10;125(10).

61. ECDC Geoportal. European Centre for Disease Prevention and Control.

62. National Outbreak Reporting System (NORS). Centers for Disease Control and Prevention.

63. Climate Change, Global Food Security, and the U.S. Food System. U.S. Department of Agriculture.

64. Act together now, to prevent 'raging food catastrophe' next year: Guterres. *U.S. News,* United Nations.

65. Ibid.

66. Climate Change and Human Health. National Institute of Environmental Health Science, National Institutes of Health.

67. Smith, M., Myers, S., "Impact of anthropogenic CO2 emissions on global human nutrition." *Nature Climate Change.* 2018;8:834-839.

68. Ibid.

69. Tudi M., *et al.* "Agriculture Development, Pesticide Application and Its Impact on the Environment." *International Journal of Environmental Research and Public Health.* 2021 Jan 27;18(3):1112.

70. Climate Change and Human Health. National Institute of Environmental Health Science, National Institutes of Health.

71. Godde, C., *et al.* "Impacts of climate change on the livestock food supply chain; a review of the evidence." *Global Food Security.* 2021 Mar;28:100488.

72. Chappell B., "Days of intense heat have killed thousands of cattle in Kansas." National Public Radio. June 16, 2022.

73. Climate Change and Human Health. National Institute of Environmental Health Science, National Institutes of Health and Climate Change Adaptation. U.S. Department of Agriculture.

74. Summary for Policy Makers, Working Group II. ICPP Sixth Assessment, 2022.

75. "How Extreme Weather Events Affect Mental Health." American Psychiatric Association. 2019; and Social Determinants of Health. Office of Disease Prevention and Health Promotion, Department of Health and Human Services.

76. Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. American Psychological Association; Climate for Health; EcoAmerica. March 2017.

77. Cunsolo, A., Ellis, N., "Ecological grief as a mental health response to climate change-related loss." *Nature Climate Change.* 2018;8:275–281.

78. Albrecht, G., *et al.* Solastalgia: "The Distress Caused by Environmental Change." *Australasian Psychiatry.* 2007;15:S95-S98.

79. "How Extreme Weather Events Affect Mental Health." American Psychiatric Association. 2019.

80. Reducing the Economic Burden of Unmet Mental Health Needs. The White House.

81. Joselow, M., "Federal office focused on climate change and health has zero funding." *Washington Post.* June 29, 2022.

82. Ghosh, A., *et al.* "Trends in National Institutes of Health Funding on the Health-Related Effects of Climate Change and Natural Disasters." *Journal of General Internal Medicine.* January 3, 2022;37:2885–2887.

83.Glicksman, R., "Protecting the Public Health with the Inflation Reduction Act — Provisions Affecting Climate Change and Its Health Effects." *New England Journal of Medicine.* Jan. 5 2023;388:84-88.

84. Cloyes, M., "On the Inflation Reduction Act of 2022." Blue Forest, August 18, 2022.

85. FACT SHEET: Biden Administration Mobilizes to Protect Workers and Communities from Extreme Heat. White House, September 20, 2021.

86. Health and Human Services at US Global Change Research Program.

87. Railroad Information Sharing Environment (RISE). Department of Transportation.

88. Health and Human Services at US Global Change Research Program.

89. Railroad Information Sharing Environment (RISE). Department of Transportation.