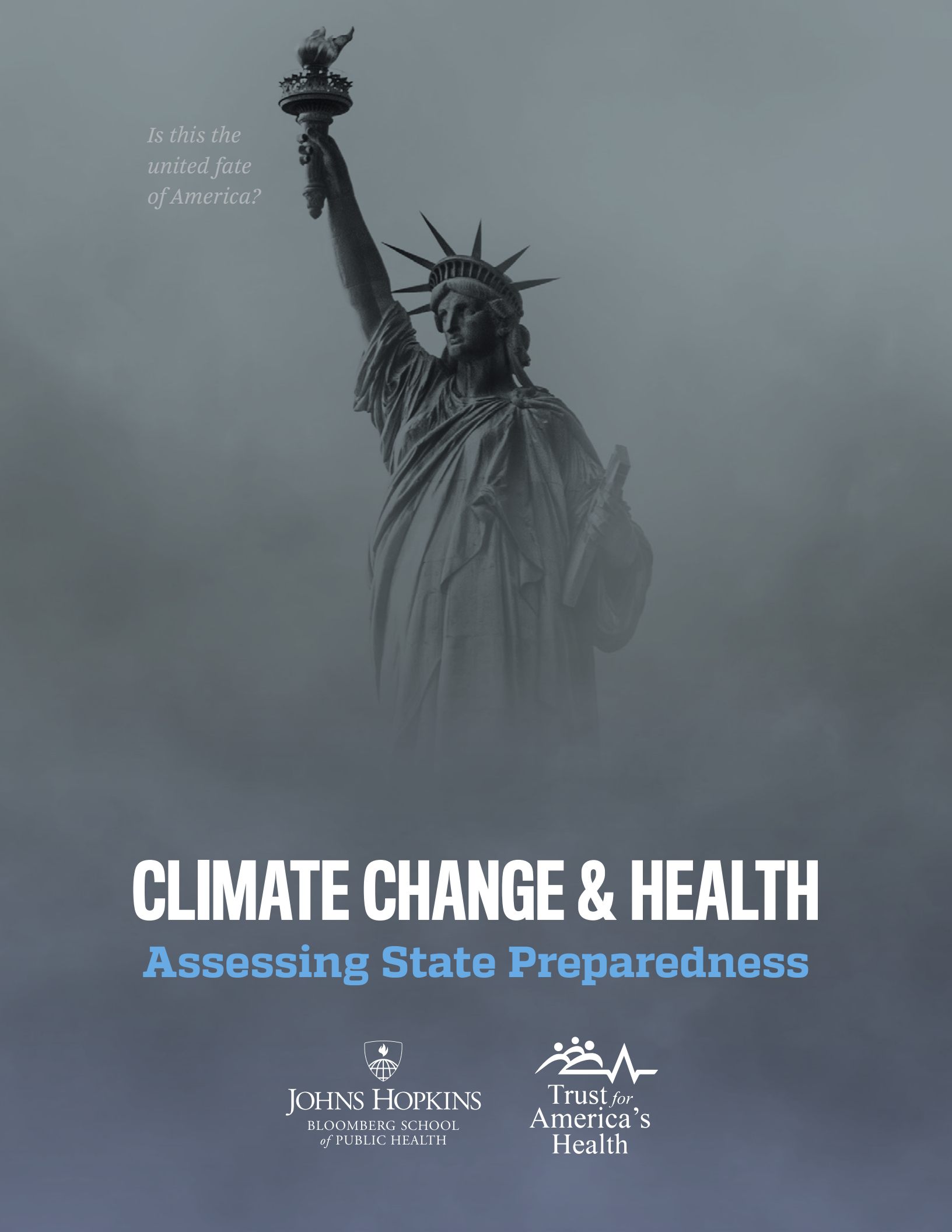

CLIMATE CHANGE & HEALTH

Assessing State Preparedness

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Trust for
America's
Health

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Trust for America's Health (TFAH) is a nonprofit, nonpartisan public health policy, research, and advocacy organization that promotes optimal health for every person and community, and that makes the prevention of illness and injury a national priority.

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EXECUTIVE SUMMARY

Climate change poses serious threats to human health. Too often, the issue is framed as a risk for the distant future, but in fact it is here today. It is a reality for communities across the United States, and around the world, many of whom are already dealing with rising seas, longer and more intense heat waves, more powerful hurricanes, warmer winters, and other devastating impacts.

To be sure, climate-related work must address the future. Because carbon dioxide and other greenhouse gases can stay in the atmosphere for hundreds of years, the choices we make today will affect the climate for centuries. By the same token, the release of greenhouse gases through human activities over the past two centuries has made some level of additional global warming inevitable. Since the turn of the 20th century, the average annual temperature across the contiguous United States increased by 1.8 degrees Fahrenheit (1.0 degrees Celsius), and the country can expect to see it rise another 2.5 degrees Fahrenheit (1.4 degrees Celsius) over the next few decades, owing to past emissions. The evidence is clear that the climate is changing and will continue to change for at least the next century. Humans must learn to live with the effects of this change (adaptation), even as they pursue the essential objective of minimizing future warming by reducing greenhouse gas emissions (mitigation).

Climate change, however, does not affect all people and places equally. It is a global phenomenon, but its effects are local, shaped by weather patterns and geography. A person's experience depends, in large part, on where she lives. That experience includes health risks. In addition to the well-understood dangers of death and injury posed by natural disasters, many health outcomes are directly or indirectly linked to environmental factors and, therefore, sensitive to changes in climate. (See Figure 1.)

Figure 1
Examples of Climate-Related Health Impacts

	Climate Driver	Exposure	Health Outcome	Impact
Extreme Heat	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Outdoor Air Quality	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Flooding	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Vector-Borne Infection (Lyme Disease)	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Water-Related Infection (*Vibrio vulnificus*)	Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with *Vibrio vulnificus*	*Vibrio vulnificus* induced diarrhea & intestinal illness, wound and bloodstream infections, death	Increases in water temperatures will alter timing and location of *Vibrio vulnificus* growth, increasing exposure and risk of waterborne illness.
Food-Related Infection (*Salmonella*)	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of *Salmonella* exposure	*Salmonella* infection, gastrointestinal outbreaks	Rising temperatures increase *Salmonella* prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
Mental Health and Well-Being	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

Source: U.S. Global Change Research Program[1]

In addition to environmental factors, social and demographic factors also drive vulnerability, meaning that the health of some communities or people could be more affected than others. Some are more vulnerable because of age (e.g., children, older adults) or preexisting medical conditions (e.g., diabetes, asthma). People who work outdoors or as first responders may face greater exposure. Large portions of other groups, such as immigrants, people of color, people living in poverty, or people experiencing homelessness may have less access to resources that would allow them to avoid exposures, seek care or treatment, or navigate long-term recovery. In many cases, vulnerability to the health impacts of climate change reflect existing health risk factors and disparities. In the United States, the legacy of colonization, slavery, and ongoing structural and systemic racism—including concentrated poverty and inequities in wealth, health, education, housing, and transportation—contribute mightily to disparities between white and nonwhite populations and, in particular, between white and Black and white and Native American populations, making climate change an area of essential importance for the vital missions of health equity and environmental justice.

Protecting people from these health impacts will ultimately require both short- and long-term thinking and action, both local and global perspectives, and both mitigation and adaptation, the primary focus of this report. Some necessary actions will require large-scale cooperation and dramatic shifts in how the nation organizes economic and societal activity. But important opportunities exist at the state and local level, especially with respect to helping people safely navigate their changing environment. This is particularly true for managing the risks to public health. Adaptation, which seeks to reduce injuries, illness, death, and suffering from climate change, can be considered an extension of traditional public health approaches that emphasize prevention and preparedness. In the United States, many of these actions are driven by state-level plans, policies, and programs, which provide a critical foundation and supply of resources to support additional efforts at the community level.

Given the size and diversity of the country, each state and its communities will experience climate change differently. State leaders must understand their particular risks and vulnerabilities in order to plan effectively. In areas of a state where vulnerability is higher, state leaders should invest more in adaptation and preparedness. Likewise, states that are more vulnerable overall should go to greater lengths to adapt to climate-related hazards.

This report examines states' readiness to protect residents from the health impacts of climate change in light of the nature and level of risks that they face. Researchers at Trust for America's Health and the Johns Hopkins Bloomberg School of Public Health developed a set of quantitative indicators to assess each state and the District of Columbia, drawing from three domains of inquiry: (1) vulnerability; (2) public health preparedness; and (3) climate-related adaptation.* American Indian and Alaska Native tribal nations and U.S. territories were not included in the assessment, owing to a lack of comparable data, a serious gap that this country must work to fill, given the acute threat that climate change poses to many of their residents.

* The District of Columbia was treated as a state in this study. Any reference to states generally should be understood to include the District.

The results provide a portrait of state-level preparedness for the health impacts of climate change in the United States. While researchers found that every state had engaged in at least some level of planning and preparation—the extent or effectiveness of plan implementation, critical to preventing adverse outcomes, was not part of the assessment—there was significant variation, and, in many places, a great deal of room for improvement. Of greatest concern, researchers found that states with the highest levels of vulnerability—predominantly located in the Southeast—tended to be among the least prepared. (See Table 1.)

Table 1
States Grouped by Level of Vulnerability and Preparedness

Vulnerability Group	State	Vulnerability Score Least Vulnerable: 3.4-4.7 More Vulnerable: 4.8-5.3 Most Vulnerable: 5.4-6.3	Preparedness Score Least Prepared: 4.0-5.0 More Prepared: 5.1-5.8 Most Prepared: 5.9-6.6
Least Vulnerable	Utah	3.8	6.6
	Maryland	4.4	6.3
	Vermont	4.3	6.3
	Colorado	4.0	6.2
	Wisconsin	4.4	6.1
	New Hampshire	4.1	6.0
	District of Columbia	4.5	5.9
	Maine	4.5	5.9
	Minnesota	4.4	5.8
	Washington	4.5	5.8
	Michigan	4.7	5.8
	Alaska	3.4	5.4
	North Dakota	4.1	5.2
	Nebraska	4.6	5.1
	Idaho	4.2	5.0
	Montana	4.3	4.8
	Wyoming	4.2	4.5
More Vulnerable	Virginia	4.8	6.3
	Massachusetts	4.9	6.2
	Rhode Island	4.9	6.0
	Illinois	4.9	6.0
	New York	5.3	5.9
	Pennsylvania	5.3	5.9
	Connecticut	4.9	5.9
	Oregon	4.8	5.8
	Delaware	4.9	5.7
	Kansas	5.1	5.3
	Iowa	4.9	5.3
	Indiana	5.0	5.0
	Ohio	5.1	5.0
	New Jersey	5.2	4.9
	Hawaii	5.3	4.8
	Nevada	4.9	4.6
	South Dakota	4.8	4.5
Most Vulnerable	North Carolina	5.5	6.0
	Arizona	5.4	5.9
	Alabama	5.8	5.8
	California	5.5	5.8
	Louisiana	5.9	5.7
	New Mexico	5.8	5.7
	Arkansas	6.1	5.5
	Missouri	5.4	5.5
	Florida	6.3	5.1
	Tennessee	5.5	4.9
	Georgia	5.6	4.9
	Kentucky	5.9	4.8
	South Carolina	5.9	4.8
	Texas	5.5	4.6
	Mississippi	5.9	4.5
	Oklahoma	5.5	4.5
	West Virginia	5.8	4.0

"Most prepared," among states that were "least vulnerable."

"Least prepared," among states that were "least vulnerable."

The COVID-19 pandemic is another reminder that long-predicted, seemingly remote health risks must continuously be high priorities for those entrusted with safeguarding Americans. The science is clear that the Earth's climate will continue to change and that those changes will adversely impact human health. Leaders at all levels of government must act with urgency and persistent focus to ensure that their people, particularly those who are most vulnerable, are safe and secure.

Specifically, Trust for America's Health and researchers at the Johns Hopkins Bloomberg School of Public Health offer the following federal and state policy and program recommendations:

Federal recommendations

1. Enact legislation requiring a national strategic plan.
2. Fully fund the Centers for Disease Control and Prevention's (CDC) Climate and Health program.
3. Provide funding for adaptation research and scientific training.
4. Fully fund the CDC's National Environmental Public Health Tracking Network.
5. Strengthen the public health infrastructure and its workforce, including by modernizing data and surveillance capacities.
6. Prioritize equity and resilience by supporting and protecting high-risk populations and by addressing the social determinants of health.

State recommendations

1. Bolster states' core public health preparedness capabilities.
2. Build health equity leadership in state and local governments.
3. Complete all steps of the CDC's Building Resilience Against Climate Effects (BRACE) framework, and continuously work to enhance and refine preparations.
4. Establish ongoing, dedicated funding and staff for climate-related preparations.
5. Engage in close coordination with local and federal partners.
6. Plan with communities, not for them.

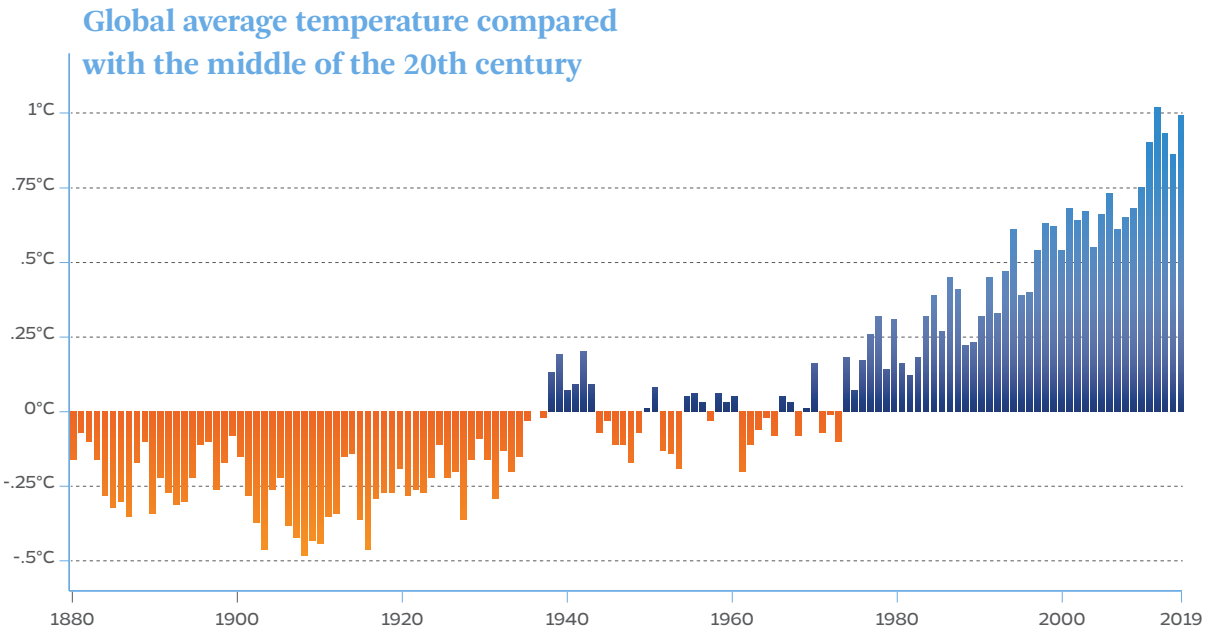
THREATS POSED BY CLIMATE CHANGE

Earth's climate is changing at a rate unprecedented over at least the past thousand years.[2] Although natural variability contributes to the observed changes, scientists overwhelmingly agree that human activities have been the dominant cause of climate change since the mid-20th century. Emissions of greenhouse gases from the burning of fossil fuels and other human actions are trapping heat in the atmosphere, causing the planet to warm.[3]

In its 2014 assessment, the Intergovernmental Panel on Climate Change (IPCC), the scientific body that informs the climate policies of the United Nations' member states, found that each of the past three decades were hotter than any preceding decade since 1850, and that 1983 to 2012 was likely the warmest 30-year period in the Northern Hemisphere over the past 1,400 years.[4] The IPCC concluded that it is "extremely likely" that human activities caused more than half of the increase in global average surface temperature between 1951 and 2010.[5]

More recently, 2019 was one of the hottest years on record, second only to 2016, according to the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).[6,7] (See Figure 2.) The world's five warmest years have all occurred since 2015, with nine of the 10 warmest years occurring since 2005. This continues a trend that dates back to the 1960s: each decade has been warmer than the previous one.

Figure 2
Global Average Temperatures Have Consistently Risen for Decades



Note: Annual average surface temperatures compared with the average temperature between 1951 and 1980.
Source: National Aeronautics and Space Administration and The New York Times[8,9,10]

Historical temperature records provide some of the clearest evidence of a warming planet, but rising surface temperatures represent only one data point in a larger cascade of Earth system changes. Researchers have documented many other indicators consistent with a warming world, including declining sea ice and snow cover, melting glaciers and ice sheets, rising seas, and more intense extreme weather events, such as hurricanes and wildfires.[11,12] Each trend has important implications for human society; taken together, they pose an existential threat to many millions of people around the world and portend destabilizing disruptions for many more.

The evidence is clear that the climate is changing and that it will continue changing for at least the next century. A certain amount of global warming can no longer be avoided: carbon dioxide and other greenhouse gases can persist in the atmosphere for hundreds of years or longer, and oceans are slowly absorbing the heat trapped by these gases.[13,14] Climate change is, therefore, a manifestation of past actions over decades. Over the past 150 years, atmospheric carbon dioxide has risen from 280 parts per million to more than 400 parts per million, primarily as a result of human activities (e.g., burning fossil fuels for electricity, heat, or transportation); more than a quarter of that increase has occurred since 2005.[15,16,17] Global average temperature rose by about 1.8 degrees Fahrenheit (1.0 degrees Celsius) from 1901 to 2016,[18] and scientists predict that current concentrations of greenhouse gases in the atmosphere will result in at least an additional 1.1 degrees Fahrenheit (0.6 degrees Celsius) of warming over this century.[19]

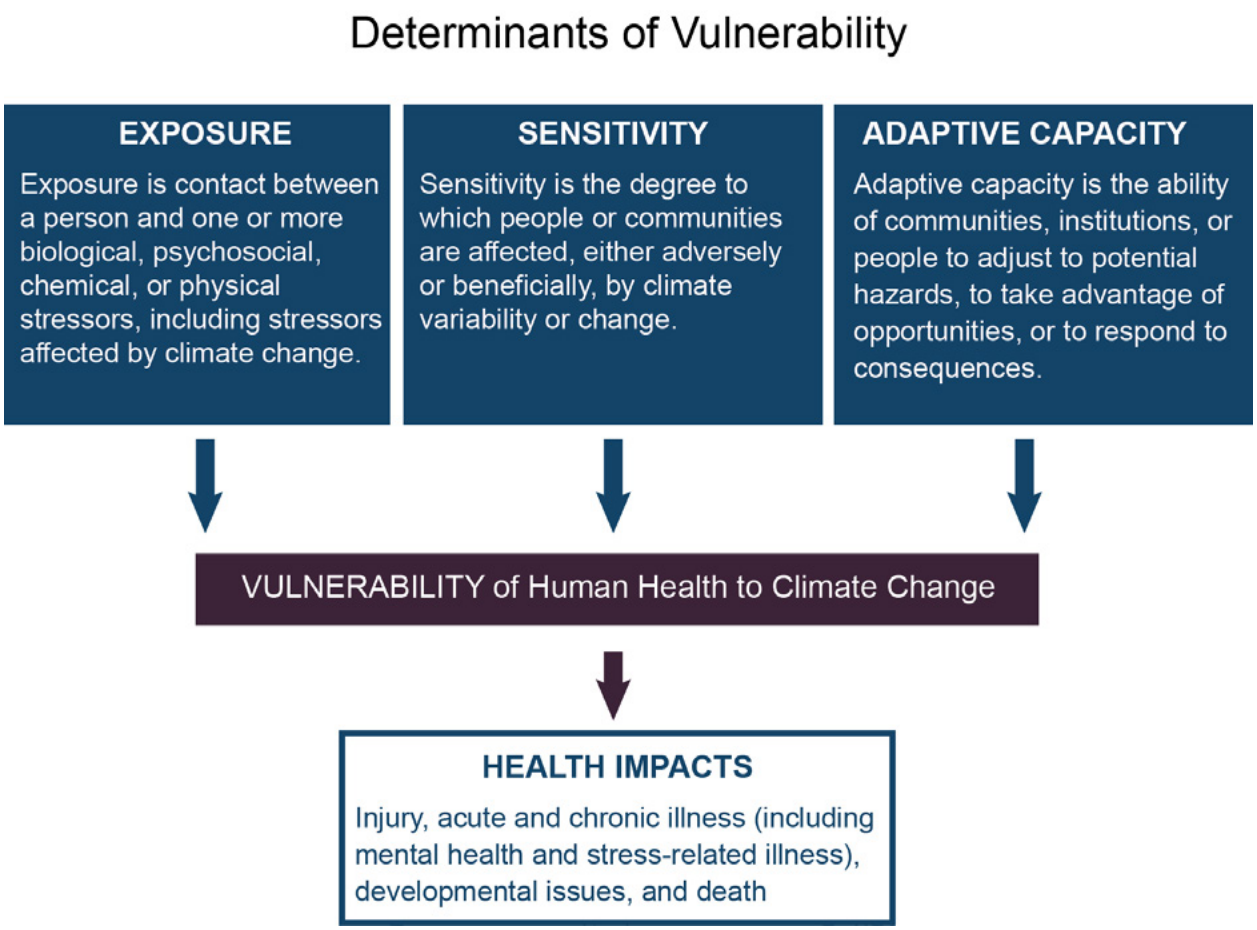
Because the climate system is so complex, the nature of changes beyond 2050 is less certain. Altering any aspect of the land-atmosphere-ocean system can create positive or negative feedback loops; for some aspects, there may be irreversible tipping points—thresholds that, once crossed, move the system out of its stable state.[20] Changes will depend significantly on actions taken over the next decade or two to mitigate greenhouse gas emissions. In the Fourth National Climate Assessment, a major report issued every four years by U.S. federal agencies, the U.S. Global Change Research Program (USGCRP) warned in 2018 that major reductions in emissions are required to limit the global temperature increase to 3.6 degrees Fahrenheit (2 degrees Celsius), compared with preindustrial temperatures.[21] Two degrees Celsius has historically been the international political and scientific consensus target for limiting risks associated with climate change, but a landmark IPCC report in October 2018 warned that even exceeding 1.5 degrees Celsius would produce calamitous effects.[22,23] Absent considerable reductions, annual average temperatures could rise by 9 degrees Fahrenheit (5 degrees Celsius) or more by the end of this century, increasing the severity of future risks, including extreme heat, heavy rains, flooding, wildfires, and drought, as well as the secondary implications for economies, political systems, and health.[24]

While meaningful steps must be taken to reduce future emissions and curtail the warming trend, such actions would only limit the magnitude and intensity of climate change and its impacts; past emissions and technological limitations mean that these impacts cannot be entirely averted. Thus, it is essential that people everywhere prepare to adapt.

Vulnerability is not an intrinsic or static characteristic; it varies over time and place, as well as across life stages. Moreover, in many cases, it is not innate, but rather the result of past and ongoing policies and practices rooted in structural and systemic inequities or discrimination. Therefore, it can be reduced through strategic planning and preparation, as well as through equitable policymaking and investment.

Climate change will not affect people and places equally. It is a global phenomenon, but its effects are local.[25] Weather patterns vary across regions and over short-term timescales, and their impacts depend in part on the vulnerability of the people affected.[26,27] Vulnerability incorporates place-based exposure to climate-related impacts (e.g., proximity to a coastline), as well as demographic characteristics (e.g., age, socioeconomic status) that shape a person's sensitivity to exposures and their ability to cope.[28] (See Figure 3.) Vulnerability is not an intrinsic or static characteristic; it varies over time and place, as well as across life stages.[29] Moreover, in many cases, it is not innate, but rather the result of past and ongoing policies and practices rooted in structural and systemic inequities or discrimination.[30] Therefore, it can be reduced through strategic planning and preparation, as well as through equitable policymaking and investment.

Figure 3
Exposure, Sensitivity, and Adaptive Capacity Determine Vulnerability



Source: U.S. Global Change Research Program[31]

CLIMATE CHANGE IN THE UNITED STATES

The United States is already experiencing the effects of climate change. From 1901 to 2016, average annual temperature over the contiguous United States increased by about 1.8 degrees Fahrenheit (1.0 degrees Celsius); and recent decades were the warmest in at least 1,500 years.[32] The western half of the country, including Alaska, experienced the largest increases in annual temperature, but warming in the Southeast has accelerated since the 1960s. As a consequence of past emissions, scientists expect the United States to see an additional 2.5 degrees Fahrenheit (1.4 degrees Celsius) increase in annual average temperature by 2050.[33] Much larger increases are projected by the end of the century.

Scientists expect extreme high temperatures to grow more common; that means more frequent and longer-lasting heat waves and more days when the temperature exceeds 90 degrees Fahrenheit. But harmful summer heat is not the only concern; higher winter temperatures are driving some of the country's fastest warming, particularly in the Northeast. Rhode Island has already surpassed the 2 degrees Celsius warming threshold, and Connecticut, Maine, Massachusetts, and New Jersey are close to reaching that unwelcome milestone.[34] In New Jersey, where ice harvesting was once an important industry, the average winter temperature is now above freezing.[35] Over the past century, every region* of the country saw an expansion of its frost-free season. With less snow and ice cover, more solar radiation is absorbed by the ground, rather than reflected back into space, contributing to further warming.[36]

Other indicators of the changing climate display strong regional differences. Since 1901, annual average precipitation increased across the Northeast, the Midwest, and the Northern and Southern Great Plains, and decreased in the Southwest and the Southeast. As with extreme heat, scientists project that the frequency and intensity of heavy precipitation events will multiply, making the kind of flooding that once skipped generations occur every few years.[37]

In parts of the United States, extreme weather events are becoming commonplace. Western states, particularly California, have experienced record-breaking droughts and high temperatures, coupled with ruinous wildfires and mudslides. At least three-quarters of California's 20 most destructive fires—measured by the number of structures destroyed—have happened since 2015.[38] Unusually powerful hurricanes have plagued the Caribbean, the Southeast, and Texas, with Hurricane Harvey dumping four feet of rain on Houston and Hurricane Maria devastating Puerto Rico in 2017.[39,40] Although it is difficult to attribute any single event to climate change, scientists are increasingly confident of its link to the greater frequency and intensity of these extreme events.[41,42]

* This report applies the regional designations defined by the U.S. Global Change Research Program. **Alaska**: Alaska; **Hawaii and U.S.-Affiliated Pacific Islands:** Hawaii. **Midwest:** Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. **Northeast:** Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. **Northern Great Plains**: Montana, Nebraska, North Dakota, South Dakota, and Wyoming. **Northwest:** Idaho, Oregon, and Washington. **Southeast:** Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. **Southern Great Plains:** Kansas, Oklahoma, and Texas. **Southwest:** Arizona, California, Colorado, Nevada, New Mexico, and Utah. Territories located in the U.S. Caribbean region were not included in the study, owing to a lack of comparable data.

Health impacts of climate change in the United States

Extreme events such as hurricanes and wildfires pose a clear threat to human health and safety. Other health impacts of climate change are less apparent, but no less important. Many health outcomes are linked to environmental factors and, as such, are sensitive to changes in climate and weather. These changes affect human health through a variety of pathways. Climate variables such as temperature and precipitation, for example, can act directly as stressors on human health; they can also create conditions that give rise to other health threats, such as infectious diseases or changes in air and water quality.

The U.S. federal government has identified seven categories of climate-related health impacts:[43]

1) ***Temperature-related death and illness.*** Temperatures that are above seasonal averages make it difficult for the human body to cool itself, leading to illnesses such as heat cramps, heat exhaustion, heatstroke, and hyperthermia. Scientists expect climate change to increase temperature averages and extremes, resulting in an increase in illness and death. Researchers expect reductions in cold-related mortality to be offset by increases in heat-related mortality.

2) ***Air quality impacts.*** Airborne pollutants and allergens in both indoor and outdoor environments harm the human respiratory and cardiovascular systems. Changing weather patterns will favor the formation of ground-level ozone over much of the United States. Wildfires emit fine particulate matter and ozone precursors that can worsen air quality for hundreds of miles.[44] In 2017 and 2018, Seattle saw 24 days of increased air pollution, stemming from wildfires in Washington and surrounding states, including four days in 2018, when the air quality was rated "unhealthy for all."[45,46] Increasing levels of carbon dioxide and warmer temperatures also promote plant growth, leading to higher pollen concentrations and longer growing seasons, which may contribute to a rise in the number of asthma episodes and allergic illnesses.

3) ***Impacts of extreme events on human health.*** Extreme events such as hurricanes, floods, wildfires, and other major storms can directly cause injury and death. They may also disrupt essential infrastructure (e.g., electricity, water, transportation, communication systems) in ways that can limit access to healthcare and emergency response services and can reduce the availability, quality, and safety of food, water, and medications.[47,48] In Texas's Harris County, encompassing Houston, historic rains from Hurricane Harvey in August 2017 severely restricted and delayed emergency rescues; volunteers with boats and high-water vehicles helped transport residents who needed medical care to hospitals that were struggling to manage amid their own flooding.[49,50] Months after the deadly Camp Fire in Paradise, California, in 2018, experts still advised residents not to drink or cook with the water due to concerns about benzene contamination.[51,52]

4) ***Vector-borne diseases.*** Some diseases spread from person to person (or animal to person) by way of a third organism, or "vector," such as a mosquito or a tick. Changes in environmental conditions that affect the prevalence, distribution, and activity of vectors also affect when, where, and how often humans get sick. As temperatures increase and frost-free seasons grow, ticks that carry Lyme disease and other human pathogens will likely continue to expand their geographic and seasonal distribution in the United States. Warmer and, in some places, wetter conditions may well also increase the abundance and range of mosquitoes that carry West Nile virus, Zika virus, and other pathogens.

5) ***Water-related illness.*** Changes in temperature and precipitation can affect the growth, survival, spread, virulence/toxicity, and seasonality of waterborne bacteria, viruses, and toxic algae that directly or indirectly cause illness in humans. Greater precipitation and extreme weather events may also lead to contamination of drinking and recreational water sources through increased runoff or infrastructure failures. Contaminants could include sewage or chemicals from human activities. Following Hurricane Maria in 2017, researchers from the University of Miami found elevated levels of polychlorinated biphenyls—a group of human-made organic chemicals that are thought to cause cancer and other ailments—in both the soil and in the people of Guánica, Puerto Rico.[53] In the immediate aftermath, the territory saw an increase in infectious diseases, including the normally rare bacterial disease leptospirosis.[54]

6) ***Food safety, nutrition, and distribution.*** In addition to disruptions in food supply caused by drought, flooding, and other extreme events, warming temperatures and changes in other environmental conditions are changing the prevalence and distribution of pests, pathogens, and food species, both on land and at sea, with health and economic consequences. Shorter and milder winters have given a boost to invasive fruit flies that threaten tart cherries in Michigan, raspberries in New York, and blueberries in Maine.[55] In the Northeast, warming seas have shifted the lobster population northward—a temporary boon for fisheries in Maine and a catastrophe for those in Rhode Island.[56,57] Warming waters off the coast of Alaska are making shellfish toxic, endangering the lives and livelihoods of Alaska Natives.[58] Scientists even expect climate change to alter the nutritional profile of some foods: higher concentrations of carbon dioxide can increase carbohydrate production, while also lowering levels of protein and other essential minerals in staple crops, such as wheat, rice, and potatoes.

7) ***Mental health and well-being.*** Exposure to climate-related disasters can produce stress and mental health disorders such as depression, anxiety, and post-traumatic stress disorder. In the months following Hurricane Katrina in 2005, calls to crisis helplines increased by 61 percent.[59] Higher rates of behavioral health disorders persisted for years.[60] Repeated exposure to disasters, as is expected in a warmer world, is also a risk factor.[61] People may also experience chronic stress from the gradual impacts of climate change, and they may experience other mental health outcomes based on related threats and perceived experience.[62] Other climate-related health outcomes can also contribute to a decline in mental health. People with existing mental illness face an especially acute threat from extreme heat, which increases their risk of both physical illness and death.[63,64]

Each of these categories represents known and, in many cases, longstanding threats to human health. That is, climate change exacerbates existing threats through increased frequency, duration, and intensity of exposure. It also shifts or expands the locations of exposures, introducing threats to populations that were not previously at risk.

While science's understanding of how climate change affects health has grown significantly in recent years, the ability to model health outcomes with precision remains limited, and it differs across climate impacts and health outcomes based in part on data availability.[65] Rather than generating pinpoint estimates, models provide insights about "how systems work and what may happen in a particular set of conditions" that can guide decision-making.[66] Many health impacts of climate change operate through indirect pathways that can be hard to quantify and predict. Because of this complexity, scientists are not yet always able to model outcomes such as disease incidence, injury, or mortality. In some cases, they instead examine how climate change might affect an exposure or an intermediate health determinant and use that as a signal of how health risks may change.[67] For example, most analyses of vector-borne disease have projected changes in season length or range expansion, rather than in infection rates.[68]

To inform USGCRP's Fourth National Climate Assessment, the Climate Change Impacts and Risk Analysis (CIRA) project, coordinated by the U.S. Environmental Protection Agency (EPA), sought to quantify some potential health effects.[69] One analysis looked at how changes in temperature under two emissions scenarios would affect the disease burden of West Nile neuroinvasive disease in the contiguous United States. CIRA projected that annual cases would more than double by 2050, compared with 1995, when the country saw just under 1,000 cases. By the end of the century, annual cases would increase by thousands more.[70] These figures are almost certainly underestimations, owing to gaps in available data.

Even relatively straightforward exposure-disease relationships pose challenges. Temperature-related illness is perhaps the most direct pathway to model, but even it can be challenging to parse using available data. For example, extreme heat exposure can lead to numerous health outcomes, and temperature may not always be reported as a cause of the morbidity or mortality.[71,72] Furthermore, the effects of temperature are different across regions and seasons, as well as population groups.[73] In its 2016 Climate and Health Assessment, USGCRP projected that temperature exposure will increase mortality on the order of thousands to tens of thousands of premature deaths each year by the end of this century.[74]

Some of the challenge of projecting the health burden of climate change is a consequence of the uncertainty of climate forecasts. Accurate predictions of health impacts—inherently local—require downscaled climate projections, which are not always available for the area of interest. The global picture matters, too: ultimately, health risks will depend in part on the scale of greenhouse gas emissions in places halfway around the world over the next decade and beyond.

Under a relatively high-emissions scenario, changes in temperature in 49 U.S. cities (accounting for about one-third of the country's population) could contribute to over 9,000 additional premature deaths each year by 2090; under a lower-emissions scenario, nearly 60 percent of those deaths could be avoided.[75,76] Extreme temperatures could result in net mortality rates of greater than eight deaths per 100,000 residents in nearly every city outside the Northwest in 2090.[77] These estimates do not account for changes in morbidity, although that burden is likely to be significant.

Human behavior shapes the trajectory of climate-related health impacts at a more local level, as well. Actual health outcomes depend not only on the environmental hazard, but on whether individuals and communities can avoid exposure to it or otherwise reduce its danger. Building adaptive capacity can change the relationship between a hazard and health outcomes. In the words of the USGCRP, "Climate change impacts can either be amplified or reduced by individual, community, and societal decisions."[80] For example, although temperatures have risen over the past century and particularly since 1970, the protective effect of air conditioning and other improvements have more than offset any rise in heat-related illness.[81]

We know with greater certainty that climate change in the United States will affect the health of some communities or people more than others. Some are more vulnerable because of age (e.g., children, older adults) or preexisting medical conditions (e.g., diabetes, asthma). People who work outdoors or as first responders may face greater exposure. Large portions of other groups, such as immigrants, people of color, and people living in poverty, may have less access to resources that would allow them to avoid exposures, seek care or treatment, or navigate long-term recovery, such as rebuilding after a fire or flood. Communities with fewer resources may be unable to meet demand for services like cooling centers, even as they suffer from greater sun exposure without the natural protection afforded to wealthier communities with more extensive tree canopies, a difference with historical ties to discriminatory housing policies such as "redlining."[82,83] In many cases, vulnerability to the health impacts of climate change reflects and exacerbates preexisting health risk factors and disparities.[84]

A CALL FOR HEALTH EQUITY AND ENVIRONMENTAL JUSTICE

Systemic racism in the United States undermines equity and opportunity, inflicting a far-reaching toll on the lives and health of Black people and other people of color. Its cross-cutting impacts are felt across health, education, economic opportunity, employment, housing, transportation, criminal justice, and other social determinants of health. And they are felt through environmental conditions, such as pollution sources regularly located near communities of color, and, indeed, climate change itself.[78] This is one reason why the two groups of Americans who care most about climate change are Latinx Americans and Black Americans.[79]

It is a regrettable axiom that people of color in the United States suffer from health threats first and worst. This was true once again with COVID-19, and it will continue to be true of climate change, unless leaders at all levels and across sectors prioritize the protection of disadvantaged people, including by finally confronting and reconciling with centuries-old biases that sit at the core of so many socially determined disparities. It is long past time to advance health equity and environmental justice.

In addition to its direct effects on human health, climate change may also produce disruptions to healthcare, social services, and other systems that are critical to a community's ability to manage or respond to health needs. This threat is particularly evident with natural disasters, which often destroy infrastructure, disrupt power and water supplies, and require a large-scale response. Even a prolonged heat wave or an extremely hot day may overwhelm power grids as people rely more heavily on fans and air conditioners. Such disruptions have a disproportionate impact on people with existing health conditions who require daily medication or treatment (e.g., dialysis), who have limited mobility, or who are more sensitive to climate-related exposures, such as high temperatures or poor air quality. Many medications and life-saving medical devices require a stable supply of electricity. People who lack reliable transportation or financial resources may find it more difficult to access services elsewhere in the event of a disruption.

Actions to mitigate climate change can also have direct health implications. For example, shifting from fossil fuels toward renewable energy sources such as solar or wind power reduces emissions, resulting in cleaner air and a subsequent reduction in the disease burden related to air pollution.[85,86] On an individual level, there is growing evidence that shifting to a plant-based diet or to more active modes of transportation (e.g., walking, biking, etc.) can promote better health outcomes.[87] Understanding potential health co-benefits can inform public health planning and policy decisions about mitigation and adaptation investments.[88]

PREPAREDNESS AND EMERGENCY MANAGEMENT IN THE UNITED STATES

As climate change increases the frequency, severity, and duration of weather-related health emergencies, communities around the world must prepare to minimize adverse impacts. They must be ready to prevent, respond to, and recover from incidents that pose public health risks. This is a key aspect of a broader preparedness regime capable of addressing natural hazards and manmade threats.[89]

In the United States, multiple actors at all levels of government share responsibility for preparedness and emergency management. Under this tiered system, action begins at the local level and expands to the state, territorial, tribal, regional, and federal levels as greater resources and capabilities are required.[90] If one tier's resources are overwhelmed, the tier above it is engaged to provide support. Strong coordination of all stakeholders is essential. Each group must be aware of its roles and responsibilities, as well as how it fits into the larger framework.

The U.S. Department of Homeland Security and the U.S. Department of Health and Human Services serve as focal points for federal emergency management and health security, coordinating preparedness efforts nationally.[91] The National Preparedness System guides these efforts and organizes them around a continuum of five interrelated mission areas: (1) prevention, (2) protection, (3) mitigation, (4) response, and (5) recovery.[92,93]

Within each mission area, the National Preparedness System identifies core capabilities for dealing with hazards.[94] The system reflects a layered approach that integrates shared responsibilities horizontally (across departments and agencies) and vertically (across all levels of government).[95] The federal government provides guidance and other resources to support its agencies, states, territories, tribes, and local jurisdictions in building their preparedness capacity.

The system is built around a whole-community approach to planning and implementing preparedness efforts; "whole community" refers to individuals and families, including those with access and functional needs; schools and academic institutions; faith-based and community organizations; businesses; nonprofits; media outlets; and all levels of government.[96,97] This approach is intended to help each group know its roles and responsibilities so that all stakeholders work well together. It also allows public officials to better understand a community's needs and capabilities, and plan accordingly.[98] Thus, it is critical that vulnerable populations be regularly engaged and that they inform planning. Ensuring government hears and acts on the perspectives of these individuals or communities can improve their outcomes in the event of an emergency.

In most cases, the local community or tribe is the first to prepare or respond.[99,100] Many incidents are managed entirely by the affected community and local leadership.[101] If the demands of preparation or response surpass local resources or capabilities, the state or territory may step in to supplement the efforts of the local government and, if necessary, coordinate with neighboring states.[102] The federal government can also get involved, providing funding, resources, or technical assistance and field support.[103] Typically, this happens when the governor of a state or territory or the chief executive of a tribe requests federal assistance. Federal resources may also be activated by a presidential emergency declaration or when the federal government has jurisdiction based on the subject matter or location of the incident.[104] The National Response Framework sums up this tiered approach as: "federally supported, state managed, locally executed."[105]

ADDRESSING THE IMPACTS OF CLIMATE CHANGE IN THE UNITED STATES

Within the National Preparedness System, the federal government has acknowledged the potential for climate change to alter communities' exposures and vulnerabilities to certain hazards.[106,107] The increasing frequency, intensity, and severity of climate change-related incidents is likely to overwhelm state and local resources more often, requiring more frequent activation at the federal and state levels.

Governments may have to deal with multiple incidents or disasters simultaneously. This has become a defining feature of the wildfire season in California and other western states, placing a strain on both local and national response systems. By July 2018—one month into its fiscal year—California had already spent about one-quarter of its emergency fire-suppression budget.[108] This is also becoming true of tropical storms. The 2017 hurricane season was the first one in which the United States experienced three Category 4 or greater hurricanes; parts of Texas, Florida, Louisiana, Puerto Rico, and the U.S. Virgin Islands are still dealing with the devastation wrought by Hurricanes Harvey, Irma, and Maria over the span of just two months.[109] Between 2016 and 2019, Harris County, Texas—the nation's third-most populous county[110]—experienced one 500-year rainfall event and two 100-year rainfall events.[111] Such frequency and intensity does not give communities time to recover or rebuild, leaving them more vulnerable when the next storm hits.

States and other jurisdictions are also likely to face new or less familiar threats. Climate change is shifting and expanding the geographic and seasonal risk of some hazards. Many of the dangers of climate change are insidious, lacking a singular event or clear catastrophe. Cities in the Southwest, already plagued by triple-digit summer temperatures, have seen a sharp increase in heat-related mortality in recent years as average temperatures—both daytime highs and nighttime lows—have risen. From 2014 to 2017, deaths related to heat exposure more than tripled in Arizona; most of these deaths were in the Phoenix area.[112] Older people and those who experience homelessness are particularly vulnerable, as are low-income and predominantly Latinx neighborhoods that lack shade and other cooling features.[113] Indeed, patchy tree cover in poor urban neighborhoods, predominantly communities of color, is a pervasive problem throughout

the United States, resulting from a mix of development, natural disasters, disease, invasive species, and a lack of resources for tree care and restoration.[114]

Recognizing that climate change does not affect all people or communities equally and addressing these differences is critical to limiting the impact of climate-related hazards. Preparedness activities offer an opportunity to think ahead about how to protect vulnerable populations across a state or local jurisdiction.

Americans broadly support action. According to an April 2020 study by the Yale Program on Climate Change Communication and the Center for Climate Change Communication at George Mason University, two in three Americans are at least "somewhat worried" about global warming.[115] More than four in 10 think global warming will harm them, and even more think it will harm their family and people in their community. Many Americans—indeed, about double the share from 2014—think a variety of negative physical and psychological outcomes harms will become more common in their community because of global warming over the next 10 years, if nothing is done to address it.[116] And a majority thinks state and local governments should place a "high priority" on protecting people's health from the effects of global warming over the next 10 years.

Mitigation and adaptation

The policy response to climate change falls into two major categories: (1) mitigation and (2) adaptation. Mitigation refers to actions that slow down or reduce the magnitude of climate change, primarily by reducing emissions of greenhouse gases or removing such gases from the atmosphere. Adaptation refers to the process of adjusting to the effects of actual or expected climate change by making decisions or investments to counter specific risks.[117,118] The global IPCC and the USGCRP's Fourth National Climate Assessment both stress that mitigation and adaptation are complementary strategies, each essential to minimizing the human impacts of climate change.

Both mitigation and adaptation can reduce injuries, illnesses, and deaths from climate-related health outcomes, but there are differences related to how quickly and locally some benefits may be realized. Much of mitigation operates over a longer time horizon to reduce future risks, while adaptation focuses on limiting the risk and impact of changes that are already underway, fueled by past greenhouse gas emissions.[119] Adaptation is grounded in the recognition that, based on past emissions, some level of climate change is inevitable, and people must prepare to live in a changing environment.[120] Its benefits are more immediate than much of those of mitigation. The risks posed by climate change are context- and place-specific, so adaptation takes place primarily at the state and local level.[121,122] Because adaptation focuses on addressing specific risks, interventions can be directed toward reducing vulnerabilities and increasing the resilience of specific groups or communities. Many of the benefits of mitigation actions are more diffuse, accruing globally instead of locally, though some—improved health owed to safer air quality or more active modes of transportation—materialize more swiftly for the communities engaged in them and can reduce related inequities.[123]

Adaptive actions are meant to manage climate-related risks, which are driven by exposure and sensitivity to hazards. The greater the adaptive capacity and follow-through—among individuals, businesses, governments, and other sectors—the lower the risk. With respect to health impacts, adaptation involves assessing vulnerabilities of a location or community to specific threats (e.g., extreme heat, flooding, vector-borne diseases), identifying evidence-based interventions, developing and implementing a plan, and then monitoring and evaluating the interventions to pinpoint and address weaknesses. The Centers for Disease Control and Prevention (CDC), through its Climate and Health Program, provides a step-by-step guide for governments and others to follow.[124]

There are numerous approaches to address the most pressing threats. For example, to help protect people from extreme heat, an area might employ a mix of early warnings, cooling shelters, and an expansion of green spaces. To combat West Nile virus and other mosquito-borne infections, a community might look to destroy breeding sites. Localities might employ crisis-counseling services to people whose mental health has been harmed by a traumatic disaster.

Climate-related adaptation, a vital element of public health preparedness efforts, is the focus of this report.[125]

COVID-19 IMPAIRS PREPAREDNESS AND EMERGENCY RESPONSE

The COVID-19 pandemic has strained U.S. emergency response systems at all levels, revealing critical health security weaknesses and exposing the nation's longstanding systemic inequities. These weaknesses affect not only the country's ability to limit the spread and impact of SARS-CoV-2, but also its resilience to climate change in both the short and long term.

As the nation grapples with the pandemic, it has also had to prepare for and respond to weather-related emergencies and natural disasters. Climate change is already increasing the frequency and intensity of heat waves, droughts, storms, and wildfires.[126] At the time of writing, the nation was in the midst of multiple record-setting disaster seasons. As NOAA predicted in spring 2020, the Atlantic hurricane season has been well above-average,[127] while a dry winter combined with an unusually hot and dry summer contributed to the most active fire season in the West on record.[128]

Protecting communities from these growing threats—already a challenge—has been further complicated by the pandemic. The COVID-19 response requires significant resources—money, staff, equipment, and supplies. Yet, resources at all levels—federal, state, and local—were already stretched thin. To support a nationwide pandemic response, the Federal Emergency Management Agency (FEMA) redirected resources from emergency response and training, reducing its available trained personnel, even as staff shortages had already been a struggle during recent severe weather seasons.[129,130] Worse, experts were expecting fewer disaster response volunteers, owing to the risk of COVID-19.[131]

Just as emergency response agencies need more resources, sharp declines in tax revenue brought on by pandemic-related economic shutdowns have created huge gaps in state budgets. In January 2020, California announced $100 million in state and federal funding to support home retrofits to make structures more fire-resistant, with a particular focus on low-income communities.[132] But facing a sudden budget deficit, the governor proposed suspending the program, as well as plans for a Climate Resilience Bond and other funding for climate-related projects. Around the country, climate-related capital projects, such as sea walls and raised roads, face a similar fate.[133,134] Delays related to the pandemic have also threatened states' ability to meet the conditions for federal funding under a program to support model climate-resilient construction projects.[135]

States must also balance the need to protect residents from competing hazards. Some measures required to protect people from a hurricane or wildfire—evacuation and shelter, for instance—are at odds with those used to mitigate the spread of infections. Under new hurricane preparedness guidelines, FEMA encourages states to use non-congregate shelters such as school dormitories or hotels,[136] making it more difficult to meet capacity needs. Additionally, adhering to physical distancing has changed the way emergency personnel respond to disasters. In states facing wildfires, officials have had to introduce new precautions, such as breaking firefighters into smaller units.[137]

Addressing the needs of acutely vulnerable populations—many of whom are also bearing a disproportionate burden from COVID-19—has been especially challenging. Struggling households have fewer resources to prepare for emergencies and rely heavily on states for relief aid. Many communities count on cooling centers for protection during extreme heat events, but physical-distancing restrictions limit the number of people who can be safely accommodated. And fear of infection may prevent some from seeking shelter.

The pandemic has revealed weaknesses in the nation's health security systems. But other emergencies will not stop for the pandemic, so state and federal agencies must take extra precautions to prepare the nation, even as they work to prevent the spread of COVID-19.

AN ASSESSMENT OF STATE CLIMATE-RELATED VULNERABILITY AND PREPAREDNESS

While climate change is impacting virtually every corner of the planet, the nature and degree of risks vary by place and community, as does readiness for protecting people. Indeed, there is an interdependent relationship between vulnerability and readiness. The more at risk an area is, the greater lengths it ought to go to prepare.

This principle applies to every country, and it applies to every U.S. state. Some states will face unforgiving rising seas and record-breaking hurricanes, while others will grapple with unprecedented wildfires and drought. The steady creep of riverine flooding will halt daily activities in some places, while disease-carrying vectors will creep into others. And the demographic characteristics that so heavily influence people's adaptive capacities differ in significant ways among and within states.

This variability, and other distinctive contexts of states and their residents, will necessitate that each state develop its own set of solutions to the challenges that climate change presents. But the planning process is essentially the same, beginning with an in-depth examination of risks and vulnerabilities, and then rigorously searching for interventions that are most likely to succeed.

To better understand the threats posed to states, and the extent of their preparations, researchers at Trust for America's Health and the Johns Hopkins Bloomberg School of Public Health studied the circumstances of every state and the District of Columbia.* (American Indian and Alaska Native tribal nations and U.S. territories were not included in the assessment, owing to a lack of comparable data, a serious gap that this country must work to fill given the acute threat that climate change poses to many of their residents.) The analysis employed a set of quantitative indicators spanning three domains of inquiry: (1) vulnerability; (2) public health preparedness; and (3) climate-related adaptation. The results provide a portrait of state-level preparedness for the public health impacts of climate change in the United States.

A review of academic and grey literature, as well as a series of structured interviews with issue experts, informed this framework of domains and indicators. Researchers closely examined more than 200 academic articles (starting from a universe of 4,000)—primarily focused on the vulnerability of discrete places—and published work by leading bodies, including the USGCRP, the CDC, and the American Public Health Association. They also spoke with a diverse group of experienced colleagues about essential elements of preparedness and the factors they depend on; best practices in the area of climate-related adaptation and how those practices are facilitated or impeded; and states or localities that are seen as leaders in this area.

* The District of Columbia was treated as a state in this study. Any reference to states generally should be understood to include the District.

States are the focus of this study because they play a central role in coordinating funding and planning, but local partners play an essential and, in some places, a leading role in putting relevant preparations into motion. State efforts are most successful when they operate in close collaboration with frontline communities. While this assessment does not directly capture local actions, researchers appreciate their importance.

Every state has a strong interest—put in stark relief by the COVID-19 pandemic—in building and maintaining a robust public health system equipped to promote health, safety, and well-being. This is the responsibility of not just public health officials, but also elected leaders and partner agencies. Certainly, every state has skilled, dedicated staff working to protect as many people as possible. But chronic underfunding and other obstacles have left room for improvement everywhere—a lot of room in some states—particularly across system elements that are most pertinent to preparedness for weather-related emergencies.[138]

Likewise, a wide range separates states with respect to basic preparations for adapting to climate change's health impacts. Some have invested real time and resources for years, including by establishing dedicated teams that continuously work to hone a detailed understanding of their state's climate-related threats and evidence-based interventions. Others, including some with higher vulnerabilities and risks, seem to have barely begun.

The following analysis lays out where states stand across the three domains and highlights lessons and examples with broad relevance.

TOPLINE FINDINGS OF THE ASSESSMENT

To help advance a comprehensive understanding of states' recent positioning vis-à-vis the health impacts of climate change, researchers, after thoroughly reviewing published literature and consulting with subject-matter experts, targeted three essential underlying elements—(1) vulnerability, (2) public health preparedness, and (3) climate-related adaptation—and rigorously selected indicators to measure them. (See Table 2.) Individually, each indicator sheds light on an important aspect of states' risk and readiness; collectively, and by juxtaposing them, they illuminate a fuller landscape than has been available to date.

Table 2

Indicators of Readiness to Confront Health Impacts of Climate Change

VULNERABILITY	PREPAREDNESS	
Domain 1: Vulnerability	**Domain 2: Public health preparedness**	**Domain 3: Climate-related adaptation**
Environmental factors		**Vulnerability assessment**
Extreme heat	Health surveillance and epidemiological investigation	Have climate-related exposures been identified?
Flooding	Environmental monitoring	Have climate-sensitive health outcomes been identified?
Drought	Incident management	Have risk factors for health outcomes been identified?
Wildfire	Information management	Have causal pathways of climate-related hazards been developed?
Severe storms	Cross-sector / community collaboration	Have climate projections been reported?
Disease vectors	Social capital and cohesion	Have vulnerable populations been identified and located?
Social and demographic factors	Prehospital care	**Intervention identification**
Poverty	Long-term care	Have interventions been identified?
Income inequality	Hospital and physician services	Were the interventions evidence-based?
Age composition	Behavioral healthcare	
Race/ethnicity composition	Home care	
Disability		
Housing		
Transportation		
Language proficiency		
Education level		

Note: See "Appendix A: Methodology" for a full description of indicators.

Researchers scored the measures and grouped states, first by level of vulnerability (Domain 1) and then by level of preparedness (Domains 2 and 3). (See "Appendix A: Methodology" for a full description of indicators and how scores were calculated.) The results provide stakeholders seeking to stratify states and target those at highest risk and/or in greatest need of improvement with critical context. More importantly, they help leaders at the state and local level better understand their risk and readiness.

There are clear regional distinctions with respect to states' relative vulnerability. (See Table 3.) All but five (Arizona, California, Missouri, New Mexico, and West Virginia) of the 17 states classified as "most vulnerable" are in the Southeast or the Southern Great Plains. In fact, all but two states in these two regions (Kansas and Virginia) were within this group, with Florida, Arkansas, Louisiana, South Carolina, Mississippi, and Kentucky found to be the most vulnerable in the country. By contrast, states that were "least vulnerable" are located throughout the country, with a slight predominance of those from the Northeast or Northern Great Plains.

Regional differences in preparedness were also fairly stark: a clear majority of the states found to be "most prepared" are in the Northeast, and a plurality of states found to be "least prepared" are in the Southeast. The most prepared states in the country were Utah, Maryland, Vermont, Virginia, Colorado, and Massachusetts, while the least prepared states were West Virginia, Mississippi, Oklahoma, South Dakota, and Wyoming.

Of cause for concern, a number of states with high levels of vulnerability were among the least prepared in the country.

Of cause for concern, a number of states with high levels of vulnerability were among the least prepared in the country. Indeed, researchers found a moderately negative correlation (correlation coefficient: -0.35) between vulnerability and preparedness. That is, the more vulnerable states were, the less prepared they tended to be—the opposite of what would be in the best interest of states and residents facing the most dangerous impacts. Just two states (Arizona and North Carolina) that were rated "most vulnerable" were also rated "most prepared." All except four states (California, Missouri, New Mexico, and West Virginia) that were classified as "most vulnerable" but *not* "most prepared" are in the Southeast or the Southern Great Plains.

While this stratified analysis is instructive for understanding the extent of states' preparedness within the context of their vulnerabilities, it is essential to also parse the data underlying these results. The following sections discuss and analyze each domain of indicators in detail, highlighting states that stand out as leaders and potential models for their peers.

Table 3

States Grouped by Level of Vulnerability and Preparedness

Vulnerability Group	State	Vulnerability Score Least Vulnerable: 3.4-4.7 More Vulnerable: 4.8-5.3 Most Vulnerable: 5.4-6.3	Preparedness Score Least Prepared: 4.0-5.0 More Prepared: 5.1-5.8 Most Prepared: 5.9-6.6
Least Vulnerable	Utah	3.8	6.6
	Maryland	4.4	6.3
	Vermont	4.3	6.3
	Colorado	4.0	6.2
	Wisconsin	4.4	6.1
	New Hampshire	4.1	6.0
	District of Columbia	4.5	5.9
	Maine	4.5	5.9
	Minnesota	4.4	5.8
	Washington	4.5	5.8
	Michigan	4.7	5.8
	Alaska	3.4	5.4
	North Dakota	4.1	5.2
	Nebraska	4.6	5.1
	Idaho	4.2	5.0
	Montana	4.3	4.8
	Wyoming	4.2	4.5
More Vulnerable	Virginia	4.8	6.3
	Massachusetts	4.9	6.2
	Rhode Island	4.9	6.0
	Illinois	4.9	6.0
	New York	5.3	5.9
	Pennsylvania	5.3	5.9
	Connecticut	4.9	5.9
	Oregon	4.8	5.8
	Delaware	4.9	5.7
	Kansas	5.1	5.3
	Iowa	4.9	5.3
	Indiana	5.0	5.0
	Ohio	5.1	5.0
	New Jersey	5.2	4.9
	Hawaii	5.3	4.8
	Nevada	4.9	4.6
	South Dakota	4.8	4.5
Most Vulnerable	North Carolina	5.5	6.0
	Arizona	5.4	5.9
	Alabama	5.8	5.8
	California	5.5	5.8
	Louisiana	5.9	5.7
	New Mexico	5.8	5.7
	Arkansas	6.1	5.5
	Missouri	5.4	5.5
	Florida	6.3	5.1
	Tennessee	5.5	4.9
	Georgia	5.6	4.9
	Kentucky	5.9	4.8
	South Carolina	5.9	4.8
	Texas	5.5	4.6
	Mississippi	5.9	4.5
	Oklahoma	5.5	4.5
	West Virginia	5.8	4.0

"Most prepared," among states that were "least vulnerable."

"Least prepared," among states that were "least vulnerable."

Note: To group states, researchers first rank-ordered them by vulnerability score, producing three groups of 17: "least vulnerable," "more vulnerable," and "most vulnerable." Separately, researchers rank-ordered states by their preparedness score—an unweighted average of their scores for Domain 2 and Domain 3, producing three groups of 17: "least prepared," "more prepared," "most prepared." The latter grouping determined the preparedness classifications of states within vulnerability categories. Within each category of vulnerability, states highlighted in turquoise are "most prepared," states highlighted in yellow are "more prepared," and states highlighted in red are "least prepared." The "border" between groupings may not yield significantly different scores. Readers should look at the actual scores provided in this report for a full understanding of each state's situation. See "Appendix A: Methodology" for a full description of indicators and how scores were calculated.

DOMAIN 1: VULNERABILITY

Vulnerability: the degree to which physical, biological, and socioeconomic systems are susceptible to and unable to cope with the adverse impacts of climate change.

Source: U.S. Global Change Research Program[139]

Climate change is a global phenomenon, touching all life on Earth. Every place will experience its effects, but not in the same way or to the same degree. The global trends discussed above are manifested through local weather patterns and environmental changes. Where a person lives will, in large part, drive her experience of climate change.

Even within a single place, however, individuals and communities may experience climate change in starkly different ways. Differences in exposure, sensitivity, and adaptive capacity mean that some people are more vulnerable to the health impacts of climate change than other people—that is, they are more susceptible to and less able to cope with these impacts.[140]

Some aspects of vulnerability are innate (e.g., age, some health conditions, disabilities). Intrinsic biological differences shape sensitivity to exposures, making some people more likely to get sick or experience a severe course of disease. But many other factors are important for health because they reflect social or economic conditions—often, patterns of deprivation and discrimination—that have meaningful health impacts. Some experts have argued that so-called natural disasters are, in fact, rarely natural; rather, "it is the social, political, and economic context that makes an environmental hazard become a disaster."[141] Even "geography is never an accident."[142]

In the United States, the legacy of colonization, slavery, and ongoing structural and systemic racism contributes to significant health disparities between white and nonwhite populations and, in particular, between white and Black and white and Native American populations. These disparities manifest in myriad ways, including less access to quality healthcare, transportation, housing, and food; greater exposure to polluted air, water, and soil; and resulting chronic stress and higher rates of chronic health conditions such as diabetes, asthma, and cardiovascular disease.[143] As examples, Black and Latinx communities are exposed to more air pollution than they produce—white Americans experience the opposite—and more than 30 percent of Black New Orleanians did not own cars when Hurricane Katrina swept ashore, making evacuation all but impossible. Socioeconomic characteristics (e.g., poverty, income inequality, education level) also affect the ability of individuals and communities to prepare for and cope with health emergencies or adverse events, in part because they determine access to resources and information.[144,145,146]

California's record-breaking, catastrophic wildfires have affected people across the socioeconomic spectrum, but the devastation is not equally distributed.[147,148] For some wealthier residents, losing their home in the 2017 Wine Country fires presented an opportunity to rebuild better with the aid of savings or insurance payouts.[149] Low-income residents and communities have not shared this experience. A year after the Camp Fire destroyed more than 11,000 houses in Paradise, California, only 11 had been rebuilt.[150] People who are poor are less likely to have robust insurance coverage; they may also face more obstacles to obtaining aid.[151] Together, differences in exposure, sensitivity, and adaptive capacity determine the likelihood that climate change will harm the health status of a person or community. This is also true at the national level: some states are more vulnerable than others by virtue of location, demographics, or both. Understanding these differences is essential to understanding how prepared each state is. Preparedness must be measured against the real risks a state faces, as well as the ability of its people to cope with those risks. A state that is more vulnerable will need to go to greater lengths to adequately protect its population from climate-related health impacts, including through dedicated work to ameliorate societally imposed sensitivities.

Measuring vulnerability

To assess the vulnerability of each state, researchers developed a set of indicators that measure environmental factors and social and demographic factors, all of which influence people's level of exposure, sensitivity, and adaptive capacity.

Gauging environmental factors

Measures of environmental factors represent key hazard pathways through which climate change affects human health:

- **Extreme heat** places people at risk for heat stress and related health outcomes, such as heat exhaustion and heat stroke. It can affect air quality, contributing to negative respiratory outcomes, particularly for people with preexisting conditions such as asthma.[152] Researchers measured vulnerability here by tracking how often local temperatures reach historical extremes.

- **Flooding** can cause death and injury, and it may also expose people to chemical and biological contaminants in floodwaters, leading to waterborne diseases and skin irritation.[153] It can also leave behind living, working, and schooling conditions with mold and mildew, which can affect the health of occupants.[154] The proportion of a state's population that resides within a Special Flood Hazard Area as designated by the Federal Emergency Management Agency (FEMA), a conservative measure,[155] determined vulnerability to floods. These areas have a 1 percent annual chance of coastal or riverine flooding.[156]

- **Drought** can reduce air quality, including by increasing the risk of wildfire and dust storms. The scarcity of water resources can affect livestock and crops, contributing to negative human health impacts through food insecurity.[157] Researchers measured drought vulnerability by the number of days with a drought event.

- **Wildfire** affects air quality through the release of particulate matter and other emissions that contribute to respiratory issues and even death.[158] In destroying property, wildfires can cause death and injury, and they can contribute to the contamination of the local environment, including water supplies.[159] Fires can also increase the risk of subsequent flooding due to the loss of vegetation. Researchers measured vulnerability to wildfire by the percentage of zones—defined by states—in a state that recently experienced a significant wildfire, defined as one that causes fatality, significant injury, and/or property damage.

- **Severe storms**, such as hurricanes and tornadoes, can cause serious injury and loss of life, destroy infrastructure (including healthcare facilities), and produce flooding that exposes people to chemical contamination and pathogens.[160] Lingering floodwaters can also contribute to mold and the proliferation of mosquitoes and the spread of vector-borne diseases. Researchers based vulnerability on the number of days in recent years with a severe storm—a storm with thunderstorm winds, a tornado, a tropical depression, or a hurricane—that caused injuries and/or deaths.

- **Disease vectors**, particularly mosquitoes and ticks, carry disease pathogens that can cause illness and death in humans. Researchers measured vulnerability to vector-borne diseases (for example, Lyme disease, Powassan virus disease, chikungunya, and West Nile virus) by the likely presence of three vectors: two mosquito genera (*Culex pipiens* and *Aedes aegypti*) and one tick genus (*Ixodes*). Lyme disease—the most common vector-borne disease in the United States—and Powassan virus each transmit through the bite of an infected tick, each producing minor symptoms such as fever or headache that can escalate to a more serious illness.[161] West Nile virus—the leading cause of mosquito-borne disease in the continental United States—and chikungunya virus spread through the bite of an infected mosquito (in rare cases, West Nile has also spread through exposure in laboratory settings, through blood transfusion and organ donation, or from mother to baby).[163,163] Fever and joint pain are common symptoms of diseases caused by both, with West Nile causing in rare instances encephalitis (inflammation of the brain) or meningitis (inflammation of the membranes that surround the brain and spinal cord).

These hazards are tied to geography and weather patterns, including extreme events. Researchers chose specific indicators based on the availability of reliable data for analysis at the state level. (See Table 4.) To be sure, a fuller understanding requires also tracking data at a smaller geographic scale, such as by county, census tract, or neighborhood.

Table 4

Measures of Vulnerability to Climate-Related Health Threats: Environmental Factors

INDICATOR	MEASURE	SOURCE
D1.1 Extreme heat	Number of days per year with a maximum temperature above the 95th percentile for the area, 2014–2016	CDC National Environmental Public Health Tracking Network
D1.2 Flooding	Percent of the population residing within FEMA-designated Special Flood Hazard Areas	CDC National Environmental Public Health Tracking Network
D1.3 Drought	Number of days with a drought event (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.4 Wildfire	Percent of zones with significant wildfire (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.5 Severe storms	Number of days with a severe storm causing injury or death (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.6 Disease vectors	Likely presence of each of three exemplar vectors, varied timeframes	NASA; CDC National Center for Emerging and Zoonotic Infectious Diseases, Division of Vector-Borne Diseases

Notes: Researchers aggregated state-level data on **extreme heat** from county-level data. FEMA defines Special Flood Hazard Areas as those that have a 1 percent annual chance of coastal or riverine **flooding**. The drought classification system of the Drought Monitor, a multiagency federal effort, defines a **drought** event. In the data, droughts begin when an area escalates to the "D2 (severe drought)" or "D3 (extreme drought)" classifications, or when droughts begin to significantly impact people, animals, or vegetation. Droughts end in the data when an area deescalates from these classifications, or when they cease causing significant impacts. Data on **wildfires** capture any significant forest fire, grassland fire, rangeland fire, or wildland-urban interface fire that consumes natural fuels and spreads in response to its environment. A "significant" wildfire is one that causes one or more fatalities, one or more significant injuries, and/or property damage. In general, the data do not capture forest fires smaller than 100 acres, grassland or rangeland fires smaller than 300 acres, and wildland-use fires not actively managed as wildfires. Data on **severe storms** include days with thunderstorm winds, a tornado, a tropical depression, a tropical storm, or a hurricane, as well as a related death and/or injury. Data on exemplar **disease vectors** capture three of particular concern: *Culex pipiens* and *Aedes aegypti* (mosquitoes), and *Ixodes scapularis* or *Ixodes pacificus* (blacklegged ticks). (See "Appendix A: Methodology" for details on data manipulation and scoring.)

Gauging social and demographic factors

In selecting measures for social and demographic factors, researchers first reviewed existing resilience and vulnerability indexes, including the CDC's Social Vulnerability Index (SVI).[164] Researchers largely based data collection on SVI's four domains: (1) socioeconomic status, (2) household composition and disability, (3) housing and transportation, and (4) minority status and language.[165] This assessment focuses on the following characteristics:

- **Poverty** restricts people's capacity to prepare for an emergency, to respond during an emergency, or to recover following a disaster.[166] For example, a lack of income or assets may prevent someone from investing in home improvements such as weatherization that could protect against storm damage. Poverty may cause some people to have trouble paying for utilities, leaving them without air conditioning or heat and vulnerable to extreme temperatures. It can also serve as a proxy for other aspects of vulnerability, such as underlying health conditions or access to healthcare.

- **Income inequality** represents the relative deprivation of those with low incomes. Areas with wide income dispersion tend to have relatively more residents who lack critical resources for resilience. Researchers measured inequality here using the Gini coefficient, a metric of income dispersion.

- **Age composition** indicates age-related vulnerability. Many climate-related health effects have a more pronounced effect on people who are elderly or very young. In some cases, these populations are more sensitive to exposure, such as extreme temperature. They are also likely to experience reduced mobility and to require caregiving and other supports. Researchers measured composition by calculating the percentage of the state population under age 5 or over age 64.

- **Race/ethnicity composition** reflects a number of social, economic, and health disparities. Many of these result from persistent patterns of marginalization, discrimination, and disenfranchisement. In the United States, race and ethnicity often influence where people live, which has a profound impact on their vulnerability to climate change. Discriminatory housing policies and practices that advantaged white people and restricted where people of color could live, such as redlining, continue to define exposure and sensitivity in cities across America.[167] The Edison-Eastlake neighborhood in Phoenix, Arizona, is one product of that segregationist history. Most of its residents are people of color; the majority reside in outdated, poorly insulated public housing. Trees shade a little more than 5 percent of Edison-Eastlake, and nighttime temperatures can be 10 degrees Fahrenheit hotter than in wealthier areas. The neighborhood's heat mortality rate is 20 times the county average.[168] Discrimination may also affect the resources for preparedness and recovery made available to areas and communities where minority groups live in disproportionate numbers.[169] This element of vulnerability is based on the share of a state's population that is nonwhite.

- **Disability** can make it harder for a person to navigate emergency response or recovery. Disabilities affect some people's mobility or cognition, meaning that planning must take their needs into consideration; they may need greater resources or support to cope with climate-related hazards and health effects. This assessment measures the percentage of a state's population with a disability.

- **Housing** provides crucial protection from climate-related hazards. The ability to shelter safely is a key component of resilience. This assessment focuses on the vulnerability of people who live in mobile homes, which are likely to suffer greater damage from storms and other natural disasters.

- **Transportation** represents a population's mobility, including its ability to evacuate in the event of an emergency. Private transportation also facilitates access to additional goods and services in the event of a local disruption. Researchers measured vulnerability based on motor-vehicle access, which, while being a significant contributor of greenhouse gas emissions, is the main mode of transportation in most of the country.

- **Language** affects people's ability to comprehend and act on public health messages and emergency alerts, such as evacuation instructions.[170] With limited or no English proficiency, a person or household may find it difficult to access the care or services they require. They may have trouble navigating complex systems to obtain health and social services, including long-term recovery benefits. They may also be subjected to discrimination in receiving those services. This is factored into the assessment by accounting for the percentage of households with members who speak limited English. Preparations must incorporate effective culturally and linguistically appropriate outreach, education, and services to meet the needs of such residents.

- **Education** is related to both income and poverty. A person with higher levels of educational attainment is likely to have greater access to information and may be more willing or able to act on that information effectively.[171] Someone who is more highly educated may find it easier to navigate the health and social services that support preparedness and recovery.[172] This is represented here by measuring the percentage of a state's adult population without a bachelor's degree.

> ***"Nothing is inherent in one's race, ethnicity, income, or education level that precludes an appropriate response in an emergency. All people are made up of a constellation of characteristics that enable them to assist in some situations but require assistance in others. None should be viewed merely as a so-called victim group or a so-called rescue group."***
>
> ***Source:*** Centers for Disease Control and Prevention

Researchers drew relevant measures from the SVI or published literature, and they collected corresponding state-level data from the U.S. Census Bureau's American Community Survey. (See Table 5.) These variables should be understood as population characteristics that make certain groups more vulnerable than others; they do not determine an individual's vulnerability.[173] CDC researchers involved in the development of the SVI cautioned: "Nothing is inherent in one's race, ethnicity, income, or education level that precludes an appropriate response in an emergency. All people are made up of a constellation of characteristics that enable them to assist in some situations but require assistance in others. None should be viewed merely as a so-called victim group or a so-called rescue group."[174]

Table 5

Measures of Vulnerability to Climate-Related Health Threats: Social and Demographic Factors

INDICATOR	MEASURE
D1.7 Poverty	Percentage of people living in poverty, 2018
D1.8 Income inequality	Gini coefficient, 2018
D1.9 Age composition	Percentage of population under age 5 or over age 64, 2018
D1.10 Race/ethnicity composition	Percentage of population that was non-white, 2018
D1.11 Disability	Percentage of population with a disability, 2018
D1.12 Housing	Percentage of population living in mobile homes, 2018
D1.13 Transportation	Percentage of population without a motor vehicle, 2018
D1.14 Language proficiency	Percentage of households with member(s) who speak limited English, 2018
D1.15 Education level	Percentage of population age 25 or older without a bachelor's degree, 2018

Notes: The **Gini coefficient** summarizes dispersion of income, ranging from 0 (perfect equality) to 1 (perfect inequality). All social and demographic indicators relied on one-year estimates of the U.S. Census Bureau's 2018 American Community Survey (ACS). The ACS, like any other sample survey, is subject to error. Researchers based each indicator on the ACS's subject definitions.

To assess and compare states, researchers converted the disparate measures into a unified scoring system using, for each indicator, a state's value in relationship to the nationwide average. They then scaled scores by normalizing their distribution and truncating the results of outliers to reduce their influence, placing all scores on a spectrum of 0 to 10 for every indicator. (See Table 6.) Then, they averaged scores for individual indicators to calculate state scores for each subdomain—environmental factors and social and demographic factors—and the domain as a whole. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

Table 6

State Scores Across Vulnerability Indicators

	ENVIRONMENTAL FACTORS						SOCIAL & DEMOGRAPHIC FACTORS								
	D1.1 Extreme Heat	D1.2 Flooding	D1.3 Drought	D1.4 Wildfire	D1.5 Severe Storms	D1.6 Disease Vectors	D1.7 Poverty	D1.8 Income Inequality	D1.9 Age Composition	D1.10 Race/ethnicity composition	D1.11 Disability	D1.12 Housing	D1.13 Trans-portation	D1.14 Language proficiency	D1.15 Education level
Alabama	5.5	5.2	6.3	3.4	7.0	6.2	6.9	6.3	5.4	5.4	7.0	6.9	4.8	3.9	6.7
Alaska	no data	4.5	2.9	3.4	1.8	0.0	4.0	2.1	2.1	5.8	4.7	4.5	6.2	4.4	5.3
Arizona	3.7	4.7	6.1	6.5	5.3	4.4	5.7	4.6	6.2	6.3	5.2	6.2	4.5	6.0	5.4
Arkansas	5.4	6.3	6.4	6.1	6.2	6.2	7.0	6.2	5.5	4.8	7.6	6.5	5.0	4.1	7.5
California	5.9	4.8	5.9	6.6	5.2	6.2	5.1	6.7	3.2	7.4	2.7	4.2	5.2	7.8	4.3
Colorado	1.8	3.5	6.2	6.4	4.5	2.4	3.2	4.2	2.9	5.2	3.0	4.4	3.5	5.3	2.9
Connecticut	5.9	5.2	5.9	3.4	5.0	4.4	3.7	7.3	4.8	5.3	3.1	2.7	6.1	6.7	3.2
Delaware	4.7	5.3	2.9	3.4	4.7	6.2	5.0	4.4	6.8	5.7	5.2	5.9	4.9	4.9	5.0
District of Columbia	5.6	0.9	2.9	3.4	4.0	6.2	6.7	8.5	1.9	7.4	3.9	1.9	8.6	5.8	1.3
Florida	6.5	8.4	6.2	6.5	6.4	4.4	5.5	6.5	8.5	6.3	5.4	5.8	4.7	7.2	5.2
Georgia	6.3	5.1	6.3	6.1	6.9	6.2	5.8	6.1	2.8	6.4	4.3	5.8	4.7	5.3	4.8
Hawaii	no data	6.6	6.6	6.6	4.0	4.4	2.6	3.3	7.1	8.2	3.9	2.1	6.1	6.9	4.4
Idaho	3.7	4.7	2.9	6.7	4.5	2.4	4.6	3.3	4.9	3.8	5.4	5.7	1.0	4.5	6.0
Illinois	4.3	3.8	5.8	3.4	5.6	6.2	4.7	6.3	4.2	5.8	3.4	3.6	6.8	6.2	4.1
Indiana	5.3	4.6	5.3	3.4	6.2	6.2	5.3	3.8	4.5	4.1	5.4	4.6	4.7	4.2	6.2
Iowa	3.0	7.1	6.1	5.7	6.2	4.4	4.2	3.0	5.8	3.3	4.0	4.2	4.3	4.6	5.6
Kansas	3.8	5.1	6.0	6.3	5.3	6.2	4.7	4.8	4.8	4.5	5.5	4.4	3.8	5.3	4.4
Kentucky	6.3	5.9	5.9	6.1	5.8	6.2	6.9	5.8	5.0	3.4	7.4	6.6	5.2	4.0	7.0
Louisiana	4.5	8.6	6.4	3.4	6.6	4.4	7.5	6.8	4.6	6.0	6.5	6.8	6.0	4.6	7.2
Maine	5.1	4.8	2.9	3.4	4.0	4.4	4.5	3.8	7.9	2.0	7.1	5.7	5.6	3.2	4.9
Maryland	5.1	3.7	2.9	3.4	5.7	6.2	2.7	4.1	4.0	6.6	3.7	3.1	6.1	5.7	3.0
Massachusetts	7.7	4.6	5.9	3.4	4.5	4.4	3.5	6.4	4.3	5.0	3.9	2.7	7.2	6.9	2.5
Michigan	5.5	3.3	2.9	3.4	5.5	4.4	5.8	5.1	5.4	4.6	5.8	4.8	5.7	4.4	5.4
Minnesota	4.8	2.9	5.6	5.7	5.2	4.4	3.2	4.0	4.6	4.1	3.3	4.0	5.2	4.9	3.7
Mississippi	5.3	7.0	6.0	3.4	6.5	6.2	7.9	6.1	4.5	6.1	7.0	7.3	4.7	3.0	7.6
Missouri	4.8	4.7	6.1	5.9	6.6	6.2	5.3	4.9	5.4	4.1	6.0	5.1	5.2	3.9	5.5
Montana	3.3	4.6	6.1	6.1	1.8	2.4	5.2	4.0	7.1	3.2	5.3	6.1	3.6	1.4	4.9
Nebraska	3.0	5.5	5.3	6.1	4.7	4.4	4.1	3.6	5.1	4.2	4.1	4.2	3.6	5.2	4.7
Nevada	4.4	3.7	2.9	6.5	1.8	6.2	5.2	5.2	4.4	6.7	4.7	4.7	5.6	6.8	6.9
New Hampshire	6.0	5.0	2.9	3.4	4.5	4.4	1.6	4.0	5.2	2.6	5.0	5.0	3.9	4.0	3.7
New Jersey	5.0	6.4	5.3	6.1	5.2	6.2	3.1	6.2	4.5	6.2	2.5	2.7	7.0	7.2	3.0
New Mexico	4.1	6.7	6.4	6.4	4.5	2.4	7.8	6.5	5.8	7.4	6.7	7.7	4.5	6.8	6.0
New York	6.2	4.8	5.3	3.4	5.7	4.4	5.5	7.9	4.7	6.2	3.7	3.5	8.4	7.5	3.6
North Carolina	5.2	4.8	5.7	6.0	6.1	6.2	5.7	5.8	4.6	5.6	5.2	6.7	4.3	4.9	4.8
North Dakota	4.1	5.2	2.9	3.4	5.0	4.4	3.9	3.1	4.7	3.5	3.2	5.2	3.7	3.9	5.4
Ohio	8.3	3.8	2.9	3.4	6.2	6.2	5.7	5.0	5.5	4.2	5.8	4.2	5.9	4.1	5.6
Oklahoma	2.6	5.2	6.4	6.6	6.0	6.2	6.4	5.2	4.7	5.4	7.0	5.9	4.2	4.7	6.7
Oregon	6.6	5.2	2.9	6.6	1.8	4.4	5.0	4.4	5.6	4.5	5.7	5.5	5.2	5.2	4.3
Pennsylvania	6.7	4.2	5.3	3.4	6.2	6.2	4.8	5.6	6.2	4.4	5.8	4.2	6.9	5.1	4.8
Rhode Island	7.7	5.2	5.3	3.4	1.8	4.4	5.2	5.2	4.9	4.9	5.8	2.8	6.6	6.7	4.2
South Carolina	5.9	6.4	5.7	6.1	6.2	6.2	6.3	5.7	5.9	5.6	5.9	7.5	4.7	3.9	5.8
South Dakota	3.1	5.4	6.2	5.7	5.2	4.4	5.3	3.2	5.9	3.8	4.3	5.7	3.0	4.0	5.6
Tennessee	5.7	4.0	6.0	5.7	6.1	6.2	6.3	5.8	4.8	4.7	6.5	5.9	4.3	4.1	6.1
Texas	3.5	6.3	6.8	6.4	7.1	4.4	6.1	6.1	2.5	7.1	3.7	5.3	3.8	7.5	5.2
Utah	3.1	1.5	6.2	6.5	4.0	6.2	2.7	1.6	2.1	4.2	1.7	4.0	1.7	4.9	4.1
Vermont	5.0	5.5	2.9	3.4	4.5	4.4	4.1	3.5	6.9	2.1	6.0	5.1	4.8	3.2	3.4
Virginia	4.4	5.3	5.3	3.4	5.8	6.2	3.9	5.6	4.0	5.7	4.2	4.7	4.7	5.2	3.3
Washington	7.1	3.9	2.9	6.5	1.8	4.4	3.7	4.3	4.1	5.2	4.7	5.1	5.2	5.9	3.7
West Virginia	6.2	7.1	5.3	3.4	4.5	6.2	7.3	5.5	7.8	2.2	8.1	7.3	6.1	1.8	8.3
Wisconsin	5.1	3.7	2.9	5.7	5.2	4.4	4.1	3.6	5.2	3.9	3.9	4.0	4.8	4.1	5.3
Wyoming	2.3	4.3	2.9	6.3	4.5	2.4	4.2	4.2	5.3	3.5	4.9	6.8	2.5	3.4	6.3

Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Researchers displayed the scores on a green-yellow-red color scale, with reds reflecting relatively higher (more vulnerable) scores and greens reflecting relatively lower (less vulnerable) scores. Data on extreme heat (D1.1) were not available for Alaska or Hawaii.

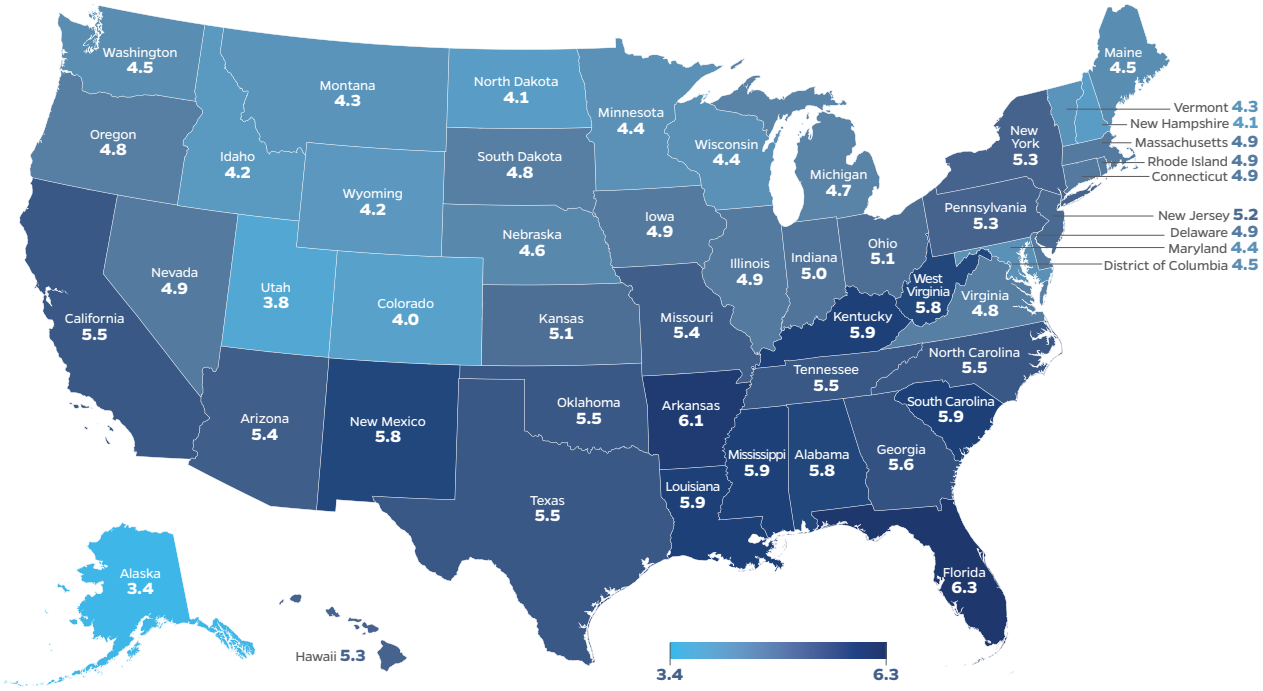
Domain 1 findings

Vulnerability—accounting for environmental factors and social and demographic factors—vary across the country with clear regional patterns. (See Figure 4.) Southern and coastal states are the most vulnerable overall and within each subdomain, although this geographic pattern is more pronounced for environmental factors, as one would expect. The least vulnerable regions are the Northern Great Plains—states in the interior of the country tend to be less vulnerable—and the Northwest. Vulnerability is relatively low in the Midwest and the Northeast as well. In addition to being physically buffered from some climate-related hazards, these regions tend to be less racially and ethnically diverse than other parts of the country, and they generally have relatively low levels of income inequality.

The states found to be most vulnerable overall were Florida (6.3), Arkansas (6.1), Louisiana (5.9), South Carolina (5.9), Mississippi (5.9), and Kentucky (5.9). By contrast, the least vulnerable states were Alaska (3.4), Utah (3.8), Colorado (4.0), North Dakota (4.1), and New Hampshire (4.1).

Figure 4

Domain 1 State Scores



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure.

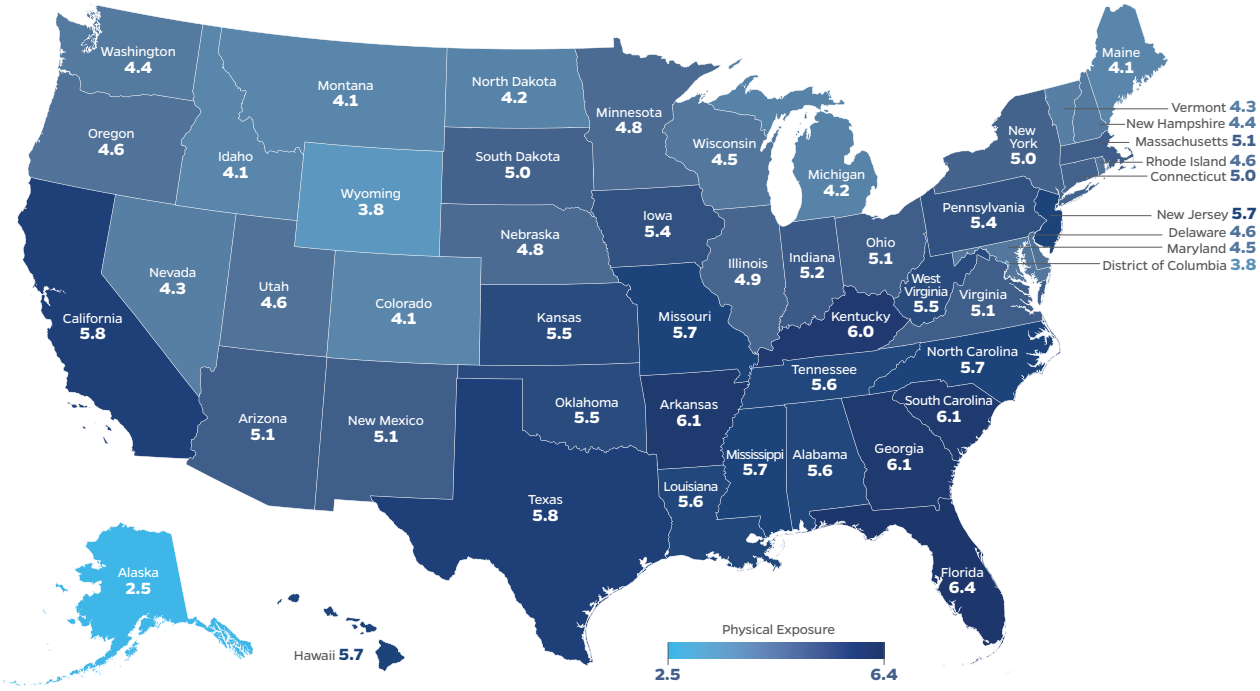
Findings for environmental factors

The states with the most dangerous levels of environmental vulnerability were Florida (6.4), Arkansas (6.1), Georgia (6.1), South Carolina (6.1), and Kentucky (6.0). Those with the least dangerous levels of environmental vulnerability were Alaska (2.5), Wyoming (3.8), the District of Columbia (3.8), Montana (4.1), Maine (4.1), Idaho (4.1), and Colorado (4.1).

For most measures of environmental vulnerability, distinct geographic patterns emerge (see Figure 5):

- Vulnerability to flooding tends to be highest in states along the Gulf Coast and the Mississippi River, along with Hawaii, the only island state. Less intuitively, a relatively large percentage of residents in New Mexico and West Virginia are also subject to flooding, owing in part to topography that creates the conditions for flash flooding near population centers.
- During the period from November 2016 through October 2019, drought was widespread across the country, with pockets of low vulnerability in the Northwest, the Northeast, and the Midwest around the Great Lakes.
- Wildfire vulnerability divides sharply: states are either at high or low risk. The western half of the country is the most vulnerable, and states in the Southeast also tend to be highly vulnerable.
- Severe storms, on the other hand, happened more frequently in the eastern half of the country, particularly in the Southeast, the Southern Great Plains, and parts of the Midwest.
- Most states fall within the range of at least one or two disease vectors. Only Alaska, with its colder climate, is outside the range of all three. Mountainous areas of the Southwest and the Northern Great Plains also appear less vulnerable to vector-borne diseases—with the exception of Nevada and Utah—due in part to their elevated altitudes.

Figure 5
Domain 1 State Scores, Environmental Factors



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater environmental vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure.

Many, but not all, of these patterns are intuitive. A notable exception is the measure of extreme heat: interior states in the Southwest are less vulnerable to extreme heat than most other parts of the country. Many of these states are renowned for their scorching temperatures, so one might expect them to be more vulnerable to heat. However, the measure used for this analysis is a relative one, based on a state's own historical climate record. States accustomed to high temperatures may have a higher level of tolerance than relatively cooler states, reflecting both the acclimatization of residents (physiological adaptation) and interventions such as—absent power failures—cooling centers, air conditioning, and heat warning systems. Of course, while these tolerance factors provide some measure of added protection, temperatures exceeding high thresholds—often pegged at 95 degrees Fahrenheit—are dangerous anywhere, especially when combined with heavy humidity.[175] (*Note:* Data on extreme heat, D1.1, were not available for Alaska or Hawaii.)

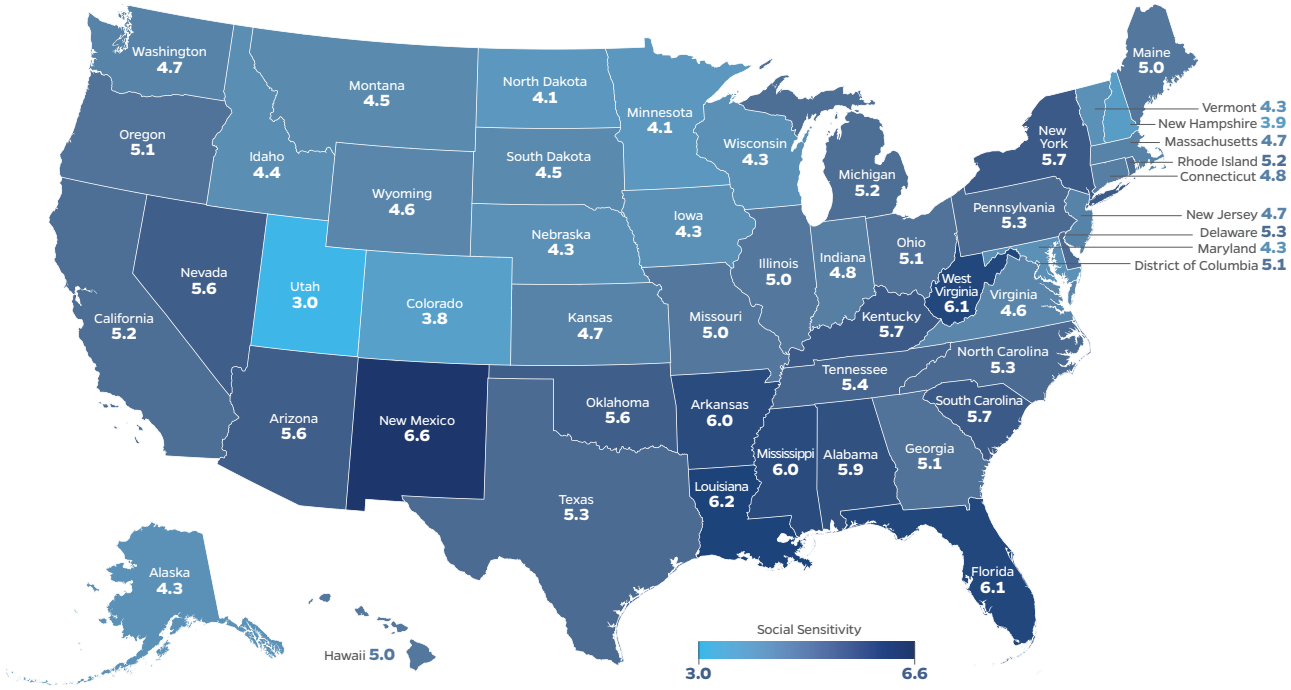
Findings for social and demographic factors

There are some notable geographic trends in social and demographic factors as well, particularly related to racial and ethnic diversity. (See Figure 6.) States in the Southeast and those bordering Mexico tend to have larger nonwhite populations than other parts of the country. New England states in the Northeast are the least diverse, followed by states in the Northern Great Plains. States near the southern border and those with large, populous cities (Illinois, Massachusetts, Nevada, New Jersey, New York) have the highest proportion of households that speak limited English. These states and their localities must consider how they will provide critical messages to such households and communities in a timely way.

States with the most serious levels of social and demographic vulnerability were New Mexico (6.6), Louisiana (6.2), Florida (6.1), West Virginia (6.1), Arkansas (6.0), and Mississippi (6.0). Those that were least vulnerable from a social and demographic standpoint were Utah (3.0), Colorado (3.8), New Hampshire (3.9), North Dakota (4.1), and Minnesota (4.1).

Figure 6

Domain 1 State Scores, Social and Demographic Factors



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater social and demographic vulnerability. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5.

Poverty rates align closely with that of overall vulnerability: states with higher poverty rates tended to be more vulnerable across the board. This combination of fewer resources and greater environmental vulnerability presents real challenges for public health professionals and other state leaders as they try to prepare communities for the impacts of climate change. Limited financial resources and longstanding disinvestment make it difficult for individuals and communities to plan for, respond to, and recover from climate-related health emergencies and disasters. People who are poor may find it more challenging to evacuate in the event of a hurricane or wildfire; they are less able to invest in weatherization or fireproofing projects that could protect their residences and, at the same time, they will find it harder to rebuild if hurricanes or wildfires destroy their homes. States in the Southeast and the Southern Great Plains tend to have poorer populations, as well as a high percentage of people living in mobile homes. Given the regions' vulnerability to severe storms, these states must continue to invest in adaptation strategies that strengthen the population's capacity to shelter and recover from such disasters.

In many of these same states, a smaller percentage of the adult population has a bachelor's degree. Like poverty, lower levels of educational attainment affect adaptive capacity through access to resources and information, among other factors.[176] Those with postsecondary education may, more often than not, find it easier to access critical safety information and factor it into decision-making and actions. They may also generally have greater success navigating healthcare and social-service networks.[177]

Many of the poorest states also have a high proportion of people with a disability.[178,179] In addition to having physical or mental conditions that may make it difficult to navigate emergency response, those with disabilities may rely on adaptive technology, equipment, or medications to support their functional needs and/or survival. Elderly residents may face similar challenges. Reducing the vulnerability of these populations, therefore, requires careful planning and dedicated resources on the part of the state.

DOMAIN 2: PUBLIC HEALTH PREPAREDNESS

Public health preparedness: actions taken to build, apply, and sustain the capabilities necessary to prevent, protect against, and ameliorate negative effects from public health emergencies.

Source: Adapted from U.S. Global Change Research Program[180]

Extreme heat, powerful hurricanes, vector-borne diseases—the dangers climate change will pose over the next few decades are familiar ones. Rather than manifesting in new phenomena, climate change can be understood as a threat multiplier, particularly from a public health perspective. Combating its health impacts then does not require a wholly novel tool kit. As states begin to grapple with the effects of climate change, they can draw on their historical experience with natural hazards and other health threats.

Public health preparedness refers to a state of readiness to prevent, prepare for, respond to, and recover from incidents that pose public health risks. This explicitly includes new and evolving threats, such as those from emerging infectious diseases or previously rare natural disasters.[181] Public health preparedness comprises several key domains, including the following capabilities:*

- Detect and track disease and health patterns through surveillance and epidemiological investigation.
- Share accurate and actionable information.
- Effectively manage and coordinate different elements of an emergency response.
- Provide countermeasures that mitigate harm.
- Expand medical services as needed.[182]

Public health preparedness also includes the readiness and resilience of the community, achieved in part through the actions of public health and emergency management professionals. These capabilities transcend individual health threats and form the foundation of public health preparedness and response for all hazards, including those related to climate change.

Adaptation refers to interventions and investments that seek to limit the impact of specific risks related to climate change. With respect to public health, the goal is to reduce disease burdens, injuries, disabilities, suffering, and deaths.[183] In this way, adaptation can be understood as a form of prevention. Public health defines three levels of prevention: primary, secondary, and tertiary. At each stage, there is an opportunity for public health departments and their partners—including individuals and communities—to intervene and reduce harm through adaptation.[184] See, for example, how Vermont's Department of Health has organized related concepts around the three levels of prevention. (See Figure 7.)

* These represent a subset of capabilities that are necessary for all-hazard preparedness and response. The CDC's Center for Preparedness and Response (national standards for state, local, tribal, and territorial public health) and FEMA's National Preparedness System both outline additional capabilities.

Figure 7

Efforts by the Vermont Department of Health to Prevent Negative Health Effects

NEGATIVE HEALTH EFFECTS	PRIMARY PREVENTION *Anticipatory*	SECONDARY PREVENTION *Reactive*	TERTIARY PREVENTION *Inherently Reactive*
Extreme heat event-related health effects	Early warning protocols to communicate health alerts to the public Health Alert Network—used to communicate health alerts to healthcare providers and responders	Environmental Public Health Tracking Program—tracking of heart attacks	All-Hazards Emergency Preparedness Plan Emergency Operations Plan (Health Operations Center) Emergency Medical Services (EMS) System Vermont Emergency Response Volunteers (VERV) Epidemiology All-Hazards Plan
Extreme weather event-related health effects	Early warning protocols to communicate health alerts to the public Health Alert Network		All-Hazards Emergency Preparedness Plan Emergency Operations Plan (Health Operations Center) Emergency Medical Services (EMS) System Vermont Emergency Response Volunteers (VERV) Epidemiology All-Hazards Plan
UV radiation-related health effects	State Cancer Plan (sun protection education) Comprehensive Cancer Control	Vermont Cancer Registry	Comprehensive Cancer Control
Vector-borne and zoonotic infectious disease-related health effects	Vector-borne disease public education Central dead bird reporting line for West Nile Virus Sentinel non-human host surveillance: Deer Sera Survey for mosquito-borne Eastern Equine Encephalitis Virus Health Alert Network	Reportable Diseases surveillance Monthly Infectious Disease bulletin—provides brief and timely updates about issues of concern in infectious disease epidemiology National Electronic Disease Surveillance System	Early Aberration Reporting System (EARS)—reports automated syndrome-sorted data useful for examining trends to VDH every 24 hours from seven hospitals

NEGATIVE HEALTH EFFECTS	PRIMARY PREVENTION *Anticipatory*	SECONDARY PREVENTION *Reactive*	TERTIARY PREVENTION *Inherently Reactive*
Water quality and quantity variation-related health effects	Water test kits available for purchase for laboratory testing of private water Water testing and maintenance guidelines 800 line to Drinking Water Program offering technical advice on protective technologies for microbial or chemical treatments and on interpretation of water test results Blue-green algae reporting line and email Health Alert Network	Reportable Diseases surveillance	Early Aberration Reporting System (EARS) Town Health Officer complaint response and management
Aero-allergen and other allergen and irritant-related health effects	Health Alert Network	Vermont Asthma Program surveillance	Town Health Officer complaint response and management
Food production and quality disruption-related health effects	Food and Lodging Program sanitarian inspections Shellfish Sanitation Program Health Alert Network	Food and Lodging Program regulatory enforcement Reportable Diseases surveillance	Food and Lodging Program and Infectious Disease Epidemiology complaint, outbreak, and recall protocols Food and Lodging Sanitarian Emergency Response
Changing material and pesticide use-related health effects		Birth Defect Registry	

Source: Vermont Agency of Natural Resources; Department of Health[185]

While important strategies extend beyond the control or responsibility of public health agencies, traditional public health approaches and capabilities such as those described above remain critical. This means that having a strong public health preparedness program today is a vital determinant of successfully adapting to climate change tomorrow. Examining how well-prepared states are to address existing public health threats illuminates a great deal about how ready they are to respond to and adapt to climate change.

Measuring public health preparedness

To measure states' preparedness, researchers drew on the National Health Security Preparedness Index (NHSPI), a joint initiative of the Robert Wood Johnson Foundation, the University of Kentucky, and the University of Colorado.[186] The index provides an objective, annual assessment of America's progress in preparing for, preventing, and responding to large-scale public health threats, including natural disasters and disease outbreaks.[187] The 2019 NHSPI—the version posted at the time of research for this assessment—presents a progress report for each state, pulling data from over 60 sources to produce a comprehensive set of 129 measures.[188] The index organizes these measures into domains of health security.

Each domain comprises multiple subdomains related to specific aspects of policy and practice.[189] NHSPI uses a set of indicators to calculate scores for each subdomain, which are aggregated into summary scores for each domain and, ultimately, an index score for every state and the District of Columbia, as well as the country overall.[190] All scores are on a scale of 0 to 10, with 10 indicating the highest level of preparedness.

The NHSPI does not focus only on the actions, responsibilities, or effectiveness of public health departments or other state agencies. In alignment with existing national preparedness frameworks, NHSPI recognizes preparedness as a shared responsibility, requiring a whole-community approach (e.g., individuals and families, schools and academic institutions, faith-based and community organizations, businesses, nonprofits, media outlets, and all levels of government).[191,192,193] This reliance on stakeholders across government and society is especially apparent among certain indicator domains, but it is present across them all.

For this assessment, researchers selected a subset of 11 subdomains from the index based on their pertinence to the health impacts of climate change. (See Table 7.) Data amounting to scores for the subdomains were used to calculate an average score for each state across the subset, producing a score between 0 and 10 for each state. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

Table 7
Climate-Related NHSPI Subdomains Measuring Public Health Preparedness

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Health security surveillance	D2.1 Health surveillance and epidemiological investigation	The development and maintenance of systems and processes that enable detection, identification, and tracking of health threats, including disease outbreaks and adverse events.
Community planning and engagement coordination	D2.2 Cross-sector / community collaboration	The coordination necessary to engage community-based organizations and social networks through collaboration among state agencies and their partners in order to return to routine delivery of services effectively and efficiently.
	D2.3 Social capital and cohesion	The degree of connection and sense of belonging among residents, including social networks among individuals, neighbors, organizations, and governments.
Incident and information management	D2.4 Incident management	The ability to establish and maintain a unified and coordinated operational structure that appropriately integrates all stakeholders and supports the execution of core capabilities and incident objectives through information sharing, strategy development, and resource management.
	D2.5 Information management	The ability to develop systems and procedures that communicate timely, accurate, accessible, and appropriate information and alerts to the public using a whole-community approach.

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Healthcare delivery	D2.6 Prehospital care	Care provided by emergency medical services (EMS), including 911 and dispatch, emergency medical response, field assessment and care, and transport to a hospital or between healthcare facilities.
	D2.7 Hospital and physician services	Care for patients who are formally admitted to a hospital or other institution for inpatient treatment.
	D2.8 Long-term care	A continuum of medical and social services, including skilled nursing and rehabilitation, designed to support the needs of people living in residential-care settings with chronic health problems that affect their ability to perform everyday activities.
	D2.9 Behavioral healthcare	The provision and facilitation of access to behavioral health services, including medical treatment, substance-abuse treatment, stress management, medication, and social-services networks.
	D2.10 Home care	Clinical and nonclinical care that allows a person with special needs to stay in their home, including skilled nursing visits, respiratory-care services, provision of durable medical equipment, hospice, and pharmacist services.
Environmental and occupational health	D2.11 Environmental monitoring	The systematic collection and measurement of environmental specimens (air, water, land/soil, and plants) to analyze the presence of an indicator, exposure, or response (warning and control). This includes monitoring the environment for disease vectors.

Note: Researchers adapted and lightly edited domain descriptions from NHSPI. See "Appendix B: Domain 2 Underlying Indicators" for a list of indicators tracked within each subdomain.

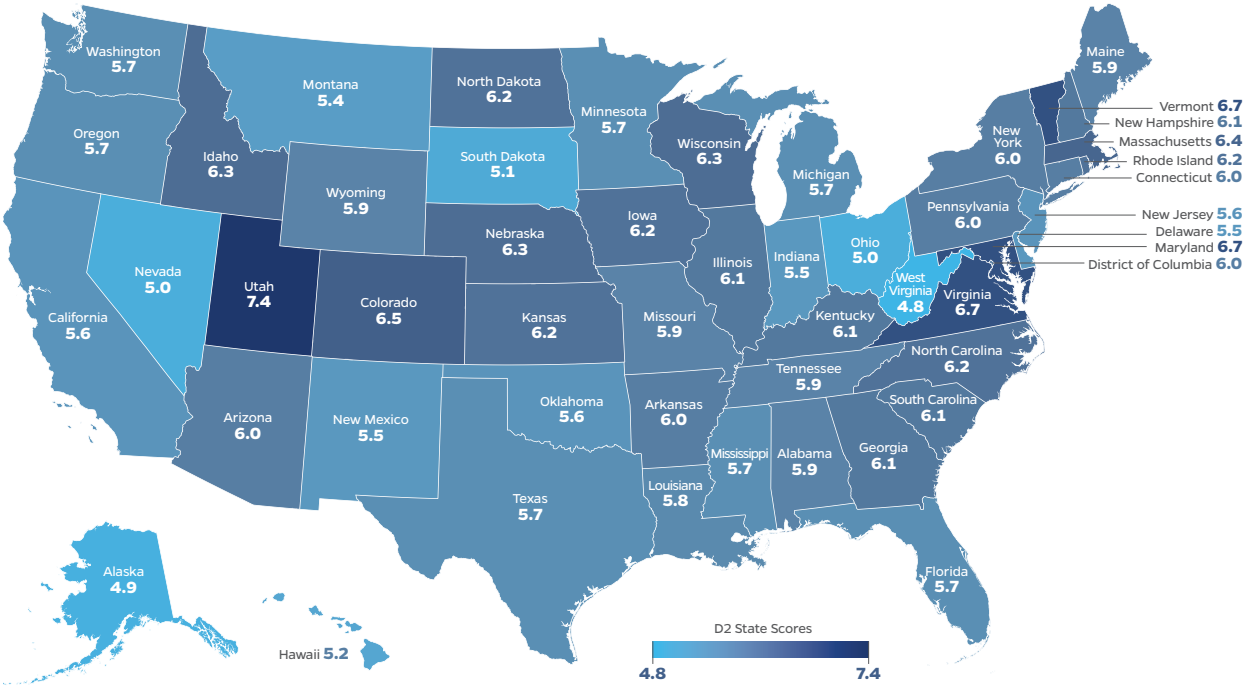
Source: National Health Security Preparedness Index[194]

Domain 2 findings

No state achieved the highest level of preparedness across all subdomains. States received an overall score of 5.9, on average, with a range of 4.8 to 7.4. Utah earned the highest score (7.4), followed by Maryland (6.7), Vermont (6.7), Virginia (6.7), and Colorado (6.5). Across the spectrum, West Virginia (4.8), Alaska (4.9), Nevada (5.0), Ohio (5.0), and South Dakota (5.1) earned the lowest scores. (See Figure 8.)

Figure 8

Domain 2 State Scores



Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5.

Within individual subdomains, state performances varied more widely. Typically, states performed best in the subdomains related to surveillance (D2.1), incident management (D2.4), and information management (D2.5), with the greatest room for improvement tending to be in the areas of social cohesion (D2.3), prehospital care (D2.6), and mental healthcare (D2.9). No clear patterns emerged—geographic or otherwise—with respect to the distribution of scores. (See Table 8.)

Table 8

State Scores Across Public Health Preparedness Subdomains

State	D2.1 Health surveillance and epidemiological investigation	D2.2 Cross-sector / community collaboration	D2.3 Social capital and cohesion	D2.4 Incident management	D2.5 Information management	D2.6 Prehospital care	D2.7 Hospital and physician services	D2.8 Long-term care	D2.9 Mental and behavioral healthcare	D2.10 Home care	D2.11 Environmental monitoring
Alabama	7	5.7	3.4	5.4	8.1	6.3	5.4	6.1	3.9	6.3	7.1
Alaska	8.2	5.2	5.8	4.8	5.6	2.9	3.6	7.1	4	2.9	4
Arizona	6.3	7.2	3.7	9.6	8.5	2	4.8	5.9	3.3	6.7	7.5
Arkansas	7.8	8.4	3.6	8.6	5.1	2.6	5.4	6.9	3.5	6.9	7.4
California	7	6.2	3.1	6.9	8.4	0.8	5.2	5.6	3.1	7	8.6
Colorado	6.4	7.4	4.9	9.4	6.2	6.3	5.8	7.1	4.1	7	7.3
Connecticut	4.9	8.8	4.3	6.6	8.5	4.2	6.4	5.4	4.3	7.1	5.2
Delaware	7.3	9	4.6	4.5	5.4	5.6	6.1	7.5	2	6.3	2.5
District of Columbia	7.2	10	5.3	6.4	5.6	7	6.7	5.7	3.7	5.3	3
Florida	7.8	6.7	3.2	9.5	5.7	3.2	5.4	5.9	3.3	6	6.4
Georgia	7.1	6.9	3.4	9.3	5.5	6.6	4.9	6.6	4.1	5.8	7.2
Hawaii	6.1	7.9	2.5	4.3	8.2	1.3	5.9	7.3	2.3	5.9	5.5
Idaho	6.7	7.4	5.1	9.2	8.6	4.4	4.9	6.1	4.8	7.7	4.6
Illinois	8.1	5.3	3.6	7	8.8	4.5	5.8	6	3.8	5.7	8.5
Indiana	8.7	3.2	4.4	3.9	8.4	2.9	5.8	5.4	4	5.7	7.8
Iowa	6.6	4.4	5.5	8.6	9	3.2	5.7	5.8	4.5	6.5	8.4
Kansas	6.4	6.8	4.5	8.6	8.5	7.1	5.8	5	3.1	7.2	5.4
Kentucky	8.5	5.5	3.7	9.3	8.2	3	5.4	6.6	3.8	6.3	6.4
Louisiana	6.5	7.5	3.3	7.3	5	2.1	5.3	7.3	4.9	6.8	8
Maine	6.1	7.8	5.9	6.9	8.7	4.7	6.2	4.6	2.7	7.1	4
Maryland	9.2	7.3	5.5	9.5	8.9	2.1	5.8	6.8	4.8	6.7	7.4
Massachusetts	9.5	8.4	4.6	6.5	9	2.8	6.1	6.5	3.2	6.8	7.2
Michigan	8.4	5.7	4	7.3	8.8	2.5	5.2	6	3.7	6	5.1
Minnesota	6	7.4	6.6	4.6	6.9	3.1	6.1	6	3.6	6.9	5.5
Mississippi	5.5	8.8	2.6	9.1	4.8	5	5.2	7.5	4.3	6.5	3.9
Missouri	8.6	5.7	4.3	8	5.8	4.8	5.8	5.7	2.6	7.1	6.1
Montana	8.2	8.6	5.3	7.1	5.6	4	4.9	4.1	3.5	5.4	3.2
Nebraska	9.7	8.4	5.5	8.8	6	5.9	5.4	5.9	4.1	7.2	2.5
Nevada	6.3	5.5	3.5	6	5.2	3	4.5	4.9	5.6	4.6	5.8
New Hampshire	7.2	3.5	5.6	5.6	9.7	6.4	6.3	5.6	3.9	7.7	6
New Jersey	6.1	6.2	3.7	6.3	5.8	2.6	5.9	6.8	5.1	5.3	7.4
New Mexico	8	5.6	3.2	8.9	4.9	3.2	4	4.3	3.7	7.1	7.2
New York	8.1	7.9	2.9	6.7	5.4	2.7	5.6	6.1	4	8.5	8
North Carolina	4.9	6.9	5	9.8	8.6	2.5	5.4	7	3	6.9	7.8
North Dakota	7.3	8.8	4.7	8.2	9	4	4.4	6.9	2.9	6.6	5.2
Ohio	3.7	5	4.6	6.4	6.1	2.6	6.2	6.1	3.7	6.6	4.5
Oklahoma	7.2	6.3	3.8	9.7	5.1	4.4	5.4	5.5	3	6.5	4.7
Oregon	8.5	7.3	6.9	4.2	6.4	4	5.6	3.6	3.5	5.8	7.3
Pennsylvania	6.8	5.3	4.9	7	8.6	4	6.1	5.5	3.6	7.2	6.8
Rhode Island	6.2	9.2	3.9	7.4	5.7	4.1	6.7	5.8	5.6	7.6	5.5
South Carolina	4.9	4.1	3.8	9.3	8.3	6.4	5.6	6.3	4.6	6.9	6.9
South Dakota	5.8	4	4.5	5.8	6.2	4.6	5.7	6.7	2.8	6.7	3.8
Tennessee	9.1	4.5	3.4	8.7	8.1	4.8	4.9	5.7	3.4	6.8	5.8
Texas	7.3	6.2	3.2	5.7	8.3	4.2	4.9	5.4	3.3	6.5	7.3
Utah	7.9	7.9	7.2	8.6	9	6.1	5.7	6.5	7.7	7.1	7.3
Vermont	10	9.1	5	5.4	8.6	3.7	6.7	7	4	7.2	6.5
Virginia	8.7	6.7	5.1	9	8.8	4.9	6.1	5.4	4.1	6.8	7.9
Washington	7.5	7.4	5.2	3.9	8.9	1.7	5.5	5.2	3.2	6.8	7.4
West Virginia	4.3	6.1	3	6.5	5.1	2.4	5.7	6.2	2.4	7.9	3.6
Wisconsin	7.4	7.5	5.7	7.9	6.5	3.4	6.5	5.9	3	7.5	8.4
Wyoming	9.6	6	4.3	6.9	5.6	7	5.4	6.5	5	5.8	2.7
State average	**7.2**	**6.8**	**4.4**	**7.3**	**7.2**	**4.0**	**5.6**	**6.0**	**3.8**	**6.6**	**6.1**

Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Researchers displayed the scores on a green-yellow-red color scale, with greens reflecting higher scores and reds reflecting lower scores.

Source: National Health Security Preparedness Index[195]

Strong surveillance performance (D2.1), including syndromic surveillance, indicates the ability to identify and track health threats in time and space. Overall, states are rated highly in this area: 25 states scored higher than 7.2, the subdomain average, and six scored above 9.0, with Vermont receiving a perfect score. This capability is critical for detecting and containing the spread of diseases and other exposures that can hurt human health. Early detection allows jurisdictions to act when a threat is still minor, conserving resources and preventing illness, injury, or death. Surveillance also ensures that public health professionals know where the problem is occurring and who it is affecting, or most likely to be affecting. This again enables more effective deployment of resources. The data provided by surveillance and other elements of epidemiological investigation provide an essential body of evidence for jurisdictions seeking to understand the factors driving vulnerability in their communities. The high performance for this subdomain is therefore promising.

The health of people in a community cannot be separated from the health of the environment. As the global climate changes, changes in the local environment serve as critical harbingers of human health problems.

However, when it comes to climate change, the health of people in a community cannot be separated from the health of the environment. As the global climate changes, changes in the local environment serve as critical harbingers of human health problems, whether infectious-disease outbreaks or cardiovascular-disease events related to extreme heat. The ability to implement primary prevention through proactive adaptation interventions requires not only effective surveillance of human exposure and disease, but the early warning provided by detecting hazardous exposures in the environment. Yet, state performance on environmental monitoring (D2.11) was much lower overall than for health surveillance. Only six states scored at or above 8.0, with California topping the list at 8.6. Across all states, the average score was only 6.1.

States performed well on both incident (D2.4) and information management (D2.5)—critical to managing the acute phases of emergency response.[196] Compared with other measures, many states have strong capabilities in both areas: 12 states received a score of at least 9.0 on incident management, and five received a 9.0 or above on information management. Most states rated over 5.0 on both measures. As NHSPI researchers have noted, this strong performance is the result of a concerted national investment in "training government agencies, health professionals, and community leaders in the incident command process and in practicing these skills regularly through exercises, drills, and real events."[197] As natural disasters become more frequent and intense, these capabilities will be even more essential to ensuring effective deployment of limited resources.

Still, the country's strength in managing acute emergency response is undercut by wide performance disparities in this domain and overall. As the climate changes, states can expect to deal with simultaneous, widespread, or long-lasting health emergencies. Their individual capabilities are likely to be overwhelmed more often, even as the federal government's capacity is stretched thin. States will need to rely more on one another, through mutual aid and assistance.[198] The ability to effectively deploy a standardized, scalable incident-management system will be critical to coordinating activities and resources across state lines.

Building capacity at the community level will also play an important role in the nation's ability to prepare for and respond to the simultaneous or prolonged health threats that climate change is bringing. Unfortunately, state performances on measures of community planning and coordinated engagement were relatively weak. While some responsibility for this set of measures clearly lies outside the control of public health departments and other state agencies, they still have an important role to play. The CDC includes both community preparedness and community recovery in its list of 15 core public health capabilities. Public health and emergency management professionals can support resilience by raising awareness, convening partners, promoting access to resources (especially those related to public health, healthcare, human services, behavioral health, and environmental health), and engaging in preparedness activities with communities.[199] Many of these functions are best achieved through partnerships—not only with community members and organizations, but also with federal, state, local, tribal, and territorial stakeholders. Effective engagement and coordination of interested parties at all levels and across sectors is critical.

In 2017, New York City launched Be A Buddy, a two-year pilot project aimed at increasing social cohesion and resilience to climate change by strengthening relationships between vulnerable communities and local organizations.[200] Under this community-led preparedness model, three local organizations received training, technical assistance, funding, and other resources to help the city disseminate public health messaging and implement check-ins to reduce vulnerability to health impacts from extreme heat and other weather-related emergencies.[201] In addition to providing training and engagement activities to bring together their staffs and community members, the organizations conducted screenings to identify people at higher risk for heat-related illness, and they recruited 64 volunteers to check on those residents as part of a "Be A Buddy network." From 2018 to 2019, the networks activated 17 times for extreme temperature events, reaching over 450 at-risk residents; in the project's first 19 months, they held 114 engagement events.[202]

On average, states' capacity to engage partners and foster collaboration across sectors (D2.2)—priorities often steered by localities, especially in large states—rated much higher than their level of social capital and community cohesion (D2.3). On cross-sector/community collaboration, 26 states scored above the average of 6.8, and four (Delaware, District of Columbia, Rhode Island, and Vermont) scored at or above 9.0, with the District receiving a perfect score. In contrast, the average score for social capital and cohesion was only 4.4. While half the states scored above this, 34 scored below 5.0. Social capital was generally weaker in the southern half of the country, stretching from California to Florida.

States' poorest performance, collectively, was on activities related to healthcare delivery. This domain examines the ability of healthcare providers and facilities to provide high-quality medical care during and after health emergencies.[203] It includes services related to the emergency itself, as well as those related to existing or unrelated patient needs. Each component addresses a specific aspect of the continuum of care: prehospital care (D2.6), hospital and physician services (D2.7), long-term care (D2.8), behavioral healthcare (D2.9), and home care (D2.10).

Performance varied across the subdomains, with states generally performing better in the areas of long-term care and home care than on other measures. Both represent relatively limited patient populations, and the underlying measures reflect this narrower scope. But they present unique challenges in that the populations they serve tend to be more vulnerable, complicating evacuation or raising the stakes around continuity of care.[204] When a nursing home in Florida lost power—and air conditioning—following Hurricane Irma in September 2017, 12 patients died. An investigation revealed that temperatures inside parts of the facility had soared to 99 degrees Fahrenheit, but the state has been slow to enforce its own new requirements for backup generators.[205,206,207]

In contrast, the other three subdomains address the needs of the general population. Prehospital and hospital services are likely to have a significant role in responding to an acute crisis. Strengthening these services will enable healthcare systems to maintain a high standard of care amid more frequent, intense, or protracted health emergencies.

Behavioral healthcare and prehospital care received the lowest average scores across all subdomains. Most states and the District of Columbia scored less than 5.0 on their ability to provide and facilitate behavioral healthcare services; 30 states and the District rated below 4.0. Utah was a clear standout for this subdomain, scoring (7.7), well above the next-highest group of states. Measures of prehospital care, or emergency medical services, rated somewhat higher. But 40 states still scored at or below 5.0, and the lowest score was 0.8 (California). Low performance in these two subdomains presents challenges for both acute response and recovery efforts, particularly for large-scale disasters such as hurricanes, floods, and wildfires. Mental health services, in particular, are a critical gap, as both immediate hazards and longer-term, more gradual losses posed by climate change are likely to have negative impacts on people's mental health. For instance, in its assessment of climate-related health threats, Alaska highlighted the risk of solastalgia—particularly for Indigenous communities—the distressing sense of loss that people experience from unwanted environmental changes (e.g., fires, floods, and storm surges; thawing permafrost and coastal erosion; weakening air or water quality, emerging disease vectors, and changing food sources) may also lead to adverse mental health outcomes near home.[208]

Individual state performance varied widely across the healthcare subdomains; a state might be the clear leader in one area and perform near the bottom in others. This may be due to the fragmented nature of the U.S. healthcare system, which comprises numerous independent health systems and providers across both the public and private sectors. Even within a single state, a variety of entities manage or fund different aspects of healthcare. While this presents a challenge, it also offers an opportunity for healthcare leaders to learn from one another and identify the best practices within their own state.

DOMAIN 3: CLIMATE-RELATED ADAPTATION

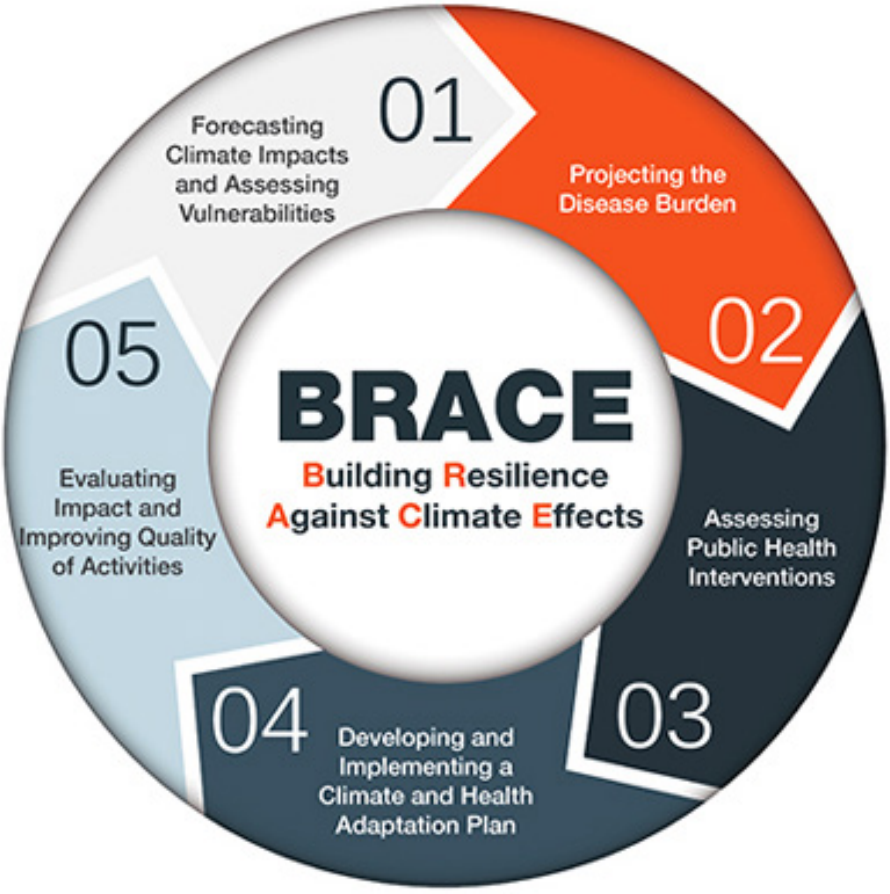
Adaptation: adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

Source: U.S. Global Change Research Program[211]

Indicators within Domain 3 specifically measure how states are planning to adapt to the public health impacts of climate change. These preparations begin with identifying the nature and extent of current and future changes within a state's boundaries. Based on expected exposures, a state can determine the likely health outcomes, consider which residents are most vulnerable, and identify adaptive interventions most likely to protect people.

The Building Resilience Against Climate Effects (BRACE) framework, a five-step process developed by the CDC to guide states and other jurisdictions as they work to prepare for the health impacts of climate change on their communities, inspired the indicators and sub-indicators for this domain.[210] (See Figure 9.) Through its Climate-Ready States and Cities Initiative, the CDC provides financial and technical assistance to help health departments implement the framework. As of October 2020, the initiative supported 16 states, as well as health departments in New York City, San Francisco, and some tribes and territories.[211,212] But the framework is designed to have universal applicability—indeed, every state would benefit from incorporating its guidance into their preparations—so it provides a useful benchmark against which to assess progress.

Figure 9
The CDC's Building Resilience Against Climate Effects (BRACE) Framework



Source: Centers for Disease Control and Prevention[213]

Domain 3 contains two indicators that draw primarily on the first and third steps of the framework. The first indicator examines whether a state has assessed its vulnerability to climate change and related public health impacts; the second measures whether it has formally identified evidence-based adaptive interventions to address them. These two indicators broadly echo those in Domains 1 and 2, which look at each state's vulnerability, and each state's public health preparedness.

The two overarching indicators were broken down into a series of sub-indicators, discrete criteria that demonstrate a state's progress in understanding and preparing for projected health impacts. (See Table 9.) The sub-indicators represent the different types of information a state needs to develop effective plans for adaptation that protect people's health as the climate changes. These criteria pay particular attention to identifying people who are most at risk or least able to cope with changing exposures or health effects. Addressing the needs of these vulnerable populations is critical to preventing adverse health outcomes.

Table 9

Indicators and Sub-Indicators of State Progress on Climate Change Preparedness and Adaptation

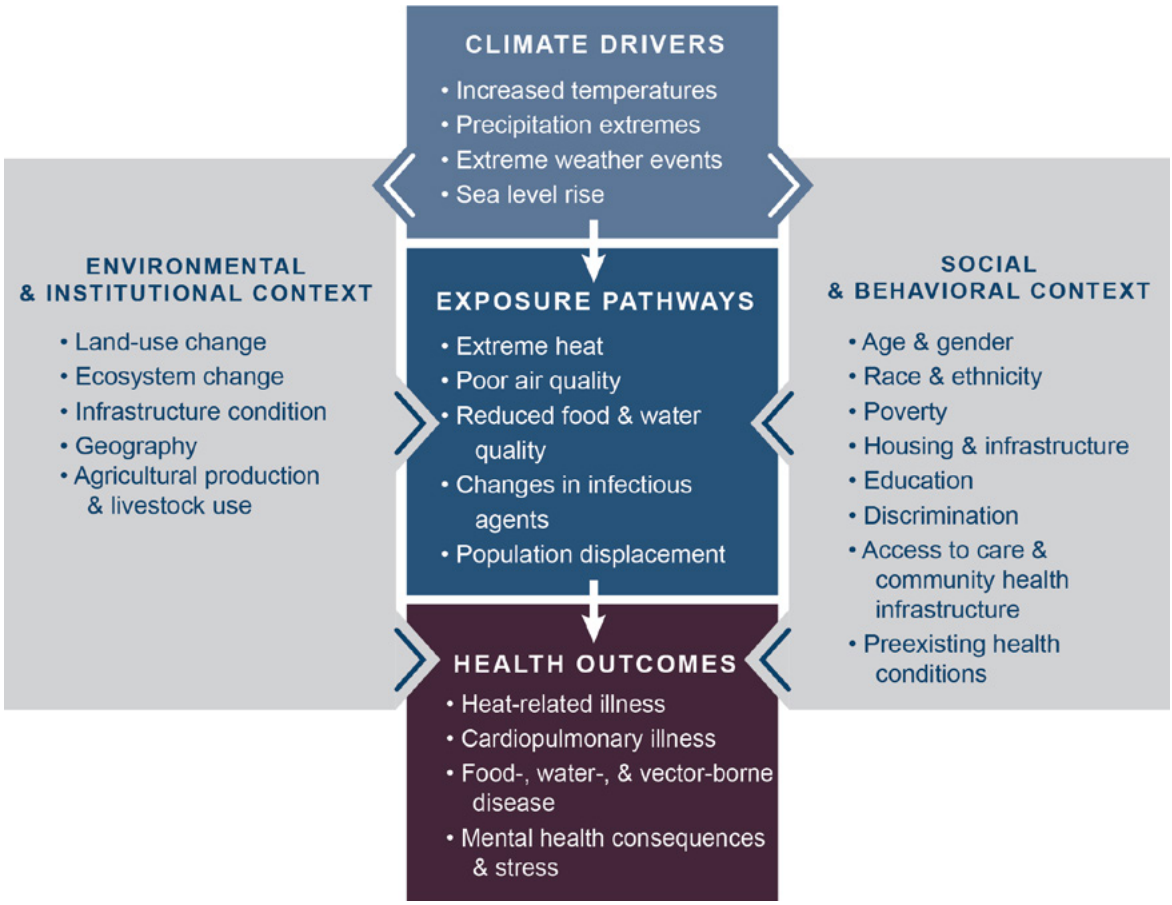
DOMAIN 3: CLIMATE-RELATED ADAPTATION	
Indicator D3.1	**D3.1 Sub-indicators**
Has the state assessed its vulnerability to the public health impacts of climate change?	D3.1.1: Have climate-related exposures (e.g., elevated temperatures, contaminated water, worsened air quality) to the state been identified?
	D3.1.2: Have climate-sensitive health outcomes (e.g., heat-related death and illness, gastrointestinal illness, premature death) been identified?
	D3.1.3: Have risk factors for health outcomes been identified?
	D3.1.4: Have causal pathways been developed for relevant climate-related hazards?
	D3.1.5: Have climate projections at the state, or state and local scale, been reported?
	D3.1.6: Have the most vulnerable populations in the state been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?
Indicator D3.2	**D3.2 Sub-Indicators**
Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	D3.2.1: Has the state identified interventions?
	D3.2.2: Are the interventions evidence-based?

The BRACE framework provides states and other jurisdictions with a set of guideposts—along with corresponding guidance—for developing, first, a detailed understanding of the specific threats they face and, then, a plan for addressing them. Using the framework, a jurisdiction begins by identifying its likely climate-related impacts. These impacts include changes in climate and weather, such as higher temperatures, heavy precipitation events, or prolonged drought, as well as indirect effects, such as rising sea levels, contaminated water, or poorer air quality. These types of climate-related impacts represent environmental exposures, factors that contribute to the health outcomes of individuals and populations. As part of the first step of BRACE, the state identifies specific health outcomes that climate-related exposures can cause and that the state finds to be most likely and acute: for example, vector- and water-borne diseases, heat-related illness, worsening asthma or allergies, or mortality related to wildfires or flooding.

Impacts vary by location, hence the need for assessing and addressing impacts locally, as BRACE recommends. To anticipate local impacts, a state must first identify the exposures it is likely to experience. States can do this qualitatively, but a more precise picture of local exposures requires the state to incorporate climate change projections. For many public health departments—and state agencies broadly—working with climate data and projections is a new experience; they may need to partner with federal or nongovernmental actors who can lend additional expertise. For example, the Florida BRACE program formed a collaborative that brought together staff with traditional epidemiological training with partners who possessed expertise in disciplines such as health education, environmental science, urban planning, demography, sustainability, geography, climatology, and meteorology.[214] The CDC has compiled guidance to help jurisdictions complete BRACE steps, including information on how to obtain and use climate data for projections, which typically address a range of greenhouse gas emissions scenarios.[215,216] Based on the temperature increase predicted under each scenario, the state may experience a different type or scale of climate-related exposures. These exposures, in turn, contribute to the scope of public health impacts a state is likely to experience.

In Step 2 of the framework, a state uses the climate and health profile created in Step 1 to take a closer look at how climate change will affect the burden of disease and ill health (i.e., the marginal difference in death and loss of health caused by climate change) within its borders.[217] For the purposes of this assessment, researchers did not examine whether states have begun developing climate change health-impact projections. Instead, the focus is on whether and how states are taking preparatory steps related to the relationship between climate change and health outcomes among their populations. Moving from climate-related exposures to public health impacts requires states to examine relevant causal pathways. (See Figure 10.) To do so, two primary questions must be answered: (1) how does climate change affect the environment a person is exposed to, and (2) how does a particular exposure act on a person's health?

Figure 10
Mapping Pathways from Climate to Health



Source: U.S. Global Change Research Program[218]

Some pathways are straightforward. (See Figure 11.) For example, scientists expect rising surface temperatures to produce an increase in the number of days with extreme heat, which could lead to an increase in heat-related illness and death. But other pathways are less direct and more complicated. In many communities in the United States, climate change is expected to increase the frequency and intensity of heavy precipitation events. These events can produce flooding, particularly in areas near bodies of water or with a large number of impermeable surfaces. Flooding events can directly produce injury and loss of life. The impacts do not stop there, though. If floodwaters infiltrate a home or other building, they can create conditions for mold growth, leading to respiratory issues and other negative health outcomes. Flooding can cause sewers to overflow or wash other pollutants into streams, rivers, and lakes that people use for recreation or drinking water, contributing to gastrointestinal illness or skin irritation. Certain kinds of contamination may lead to the growth of harmful algal blooms, which have their own serious health repercussions.

Figure 11
Examples of Climate-Related Health Impacts

	Climate Driver	Exposure	Health Outcome	Impact
Extreme Heat	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Outdoor Air Quality	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Flooding	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Vector-Borne Infection (Lyme Disease)	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Water-Related Infection (*Vibrio vulnificus*)	Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with *Vibrio vulnificus*	*Vibrio vulnificus* induced diarrhea & intestinal illness, wound and bloodstream infections, death	Increases in water temperatures will alter timing and location of *Vibrio vulnificus* growth, increasing exposure and risk of waterborne illness.
Food-Related Infection (*Salmonella*)	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of *Salmonella* exposure	*Salmonella* infection, gastrointestinal outbreaks	Rising temperatures increase *Salmonella* prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
Mental Health and Well-Being	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

Source: U.S. Global Change Research Program[219]

In some cases, there may be uncertainty about how changing exposures will affect health outcomes. This is particularly true with complex systems like vector-borne diseases. The more carefully a state considers potential pathways, the more it can prepare for—and protect against—the likely health impacts.

It is critical that states and their localities know who and where vulnerable populations are so they can direct interventions effectively.

Understanding exposure pathways also enables a jurisdiction to identify who is most at risk or vulnerable. Risk factors are characteristics that make an individual more likely to experience a specific health outcome. They are an important element of vulnerability, but they do not tell the full story. As described in the section on Domain 1, vulnerability encompasses a person's sensitivity and susceptibility to the exposure as well as their ability to cope with the exposure and its impacts. Some populations are vulnerable based on their location. They may be more likely to experience an exposure (e.g., if they live in a county with frequent flooding events) or they may be at higher risk for negative health outcomes related to an exposure (e.g., if they live close to a dam or levee in that county). Vulnerability can also be tied to demographic factors, such as income, race (because of structural and systemic racism), or age. These factors may influence the risk of exposure, the likelihood or severity of illness, or the availability of coping tools. It is critical that states and their localities know who and where vulnerable populations are so they can direct interventions effectively.

Once a state has assessed its vulnerabilities, it is ready to start identifying the best strategies to protect its population from these threats. Adaptation is the primary strategy for public health and the focus of this report. In Step 3 of the BRACE framework, states contemplate the types of interventions they will implement. While practical considerations such as budget constraints inevitably influence decision-making, identified interventions should reflect the scale of the threat, be evidence-based, and be appropriate for the needs of the population overall and especially its most vulnerable groups.[220]

The framework provides a tool for public health departments and their partners to think iteratively about the threats posed by climate change and the actions they can take to protect people's health. Essential to the BRACE approach is an emphasis on following the best available science.[221] Throughout the process, decision-makers rely on data and evidence to determine which impacts are likely, to identify the most promising adaptive interventions, and to evaluate whether these interventions are working as expected. BRACE encourages states to learn and adjust their approaches based on new information, which will be critical to successfully adapting as the threat of climate change evolves.

Under the CDC's Climate-Ready States and Cities Initiative, the BRACE steps are sequential.[222] This sequence is logical and preferred, but it is not necessary. In practice, jurisdictions may implement certain steps simultaneously or out of order. Even among grantees, there has been variation in how states implement the framework. For grantees and non-grantees alike, it may make sense to begin with a step that can build on existing work, including work done by other state agencies, other states, or the federal government.

For this reason, while based on elements of the BRACE framework, the sub-indicators used for this assessment are, for the most part, not contingent on one another. There are two exceptions: (1) to locate vulnerable populations (D3.1.6.2), states must first identify them (D3.1.6.1); and (2) similarly, states did not receive credit for evidence-based interventions (D3.2.2) if they did not identify any interventions to protect their populations from the health effects of climate change (D3.2.1). For all other sub-indicators, researchers measured states' preparations independently.

Collecting data for the assessment

To answer the questions posed by the indicators and sub-indicators, researchers collected and reviewed state-level documents related to climate change and health. Researchers defined relevance broadly and applied an inclusive strategy to gathering documents to account for varied approaches by governments. Documents had to be produced by the state government or at its direction (e.g., assessments from an academic institution commissioned by a state agency), but otherwise, researchers could include any document that addressed climate change or its effects on human health in the assessment. Data did not have to come from reports modeled on the BRACE framework, or even focus solely on climate change and its public health implications. While the framework is specifically geared toward public health agencies, documents for this assessment could come from any agency or government entity.

Because each state must develop a hazard-mitigation plan to be eligible for certain kinds of non-emergency disaster assistance from FEMA, these documents became the starting point for assessments.[223] States must develop and adopt a new or updated hazard-mitigation plan every five years, following guidelines set out by the agency.[224] FEMA reviews and approves the plan and can provide technical assistance, but the states themselves lead the process of evaluating and mitigating hazards.[225] In many ways, FEMA's hazard-mitigation planning process aligns closely with the BRACE framework, albeit with a broader view of potential threats and impacts. Through it, states assess their vulnerabilities and identify interventions to reduce the risks posed by top-priority hazards.[226]

Hazard-mitigation planning requirements derive from federal law, and FEMA provides guidance to ensure consistent application of the legal requirements by states and federal evaluators.[227] FEMA incorporates principles from presidential directives and other relevant federal policy, such as the National Mitigation Framework. According to the version of the guide that went into effect in March 2016, states must consider the probability of future hazard events as part of the risk assessment in their plans,

and FEMA explicitly identifies changing environmental or climate conditions as a key element of risk they must address.[228] Thus, state hazard-mitigation plans are a useful baseline for understanding how each state is preparing for the impacts of climate change. These plans do not necessarily address public health impacts, however.

Whenever available—indeed, for most states—data were pulled from additional state documents to address each sub-indicator. To identify relevant documents, data collectors first looked to four existing repositories of state-level adaptation resources:

1) Georgetown Climate Center's Adaptation Clearinghouse[229]
2) Center for Climate and Energy Solutions' (C2ES) U.S. State Climate Action Plans database[230]
3) EcoAdapt's 2019 report *The State of Climate Adaptation in Public Health: An Assessment of 16 U.S. States*[231]
4) CDC's Climate-Ready States and Cities Initiative grantee website.[232]

Researchers identified additional documents using an advanced Google search of state government websites, employing the following terms: "[state name] climate change adaptation." For all documents, researchers assessed relevance by skimming tables of content and using a keyword search with the terms: "climate change," "climate," and "health." Within relevant documents, researchers looked for data that addressed each indicator and sub-indicator within the third domain of the assessment, and they collected excerpts of relevant data to illustrate a state's preparations.

Once researchers completed an analysis of documents for every state, they sent state leaders—typically, the highest-ranking public health and emergency management officials—a copy of the data collected for their state and requested that they or their designees verify the data's accuracy and completeness. Researchers invited states to share additional documents or excerpts that contained information relevant to the assessment: 29 states responded.* Researchers reviewed and reconciled the information provided in state responses to correct data gaps or errors.

* States that responded included Alabama, Arkansas, Arizona, Connecticut, Delaware, Georgia, Iowa, Idaho, Indiana, Kansas, Massachusetts, Maryland, Michigan, Minnesota, Missouri, Montana, New Hampshire, Nevada, New York, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Utah, Virginia, Vermont, and Washington.

Analyzing state data

After data were collected and offered to state officials for verification, researchers used them to score sub-indicators dichotomously, based on the presence or absence of relevant data in the state-produced materials. For example, if a state documented at least some relevant health outcomes that it expects to change or worsen, it received credit for the corresponding sub-indicator (D3.1.2). To limit subjectivity and preserve consistency in this assessment, researchers did not evaluate the content or extent of the data presented. That is, they did not factor into the assessment the veracity, completeness, or depth of the data provided. This approach obscures in some cases meaningful differences between states that had taken tentative early steps and those that had made more substantive progress.

To compare states, researchers scaled scores by normalizing their distribution and truncating the results of outliers to reduce their influence, placing all scores on a spectrum of 0 to 10 for every indicator. Then, they averaged scores for individual indicators to calculate state scores for the domain as a whole. (See "Appendix A: Methodology" for a detailed description of how scores were calculated.)

For sub-indicators D3.1.1 and D3.1.2, states had to identify at least one climate-related exposure and climate-sensitive health outcome, respectively. For the latter, this assessment required states to be specific; it was not sufficient to simply mention that climate change could cause poor health or loss of life. Ideally, risk factors and vulnerable populations would correspond directly to the identified exposures and health outcomes. However, for the purposes of this assessment, researchers permitted the identification of any reasonable risk factors or vulnerable populations, though risk factors had to be tied explicitly to health outcomes.

Domain 3: Climate-Related Adaptation

Indicator D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?

- **D3.1.1:** Have climate-related exposures been identified?
- **D3.1.2:** Have climate-sensitive health outcomes been identified?
- **D3.1.3:** Have risk factors for health outcomes been identified?
- **D3.1.4:** Have causal pathways been developed?
- **D3.1.5:** Have climate projections been reported?
- **D3.1.6:** Have the most vulnerable populations been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?

Indicator D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?

- **D3.2.1:** Has the state identified interventions?
- **D3.2.2:** Are the interventions evidence-based?

Researchers allowed for a wider approach to vulnerability identification and mapping than that prescribed by the BRACE framework. A state could receive credit for identifying vulnerable people based on environmental factors or social or demographic factors, such as age, income, race or ethnicity, or occupation. Researchers did not require states to assess social or demographic factors strictly through the lens of climate change and its public health impacts. Location had to be precisely defined—for example, at the census tract or county level—except in cases where states broadly addressed urban/rural disparities, such as those that might be expected with vulnerability to extreme heat. This assessment employed this more permissive approach to acknowledge that broader vulnerability assessments, particularly those related to natural disasters or other environmental hazards, can play an important role in guiding climate and health planning. For example, FEMA requires that states conduct a vulnerability assessment as part of the hazard-mitigation planning process, and many contain useful information for climate-related preparations.[233] However, those focused only on geography and economic losses based on historical data are less applicable, and states should be mindful of the distinctions.

For indicator D3.2, researchers included any intervention that was reasonably specific and relevant to climate-related health impacts. Clearly, however, not all interventions were rigorously identified or selected. The second part of this indicator examined whether interventions were evidence-based. Recognizing that the published scientific literature on adaptive interventions remained limited, researchers applied a generous definition to "evidence-based."[234] States could meet the threshold by citing evidence that the intervention had been implemented and that it was effective within the state or in another state, or by citing credible evidence that the intervention would be effective for the identified risk. Failing to meet any of these criteria, researchers would still consider an intervention evidence-based if a relevant CDC BRACE guidance document classified it as "scientifically supported," grounded in "some evidence," or supported by "expert opinion."[235]

Researchers did not assess states on the degree to which they had successfully implemented interventions, or on the interventions' effectiveness in meeting intended objectives. Certainly, these are critical determinants of whether residents are ultimately protected adequately and equitably, but they were outside the scope of this project.

PREPARING FOR CLIMATE-RELATED HEALTH IMPACTS IN MICHIGAN

Michigan has been actively involved in climate and health efforts since 2009, when it received an 11-month planning grant from the Association of State and Territorial Health Officials (ASTHO)—sub-awarded from a CDC grant to ASTHO—to conduct a needs assessment and to prepare a strategic plan to address the health impacts of climate change.[236,237]

Through the needs assessment, the state used the 10 Essential Public Health Services to examine current work and gaps related to the health effects of climate change.[238,239] Among other findings, the state determined that, while all local health departments had comprehensive all-hazard emergency plans (including for some types of extreme weather), none specifically addressed climate change. In a survey of local public health practitioners, only 9 percent indicated that their department provided public information or education on the health effects of climate change.[240] Information from the needs assessment informed the development of a five-year strategic plan. The strategic-planning process, led by the state health department and an outside facilitator, brought together stakeholders from other state agencies, local health departments, major research universities, and nonprofit and professional advocacy organizations. The importance of identifying and involving partners early was one of the planning team's main lessons. The involvement of universities fostered particularly rich partnerships, "start[ing] a dialogue on Michigan-specific research needs" and identifying resources to support that work, as well as the planning itself.[241] The health department recommended that other states looking to undertake similar work engage not only local health departments but also local government or community planners, especially those focused on sustainability, walkability, and green planning.[242]

The team also highlighted the time and staffing commitment involved, noting the complexity of the subject and the lack of easily digestible or locally relevant information to guide their work.[243,244] Climate change had not previously been a focus of the state health department; the planning grant "provided critical resources and a structured process to begin raising awareness of the issue in Michigan and to engage the public health community as well as the environmental and emergency planning communities in development of a statewide coordinated plan."[245] This work led to the launch in 2010 of the Michigan Climate and Health Adaptation Program (MICHAP).[246]

That same year, Michigan joined the CDC's Climate-Ready States and Cities Initiative as part of its initial cohort. The state health department received a three-year grant (2010–2013) to support the implementation of its strategic plan. While there were some challenges in reconciling the original plan and the CDC's implementation expectations, the new funding allowed the department to undertake a more ambitious implementation program.[247] Many early efforts focused on educating state and local health department staff, as well as the public. MICHAP also invested in establishing and strengthening partnerships to facilitate the integration of state and local climate-related activities—for example, the program has worked with the Land Information Access Association to provide training and to incorporate public health into other climate-resiliency planning, and it has worked with the Detroit Climate Action Collaborative to address environmental-justice issues.[248,249] The program also expanded environmental health surveillance to track the health impacts of severe weather; similarly, the program expanded environmental health preparedness plans to include natural disasters.[250]

The growing number of extreme heat events and the resultant heat-related illness and mortality have topped MICHAP's list of priorities since the program's establishment. In addition to improving surveillance of heat-related illness and mortality, the health department helped pilot two heat-related decision tools in its first three years:[251]

1) The Internet-Based Heat Evaluation and Assessment Tool, or I-HEAT, developed by the University of Michigan to map heat-related vulnerability and land surface temperature.[252,253]

2) A dynamic heat model, developed by Michigan State University, that incorporates heat-related social and behavioral factors in order to help decision-makers evaluate intervention options.[254,255]

During this same period, MICHAP supported two local health departments in conducting over 3,000 surveys to assess residents' heat vulnerability and readiness.[256] A heat wave in summer 2012 provided an opportunity to show what the program had accomplished in its first two years. For example, syndromic surveillance was used to track the impact of extreme heat on emergency department visits and to develop appropriate public health messaging. Afterward, the state health department hosted local officials to discuss their responses to the event.[257]

A second three-year grant (2013–2016) introduced the CDC's BRACE framework into MICHAP's work.[258] During this phase, MICHAP collaborated with partners to produce the Michigan Climate and Health Profile Report and conducted a statewide vulnerability assessment.[259,260] It also worked with Great Lakes Integrated Sciences + Assessments, a partnership between the University of Michigan and Michigan State University, to develop downscaled climate models for the state.[261]

Since its inception, MICHAP has worked with partners across the state to encourage and support community planning pertaining to climate-related health impacts, particularly by building local capacity to conduct health-impact assessments.[262,263,264] Under its updated strategic plan (2016–2021) and third round of CDC funding, MICHAP has intensified its focus on implementing and monitoring adaptation strategies that address priority climate-related health outcomes, particularly for the most vulnerable communities.[265] Pilot interventions in Detroit and Marquette County—representing urban and rural parts of the state, respectively—will help to inform broader efforts and tools for local planning.[266,267,268]

Despite significant investments and progress, challenges remain. Michigan does not have an overarching climate change adaptation plan, although the state's 2009 Climate Action Plan recommended developing one.[269] Health is one of the only sectors to have its own action plan.

May 2020 dam failures in Midland County served as a harsh reminder of the risks posed by climate change, as well as the challenges for health departments and other state officials in preparing for them.[270] State authorities, already grappling with the COVID-19 pandemic, were suddenly faced with another emergency. Floodwaters ran through a Dow Chemical Company complex and an adjacent Superfund site.[271] With more frequent extreme rainfall events projected under climate change, on top of the nation's aging infrastructure, the event presaged additional disasters.[272,273]

Dam failures pose real threats to human health, both immediately and in the longer term. Yet most of the relevant hazard mitigation and adaptation activities fall outside the scope of public health departments. Addressing the health risks and vulnerabilities of climate change depends on multiple sectors and many different partners. Effective preparedness and adaptation will require investments and cooperation across sectors, as well as strategic direction from state leaders and their regional and federal partners.[274]

Domain 3 findings

Encouragingly, every state has documented at least some preparation for the impacts of climate change. By and large, states have begun to analyze the climate-related exposures they are likely to face and the impacts each could have, including on public health. This foundation may be attributed in part to FEMA's hazard-mitigation planning requirements, described above. Many states, however, have not moved beyond an initial identification of potential threats and have not examined them in depth or planned for specific risks. One area of weakness is the documentation of causal pathways linking exposures to health outcomes. This critical exercise underpins a state's ability to intervene effectively and protect the people or places most at risk. States have also made less progress in identifying the evidence-based interventions they can deploy to protect residents from the adverse health impacts of climate change. As seen in Table 10, states' collective performance on Indicator D3.2 was substantially weaker than it was for Indicator D3.1. It is not surprising that states' initial climate change efforts have focused on describing the likely impacts, as they come to terms with the scope of the threat. Successful adaptation, however, will require states to move quickly toward concrete responses.

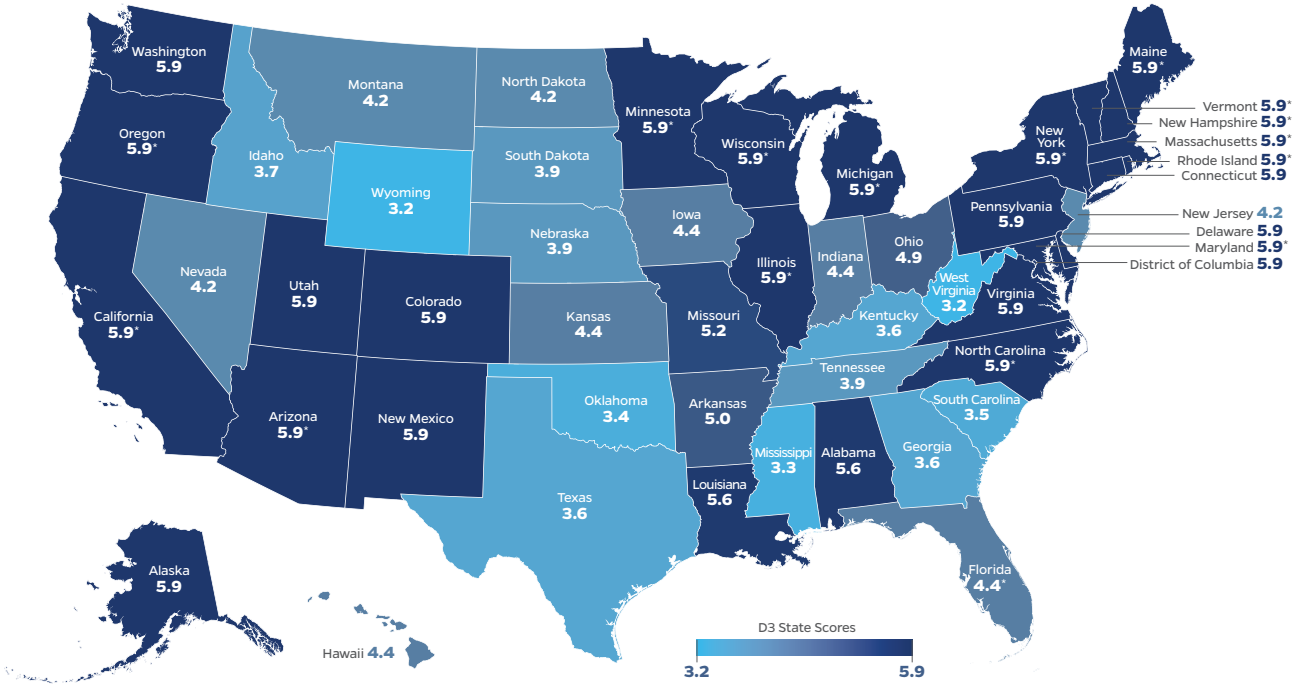
Across all measures, leading states will play an important role in laying out a path for others to follow. These states will have done more than present a list of possible impacts; they will place global and regional trends within a local context in a way that prepares them to anticipate how climate change might affect the state and its people and to develop precise response plans.

Table 10
State Performance on Domain 3, Measured by Completion of Each Sub-Indicator

	INDICATOR D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?							INDICATOR D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	
	D3.1.1 Have climate-related exposures to the state been identified?	D3.1.2 Have climate-sensitive health outcomes been identified?	D3.1.3 Have risk factors for health outcomes been identified?	D3.1.4 Have causal pathways been developed for relevant climate-related hazards?	D3.1.5 Have climate projections at the state or state and local scale been reported?	D3.1.6 Have the most vulnerable populations in the state been identified and located?		D.3.2.1 Interventions identified	D.3.2.2 Interventions evidence-based
						D.3.1.6.1 Populations identified	D.3.1.6.2 Populations located		
Alabama	✓	✓	✓		✓	✓	✓	✓	✓
Alaska	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arizona	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arkansas	✓	✓	✓			✓		✓	✓
California	✓	✓	✓	✓	✓	✓	✓	✓	✓
Colorado	✓	✓	✓	✓	✓	✓	✓	✓	✓
Connecticut	✓	✓	✓	✓	✓	✓	✓	✓	✓
Delaware	✓	✓	✓	✓	✓	✓	✓	✓	✓
District of Columbia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Florida	✓	✓	✓	✓	✓	✓	✓		
Georgia	✓				✓	✓	✓		
Hawaii	✓	✓	✓	✓	✓	✓	✓		
Idaho	✓	✓			✓	✓			
Illinois	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indiana	✓	✓	✓	✓	✓	✓	✓		
Iowa	✓	✓	✓	✓	✓	✓	✓		
Kansas	✓	✓	✓	✓	✓	✓	✓		
Kentucky	✓				✓	✓	✓		
Louisiana	✓	✓		✓	✓	✓	✓	✓	✓
Maine	✓	✓	✓	✓	✓	✓	✓	✓	✓
Maryland	✓	✓	✓	✓	✓	✓	✓	✓	✓
Massachusetts	✓	✓	✓	✓	✓	✓	✓	✓	✓
Michigan	✓	✓	✓	✓	✓	✓	✓	✓	✓
Minnesota	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mississippi	✓	✓				✓			
Missouri	✓	✓	✓	✓	✓	✓	✓	✓	
Montana	✓	✓	✓		✓	✓	✓		
Nebraska	✓	✓			✓	✓	✓		
Nevada	✓	✓	✓		✓	✓	✓		
New Hampshire	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Jersey	✓	✓	✓		✓	✓	✓		
New Mexico	✓	✓	✓	✓	✓	✓	✓	✓	✓
New York	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Carolina	✓	✓	✓	✓	✓	✓	✓	✓	✓
North Dakota	✓	✓	✓		✓	✓	✓		
Ohio	✓			✓	✓			✓	✓
Oklahoma	✓				✓	✓			
Oregon	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pennsylvania	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhode Island	✓	✓	✓	✓	✓	✓	✓	✓	✓
South Carolina	✓	✓				✓	✓		
South Dakota	✓	✓			✓	✓	✓		
Tennessee	✓	✓			✓	✓	✓		
Texas	✓				✓	✓	✓		
Utah	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vermont	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virginia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Washington	✓	✓	✓	✓	✓	✓	✓	✓	✓
West Virginia	✓					✓	✓		
Wisconsin	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wyoming	✓					✓	✓		
Total	**51**	**44**	**37**	**33**	**46**	**50**	**46**	**30**	**29**

Figure 12 displays domain-wide state scores: 24 states and the District of Columbia earned a perfect score, reflecting a broad base of early progress in examining vulnerabilities and identifying interventions. Researchers found top-scoring states in most regions of the country (all except the Northern Great Plains and the Southern Great Plains), but there was a swath of states stretching diagonally across the country from Idaho and Montana southeast into Georgia and South Carolina that had greater room for improvement. The states that were furthest behind included Georgia, Kentucky, Mississippi, Oklahoma, South Carolina, Texas, West Virginia, and Wyoming. It is cause for concern that the residents of several of these states are also the most vulnerable to adverse health impacts from climate change.

Figure 12
Domain 3 State Scores



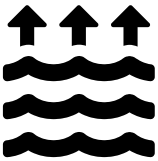
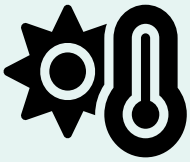
Note: Researchers scored states on a scale of 1 to 10, based on their deviation from the national mean, with higher scores representing relatively greater preparedness. The normalization/scaling process for each indicator results in an average scaled value of approximately 5. The process preserves the state-by-state variation, so greater variation among states equates to a distribution of scaled state scores with lower scores closer to 0 and higher scores closer to 10, whereas less variation equates to a distribution of state scores that are closer to each other and to 5. Grantees of the CDC's Climate-Ready States and Cities Initiative have an asterisk to the right of their score. Every grantee but Florida earned a perfect score.

Every state has identified at least one likely impact of climate change on its climate patterns and natural hazards (D3.1.1), and most states have projected those changes at a local level or contextualized interstate regional projections (D3.1.5). While it was common for states to have a climate action plan or other report (e.g., report from a governor's commission or advisory group) summarizing the expected effects, the state hazard-mitigation plan was the most common—and typically the most recent—source for this information. Many states have embraced FEMA's requirements, going beyond a single discussion of climate change to incorporate its effects or future trends into each hazard analysis.

Massachusetts has gone even further, fully integrating its hazard-mitigation and climate-adaptation planning into a single document and process in 2018.[275] Its approach could serve as a model for other states to address climate change more robustly through existing mechanisms. Previously, Massachusetts developed these two plans separately. The 2017–2018 process brought together a wide range of agency stakeholders, led jointly by the state's Executive Office of Energy and Environmental Affairs, the Executive Office of Public Safety and Security, and the Massachusetts Emergency Management Agency. To conduct its risk assessment, the plan incorporates the findings of nearly 80 climate change vulnerability assessments conducted by state agencies.[276] The assessment looks at impacts across five dimensions: (1) populations, (2) government, (3) built environment, (4) natural resources and environment, and (5) economy. The plan addresses 14 natural hazards through the lens of four projected climate changes: (1) changes in precipitation, (2) sea-level rise, (3) rising temperatures, and (4) extreme weather. (See Figure 13.) Climate change adaptation is a facet of hazard mitigation; as such, the report defines both as: "A specific action, project, activity, or process taken to reduce or eliminate long-term risk to people, property, and natural systems from climate change and/or natural hazards and their impacts."[277] Establishing this relationship provides a familiar framework for a relatively new area of focus and allows the state to leverage limited resources to achieve multiple goals. In the spirit of BRACE, Massachusetts refers to the plan as a living document that will be continually reviewed and revised during its five-year lifespan.[278]

Figure 13

Massachusetts's Climate Change and Natural Hazard Taxonomy

PRIMARY CLIMATE CHANGE INTERACTION	NATURAL HAZARD	OTHER CLIMATE CHANGE INTERACTIONS	REPRESENTATIVE CLIMATE CHANGE IMPACTS
 **Changes in Precipitation**	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to drinking water supply, public health impacts from mold and worsened indoor air quality, vector-borne diseases from stagnant water, episodic drought, changes in snow-rain ratios, changes in extent and duration of snow cover, degradation of stream channels and wetland
	Drought	Rising Temperatures, Extreme Weather	
	Landslide	Rising Temperatures, Extreme Weather	
 **Sea Level Rise**	Coastal Flooding	Extreme Weather	Increase in tidal and coastal floods, storm surge, coastal erosion, marsh migration, inundation of coastal and marine ecosystems, loss and subsidence of wetlands
	Coastal Erosion	Changes in Precipitation, Extreme Precipitation	
	Tsunami	Rising Temperatures	
 **Rising Temperatures**	Average/Extreme Temperatures	Not Applicable (N/A)	Shifting in seasons (longer summer, early spring, including earlier timing of spring peak flow), increase in length of growing season, increase of invasive species, ecosystem stress, energy brownouts from higher energy demands, more intense heat waves, public health impacts from high heat exposure and poor outdoor air quality, drying of streams and wetlands, eutrophication of lakes and ponds
	Wildfires	Changes in Precipitation	
	Invasive Species	Changes in Precipitation, Extreme Weather	
 **Extreme Weather**	Hurricanes/ Tropical Storms	Rising Temperatures, Changes in Precipitation	Increase in frequency and intensity of extreme weather events, resulting in greater damage to natural resources, property, and infrastructure, as well as increased potential for loss of life
	Severe Winter Storm/ Nor'easter	Rising Temperatures, Changes in Precipitation	
	Tornadoes	Rising Temperatures, Changes in Precipitation	
	Other Severe Weather (Including Strong Wind and Extreme Precipitation)	Rising Temperatures, Changes in Precipitation	
Non-Climate Influenced Hazards	Earthquake	N/A	There is no established correlation between climate change and this hazard

Source: Massachusetts Emergency Management Agency and Executive Office of Energy and Environmental Affairs[279]

In addition to broadly recognizing the threat of climate change, most states acknowledge that climate change will have an effect on public health, and most have identified at least one likely health outcome (D3.1.2). One of the most commonly discussed health threats is heat-related illness and death. There is good reason for this: extreme heat is responsible for more deaths in the United States than any other weather-related hazard, including natural disasters such as hurricanes and tornadoes.[280] Many states reported having robust plans and programs to address heat emergencies. Higher temperatures and prolonged heat waves are also a more easily recognized effect of climate change. States also frequently cited vector-borne diseases and respiratory issues, including allergies and asthma, related to changes in air quality from higher temperatures or wildfire smoke.

The state of Washington stands out by segmenting health implications into three categories: (1) increased morbidity, (2) impacts to health and safety protections, and (3) exacerbated health disparities in its state health assessment.[281] It outlines specific risks to health and safety, including those related to heat, infectious conditions, allergies, respiratory and cardiovascular illness, and mental health, as well as disruptions caused by natural disasters. And the state highlights the fact that populations at greatest risk already carry a disproportionate burden of disease, necessitating adaptive actions that vary by location and community.

Fewer states documented deeper-level analyses of how climate-related health threats will impact specific segments of their population. Understanding the specific risk factors in a community is an important part of this process (D3.1.3). Surveillance and epidemiological investigations can help states identify patterns in terms of who experiences certain health outcomes, as well as when and where they do. For example, Maryland used state-specific data to develop a baseline health assessment and to identify risk factors that were then used, along with climate projections, to model current and future climate-related health impacts across the state and in four pilot counties. A report commissioned by the state notes: "The impacts of climate change on human health will vary and depend on, among other factors, an individual's sensitivity and exposure to a given threat and the capacity to adapt. … Preventative actions are dependent on Maryland's capacity to track current disease patterns and project future threats to human health."[282]

The broader definition used for vulnerability (D3.1.6) may help explain why states overall did not perform as well on D3.1.3, which asked whether the state had identified risk factors for climate-related health outcomes. While most states have some process for identifying—and, to a slightly lesser extent, locating—populations that are vulnerable to environmental hazards and natural disasters, fewer states are planning around specific climate-related health outcomes. States that devoted more than a passing glance to risk factors also often presented information as part of a comprehensive discussion of the health outcome(s) and relevant causal pathway(s).

Just under two-thirds of states presented a causal pathway (D3.1.4). These pathways provide a rationale for climate and health interventions, and indicate that states have studied in detail their changing exposures and the associated risks posed for specific populations. States that scored higher overall were more likely to frame their work using complex and multifaceted pathways. (See Figure 14.)

In its 2014 Climate and Health Profile Report, Oregon devoted a whole section to describing causal pathways related to the state's projected climate changes.[283] The state outlines pathways for eight key threats: (1) heat, (2) drought, (3) wildfire, (4) floods and storms, (5) sea-level [rise], (6) allergens, (7) infectious disease, and (8) indirect impacts. The pathways are evidence-based and used as a framework for discussing not only potential health outcomes but also the relevant risk factors and vulnerable populations. As part of the pathway linking heat to illness or death, for example, Oregon addressed direct effects of temperature exposure, as well as violence, air pollution, harmful algal blooms, and recreational risk. The state further broke down heat-related death into immediate causes, such as heart attack, stroke, renal failure, heat stroke, and respiratory illness. Oregon identifies those who are vulnerable to heat-related deaths as people with chronic health conditions such as cardiovascular disease, infants and children, older adults, people with low income, people who are socially isolated, city dwellers, and outdoor workers—a list that accounts for variations in sensitivity, exposure, and adaptive capacity. The state has focused on social factors in locating its most vulnerable census tracts, while acknowledging that it should integrate additional measures of climate-related exposures and adaptive capacity into future assessments.[284,285]

Figure 14
Oregon's Climate Change Causal Pathway

Source: Oregon Health Authority, Public Health Division[286]

Utah has prepared a report that specifically addresses the state-level public health risks posed by climate change.[287] This document reflects the Utah Department of Health's analysis of the risks and its efforts to minimize the impacts on Utahans. The causal pathways presented in the document may be helpful for other Western states that want to build on existing climate change work related to drought, wildfire, or natural resource management. The health department is the only state agency that has undertaken this type of assessment, but there are signs that the state is moving toward broader action. In its 2019 hazard-mitigation plan, Utah's Division of Emergency Management recommended the state require a comprehensive climate change assessment to pave the way for identifying specific and meaningful adaptation and mitigation actions.[288] Later that year, the Utah legislature asked the University of Utah to identify policy options that would reduce air pollution and address the causes and impacts of climate change; the final and positively received report encourages policymakers to follow the lead of other states and "adopt a Utah-style changing climate action plan."[289] If the state moves forward with this work, there is an opportunity for the health department to play a leadership role in developing those wider plans.

Similarly, Alaska conducted a health-impact assessment on climate change in the state and used the findings from that report to develop recommendations for the governor's climate change action plan.[290] As part of its assessment, the state provided a framework to help local communities use the information to prioritize adaptation strategies and plan for resource needs. The state suggested that prioritization criteria might include: (1) potential time to impact, (2) geographic extent of the impact, (3) the number of people directly impacted, (4) the number of people impacted who could experience serious health issues, and (5) the resources required to adapt to the impact.[291] (See Figure 15.)

Figure 15
Alaska's Example of a System to Rank the Timing and Magnitude of Health Impacts

Health Effect Category	Selected Adverse Health Impacts	Time to Impact	Geographic Extent	# of People Directly Impacted	# of People Experiencing Serious Health Problems	Resources Needed to Adapt/ Respond
Mental Health and Wellbeing	Increase in solastalgia, anxiety, and depression due to the changing environment	< 20 years	Statewide	Many	Intermediate	Intermediate
Accidents and Injuries	Increased heat stress and associated disorders	20-50 years	Local	Few	Few	Few
	Increased accidents/injuries due to infrastructure damage	< 20 years	Regional	Few	Few	Intermediate
	Increased accidents/injuries due to wildfires	< 20 years	Regional	Few	Few	Intermediate
	Increased accidents/injuries due to extreme weather events (e.g., flooding)	< 20 years	Regional	Intermediate	Intermediate	Intermediate
	Increased accidents/injuries due to unsafe ice conditions	< 20 years	Regional	Few	Few	Few
Exposure to Potentially Hazardous Materials	Increased cardiovascular disease morbidity/mortality due to air pollution (e.g., caused by wildfires)	20-50 years	Regional	Few	Few	Few
	Increased respiratory disease mobidity/mortality due to air pollution (e.g., caused by wildfires)	20-50 years	Regional	Few	Few	Few
	Increased exposure to hazardous materials (e.g., due to infrastructure damage, storm events)	< 20 years	Regional	Few	Few	Intermediate
Food, Nutrition, and Subsistence Activity	Decrease in subsistence food consumption and food security (e.g., due to migration changes, increased costs of importing foods)	20-50 years	Regional	Intermediate	Intermediate	Intermediate
Infectious Diseases and Toxins from Microorganisms	Increased morbidity/mortality related to vectorborne diseases	20-50 years	Regional	Intermediate	Few	Intermediate
	Increased morbidity/mortality related to zoonotic diseases	20-50 years	Regional	Few	Few	Few
	Increased morbidity/mortality related to food- and waterborne diseases (e.g., botulism, PSP, *Vibrio parahaemolyticus*)	< 20 years	Regional	Few	Few	Few
Non-communicable and Chronic Diseases	Increased rates of chronic diseases such as obesity, diabetes, and hyperlipidemia due to changing lifestyles	20-50 years	Local	Few	Few	Few
	Increased rates of chronic respiratory diseases due to aeroallergens	20-50 years	Regional	Few	Few	Few
Water and Sanitation	Increased morbidity/mortality due to compromised access to water and sanitation facilites (e.g., infrastructure damage)	< 20 years	Regional	Few	Few	Intermediate
Health Services Infrastructure and Capacity	Increased morbidity/mortality due to compromised access to health care (e.g., infrastructure damage)	20-50 years	Regional	Few	Few	Intermediate

Note: The state cautions that this table was constructed as a notional example for Alaska communities to consider replicating when developing the community health component of their own climate change adaptation plans. It is primarily an instructional tool rather than a precise representation of the likelihood of specific health impacts due to climate change in Alaska.

Source: Alaska Department of Health and Social Services[292]

Many states have formally identified and located their most vulnerable residents (D3.1.6), typically applying either the CDC's Social Vulnerability Index, which uses 15 U.S. Census variables to help local officials identify communities that may need support in preparing for hazards or recovering from disaster, or one designed by the Hazards and Vulnerability Research Institute at the University of South Carolina, which synthesizes 29 socioeconomic variables to characterize vulnerability to environmental hazards at the county level.[293,294] While these tools do not explicitly consider climate change, they examine the types of hazards and vulnerabilities that climate change is likely to amplify.

However, states may not recognize this connection, and indeed some states mapped one of the social vulnerability indexes but did not explicitly address climate change or climate-related health outcomes. Few states reported on vulnerability driven by climate change in a comprehensive way, encompassing environmental, social, and demographic factors and projected future trends. Considering all such factors produces more useful data for planning—especially if data are based not just on past observations but also projections of future risk—and does not necessarily require complex analyses.

For example, California, Minnesota, and South Carolina are three states that have presented composite data in such a layered fashion. (See Figure 16.) While the basic concept is the same in all three states, each one has tailored it to their own purposes. A state may inform its approach with practical considerations, such as the availability of data, staffing resources and expertise, or the priorities of the agency leading the analysis; the approach may also reflect an examination of the particular characteristics that influence vulnerability (broadly or specific to certain hazards or outcomes) in the state.

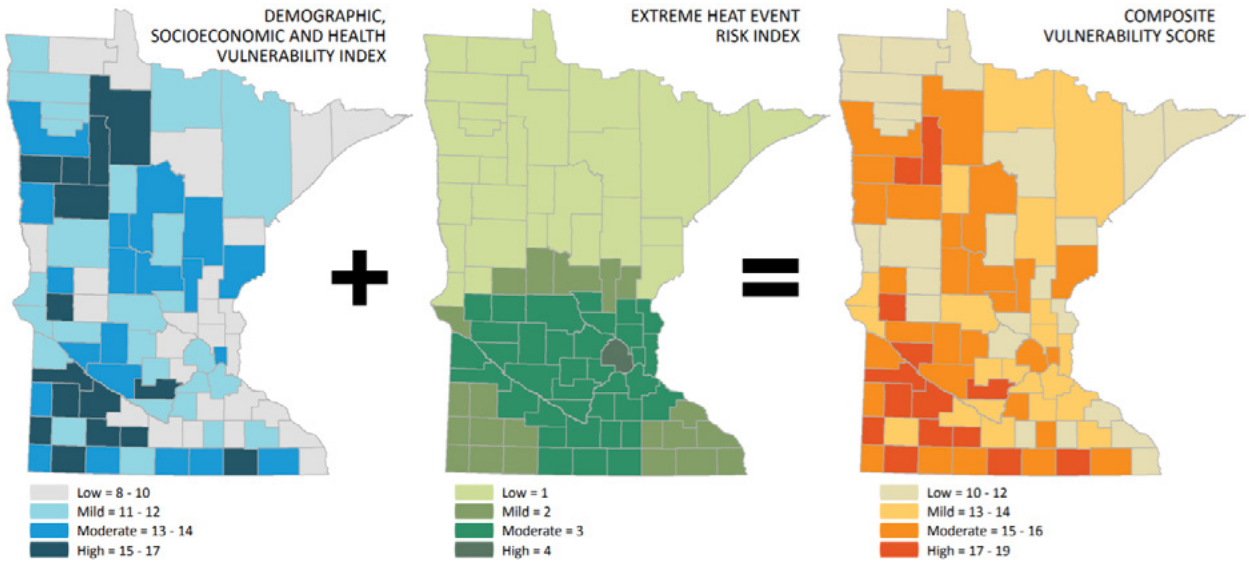
Minnesota began by conducting a review of existing literature on climate change indicators and vulnerable populations.[295] The Minnesota Department of Health used this review to develop a master list of indicators, which it split into four categories: (1) climate hazard, (2) health risk, (3) population vulnerability, and (4) built-environment hazard. Using these indicators and the Association of State and Territorial Health Officials (ASTHO) Climate Change Population Vulnerability Screening Tool, the health department developed a vulnerability index and county-level composite maps for three climate-related hazards: (1) extreme heat events, (2) air pollution, and (3) flooding. Each index uses a different set of population vulnerability indicators, reflecting the causal pathways and risk factors specific to that hazard and specific to Minnesota.

Other states have taken a simpler approach, drawing on existing tools like the indices mentioned above. In its hazard-mitigation plan, South Carolina depicted overall and hazard-specific vulnerability by mapping data on hazard risk blended with data from the University of South Carolina's Social Vulnerability Index.[296,297] Hazard risk incorporated data on past events and associated losses (property damage, crop damage, deaths, and injuries). The state also looked at how social factors had changed over recent years, but the assessment did not project future changes.

Some states provide their vulnerability data through a dashboard or tool that local health departments and other stakeholders can use to create their own maps or to conduct analyses. For example, through the CalBRACE program, California offers CCHVIz, an online data-visualization platform for its Climate Change & Health Vulnerability Indicators. Data are provided for 18 indicators across three categories: (1) environmental exposures, (2) population sensitivity, and (3) adaptive capacity.[298] It is one of few states that has incorporated climate projections into its vulnerability assessments, although projected estimates are only available for certain exposures (e.g., extreme heat, sea-level rise).[299] The CCHVIz website includes step-by-step guidance on how to use the platform to understand and map the main types of vulnerability in a specific county, as well as resources on how to begin acting on the information.[300]

Figure 16

Minnesota's Population Vulnerability, Extreme Heat Event Risk, and Composite Health Vulnerability Maps



Source: Minnesota Department of Health[301]

Of course, historical data alone can still be instructive. Observing wide variation in the association between certain climate-related exposures and health impacts in different parts of the state, New York has used its findings, combined with other scientific literature, to identify population, social, and environmental factors that might contribute to individual- and neighborhood-level vulnerability.[302] For heat, these factors were used to develop a composite vulnerability index, which was validated against state data on related health outcomes.[303,304] New York has used this information to create Heat and Health Profile Reports for each county to help them plan and allocate resources for heat-related illness.[305] For example, the Heat Vulnerability Index can inform county officials about where to set up cooling centers or how to arrange home visits to elderly residents living alone.[306]

While tools like the social vulnerability indexes created by the CDC or the University of South Carolina are designed to be broadly applicable, state and local characteristics determine the salience of specific factors, particularly those related to adaptive capacity. The better a state parses the drivers of vulnerability among its residents, the more effectively it can prepare for and prevent the related negative health impacts among those groups. New York's Heat Vulnerability Index draws on 13 measures across four categories: (1) language vulnerability, (2) socioeconomic vulnerability, (3) environmental and urban vulnerability, and (4) elderly isolation and elderly vulnerability.[307] Vermont's index draws on 17 measures, organized around six themes: (1) population, (2) socioeconomic, (3) health, (4) environmental, (5) climate, and (6) heat illness.[308] Both present valuable information that can guide communities and state officials in developing and implementing life-saving interventions.

PERFORMANCE OF CDC'S CLIMATE-READY STATES AND CITIES INITIATIVE GRANTEES

States that had received funding from the CDC's Climate-Ready States and Cities Initiative as of the time of this analysis were generally among those that were furthest along in the process of assessing their specific vulnerabilities and preparing to adapt, scoring highest in the assessment (all but Florida earned a perfect score) and demonstrating reporting that was characteristically methodical and comprehensive. Many grantees have prioritized the health impacts of greatest concern to the state, enabling them to effectively plan and implement meaningful interventions. They also tended to transparently lay out work left to be done, explicitly identifying limitations and next steps.

Nearly all grantees had started to identify interventions that could protect their residents from the public health impacts of climate change. Three-quarters of these states had a written plan or strategy that specifically focused on steps they would take to adapt to climate change; nationwide, fewer than half of states had produced such a document. Existing adaptation plans are not necessarily specific to health, but they represent an important step toward action. In one of its earliest reports on adaptation, Maine noted that, "the very process of adaptation *planning* results in enhanced adaptation *capacity* across a range of actions."[309]

Once states have identified climate-related hazards and climate-related health outcomes, they can begin preparing for them. The second primary indicator used for this assessment looks at how states are planning to adapt to climate change. Worryingly, given fast-approaching threats, fewer states (30) had reached this stage.

Most states that have started to identify potential interventions did so in a tentative way, listing options or compiling recommendations for state agencies or future working groups to consider. Indeed, it was common for recommendations to acknowledge, at least tacitly, a state's beginner status by calling for training or the raising of awareness, among both state employees and the public. To earn credit for this indicator, states had to identify strategies that addressed the plausible public health impacts of climate-

related hazards. In many cases, the health department or a health-focused working group compiled these recommendations, but states also identified health-related recommendations in broader climate change commission reports and action plans or in their hazard-mitigation plans. Less often, plans from other sectors, such as water resource management, discussed adaptation strategies that would protect human health.

A common approach was to consider climate change efforts in relation to existing public health capabilities, with recommendations that focused on capacity building or expanding to incorporate climate-related issues. States often presented disease surveillance and environmental monitoring as tools to guide interventions and future programming. Many states already have programs in place for monitoring climate-related exposures—such as temperature and air and water quality—and alerting the public when the exposures reach unsafe levels. These thresholds can provide guidance for individual behavior changes and they can activate other community resources. Deploying such existing programs and resources effectively can help communities affordably avoid some of the adverse health effects of climate change. Data from these programs can also provide a foundation for other adaptation efforts and help public health departments understand whether existing interventions are reaching the right populations at the right time. New Hampshire described using real-time hospital data to track heat-injury admissions, especially among vulnerable populations; this information helps officials decide whether to open cooling centers.[310] New Mexico was planning to build on its emergency weather risk communication programs by engaging local emergency managers to coordinate and strengthen their response to these events.[311]

Frequently, states identified interventions that could address specific climate-related hazards; for example, many discussed the use of cooling centers and air conditioning as an adaptive strategy for extreme heat. Others took a broader approach, presenting cross-cutting strategies that could address all or multiple hazards.

In nearly all cases, the identified interventions were supported by at least some evidence. Rhode Island, for instance, compiled best practices from other states. A few states have begun piloting or evaluating specific strategies. For example, in an addendum to its climate- and health-adaptation plan, Arizona described the progress of successful or promising county-level interventions.[312]

Some states used their vulnerability assessments to steer interventions to people or places with the greatest need. States often focus on vulnerable populations in their efforts to reduce the health impacts of extreme heat. Many states highlighted the greater needs of people who are elderly or socially isolated, residents who do not have or cannot afford to use air conditioning at home, and neighborhoods with a lot of pavement and little tree cover or green space. For example, the Vermont Department of Health partnered with the state's Urban & Community Forestry Program to provide 500 trees to residents in four communities that were identified as high-risk using the Vermont Heat Vulnerability Index, which includes a lack of tree cover as a key risk factor for heat-related illness.[313]

Some states were pushing for the integration of adaptation throughout the health department's portfolio. Washington's climate strategy called for climate adaptation to be "a standard part of agency planning" across all state agencies.[314] The Minnesota Department of Health's Climate & Health Program leads an agency-wide working group with the explicit goal of fully integrating climate change adaptation throughout the agency's work.[315] Every five years, the program surveys staff to assess their knowledge and opinions on climate and health.[316] One of their first interventions was to develop regional climate and health data profiles to help emergency managers and emergency preparedness professionals understand and use climate projection data for planning.[317]

Like Massachusetts, Minnesota is one of a small group of states that explicitly recognizes climate change adaptation as a variant of hazard mitigation focused on future conditions, rather than historical ones.[318] Recognizing this intersection also acknowledges the multi-sectoral nature of adaptation. States often pointed out that relevant interventions do not always fall under the purview of health departments and emphasized the importance of partnerships across agencies and external stakeholders. For instance, the New York State Department of Health "integrat[es] climate change as a determinant of health into all relevant public health programs and services including other agencies."[319]

Some states were looking at ways to leverage other efforts, including climate change mitigation activities, to achieve human health goals of adaptation. For example, California found that shifting to active transportation (walking and biking) decreased greenhouse gas emissions and reduced the burden of cardiovascular disease and diabetes, both of which can increase vulnerability to climate-related hazards.[320] Other examples include green infrastructure, energy-efficient housing, and zoning and land-use policy.[321] Recognizing health co-benefits can improve cost-benefit calculations and help decision-makers understand the full impact of policies and programs. Another way that states (e.g., Alaska, Massachusetts, Michigan, Vermont) are evaluating the climate and health implications of their plans, policies, and programs is by using health impact assessments to identify the potential health effects of actions across sectors, as well as to identify how impacts might disproportionately affect various groups and influence health outcomes.[322,323,324,325,326]

PROGRAM AND POLICY RECOMMENDATIONS

This report has documented the scientific certainty that Earth's climate is changing and that the United States can expect major health impacts as a result. To that end, states have shown areas of progress and areas that demand improvement with respect to the nation's readiness to effectively adapt. Protecting people, particularly those who are most vulnerable, must be treated everywhere as a critical public health priority necessitating swift, concrete, and persistent action. The planet reminds us of this urgency on a near-constant basis.

The program and policy recommendations outlined below can help guide this work. Just as adaptation was the focus of this assessment, it is also the orientation of these recommendations. As the USGCRP has warned, major reductions in greenhouse gas emissions (mitigation) are necessary to limit global temperature increases. Critically, such actions would soften the magnitude and intensity of climate change and its impacts, but the United States must make progress on parallel and complementary tracks (mitigation and adaptation), as each are essential to minimizing harmful consequences.

In addition to the results of this assessment, these recommendations were further informed by interviews that researchers conducted with experts, including those on the front lines, as well as a review of published literature. The recommendations are divided into two segments—federal and state—based on the respective roles of policymakers and other officials at each level, but close coordination between all levels, including localities, territories, and tribes, is essential for success.

FEDERAL RECOMMENDATIONS

States rely on the federal government for guidance and coordination. The United States must develop and implement a national plan to address the health impacts of climate change—in addition to other related effects—including by enacting a law that would ensure a measure of attention from relevant agencies. But laws will not be enough; Congress also needs to appropriate funds to strengthen the evidence base behind adaptation interventions and their implementation, and to ensure that every state health department can prepare for climate change and track its progress through local-level monitoring. And the country must rebuild its public health infrastructure and workforce, a necessity with benefits that transcend discrete health threats.

1. **Enact legislation requiring a national strategic plan.**
   The United States urgently needs a strategic action plan to address the health impacts of climate change. Legislation should be enacted requiring the U.S. Department of Health and Human Services to develop such a plan and to fund development and ongoing maintenance of health system capacity specifically for this purpose.

The Climate Change Health Protection and Promotion Act of 2019, which requires the creation of such a plan, provides a valuable starting point for legislation that could address the concerns presented in this report.[327] It mandates that federal agencies engage in forecasting and modeling, and that they track both environmental and disease data, expanding an understanding of the relationship between climate change and health outcomes. Importantly, the bill explicitly recognizes that "climate change disproportionately impacts communities of color and low-income communities," and it calls for the federal government to use all practicable climate-related means and measures to improve health equity, including by prioritizing such communities in the plan and by requiring the inclusion of people with "practical or lived experience with relevant issues" in a newly formed science advisory board.

2. **Fully fund the CDC's Climate and Health program.**
Congress and the CDC should ensure sufficient funding to support every state, locality, U.S. territory, and tribe that wishes to become a Climate-Ready States & Cities Initiative (CRSCI) grantee. Through training and other technical assistance, CRSCI helps grantees use the five-step Building Resilience Against Climate Effects (BRACE) framework to identify likely climate impacts in their communities, potential health effects, and their most at-risk populations and locations. Additional funding should also enable the CDC to bolster its guidance on evidence-based adaptation interventions.

   Importantly, the CDC's Climate and Health Program is part of a broader array of critical preparedness programs, including the CDC's Public Health Preparedness Program, the Office of the Assistant Secretary for Preparedness and Response's Hospital Preparedness Program, and grants to states made by FEMA and the EPA.

3. **Provide funding for adaptation research and scientific training.**
Federal priorities should include research funding via the National Institutes of Health or other agencies for academic centers of excellence, training of skilled researchers, and educational programming conducted by academic institutions. Research should study the effectiveness of promising interventions and risk-reduction initiatives in order to advance implementation science. These efforts would help build a full-fledged, evidence-based climate adaptation program to protect health.

4. **Fully fund the CDC's National Environmental Public Health Tracking Network.**
This program works with a network of partners to collect, integrate, and analyze disease and environmental data to help public health and other practitioners identify and target health risks. The agency's Climate and Health Program and Tracking Network collaborate often, with mutual benefits, including the provision of climate data. But the CDC is only able to fund participation in the Tracking Network for about half the states, many of which are already using the data to support their climate and health work.[328] The CDC has estimated that it needs roughly $75 million to expand the program to all 50 states, the District of Columbia, and U.S. territories. Additional funding, alongside technical improvements to make reporting as smooth and straightforward as possible, would also allow the program to expand the type of health data available to policymakers, public health professionals, and the public.

5. **Strengthen the public health infrastructure and workforce, including by modernizing data and surveillance capacities.**
   Public health and climate change work relies on good data that is comprehensive, comparable across jurisdictions, near real-time, and granular enough to allow for disaggregation by key factors of vulnerability (e.g., income, race, age, disability status, etc.). The nation needs mechanisms to collect these data to ensure they are being critically analyzed and used to drive policy. Federal leaders should establish a Core Public Health Infrastructure Program at the CDC, awarding grants to state, local, tribal, and territorial health departments to ensure they have the tools, highly trained workforce, and systems in place to address existing and emerging health threats. A critical imperative is filling the gap in relevant data on American Indian and Alaska Native tribal nations and U.S. territories, a priority made even more important by the acute threat that climate change poses to many of their residents.

6. **Prioritize equity and resilience by supporting and protecting high-risk populations, and by addressing the social determinants of health.**
   As this report has documented, the health impacts of climate change will not be felt equally. Some people, owing to a mix of environmental, social, and demographic factors, will bear a disproportionate burden. Therefore, all relevant federal policies, programs, and funding must maintain a constant focus on the identification of these areas and people, and persistently intervene to reduce vulnerability and work side by side with high-risk groups to protect their health and safety.

   Governments at all levels should direct funding to programs that address the social determinants of health—factors that improve the conditions in people's lives and that impact their health and resilience. The CDC and other federal agencies should be funded to address social determinants through cross-sector collaboration, policy change, and community partnerships. One concrete step would be enacting the Improving Social Determinants of Health Act of 2020, which would create a program at the CDC to provide capacity-building grants to public health departments, community organizations, nonprofit organizations, and institutions of higher education.[329]

STATE RECOMMENDATIONS

No state earned a perfect score across all indicators tracked for this analysis. All states need to better invest in public health and emergency management preparedness; engage in deeper-level adaptation planning, guided by the CDC's BRACE framework; dedicate resources to preparing for the health impacts of climate change; and partner with others to bring about better outcomes.

1. **Bolster states' core public health preparedness capabilities.**
   State decision-makers—from governors to legislators to agency directors—must adequately fund core public health functions, including surveillance and epidemiological investigation capabilities, environmental monitoring, incident and information management, and healthcare readiness. Moreover, they must strengthen collaboration across stakeholders and work to earn public trust and build social cohesion, essential intangibles of effective preparedness.

2. **Build health equity leadership in state and local governments.**
   All state and local governments, including health departments, should build up internal infrastructure to drive equity, including identifying a chief health equity or health resilience officer. Health equity and emergency preparedness officials should work across programs to incorporate equity issues and goals into preparedness policies and plans, improve staff understanding of how the legacies of structural and systemic racism affect disaster resilience and recovery, and collect and leverage data to identify unique community assets and advance equity on an ongoing basis.[330]

3. **Complete all steps of the CDC's BRACE framework, and continuously work to enhance and refine preparations.**
   State agencies must conduct and facilitate rigorous vulnerability assessments at the state and local levels. The assessments should focus especially on populations at highest risk and the health threats most pertinent to them. States must also push ahead to complete all steps of the framework, including identifying and implementing evidence-based interventions to protect residents. Finally, as agencies implement interventions, they should continually evaluate effectiveness, and strive for quality improvement.

4. **Establish ongoing, dedicated funding and staff for climate-related preparations.**
   Given the many competing demands on the public health workforce, health departments must designate at least one staff person to dedicate their time to preparing for and responding to climate change. Climate change preparations, however, do not just need to happen in health departments; agencies such as environmental and emergency management departments should designate similar positions. All these individuals should coordinate with each other across the state via regular meetings and common goals. To ensure accountability, climate change work should appear in the position descriptions and be part of these employees' annual review process. Goals for these positions should be specific, measurable, achievable, results-oriented, and time-bound.

5. **Engage in close coordination with local and federal partners.**
   Given the complex natures of both the climate and health, creating and funding positions at one level of government is not enough. Those on the front lines must drive planning and implementation at the state level. Where possible, state health departments should provide mechanisms for regular communication with local departments and tribal nations. This might take the form of calls or meetings. Similarly, state-level needs and successes must inform what happens at the federal level. State health departments should work with the Association of State and Territorial Health Officials to ensure agencies such as the CDC, EPA, and FEMA are aware of state needs.

6. **Plan with communities, not for them.**
   Preparedness officials must include members of communities at greatest risk—and compensate them for their involvement, when appropriate—in planning and decision-making. Health departments and emergency management agencies should rely on the expertise of those who may bear a disproportionate risk, such as older adults, people with disabilities, and individuals with chronic health conditions, to ensure plans and procedures meet the needs of everyone. Community-driven planning strengthens resilience, as residents play a lead role in defining the challenges they face and the solutions most relevant to their unique circumstances.

CONCLUSION

"What's at stake here is a livable world."[331] That was how a leading climate scientist summed up the cataclysmic levels of species extinction brought about by climate change, but the sentiment also succinctly captures the urgency of adequately addressing its impacts on human health. The essential question remains: Will humanity take the necessary actions to ensure that over the long-term people, regardless of their station or circumstances, can live healthful lives on the only planet available to them? At present, the answer is unclear.

This report makes the case that public health preparedness is vitally important, a lesson that tends to be relearned with every predicted emergency. This means, in part, preparations to safely adapt to longstanding threats—threats that climate change will turbocharge. It means preparing to protect people, particularly those who are most vulnerable, as heat waves get hotter and longer; severe storms break records year after year; wildfires outmatch traditional methods of control; pollution and contaminants increasingly endanger the quality of the air and water; pests bring disease and threaten staple foods; and the trauma of it all tests mental health. All of this must happen even as the nation pushes for stronger mitigation efforts, essential for ensuring that adaptation efforts are not overwhelmed, to avert worst-case scenarios.

The good news is that the nation's public health leaders have charted at least a partial pathway for officials to follow. The CDC's BRACE framework provides clear and precise guidance for state, local, tribal, and territorial governments. Its straightforward five-step cycle moves from assessing and understanding vulnerabilities and potential impacts to identifying and implementing adaptive interventions to continuous evaluation and improvement. With the requisite prioritization and support from leaders at all levels of government, every state and sizeable locality in the country is capable of employing a version of the framework—a step that would significantly improve the health security of residents. While this study found that every state has documented some preparations to protect its people from climate change's health impacts, it also found significant room for improvement, particularly in many of the places at greatest risk.

At the same time, federal partners play an indispensable role and must do more to guide, assist, and support states and localities. This will be a long-term project, but immediate actions that would make a meaningful difference include legislation requiring the U.S. Department of Health and Human Services, including the CDC, to elevate, expand, and strengthen climate-related preparedness, as well as targeted funding for environmental health tracking and public health infrastructure and data modernization. The more robust this country's public health system becomes, the safer Americans will be from a whole host of threats, including climate change.

Humanity faces an unprecedented challenge. Nothing less than the viability of life on Earth demands that nations move with urgency to address it. We know much of what we need to do; and we are capable of doing it. It is past time to summon the necessary will and seriousness of purpose.

APPENDIX A: METHODOLOGY

This appendix describes the process used to scope and conceptualize the research for this project; fashion and refine indicators of climate-related vulnerability and preparedness; collect, normalize, and code credible data to support the indicators; and calculate scores to assess states' preparedness vis-à-vis vulnerability.

PROJECT SCOPING AND INFORMATION GATHERING

This project sought to answer four sequential research questions.

1. What, if any, are the direct and indirect health impacts—positive and negative—of climate change on U.S. residents, and how are those impacts expected to change over time?

    a. How do these impacts, and how will these impacts, vary by state or region?
    b. How do these impacts, and how will these impacts, vary by population or community?
    c. Do these impacts represent new threats, or is climate change accelerating and intensifying preexisting threats—or both?

2. Besides measures to mitigate the nature and extent of future climate change, what adaptive preparations, if any, could be made to protect residents from the health risks posed by climate change? How, if at all, should preparations vary by state or region?

Researchers did not engage in original research to answer these first two questions. Rather, they relied on a robust and growing body of credible literature, as well as on interviews with issue experts.

3. How should states' preparedness be tested or measured? How, if at all, should tests or measures vary by state or region?

4. To what extent are states prepared to protect their residents from the public health impacts of climate change? How should lessons learned from leading states be applied to those with greater room for improvement?

Researchers sought to answer the third and fourth questions through a mix of secondary and original research. That is, they used the information gathered through the exploration of the first two questions to inform a set of indicators, and, ultimately, an assessment.

In the first stage of the project, researchers laid the groundwork by gathering information on the connections between climate change and public health, reviewing past work that might serve as models to inform the project, and exploring how to conceptualize preparedness for climate-related health impacts. Researchers relied principally on three sources of information: expert interviews, an academic literature review, and a grey literature review.

1. **Expert interviews.** Researchers conducted structured interviews with a diverse group of subject-matter experts to learn about their work and how to best approach this project. Standard topics included key research and other literature, essential elements of preparedness and the factors on which they depend, best practices in the area of climate-related adaptation and how those practices are facilitated or impeded, and reviews of states or localities seen as leaders in this area.

   These discussions produced a wealth of useful information. In particular, three common themes emerged:

   a. **Near-term focus**. Advisors urged states—and therefore researchers for this project—to focus principally on the near-term (e.g., five to 10 years). They argued that a good indication of how states will fare when more intense impacts arrive in 2050 is how they cope with milder impacts in 2025.
   b. **Preparedness and vulnerability.** Advisors argued that it would be incomplete to measure preparedness without also assessing vulnerability (i.e., environmental, social, and demographic factors), as the two are inextricably linked. For example, states with relatively more vulnerability arguably need to make more extensive preparations to protect their residents.
   c. **Core public health preparedness.** Advisors argued that core elements of public health preparedness, which transcend specific threats, are essential ingredients for handling climate-related impacts.

2. **Academic literature review.** Researchers closely examined more than 200 articles (starting from a universe of 4,000). They identified the articles through three databases:

   - **PubMed.** Search terms included:
     a. "Climate Change"[Mesh] OR climate change*[tw] OR climate extreme*[tw] OR changing climate*[tw]
     b. "Public Health/methods"[Mesh Terms] OR "Risk Assessment/methods"[Mesh] OR "Risk/methods"[Mesh] OR readiness[tw] OR vulnerability[tw] OR vulnerable[tw] OR preparedness[tw] OR risk*[tw]
     c. "Health Status Indicators"[Mesh] OR indicators[tw] OR indices[tw]
     d. A and B and C

- **GeoBase.** Search terms included:
  a. ({Climate change} WN CV) OR ({climate effect} WN CV) OR ((climate change* OR climate extreme* OR changing climate*) WN KY)
  b. ({vulnerability} WN CV) OR ({assessment method} WN CV) OR ({risk assessment} WN CV) OR ((readiness OR vulnerability OR vulnerable OR preparedness OR adaptation OR risk*) WN KY)
  c. ({general biological phenomena} WN CV) OR ({life table} WN CV) OR ({environmental aspects and related phenomena} WN CV) OR ({environmental indicator} WN CV) OR ((indicators OR indices) WN KY)
  d. A and B and C

- **Scopus.** Search terms included:
  a. TITLE-ABS-KEY ("climate change*" OR "climate extreme*" OR "changing climate*")
  b. TITLE-ABS-KEY (readiness OR vulnerability OR vulnerable OR preparedness OR adaptation OR risk*)
  c. TITLE-ABS-KEY (indicators OR indices)
  d. TITLE-ABS-KEY("public health" OR disease* OR health OR asthma OR "food borne" OR "water borne" OR illness OR epidemiolog* OR morbidit* OR outbreak OR prevalence OR endemic OR incidence OR mortalit* OR "survival rate" OR "death rate" OR "fatality rate" OR "fatal outcome" OR "burden of disease" OR "disease burden" OR "years lived with disability" OR YLD* OR "Disability Adjusted Life Years" OR DALY* OR "years of life lost" OR YLL OR "health outcome*" OR population OR illness OR communities OR zoonotic OR "mental health")
  e. A and B and C and D

To be included, articles had to have a publication date within 10 years of the search and be available in English.

Once researchers identified an initial collection of articles, reviewers used Covidence to screen them for relevance, based on whether they included discussion or recommendations of (a) specific indicators or measures of state preparedness, or (b) adaptive actions. Researchers included the article if it met at least one of these criteria. Reviewers then coded the articles to address the following topics:

- Which of the following health impacts of climate change are directly addressed by the piece's indicators or adaptive actions? (Select all that apply.)
    - Extreme weather or weather-related events (extreme heat, drought, wildfires, extreme precipitation, flooding, hurricanes, sea-level rise, cold waves, and winter storms).
    - Outdoor air quality
    - Vector-borne infection
    - Water-related infection
    - Food-related infection
    - Mental health and well-being
    - Other (describe)
- Briefly list or describe the indicators and/or adaptive actions included in the piece.
- Briefly describe the underlying evidence and/or arguments for the indicators and/or adaptive actions included in the piece.
- For what time horizon (e.g., 2030, 2050, 2070) are the indicators and/or adaptive actions intended?
- How, if at all, do the indicators and/or adaptive actions address health equity (i.e., removal of economic and social obstacles to health)?
- Are the indicators or adaptive actions described as relevant or appropriate for:
    - A single state
    - A group of states or geographic region
    - All states
    - All states and territories
    - A mix (describe)
- If the piece includes indicators, what are their data sources and methods for collection of supporting data?
- If the piece includes adaptive actions, what is involved with implementation?
- Is there discussion of effective partnership, including through funding relationships, between states and federal, local, or peer state partners? Describe.
- Does the piece mention model states or localities? Describe.
- Are any studies or other materials referenced that should be included in the review?

Many of the included articles focused on the vulnerability of discrete places. Besides bolstering an understanding of those elements and how others have measured them, the prevalence of such articles reinforced that researchers needed to incorporate vulnerability into the set of indicators for this project.

3. **Grey literature review.** Researchers reviewed research completed by a number of leading organizations, including the USGCRP; the Council of State and Territorial Epidemiologists; *The Lancet*; the CDC; the U.S. National Academies of Sciences, Engineering, and Medicine; the World Health Organization; Climate Central & ICF International; the American Public Health Association; the Public Health Institute; and EcoAdapt. This research provided valuable insights that informed the scope and methodology of this project.

After gathering instructive information from these three sources, researchers conceptualized and shaped a coherent and comprehensive organizing framework built on three interrelated domains that would drive indicator selection:

- **Domain 1—Vulnerability.** This domain captures environmental factors (e.g., proximity to coastal flooding, frequency of extreme heat events), as well as social and demographic factors (e.g., poverty, race/ethnicity).

- **Domain 2—Public health preparedness.** This domain captures core elements of public health preparedness (e.g., surveillance, incident management, community engagement and coordination) that transcend individual threats. It measures readiness to prevent, prepare for, respond to, and recover from incidents that pose public health risks.

- **Domain 3—Climate-related adaptation.** This domain captures state preparations for understanding likely climate-related health impacts, assessing vulnerabilities and capacities, and planning for adaptive interventions.

Informed by this framework, researchers worked with a panel of advisors to identify and vet prospective indicators, data sources, and data-collection and analysis methods. The panel included the following advisors:

- John Balbus, M.D., MPH
  Senior Advisor, Public Health
  National Institute of Environmental Health Sciences (NIEHS)
  Director
  NIEHS-WHO Collaborating Centre for Environmental Health Sciences

- James S. Blumenstock
  Chief Program Officer, Health Security
  Association of State and Territorial Health Officials
- Anthony D. Moulton, Ph.D.

Senior Fellow
University of Minnesota School of Public Health

- Surili Sutaria Patel, M.S.
  Director, Center for Climate, Health and Equity
  American Public Health Association

- Linda Rudolph, M.D., MPH
  Senior Advisor
  Center for Climate Change and Health
  Public Health Institute

- Shubhayu Saha, Ph.D.
  Health Scientist
  Climate and Health Program
  National Center for Environmental Health
  Centers for Disease Control and Prevention

DATA COLLECTION AND CLEANING

Researchers collected raw data for every indicator. In some cases, data had to be normalized to make them comparable across states. After data were gathered, researchers who were uninvolved with the initial collection verified the accuracy of every data point. This was one of several quality-assurance steps taken.

Domain 1: Vulnerability

Domain 1 comprises two parts:

1. **environmental factors:** aspects of place that make consequential physical environmental change more likely or severe; and

2. **social and demographic factors:** population characteristics that—owing to a variety of circumstances, including the legacy and continuation of structural and systemic racism—influence vulnerability.

Environmental factors

Measuring environmental factors requires a set of indicators that represent different types of geography and extreme weather events. Existing measures include indicators of harm, as well as indicators of vulnerability to harm (e.g., numbers of events vs. proximity to a hazard or potential exposure).

The measures of environmental vulnerability used in this analysis include (see Table A.1):

- **Extreme heat (D1.1): Number of days per year with a maximum temperature above the 95th percentile for the area**

  Researchers calculated county-level data from the CDC's National Environmental Public Health Tracking Network for 2014 to 2016, the most recent years available. For each year, researchers averaged the number of days of extreme heat in counties to calculate an annual statewide mean. Then, they averaged each state's three annual means to calculate a three-year statewide mean. They included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

- **Flooding (D1.2): Percent of state population living within a Special Flood Hazard Area (SFHA)**

  Researchers collected data from the CDC's National Environmental Public Health Tracking Network, which provides estimates of the number of people residing within the SFHA, based on FEMA's 2011 National Flood Hazard Layer, a conservative measure. SFHAs have a 1 percent annual chance of coastal or riverine flooding. Researchers normalized data by dividing the number of people living within an SFHA by that state's 2010 population, according to the U.S. Census Bureau, producing an approximate percentage of people in each state living in an SFHA.

- **Drought (D1.3): Number of days with a drought event**

  Researchers collected data for this indicator from NOAA's Storm Events Database. This measures the number of days with drought conditions over a three-year period (November 1, 2016, to October 31, 2019). Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

  The Storm Events Database registers a drought event based on the drought classification system, which is the foundation of the Drought Monitor, a multiagency effort. Droughts begin when an area reaches Severe (D2) or Extreme (D3) classification, or when drought begins to cause significant impact to people, animals, or vegetation. Droughts end when an area is no longer in at least Severe (D2) or Extreme (D3) classification, or when drought no longer causes significant impacts.

- **Wildfire (D1.4): Percentage of zones in a state affected by "significant wildfire"**

  Researchers collected data for this indicator from NOAA's Storm Events Database. The indicator measures the number of zones in a state with any significant forest fire, grassland fire, rangeland fire, or wildland-urban interface fire that consumed natural fuels and spread in response to its environment over a three-year period (November 1, 2016, to October 31, 2019). NOAA defines "significant" as a wildfire that directly causes one or more fatalities, one or more significant injuries, and/or property damage. In general, it does not include forest fires smaller than 100 acres, grassland or rangeland fires smaller than 300 acres, and wildland use fires not actively managed as wildfires. Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

  Researchers divided the number of zones affected by the number of zones in a state to derive a percentage for each state.

- **Severe storms (D1.5): Number of days with a severe storm causing injury and/or death**

  Researchers collected data for this indicator from NOAA's Storm Events Database. This indicator represents the number of days with severe storms causing injury and/or death over a three-year period (November 1, 2016, to October 31, 2019). Types of severe storms included in the indicator were those with thunderstorm winds, tornados, tropical depressions, tropical storms, and hurricanes. Researchers included data for multiple years to help reduce the effect of any one single event, which could be anomalous.

- **Vector-borne infectious disease (D1.6): Presence of vectors for Lyme disease, Powassan virus, chikungunya virus, and West Nile virus**

  This indicator considers the presence or absence of exemplar disease vectors of concern in order to assess future risk. Using NASA's mosquito distribution map and the CDC's estimates of the range of *Aedes aegypti* and various tick species, the indicator assesses the likely presence of exemplar mosquitoes (*Culex pipiens* and *Aedes aegypti*) and blacklegged ticks (*Ixodes scapularis* or *Ixodes pacificus*).[332,333,334]

  Researchers quantified presence by assessing 1 point for each vector if any part of a state appeared to be within the boundaries of that vector's range, and 0 points for each vector if no part of the state appeared to be within its range. Then researchers added the points, producing a scale of 0 to 3, with 3 points reflecting the presence of every vector and 0 points reflecting the presence of no disease vectors.

Table A.1
Measures of Environmental Vulnerability

INDICATOR	MEASURE	SOURCE
D1.1 Extreme heat	Number of days per year with a maximum temperature above the 95th percentile for the area, 2014–2016	CDC National Environmental Public Health Tracking Network
D1.2 Flooding	Percent of the population residing within FEMA-designated Special Flood Hazard Areas	CDC National Environmental Public Health Tracking Network
D1.3 Drought	Number of days with a drought event (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.4 Wildfire	Percent of zones with significant wildfire (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.5 Severe storms	Number of days with a severe storm causing injury or death (November 1, 2016–October 31, 2019)	NOAA Storm Events Database
D1.6 Disease vectors	Likely presence of each of three exemplar vectors, varied timeframes	NASA; CDC National Center for Emerging and Zoonotic Infectious Diseases, Division of Vector-Borne Diseases

Social and demographic factors

Following a review of existing resilience and vulnerability indexes, the CDC's Social Vulnerability Index heavily informed the social and demographic measures in this analysis. They span four key areas: (1) socioeconomic status, (2) household composition and disability, (3) housing and transportation, and (4) minority status and language. Researchers collected all data from the U.S. Census Bureau's 2018 American Community Survey. (See Table A.2.)

Table A.2
Measures of Social and Demographic Vulnerability

INDICATOR	MEASURE	SOURCE
D1.7 Poverty	Percentage of people living in poverty, 2018	U.S. Census Bureau 2018 American Community Survey
D1.8 Income inequality	Gini coefficient, 2018	
D1.9 Age composition	Percentage of population under age 5 or over age 64, 2018	
D1.10 Race/ethnicity composition	Percentage of population that was nonwhite, 2018	
D1.11 Disability	Percentage of population with a disability, 2018	
D1.12 Housing	Percentage of population living in mobile homes, 2018	
D1.13 Transportation	Percentage of population without a motor vehicle, 2018	
D1.14 Language proficiency	Percentage of households with member(s) who speak limited English, 2018	
D1.15 Education level	Percentage of population age 25 or older without a bachelor's degree, 2018	

Notes: The **Gini coefficient** summarizes dispersion of income, ranging from 0 (perfect equality) to 1 (perfect inequality). All social and demographic indicators relied on one-year estimates of the U.S. Census Bureau's 2018 American Community Survey (ACS). The ACS, like any other sample survey, is subject to error. Each indicator was based on the ACS's subject definitions.

Quality assurance

Once data supporting each indicator were collected by one researcher, a second researcher double-checked each data point to confirm its accuracy.

Limitations

This assessment measures statewide vulnerability. Thus, it draws on measures that are available and meaningful at the state level. These measures do not capture all facets of vulnerability. Researchers excluded many individual risk factors, such as those related to occupation or lifestyle. The assessment does not take into account the built environment and other neighborhood-level characteristics, nor does it consider differences in culture or governance that could mitigate or exacerbate vulnerabilities.[335] Indicators tracked within Domain 2 explore some of these attributes through the lens of public health preparedness, but the landscape of relevant policies, programs, and social institutions extends further.

The measures captured here provide valuable information about states, but a fuller understanding requires also tracking them at a smaller geographic scale, such as by county or census tract. Just as there is variation across states, there is also significant variation within states that is obscured by the absence of more granular data.

Data on extreme heat (D1.1) were not available for Alaska or Hawaii; their scores do not capture that element of exposure. This is unfortunate, given that the western half of the country, including Alaska, has experienced the country's largest increases in annual temperature since 1901, and Alaska in particular has experienced sharp increases in recent decades.

Data on flooding (D1.2) were calculated using FEMA-designated Special Flood Hazard Areas, a source widely considered to use conservative and, in some cases, outdated estimates. For example, a June 2020 report identified nearly 70 percent more homes at substantial risk of flooding than are within SFHAs.[336,337]

Domain 2: Public health preparedness

The National Health Security Preparedness Index (NHSPI), a joint initiative of the Robert Wood Johnson Foundation, the University of Kentucky, and the University of Colorado, organizes its indicators across six domains: (1) health security surveillance, (2) community planning and engagement coordination, (3) incident and information management, (4) healthcare delivery, (5) countermeasure management, and (6) environmental occupational health. The NHSPI breaks out each domain into subdomains, ultimately encompassing 129 measures in its 2019 edition, the one used for this project.

To home in on segments of the index most pertinent to preparations for the health effects of climate change, while also retaining an expansive view, researchers for this project worked closely with those who manage NHSPI to select a targeted set of 11 subdomains (out of 19). Each subdomain contains multiple measures. (See Table A.3.) "Appendix B: Domain 2 Underlying Indicators" provides a list of measures tracked within each NHSPI subdomain.

Table A.3
Climate-Related NHSPI Subdomains Measuring Public Health Preparedness

DOMAIN	SELECTED SUBDOMAIN(S)	DESCRIPTION
Health security surveillance	D2.1 Health surveillance and epidemiological investigation	The development and maintenance of systems and processes that enable detection, identification, and tracking of health threats, including disease outbreaks and adverse events.
Community planning and engagement coordination	D2.2 Cross-sector / community collaboration	The coordination necessary to engage community-based organizations and social networks through collaboration among state agencies and their partners in order to return to routine delivery of services effectively and efficiently.
	D2.3 Social capital and cohesion	The degree of connection and sense of belonging among residents, including social networks among individuals, neighbors, organizations, and governments.
Incident and information management	D2.4 Incident management	The ability to establish and maintain a unified and coordinated operational structure that appropriately integrates all stakeholders and supports the execution of core capabilities and incident objectives through information sharing, strategy development, and resource management.
	D2.5 Information management	The ability to develop systems and procedures that communicate timely, accurate, accessible, and appropriate information and alerts to the public using a whole-community approach.

Healthcare delivery	D2.6 Prehospital care	Care provided by emergency medical services (EMS), including 911 and dispatch, emergency medical response, field assessment and care, and transport to a hospital or between healthcare facilities.
	D2.7 Hospital and physician services	Care for patients who are formally admitted to a hospital or other institution for inpatient treatment.
	D2.8 Long-term care	A continuum of medical and social services, including skilled nursing and rehabilitation, designed to support the needs of people living in residential-care settings with chronic health problems that affect their ability to perform everyday activities.
	D2.9 Behavioral healthcare	The provision and facilitation of access to behavioral health services, including medical treatment, substance-abuse treatment, stress management, medication, and social-services networks.
	D2.10 Home care	Clinical and nonclinical care that allows a person with special needs to stay in their home, including skilled nursing visits, respiratory-care services, provision of durable medical equipment, hospice, and pharmacist services.
Environmental and occupational health	D2.11 Environmental monitoring	The systematic collection and measurement of environmental specimens (air, water, land/soil, and plants) to analyze the presence of an indicator, exposure, or response (warning and control). This includes monitoring the environment for disease vectors.

Note: Researchers adapted domain descriptions with light edits from NHSPI. See "Appendix B: Domain 2 Underlying Indicators" for a list of indicators tracked within each subdomain.

Source: National Health Security Preparedness Index[338]

NHSPI researchers use a normalization method to convert each measure to a standardized scale (0–1) before combining measures into subdomain, domain, and overall composite measures of preparedness. This improves the validity and reliability of composite measures. NHSPI then aggregates individual measures for each state using a weighted arithmetic mean. The index bases the weighting on a multistage Delphi process in which experts judged the relative importance of each measure, subdomain, and domain. Finally, NHSPI multiplies each measure by 10 to place it on a 10-point scale, with 10 being the highest possible level of preparedness.

Researchers for this project incorporated NHSPI's data by collecting aggregated subdomain scores for each of the 11 subdomains selected and for every state and the District of Columbia.

Quality assurance

Once one researcher collected NHSPI's aggregated subdomain scores, a second researcher double-checked each data point to confirm its accuracy.

Limitations

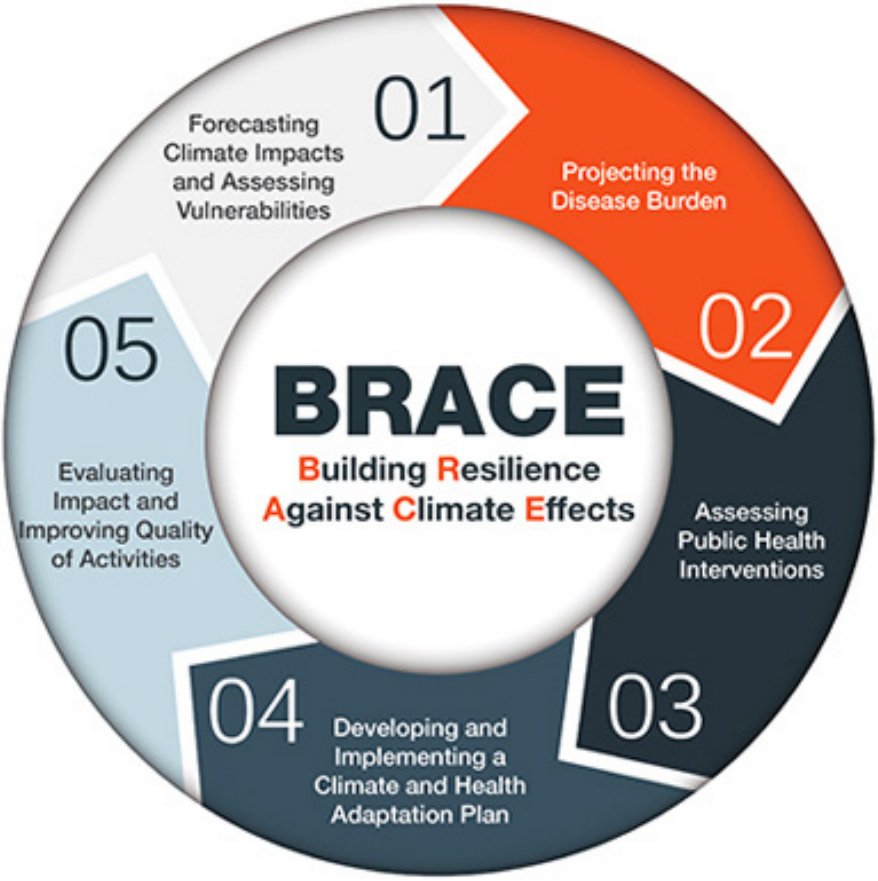
NHSPI is transparent that each indicator comprising the index has its own limitations.[339] The index overall is considered highly credible, drawing on input from experts as well as a broad range of stakeholders. NHSPI rigorously vets indicators, and each iteration of the index refines these measures further. Of greater uncertainty is whether the subset of measures chosen for this assessment provides an accurate picture of state preparedness for climate-related health threats. Researchers drew on expert resources and worked closely with NHSPI staff to identify the subdomains that best reflect the core public health capabilities required to address climate change impacts. However, researchers have not validated this collection of measures against data on state performance in responding to actual climate-related health emergencies.

Unlike NHSPI, which released its sixth annual index in 2019, this assessment does not provide information about trends over time. The 2019 index suggested that, overall, the country's performance is improving, but there are important differences between states and regions. While almost two-thirds of states saw an improvement in health security in 2018, four states saw a decline, and 14 held steady.[340] Given the expectation of worsening threats owed to climate change and other trends, improvements in health security are needed just to keep pace. Thus, it is important to understand how the relevant core public health capabilities are changing over time.

Domain 3: Climate-related adaptation

Following the initial literature review and planning process, researchers developed a set of indicators and sub-indicators based on the CDC's BRACE framework. The framework is an iterative five-step cycle for health officials to identify the likely effects of climate change on local communities and their health and to incorporate this information into preparedness and adaptation planning.[341] (See Figure A.1.) Through its Climate-Ready States and Cities Initiative, the CDC had supported implementation of the BRACE framework in 16 states and two cities, as of October 2020. The agency has also developed publicly available resources to guide other jurisdictions in conducting this work.

Figure A.1
The CDC's Building Resilience Against Climate Effects (BRACE) Framework



Source: Centers for Disease Control and Prevention[342]

Drawing primarily on the first and third steps of the framework, researchers developed two main indicators to measure each state's progress in assessing its vulnerabilities and identifying evidence-based adaptive interventions. The assessment was based on a systematic review of relevant state documents. Researchers developed a coding rubric, breaking down each indicator into a set of criteria represented by yes/no questions. (See Table A.4.)

Table A.4
Domain 3 Indicator Coding Rubric

INDICATOR	SUB-INDICATORS	CODE 0	CODE 1
D3.1: Has the state assessed its vulnerability to the public health impacts of climate change?	D3.1.1: Have climate-related exposures (e.g., elevated temperatures, contaminated water, worsened air quality) to the state been identified?	No identification of climate-related exposures.	Identified climate-related exposures.
	D3.1.2: Have climate-sensitive health outcomes (e.g., heat-related death and illness, gastrointestinal illness, premature death) been identified?	No identification of climate-sensitive health outcomes.	Identified climate-sensitive health outcomes.
	D3.1.3: Have risk factors for health outcomes been identified?	No identification of risk factors.	Identified risk factors for specific climate-related health outcomes.
	D3.1.4: Have causal pathways been developed for relevant climate-related hazards?	No causal pathway(s) developed.	Developed causal pathway(s) linking climate-sensitive exposures to health outcomes. Pathways generally had to involve at least three parts: (1) changes in climate --> (2) manifestations of weather/ exposure --> (3) health impact.
	D3.1.5: Have climate projections at the state or state and local scale been reported?	No climate projections reported.	Reported climate projections framed in the context of the state.
	D3.1.6: Have the most vulnerable populations in the state been identified (D3.1.6.1)? If so, have they been located (D3.1.6.2)?		
	D3.1.6.1: Have the most vulnerable populations in the state been identified?	No identification of the most vulnerable populations.	Identified the most vulnerable populations based on social or demographic factors. OR Identified the most vulnerable populations based on environmental factors. *Either relevant excerpt(s) in state documents or the entire document must have had a health and/or climate change orientation.*
	D3.1.6.2: Have the most vulnerable populations in the state been located? *Location must have been precisely defined (e.g., census tract, county, climate zones, neighborhoods). Maps were not required.*	No identification of the most vulnerable populations. AND/OR No location of the most vulnerable populations.	Locates vulnerable populations based on social or demographic factors. OR Locates vulnerable populations based on environmental factors. *Either relevant excerpt(s) in state documents or the entire document must have had a health and/or climate change orientation.* OR Discusses urban heat islands and/ or other aspects differentiating urban and rural locations in the state. *Urban/rural locations did not need to be precisely defined.*

INDICATOR	SUB-INDICATORS	CODE 0	CODE 1
D3.2: Has the state identified evidence-based interventions to protect residents from the public health impacts of climate change?	D3.2.1: Has the state identified interventions?	No interventions identified.	Identified interventions.
	D3.2.2: If interventions have been identified, are they evidence-based? *To qualify as "evidence-based," an intervention must have been supported by citing: (1) evidence that the intervention has been implemented and effective within the state's borders, (2) evidence that the intervention has been implemented and effective in another state, or (3) credible third-party evidence that the intervention would be effective for the identified risk.* *The intervention was also considered to be evidence-based if it was classified in a relevant CDC BRACE guidance document as: (1) scientifically supported, (2) having some evidence, or (3) supported by expert opinion.*[343]	No interventions identified. AND/OR Interventions not evidenced-based.	Qualifying evidence was cited and/or the interventions were identified as evidence-based by the CDC guidance document.

A group of data collectors were trained on the Domain 3 assessment approach and provided with a written protocol to guide data collection. Each data collector was assigned a set of states at random and asked to identify and review relevant documents, and then code state data using the rubric.

Document identification

To answer the questions posed by the indicators and sub-indicators, researchers reviewed and collected relevant qualitative data from state documents related to climate change and health. Because the goal was measuring state preparedness, documents had to have a state-level focus and be produced by the state government or on its behalf (e.g., assessments from an academic institution that were commissioned by a state agency). But no other restrictions were placed on the type of document; any document that addressed climate change or its impact on human health was considered relevant, as was content on relevant web pages. Some states had produced formal climate adaptation plans or climate action plans, but documents did not have to meet this standard for inclusion.

Data collectors began by reviewing each state's most recent hazard-mitigation plan. FEMA requires states to develop and submit these plans in order to receive certain funding, and the plans must address "changing environmental or climate conditions" in their risk assessment.[344] Thus, each state has a hazard-mitigation plan that can serve as a baseline source for climate change planning. To locate the document, data collectors conducted a basic Google search using the state's name and the keywords

"state hazard mitigation plan." To ensure that they located the current plan, data collectors checked the most recent year of publication, according to a September 2019 report by the Columbia Law School Sabin Center for Climate Change Law.[345] In some cases, data collectors identified a hazard-mitigation plan published more recently than the year listed by Columbia. They used the most recent document for review. In addition to identifying and reviewing documents, data collectors archived the relevant files in a standardized format.

To identify additional documents, data collectors first looked to four existing repositories of state-level adaptation resources:

1) Georgetown Climate Center's Adaptation Clearinghouse[346]
2) Center for Climate and Energy Solutions' (C2ES) U.S. State Climate Action Plans database[347]
3) EcoAdapt's 2019 report *The State of Climate Adaptation in Public Health: An Assessment of 16 U.S. States*[348]
4) CDC's Climate-Ready States & Cities Initiative grantee website[349]

Data collectors checked each resource and reviewed the materials listed for each state to determine which, if any, were relevant to the scope of this assessment. They determined relevance through a quick keyword search for certain terms: "climate change," "climate," and "health." Once reviewed, they archived both relevant and non-relevant documents, using a naming convention that tracked the document's source.

Data collectors identified additional documents through an advanced Google search using the term: "[state name] climate change adaptation." Data collectors first identified the appropriate state government web domain or sub-domain. They used this domain to restrict the search results through Google's Advanced Search function. They determined document relevance using the keyword method described above. Once they identified relevant documents, data collectors archived the document file in a standardized format.

Document evaluation and coding

Data collectors used the table of contents and keyword searches ("climate change," "climate," and "health") to identify relevant sections in source documents. They highlighted these sections of text in archived PDF files to facilitate later review. Data collectors looked for information relevant to each sub-indicator. If they found such information, they excerpted relevant sections of text and pasted them into an Excel spreadsheet table, along with the source and page numbers. Data collectors did not intend the excerpts to be comprehensive. Depending on the extent of the information presented in a document, the collected excerpts might represent only a small sample of the relevant text. For each sub-indicator, data collectors provided a brief, one-sentence summary describing the relevant information in that source; they intended this summary to provide a rationale for the coding. On average, researchers collected data from four documents per state; they may have reviewed additional documents.

Researchers ultimately coded each sub-indicator dichotomously as 0 or 1, after first exploring a 0–1–2 coding system, with 2 representing deeper-level information. Researchers coded most sub-indicators independently, but there were two exceptions in which one sub-indicator was contingent on another: vulnerable populations cannot be located (D3.1.6.2) without first being identified (D3.1.6.1), and an intervention must be identified (D3.2.1) to be considered evidence-based (D3.2.2).

To limit subjectivity and maintain consistency across data collectors, researchers premised scoring on the presence of relevant information, rather than an evaluation of the quality or depth of content. Beyond determining whether data reasonably addressed the question, researchers did not consider the veracity, completeness, or depth of the data.

Data verification and reconciliation

Once data had been collected for every state, researchers transferred each state's data to a separate Excel file and provided it, along with instructions and background information on the project, to the state government for review and verification. Typically, this information went to the highest-ranking public health and emergency management officials. The verification file contained three worksheets: one sheet with instructions and a copy of the data that had been collected, and two sheets with blank tables for the state to provide additional documents or excerpts that were relevant. In response, 29 states confirmed the veracity and completeness of the data or provided additional materials for possible inclusion.

As states responded, a single data collector reviewed the information and filled in gaps as new information allowed. Because of the dichotomous coding system, based on presence rather than depth or breadth, researchers did not review all submitted documents. During this reconciliation process, researchers reviewed data compiled for each state again to ensure accurate and consistent coding. They revised coding, as necessary, based on newly submitted information or to correct for previous inconsistencies.

Quality assurance

Once researchers completed coding, they developed a quality-assurance protocol implemented by two researchers—one who had been involved in the data-collection and review process, and one who had not. Independently, the two researchers went through each state's Excel verification file to ensure that codes had been assigned appropriately—that is, a code of 1 was assigned when data were provided in the relevant cell(s) and a code of 0 was assigned when no data were provided. For each sub-indicator that received a code of 0, researchers reviewed the original verification file to ensure that no relevant information had been lost during the state response process or subsequent reconciliation. Researchers also confirmed that the appropriate source document was excerpted and cited (i.e., the cell did not merely contain a reference to work done elsewhere), and that all source documents were listed on the verification file. Finally, researchers checked the response provided by the state (if any) to ensure that all relevant resources and data had been collected and were reflected in the final coding.

Limitations

While the CDC's BRACE framework inspired the Domain 3 indicators, researchers did not measure states against the standard of an extensive application of it. Scoring states based on the presence or absence of relevant data obscures in some cases meaningful differences between states that had taken tentative early steps and those that had made more substantive progress toward adapting to new climate conditions. For example, one state might have included a passing reference to climate change in its hazard-mitigation plan, noting that the state expects to experience an increase in temperature and a change in precipitation patterns over the next few decades, and that heat-related illnesses could increase, along with a loss of life related to flooding or severe storms. In contrast, another state might have included a detailed analysis of climate trends and potential impacts related to each hazard in its mitigation plan and produced documents on the likely health impacts of multiple climate-related exposures. Although the latter state demonstrated a deeper level of planning for specific local climate changes, the two states might receive the same score in this analysis. A perfect score does not necessarily indicate that a state has fully prepared for the health impacts of climate change, but rather that it has laid a foundation for doing so by identifying at least some of its vulnerabilities and potential interventions.

Importantly, this assessment does not address implementation. The data gathered come from state-level discussions and plans; the study does not consider whether these plans have been funded or carried out. States can appear on par with one another when assessed based on planning documents but differ significantly in actual performance. This limitation is particularly salient for Indicator 2, which addresses the identification of evidence-based interventions. Furthermore, because adaptation seeks to address and minimize specific risks, important interventions often take place at the local level. A number of states highlighted county- or city-level initiatives in their documents—not factored into scores for this analysis—but state-level assessments do not always capture the full extent of work done by localities.

During the initial review process, data collectors searched using the terms, "climate," "climate change," and "health." These terms did not always return relevant sections of documents. States may be preparing for likely impacts of climate change without defining preparedness and adaptation efforts as such. This may reflect political considerations or the division of roles and responsibilities among state agencies. Furthermore, the absence of publicly available documents does not necessarily indicate that a state is not analyzing or preparing for the public health impacts of climate change. In some cases, researchers identified or were provided with presentations and other resources that hint at a larger body of relevant work. The low profile may represent the early stages of a state's response, an intentional decision to conduct this work under the auspices of existing health and emergency management programs, or a decision to not post their work publicly.

Finally, the data-verification process, during which researchers provided state leaders with collected data and invited them to review them for completeness and accuracy, was intended to give states an opportunity to correct oversights or misunderstandings, and 29 states responded. However, given the timing—as the COVID-19 pandemic began to sweep across the country in early 2020—some health departments may not have been able to devote as much attention to their responses as they would have under usual circumstances. Others did not respond at all, leaving open the possibility that relevant data were inadvertently left out of this analysis.

SCALING AND SCORING INDICATORS ACROSS DOMAINS

Once the normalized data set for all indicators was complete, researchers scored states at the sub-sub-indicator, sub-indicator, indicator, subdomain, domain, and grouped domain (Vulnerability: Domain 1; Preparedness: Domains 2 & 3) levels.

To score indicators, researchers first transformed disparate state data. They did this for every indicator except for those within Domain 2, as the data collected from NHSPI had already been transformed using a similar process. Transformation was applied using a multistep process:

1. Researchers first applied the Box-Cox transformation, a parameterized power transformation, to normalize the distribution of states' data.
2. To make indicator scores comparable across states, researchers then applied z-score transformation, an expression of the number of standard deviations by which a data value is above or below the mean for a given indicator. State scores, for every indicator, were then centered at a z-score of 0 (i.e., the state mean) and at the same level of variability, making data for different indicators comparable and allowing researchers to average scores for multiple indicators to calculate aggregate values.
3. To reduce the influence of outliers, z-score values were truncated for each indicator at 3.5 standard deviations above or below the state means. That is, state data that diverged by more than 3.5 standard deviations were converted to a z-score of 3.5.
4. Finally, researchers applied a min-max scale to place state scores for every indicator within a range of 0–10.

After completing the transformation process, researchers were able to aggregate state scores for discrete indicators into summary measures across subdomains, domains, and grouped domains. They combined measures into simple unweighted averages, ignoring missing values. Aggregate calculations included:

- **Domain 1. Vulnerability**—unweighted average of scores for two subdomains: environmental factors and social and demographic factors.
    - **Subdomain: environmental factors**—unweighted average of scores for indicators D1.1 through D1.6.
    - **Subdomain: social and demographic factors**—unweighted average of scores for indicators from D1.7 to D1.15.
- **Domain 2. Public health preparedness**—unweighted average of scores for indicators D2.1 through D2.11.
- **Domain 3: Climate-related adaptation**—unweighted average of scores for indicators D3.1 and D3.2.
    - **Indicator D3.1: vulnerability assessment**—unweighted average of sub-indicators D3.1.1 through D3.1.6. The score for sub-indicator D3.1.6 reflects an unweighted average of sub-sub-indicators D3.1.6.1 and D3.1.6.2.
    - **Indicator D3.2: intervention identification**—unweighted average of sub-indicators D3.2.1 and D3.2.2.
- **Grouped domain: Vulnerability**—score for Domain 1.
- **Grouped domain: Preparedness**—unweighted average of scores for Domain 2 and Domain 3.

APPENDIX B: DOMAIN 2 UNDERLYING INDICATORS

Table B.1
Indicators Supporting Selected NHSPI Subdomains

NHSPI Subdomain	Indicator	Year Tracked	Source
Health surveillance and epidemiological investigation	State health department participates in the Behavioral Risk Factor Surveillance System (BRFSS)	2015	CDC, BRFSS, survey data analyzed by authors
	Number of epidemiologists per 100,000 population in the state, by quintile	2017	Bureau of Labor Statistics (BLS), Occupational Employment Statistics (OES), and ASTHO Profile of State and Territorial Public Health—2012 and 2016 Epidemiologists by Jurisdiction
	State health department participates in the Epidemic Information Exchange (Epi-X) System	2013	CDC Epi-X Program
	State health department participates in the National Electronic Disease Surveillance System (NEDSS)	2015	CDC Division of Health Informatics and Surveillance (DHIS), NEDSS
	State health department has an electronic syndromic surveillance system that can report and exchange information	2016	ASTHO Profile of State Public Health: Volume Three
	State public health laboratory has implemented the laboratory information management system to exchange laboratory information and results electronically with hospitals, clinical labs, state epidemiology units, and federal agencies	2016	Association of Public Health Laboratories (APHL), Comprehensive Laboratory Services Survey (CLSS)
	State has legal requirement for nongovernmental laboratories (e.g., clinical, hospital-based) in the state to send clinical isolates or specimens associated with reportable foodborne diseases to the state public health laboratory	2016	APHL, CLSS
	State public health laboratory participates in either of the following federal surveillance programs: Foodborne Diseases Active Surveillance Network or National Molecular Subtyping Network for Foodborne Disease Surveillance	2014	APHL, CLSS
	Percent of foodborne illness outbreaks reported to the CDC by state and local public health departments for which a causative infectious agent is confirmed	2017	CDC National Outbreak Reporting System (NORS)
	State health department participates in a broad prevention collaborative addressing healthcare-associated infections	2013	CDC National Healthcare Safety Network (NHSN), Prevention Status Reports
	State has a public health veterinarian	2019	National Association of State Public Health Veterinarians, Designated and Acting State Public Health Veterinarians
	State uses an Electronic Death Registration System	2018	National Association for Public Health Statistics and Information Systems, Electronic Death Registration Systems by Jurisdiction (State)
	State public health laboratory participates in the CDC influenza surveillance program, and/or the World Health Organization Influenza Surveillance Network	2014	APHL, CLSS

NHSPI Subdomain	Indicator	Year Tracked	Source
Cross-sector/ community collaboration	State health department is accredited by the Public Health Accreditation Board (PHAB)	2018	PHAB, Health Departments in e-PHAB
	Percent of the state's population served by a comprehensive public health system, as determined through the National Longitudinal Survey of Public Health Systems	2016	National Longitudinal Survey of Public Health Systems, National Association of County and City Health Officials (NACCHO), and Area Resource File data analyzed by project management office (PMO) and affiliated personnel
	Percent of hospitals in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of the Office of the Assistant Secretary for Preparedness and Response (ASPR)	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of emergency medical service agencies in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of emergency management agencies in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
	Percent of local health departments in the state that participate in healthcare-preparedness coalitions supported through the federal Hospital Preparedness Program of ASPR	2017	Division of National Healthcare Preparedness Programs in ASPR at the U.S. Department of Health and Human Services
Social capital and cohesion	Percent of voting-eligible population in the state participating in the highest office election	2016	United States Election Project, General Election Turnout Rates
	Percent of adults in the state who volunteer in their communities	2017	Current Population Survey (CPS), Volunteer Supplement data analyzed by PMO personnel
	Number of annual volunteer hours per state resident, 15 years or older	2017	CPS, Volunteer Supplement data analyzed by PMO personnel

Incident management	State public health laboratory uses a rapid method (e.g., Health Alert Network, blast e-mail, or fax) to send messages to their sentinel clinical laboratories and other partners	2016	APHL, All-Hazards Laboratory Preparedness Survey
	State all-hazards emergency management program is accredited by the Emergency Management Accreditation Program (EMAP)	2018	EMAP
	Percent of local health departments in the state with an emergency preparedness coordinator for states with local health departments, excludes Rhode Island and Hawaii	2016	NACCHO, 2013 National Profile of Local Health Departments
	State public health laboratory has a 24/7/365 contact system in place to use in case of an emergency	2014	APHL, CLSS
	State uses a system for tracking hospital-bed availability during emergencies	2018	ASPR Hospital Preparedness Program
	Average number of minutes for state health department staff with incident management lead roles to report for immediate emergency response duty	2016	CDC Office of Public Health Preparedness and Response, National Snapshot of Public Health Preparedness
	State has adopted the Nurse Licensure Compact (NLC)	2018	National Council of State Boards of Nursing (NCSBN), NLC Member States
	State requires healthcare facilities to report healthcare-associated infections to the CDC's National Health Safety Network (NHSN) or other systems	2013	CDC, NHSN Healthcare-Associated Infections Progress Report
	State law includes a general provision regulating the release of personally identifiable information held by the health department	2013	CDC Public Health Law Program resources (https://www.cdc.gov/phlp/)
	State law requires healthcare facilities to report communicable diseases to a health department	2013	CDC, DHIS, NEDSS
	State has adopted Emergency Management Assistance Compact legislation	2014	National Emergency Management Association

Information management	State has a public-information and communication plan developed for a mass prophylaxis campaign	2018	CDC Public Health Emergency Preparedness and Response Cooperative Agreement Program
	Percent of households in the state with broadband in the home	2017	U.S. Census Bureau American Community Survey (ACS), one-year estimate
	Percent of hospitals in the state that have demonstrated meaningful use of certified electronic health record technology; this includes the demonstration of meaningful use through either the Medicare or Medicaid EHR Incentive Programs. Critical Access hospitals are facilities with no more than 25 beds and located in a rural area farther than 35 miles from the nearest hospital, and/or are located in a mountainous region.	2016	The Office of the National Coordinator for Health Information Technology, a division of the U.S. Department of Health and Human Services
	The state's 911 authorities are capable of processing and interpreting location and caller information using Next Generation 911 infrastructure	2017	National 911 Program, Office of Emergency Medical Services, National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation
	Number of emergency medical technicians and paramedics per 100,000 population in the state	2017	BLS, OES
Prehospital care	Percent of local emergency medical services (EMS) agencies that submit National EMS Information System (NEMSIS) compliant data (e.g., Version 2 in earlier years, Version 3 in later years) to the state	2019	NHTSA, State NEMSIS Progress Reports: State & Territory Version 2 Information
	State has adopted EMS Personnel Licensure Interstate CompAct legislation	2018	National Association of State EMS Officials
	The average length of time in minutes between EMS notification and arrival at a fatal motor vehicle crash (MVC) in urban areas	2017	NHTSA, Fatality Analysis and Reporting System (FARS)
	The average length of time in minutes between EMS notification and arrival at a fatal MVC in rural areas	2017	NHTSA, FARS
	Median time in minutes from hospital emergency department (ED) arrival to ED departure for patients admitted to hospitals in the state (identifier ED-1)	2018	Centers for Medicare and Medicaid Services (CMS), Timely and Effective Care—State

Hospital and physician services	Median time in minutes from hospital admission decision to ED departure for patients admitted to hospitals in the state (identifier ED-2)	2018	CMS, Timely and Effective Care—State
	Percent of the state's population who live within 50 miles of a trauma center, including out-of-state centers	2017	American Hospital Association (AHA) Annual Survey of Hospitals data and U.S. Census
	Number of physicians and surgeons per 100,000 population in the state	2017	U.S. Census ACS
	Number of active registered nurse and licensed practical nurse licenses per 100,000 population in the state	2019	NCSBN, National Nursing Database
	Percent of the state's population living within 100 miles of a burn center, including out-of-state centers	2018	American Burn Association data on Burn Care Facilities analyzed by PMO personnel
	Percent of hospitals in the state providing a specialty geriatric-services program (includes general as well as specialized geriatric services, such as psychiatric geriatric services/ Alzheimer care)	2017	AHA Annual Survey of Hospitals
	Percent of hospitals in the state providing palliative-care programs (includes both palliative-care program and/or palliative-care inpatient unit, but excludes pain-management program, patient-controlled analgesia, and hospice program)	2017	AHA Annual Survey of Hospitals
	Number of hospital airborne infection isolation room (AIIR) beds per 100,000 population in the state, including hospitals with AIIR rooms within 50 miles from neighboring states	2017	AHA Annual Survey of Hospitals
	Risk-adjusted 30-day survival rate (percent) among Medicare beneficiaries hospitalized in the state for heart attack, heart failure, or pneumonia	2016	The Commonwealth Fund, Aiming Higher: Results from a Scorecard on State Health System Performance
	Percent of hospitals in the state with a top-quality ranking (Grade A) on the Hospital Safety Score	2018	The Leapfrog Group, Hospital Safety Score
	Average number of nurse staffing hours per resident per day in nursing homes in the state	2018	CMS Nursing Home State Averages

Long-term care	Average number of nursing assistants (staffing hours per resident per day) in nursing homes in the state	2018	CMS Nursing Home State Averages
	Percent of long-stay nursing-home residents in the state who are assessed and appropriately given the seasonal influenza vaccine	2018	CMS Nursing Home State Averages
	Average number of licensed practical nurse staffing hours per resident per day in nursing homes in the state	2018	CMS Nursing Home State Averages
	Number of licensed skilled nursing facilities with deficiencies in compliance with CMS Emergency Preparedness requirements, per 100 facilities in the state (expressed as quintiles)	2018	CMS Nursing Facility Inspection Reports
	Number of disease outbreaks in nursing homes or assisted-living facilities per 1,000 certified nursing-home residents in a state	2017	CDC, NORS
	Percent of hospitals in the state providing psychiatric emergency services	2017	AHA Annual Survey of Hospitals
Behavioral health care	Percent of need met for mental healthcare in health professional shortage areas (HPSA) in the state	2018	The Henry J. Kaiser Family Foundation, Mental Health Care HPSA
	Percent of the state's population not living in a U.S. Census Bureau and Health Resources and Services Administration (HRSA) Mental Health Professional Shortage Area	2019	U.S. Census Bureau and HRSA data analyzed by PMO personnel
	Percent of home health episodes of care in the state where the home health team determined whether their patient received a flu shot for the current flu season	2018	CMS Home Health Care State-by-State Data
Home care	Percent of home health episodes of care in the state where the home health team began their patients' care in a timely manner	2018	CMS Home Health Care State-by-State Data
	Number of home health and personal care aides per 1,000 population in the state aged 65 or older	2017	ACS, one-year Public Use Microsample data analyzed by PMO personnel (three-year average)
	State public health laboratory provides or assures testing for air samples	2016	APHL, CLSS

Environmental monitoring	State public health laboratory is certified or accredited by the American Industrial Hygiene Association	2016	APHL, CLSS
	State public health laboratory is certified or accredited by the EPA	2016	APHL, CLSS
	State public health laboratory is certified or accredited by the National Environmental Laboratory Accreditation Conference	2016	APHL, CLSS
	State public health laboratory provides or assures testing for environmental samples in the event of suspected chemical terrorism	2014	APHL, CLSS
	Percent of 12 tests for different contaminants in environmental samples that the state public health laboratory provides or assures, including asbestos, explosives, gross alpha and gross beta, inorganic compounds (e.g., nitrates), metals, microbial, lead, persistent organic pollutants, pesticides (including organophosphates), pharmaceuticals, radon, or volatile organic compounds	2016	APHL, CLSS
	State public health laboratory provides or assures testing for hazardous waste	2016	APHL, CLSS
	State participates in the National Plant Diagnostic Network (NPDN)	2014	NPDN, National Plant Diagnostic website
	Number of environmental scientists and specialists (including health) per 100,000 population in the state	2017	BLS, OES, OES 19-2041
	Number of disease outbreaks in a state due to animal contact per 1 million population	2017	CDC, NORS

Source: National Health Security Preparedness Index

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