

**ADAPTATION ROADMAP**

# Human Health

**Measuring the impact of rising temperatures  
on mortality to target adaptation planning**

Emily Grover-Kopec, Tamma Carleton, Michael Greenstone

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**Climate  
Impact Lab**

# Executive Summary

Recent research has uncovered that the greatest projected costs from climate change stem from the increased risk of mortality. However, understanding how a warming climate will impact mortality isn't as simple as looking at what areas of the world will be the hottest. It also depends on the measures that individuals and governments can take to protect themselves. To date, the world has not paid enough attention to the potential benefits of adaptation investments or measures that can protect people from climate change's projected damages, including its likely impacts on mortality.

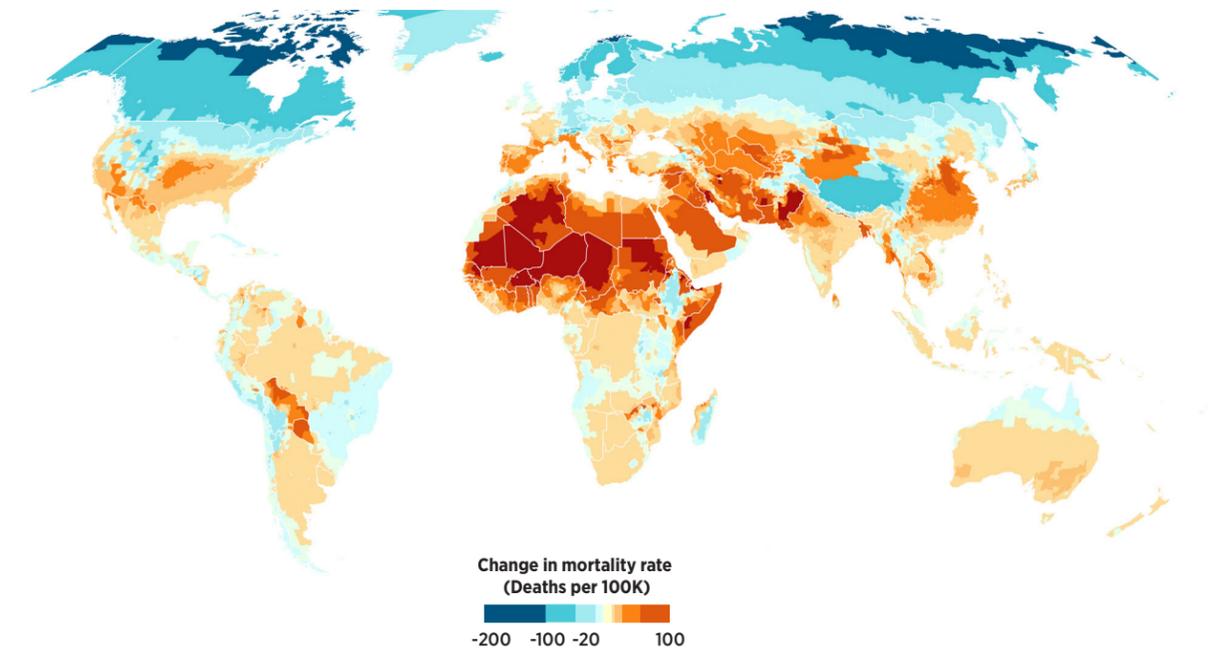
This report identifies the regions around the world where climate adaptation offers the greatest opportunity to save the most lives, based on the Climate Impact Lab's projections of temperature-related mortality in 2050. The necessary adaptation investments will take many forms (e.g., changes in behavior, adoption of cooling technologies, etc.) and will need to be undertaken by people on the ground living these changes, the national and local governments that serve them, and philanthropic organizations that aim to support these people and governments.



## Adaptation Roadmap Series

This report is the first in a new series that takes as its starting point the urgent need to embrace adaptation as a central part of the strategy to confront climate change, alongside greenhouse gas emissions mitigation. Just as one cannot get where they are going without a map, adaptation to climate change cannot succeed without knowing where it is needed most and what investments will deliver the greatest payoffs. This series will provide that adaptation roadmap, identifying the impacts and locations where climate adaptation investments will be most beneficial. Each report in the series will build off landmark Climate Impact Lab research that leverages rich global data to uncover the relationship between increasing temperatures, adaptation, and human well-being, while accounting for the expected benefits of projected income growth over the coming decades.

## Unequal Distribution of Mortality Impacts



Note: Change in region-level net mortality rates (deaths/100,000 people) in 2050 compared to the 2001-2010 average due to climate change.

## Key Take Aways

**How likely a person is to die from a warming climate depends on where they live.**

A warmer climate will lead to more deaths from extreme heat, and fewer deaths from extreme cold. As a result, cooler regions (mid-to-high latitudes) are projected to see a decrease in deaths, such as countries in Scandinavia where the temperature-related mortality rate is expected to decline by more than 70 deaths per 100,000 people. Meanwhile, hotter regions (lower-latitudes) such as Northern Africa, the Middle East, and Southwest Asia are projected to see more deaths. Those across the Sahel, such as Niger and Burkina Faso, are projected to see increases exceeding 60 deaths per 100,000 people—more than the mortality rate from malaria in Africa today (i.e., 52 deaths per 100,000). In Southwest Asia, Pakistan is projected to see a net increase in mortality of 51 deaths per 100,000 people by 2050, comparable to the loss of life due to stroke in that country today.

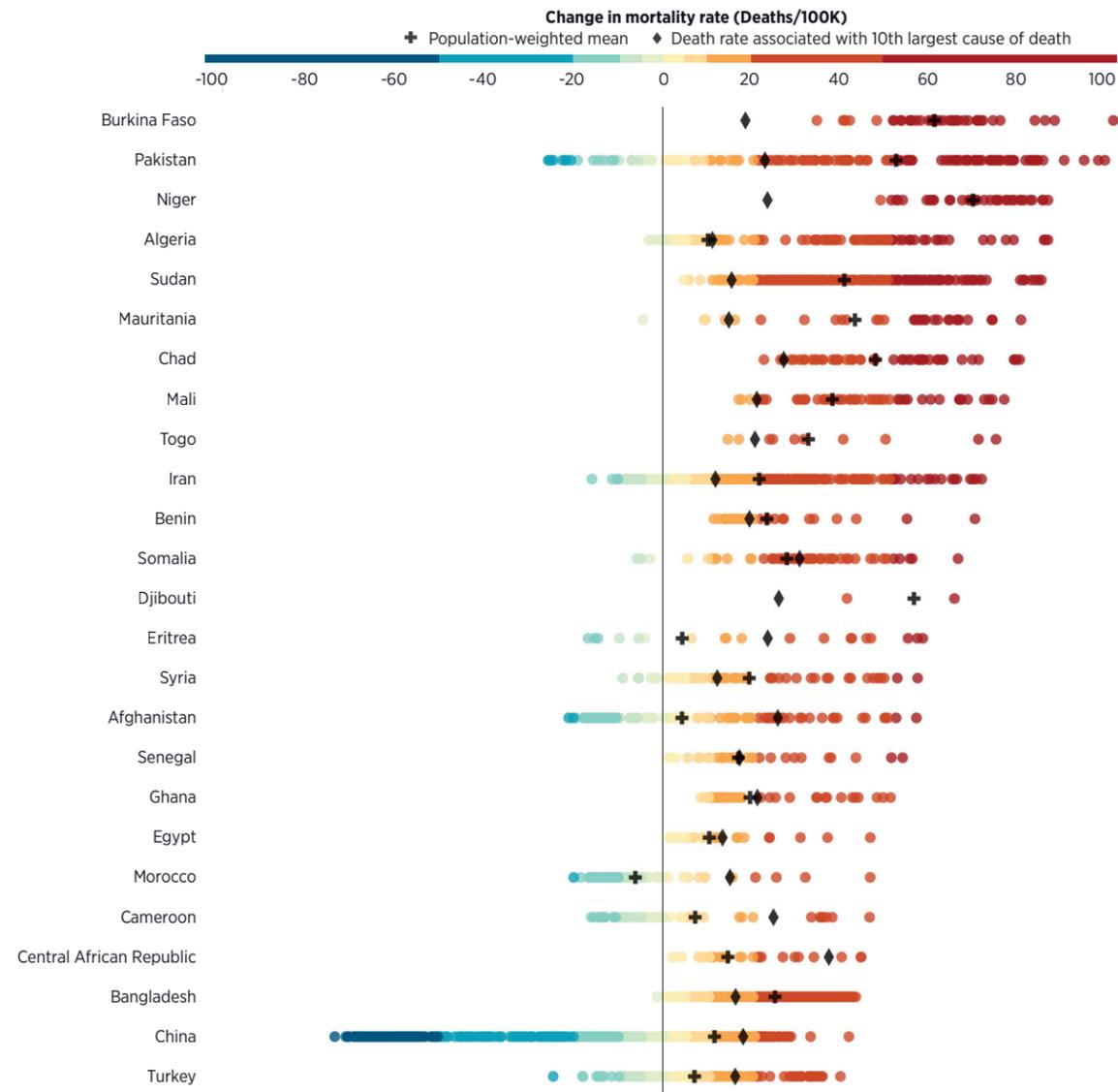
**Today's poorest populations are projected to suffer the most from a warming climate, making adaptation investments in low-income areas critical.**

Investments in adaptation measures will be critical in low-income countries where the wealth necessary to reduce vulnerabilities is often lacking. Ten times more people are projected to die each year in lower-income countries (about 391,000 people) than in higher-income countries (about 39,000 people) due to shifting temperatures, despite being expected to have roughly equal populations. As an example, the country of Djibouti in East Africa is projected to experience an increase in temperature-related deaths that is two times that of the wealthier country of Kuwait in the Middle East, despite their similar climate. In Djibouti, temperature-related mortality is projected to increase by 55 deaths per 100,000, on par with the current death rate of HIV/AIDS, while Kuwait is projected to experience 25 additional deaths per 100,000, less than half the current death rate of heart disease.

The same is true for the world's densely-populated cities. While warm, wealthier cities like Phoenix and Madrid are projected to lose an additional 600 and 525 lives each year, respectively, due to a warming climate, Faisalabad, Pakistan, will lose an additional 9,400 lives. In fact, Pakistani cities will be the hardest hit as they see changes in temperature-related

mortality exceeding that of today's rates associated with tuberculosis, chronic obstructive pulmonary disease (COPD), and stroke. Within the cities that will experience an increase in temperature-related mortality, more than 100,000 lives will be lost across the globe, and 1 in 3 of those deaths will occur in Pakistani cities.

### Top 25 Countries with the Greatest Increase in Temperature-Related Mortality Rates



Note: Change in region-level net mortality rates in 2050 compared to the 2001-2010 average due to climate change. Colored dots represent the change in net mortality rate for each region. Countries are listed in order of the maximum region-level net mortality rate changes within their boundaries, with the top 25 countries shown.

### Highly-varied climates within countries underscore the need for targeted adaptation.

While some countries will experience significant increases in mortality across their entire territory, nations with diverse climates and topographies will see some areas benefit while others will experience negative impacts. For example, the continental United States is projected to see a wide range of impacts, with the northern states and Rocky Mountains experiencing a decrease in mortality rates by 30-60 deaths per 100,000 and the southern tier experiencing an increase of approximately 10 deaths per 100,000. This intra-country disparity is particularly important for those in lower-income countries deciding where to target their limited adaptation dollars, such as Bolivia. The mountainous regions of that South American nation, where it is generally cooler, fare significantly better than the more lowland parts of the country. Targeted interventions there would seek to address climate-related mortality in the southeast, which is projected to experience an additional 30 deaths per 100,000—on par with the current death rate of diabetes—rather than La Paz, which will see 17 fewer deaths per 100,000.

### Without economic growth, there would be seven times more temperature-related deaths globally.

By 2050, projected income growth will reduce climate change's global impact on mortality by about 9 deaths per 100,000 people, about equal to eliminating suicides across the globe. Accounting for this growth allows philanthropic organizations and decision makers of all levels to better target where adaptation measures are most needed by ensuring their efforts are additive. This report takes that projected income growth into account.

Climate Impact Lab research shows that temperature-related deaths are an inequitable threat to human well-being. This report identifies where additional resources and policies can most effectively reduce preventable deaths. Directing adaptation efforts toward the regions and cities highlighted would benefit communities across a wide range of possible climate futures.

## PREFACE

The world has made meaningful progress in slowing the growth of greenhouse gas (GHG) emissions, especially over the last decade. But even if countries meet their current nationally determined contributions and net zero targets under the Paris Agreement—indeed, even if global emissions fell to zero tomorrow—the climate will continue to warm for at least the next few decades. Efforts to mitigate climate change must therefore be coupled with concerted action to help society adapt to the warming that is already underway to prevent its worst impacts.

A growing body of research shows that the poorest and hottest communities around the world are already bearing the brunt of climate change impacts. Extreme heat reduces labor productivity, especially in outdoor sectors like agriculture, while exposing workers to dangerous conditions. Energy demand is rising to meet the increasing need for air conditioning, even as billions still lack reliable, or even any, electricity. Changes in precipitation and rising sea levels are putting increased strain on urban infrastructure. All of these temperature-driven challenges disproportionately affect people and communities in the Global South. Key international organizations, such as the [United Nations](#) and [Global Center for Adaptation](#), are calling on governments and philanthropies to increase their financial support to help these communities adapt as the severity of those impacts grows.

Historically, adaptation has been deprioritized for funding for multiple reasons, including concern that allocating resources to prepare for climate impacts could undercut demand for emissions reductions. This, in turn, has led to what is now an urgent shortage of reliable information on where adaptation investment can be most beneficial and on what adaptation interventions are most effective—as well, of course, to underinvestment in adaptation solutions.

Governments are increasingly poised to act on adaptation if they have sufficient information and resources to do so. More countries than ever either have a National Adaptation Plan in place or are actively developing one (193 of 197 countries) and they are

improving their ability to incorporate adaptation into broader national development planning (UNEP, 2025a).

There is an increased appetite among both international donor governments and private philanthropy to support adaptation efforts as well, particularly in low-income countries. In 2024, a group of more than 60 philanthropies joined the [Adaptation and Resilience Funder Collaboration](#) (ARC), which was organized by the ClimateWorks Foundation to jointly make progress on climate adaptation. At the 2025 UN Climate Change Conference in Brazil, countries set a goal of tripling international adaptation finance by 2035.

Despite this growing interest in adaptation, the supply of adaptation funding, both domestic and international, will almost certainly fall far short of the scale of adaptation investment needs. As a result, decision makers at all levels need rigorous, objective, and comparable information on where climate change presents the most significant threats to human well-being, and what adaptation interventions are most effective.

The mission of the Climate Impact Lab (CIL) is to provide such information. For over a decade, the CIL has combined high resolution global climate models with cutting-edge econometric research to develop evidence-based estimates of the impacts of climate change both now and in the future at a highly

granular level<sup>1</sup>. All climate impacts are assessed in terms of their impact on human well-being in a way that allows for apples-to-apples comparison across economic sectors and countries, as well as comparison to non-temperature-related threats those same communities face. CIL research has been published in leading academic journals across disciplines, including [Nature](#), [Science](#) and the [Quarterly Journal of Economics](#). CIL models serve as a foundation for the [U.S. Government's estimate of the Social Cost of Carbon](#) as well as the UN Development Program's [Human Climate Horizons](#) data platform. The CIL also maintains an [Adaptation Inventory](#) of evidence-based adaptation interventions that decrease vulnerability and impact from the temperature-related threats to human well-being.

A fundamental aspect of ensuring that adaptation investments are effectively targeted is to ensure that they are additive—in other words, that they do not fund adaptations that are likely to naturally occur as countries get richer. CIL research accounts for this type of adaptation, such as increasing access to air conditioning. That allows decision makers using CIL data and models to focus specifically on what we call the “adaptation gap”—the protective steps individuals, communities, and countries can take but are unlikely to do so without better information, additional resources, and/or policy intervention. Examples of those additive investments include enhancing the overall economic resilience of households and communities so they can better absorb income instability due to climate conditions, driving changes in labor policy that support the health and efficiency of outside workers, and backing financial instruments such as index insurance that help households continue to invest in their livelihoods in the face of climate variability.

The CIL's research provides people, governments, funders, and businesses with rigorous estimates of climate change impacts to identify where they most threaten human well-being and how they compare to and interact with other threats. This ensures priorities can be set by quantified metrics, which is particularly important as the climate impacts that

generate the most news are often not the ones that most threaten human well-being. For example, while tropical cyclones capture headlines and generate large losses, they are also relatively rare and geographically concentrated events compared with persistent heat-induced health effects. In fact, 10 times more people across the globe are exposed to temperatures exceeding 90°F at least 5 days of the year (5.8 billion, CIL analysis) than those exposed to tropical cyclones on an annual basis (560,000 million, Jing et al., 2023). Sound evidence is required to separate the signal from the noise and ensure that limited resources are spent as effectively as possible.

Outside of providing guidance to target funding, the CIL's insights will help policymakers and other decision makers better understand the challenges they may face in the future so they can set priorities and determine how best to manage the demands of adapting to unavoidable climate impacts. At the same time, the insights will help the academic community identify new impactful areas of research and assess the efficacy of adaptation policies and programs to inform where and how they can potentially be scaled.

Global momentum on adaptation is at a turning point. At COP30 in Brazil, adaptation was recognized as an [important theme alongside mitigation](#), and [funding trends are moving in a positive direction](#). The opportunity to ensure adaptation investments and programs are effective and evidence-based is now—and CIL aims to do just that.

This is the first in a series of reports that use CIL research to help climate adaptation decision makers identify priorities and develop strategies. This report focuses on the impact of climate change-driven shifts in temperature on human mortality. Future reports will focus on other ways that climate affects human well-being, including the impact of climate change on food production, energy consumption, sea level flooding, and labor supply. The CIL also anticipates releasing a comprehensive online data platform that will support data-driven decision-making across the adaptation spectrum by connecting information on future climate conditions, projected climate impacts, and their relationship with effective adaptation measures.

<sup>1</sup> The 24,378 Impact Regions (hereafter “regions”) in the CIL's models provide a consistent, granular underlying spatial reference for all its research. They are agglomerated from second administrative units across the globe based on maintaining approximately similar population and average climate within each region (Rode et al., 2021; Carleton et al., 2022). For reference, their size is similar to that of counties in the United States and districts in India and China.

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# Introduction

Communities that experience the most extreme temperatures are commonly assumed to also experience the largest number of temperature-related deaths. It is an intuitive connection, but it is also incomplete. Extreme temperatures affect mortality rates in a more nuanced and complex way, with a community's resilience and ability to adapt playing a critical role in the ultimate impact of climate change-driven shifts in temperature on human welfare. This multidimensional relationship is vital to understanding where and how to prioritize future efforts to manage temperature-related mortality because it isn't as simple as looking at where it will be the hottest.

Landmark research by the Climate Impact Lab (CIL) on temperature-related excess mortality highlights the interplay between climate change and the ability of a community to adapt (Carleton et al., 2022). That study projects the future impact of climate change on mortality rates and the costs and benefits of adaptation measures that populations are likely to undertake. It demonstrates that extreme temperatures take a greater toll on lower income communities compared to higher income communities in a similar climate. For example, we project Djibouti to experience an increase in temperature-related mortality two times that in Kuwait City despite their similar climate profiles due largely to Kuwait's relative wealth. Similarly, the mortality impacts of

extreme temperatures in communities that regularly experience them are smaller, because people tend to prepare and respond to a known threat. For example, Houston's population fares better than that of Seattle on a hot day because these two wealthy U.S. cities have differing levels of experience and resilience with extreme heat. These findings are key principles relevant to adaptation planning.

CIL research reveals which communities around the world are the most vulnerable to changes in temperature-related mortality today, as well as in the future, after accounting for the adaptation that they will take on their own. Many of those self-directed adaptations (often referred to as autonomous adaptation in economics research) are income driven, such as managing exposure to extreme heat by adjusting time outside and increasing access to air conditioning. However, even after these autonomous interventions, many communities are at great risk for elevated mortality rates due to high temperatures, both today and in the future. The CIL work helps to identify the places where further adaptation investments by people, governments, and funders can save lives.

## Analysis background

To guide public and philanthropic adaptation funding strategies and provide additional insights to decision makers, we leverage the temperature-mortality models developed in Carleton et al. (2022) and focus on the impacts of climate change in 2050<sup>2</sup> under an emissions scenario consistent with recent global projections. The [UN Environmental Program](#) (2025b), [Rhodium Group](#), and the [Climate Action Tracker](#) all project that under current policy and technology trends, the world is on track for roughly 3°C<sup>3</sup> of warming by the end of the century. On that trajectory, the global mean surface temperature (GMST) in 2050 will be approximately 2.1°C warmer than the pre-industrial period. For population and economic growth, we use the central "Middle of the Road" SSP2 scenario used by the Intergovernmental Panel on Climate Change (Fricko et al., 2017), as modeled by IIASA<sup>4</sup> (Riahi et al., 2017).

Extreme temperatures impact human health at both ends of the thermometer. Extreme cold and hot environments both stress the human body and contribute to physical conditions like cardiovascular stress and higher mortality rates than more moderate temperatures. As global average temperatures increase, so do the number of hot days and the number of deaths due to extreme heat. However, this warming climate also shrinks the number of cold days, lowering the number of deaths due to extreme cold.

In many areas of the world, particularly those in mid-latitude temperate climates, these dual, competing effects on mortality rates moderate the net human health outcomes. In the coldest parts of the world, climate change results in a significant net decline in temperature-related mortality, as the decline in cold-related deaths exceeds the increase in heat-related deaths. At the other end of the spectrum, in the currently hottest parts of the world, climate change results in large net increases in temperature-related mortality as the increase in heat-related deaths far outpaces the decline in cold-related deaths.

Averaged out globally, climate change results in a small net incline in average mortality rates by mid-century, but this global average masks very stark regional disparities. By the end of the century, the CIL's models project a large net global increase in temperature-related mortality. Even within regions that see net declines or small net increases (like the northern portions of Europe and the United States), climate adaptation is still important to reduce heat-related deaths that will continue to grow as the global temperatures increase.

Existing estimates of climate change threats to human health fail to account for the economic growth that will take place, providing the means for people to protect themselves. When we project the impacts of climate change on mortality rates in 2050, we account for this income growth and find that it unlocks resilience to climate change. By 2050 projected income growth will reduce climate change's global impact on mortality by approximately 9 deaths per 100,000 people, a change in death rate on par with the current absolute rate of suicide across the globe (WHO, 2024a)<sup>5</sup>; the global average change in net mortality with no income growth is 10.7 additional deaths per 100,000 people compared to a global average of 1.4 additional deaths per 100,000 people when accounting for income growth. In other words, without economic growth, there would be seven times more temperature-related deaths globally.

This report takes that projected income growth into account, underscoring the areas of the world where adaptation is unlikely to occur without external support and actions taken by city, state or national governments, international aid agencies or private philanthropies. Funders and policymakers can use this information to prioritize places where resources are scarce, heat risk is persistent, and investment in intervention strategies will move the needle the most.

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2 Results represent a 20-year average centered on 2050 (i.e., 2040-2059).  
3 3°C warming level represents an increase in Global Mean Surface Temperature (GMST) at 2100 compared to that during pre-industrial time period (1850-1900) and sits within the central estimates of the aforementioned organizations.  
4 This analysis is based on the SSP database hosted by the IIASA Energy Program at <https://tntcat.iiasa.ac.at/SspDb>.

5 Throughout the report, we compare temperature-driven changes in mortality (deaths per 100,000 people per year) to the current level of selected cause-specific death rates to convey scale. These comparisons are for context only. For example, a projected change in temperature-driven death rate that is on par with the current death rate for heart disease suggests that a changing climate will bring an additional number of deaths comparable in magnitude to those currently caused by heart disease.

CIL research helps to identify the places where further adaptation investments by people, governments, and funders can save lives.

## Unpacking the Inequality of Temperature-Related Mortality: Geographic Priorities for Adaptation

Due to differences in both income and the local climate, the impact of rising global temperatures on human health will be highly unequal around the world. Figure 1 shows the change in net mortality rates for 24,378 regions that comprise the world, with approximately one-third of those residing in low- and lower-middle income countries.

Because a warmer climate will lead to more deaths from extreme heat, and fewer deaths from extreme cold, Figure 1 shows that cooler regions (mid-to-high latitudes) are projected to see a decrease in deaths. This includes countries in Scandinavia where the temperature-related mortality rate is expected to decline by more than 70 deaths per 100,000 people.

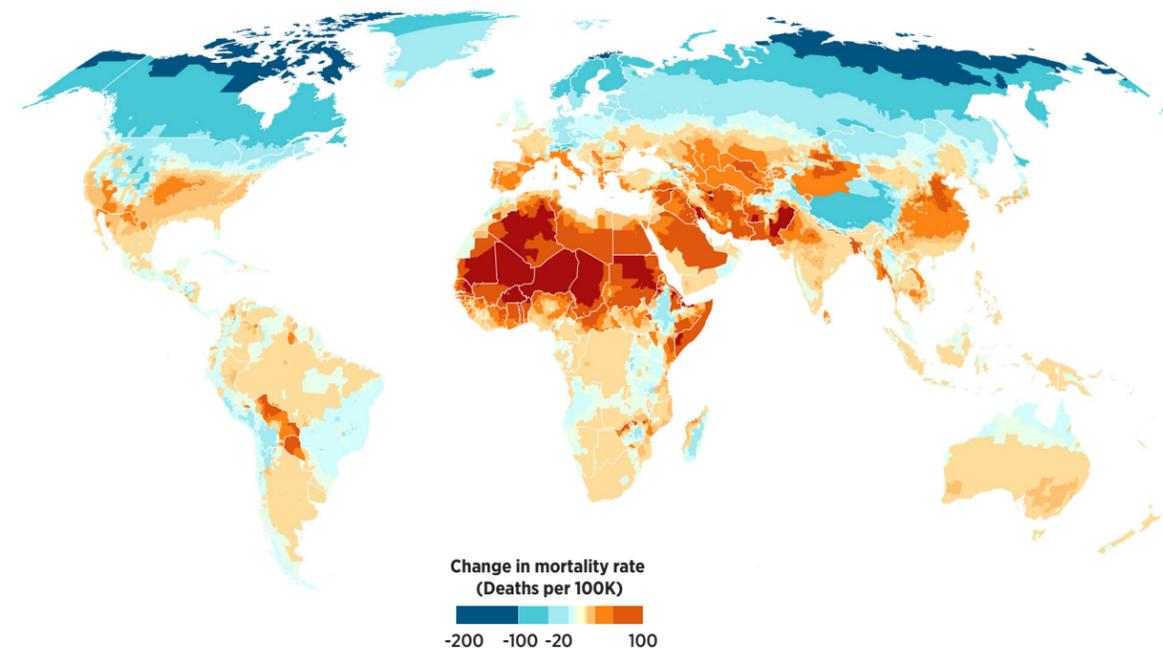
Meanwhile, hotter regions (lower-latitudes) such as Northern Africa, the Middle East, and Southwest Asia

are projected to see more deaths. Niger and Burkina Faso experience the greatest increases in mortality, with the rate increasing by 68 and 60 deaths per 100,000 people, respectively—material increases for countries that already experience a significant number of heat-related deaths. This increase in the death rate exceeds that of some of the greatest causes of mortality in the region today, including diarrheal diseases in Burkina Faso and stroke in Niger (WHO, 2024b). In Southwest Asia, Pakistan sees a net increase in mortality of 51 deaths per 100,000 people by 2050, comparable to the loss of life due to stroke in that country today.

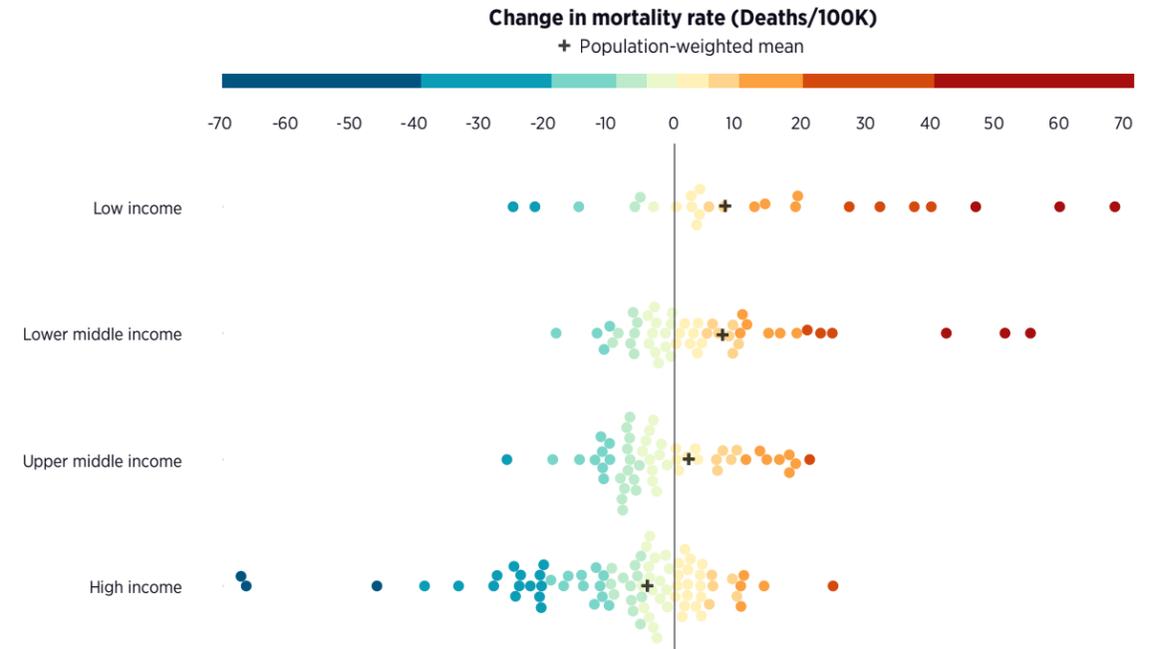
### Variation by income

Today's poorest populations are projected to suffer the most from a warming climate, making adaptation investments in low-income areas critical (Figure 2). Specifically, Figure 2 shows the population-weighted mean of the change in the net mortality rate of the low-income group increases by approximately 8 deaths per 100,000 people while that of the high-income groups decreases by about 4 deaths per 100,000 people. While lower income (i.e., low- and lower middle-income) and higher income (i.e., upper middle-

**Figure 1.** Change in region-level net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average due to climate change



**Figure 2.** Change in country-level net mortality rates (deaths per 100,000 people) grouped by World Bank income categories



Note: World Bank, 2025. Crosses indicate the population-weighted average net mortality rate for each income category.

and high-income) countries will have approximately equal populations in 2050 (52% and 48% of global population, respectively), 10 times more people are projected to die each year in lower-income countries due to a warmer climate than in higher income countries (-391,000 and -39,000 people, respectively).

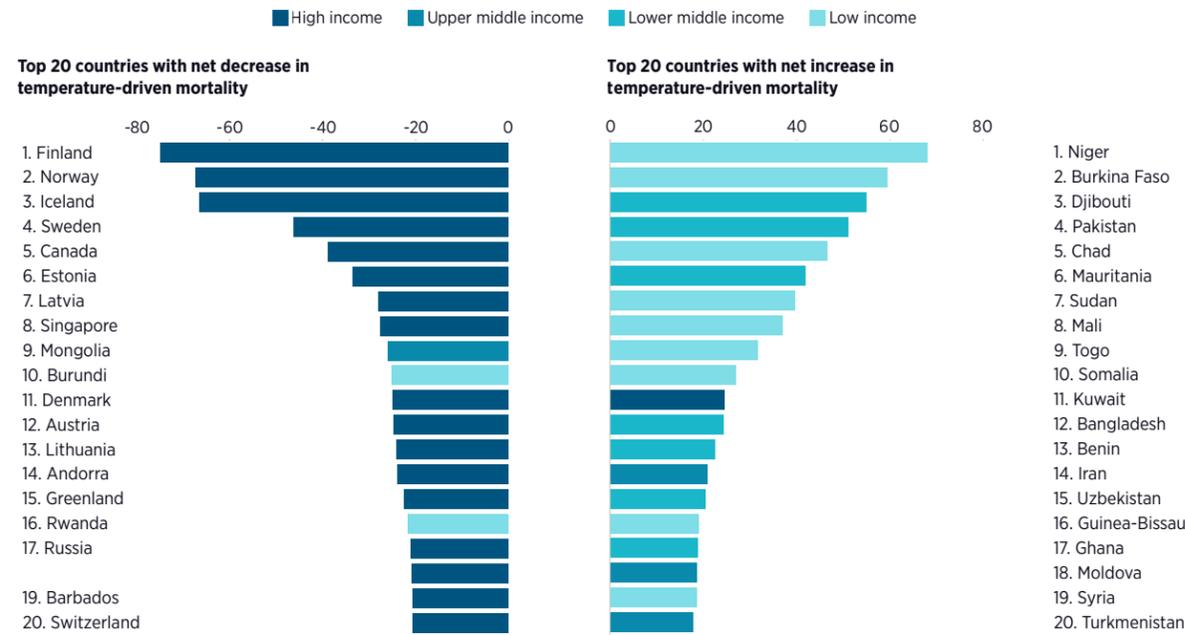
As an example, the country of Djibouti in East Africa is projected to experience an increase in temperature-related deaths that is two times that of the wealthier country of Kuwait in the Middle East, despite their similar climate. In Djibouti, temperature-related mortality is projected to increase by 55 deaths per 100,000, on par with the current death rate of HIV/AIDS, while Kuwait is projected to experience 25 additional deaths per 100,000, less than half the current death rate of heart disease.

Eighteen of the top 20 countries with the largest net decreases in deaths are relatively wealthy, while 16 of the top 20 countries with the largest net increases are relatively poor (Figure 3). While increases in mortality are always of a concern and worthy of adaptation efforts to mitigate the loss of life, wealthy countries,

such as Kuwait and Moldova, generally have fewer obstacles to fund and execute their own adaptation measures than those with emerging and developing economies. In general, low-income countries will have less means to self-finance adaptation measures and will therefore carry a greater need for allocation of the finite amount of public and philanthropic capital available for adaptation.

Figure 4 puts these mortality rate changes in the context of the broader public health drivers in low- and lower middle-income countries. The diamonds indicate the mortality rates associated with the 10th leading cause of death in each country, such that all regions (i.e., colored dots), to the right of the diamonds indicate areas where the increase in temperature-driven mortality will sit among the top 10 causes of death. Nearly two-thirds of the population (64%) of those countries shown in Figure 4, or about 800 million people, live in regions that will exceed that threshold, highlighting how changes in temperature-related mortality contribute to other public health priorities in these regions and where adaptation could be particularly beneficial.

**Figure 3.** Change in country-level net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average due to climate change



Note: The top 20 countries with the largest net increases and decreases in temperature-driven mortality are on the right and left, respectively. Countries in the low and lower middle-income categories are shown in light blue, while those in the higher income categories are shown in dark blue (World Bank, 2025). Positive values indicate a net increase in mortality rates. Negative values indicate a net decrease in mortality rates.

The rich and poor divide is also seen at the city level, where the largest numbers of people live. Figure 5 illustrates the top 100 cities<sup>6</sup> when ranked by their projected increases in net mortality rates and their gross domestic product (GDP) per capita. Cities residing in lower income countries are seen here, many with rates exceeding 25 deaths per 100,000 people. In contrast, the cities projected to see a change in rates less than 25 deaths per 100,000 people are much more diverse in terms of their relative wealth. Warm, wealthier cities like Phoenix and Madrid are projected to lose an additional 600 and 525 lives each year, respectively, due to a warming climate, while poorer cities, like Faisalabad, Pakistan, will lose an additional 9,400 lives.

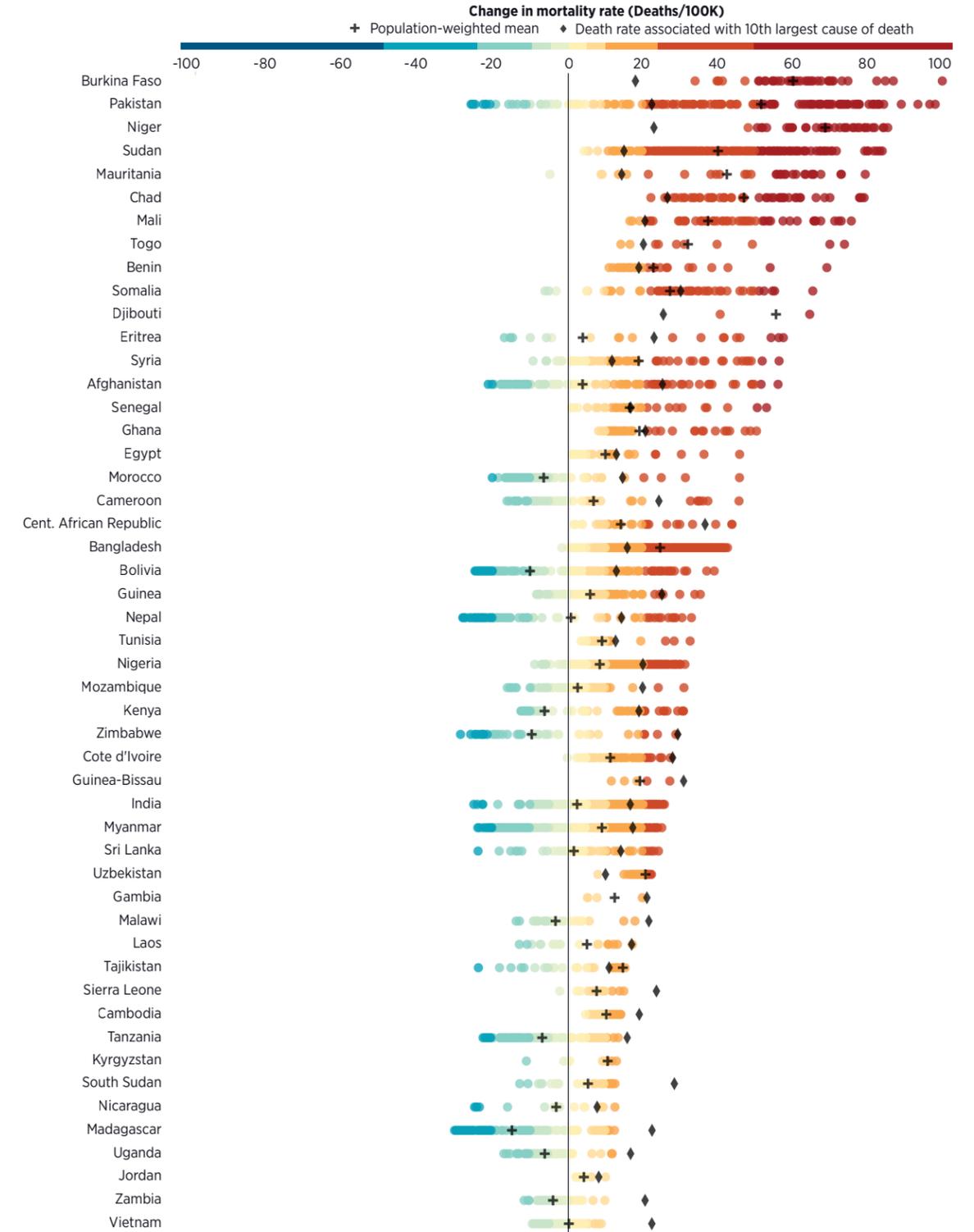
Figure 6 ranks cities in low- and lower-middle income countries by the projected increases in mid-century net mortality rates, which translate to a significant number of additional lives lost. The figure shows that Pakistani cities will be the hardest hit as they see

<sup>6</sup> Cities must have a current population of at least 500,000 people to be included.

changes in temperature-related mortality exceeding that of today's rates associated with tuberculosis, chronic obstructive pulmonary disease (COPD), and stroke. When considering the 301 cities across the globe that we project to see a net increase in temperature-related deaths in 2050, more than 100,000 additional lives will be lost annually and approximately 1 in 3 of those deaths will occur in Pakistani cities.

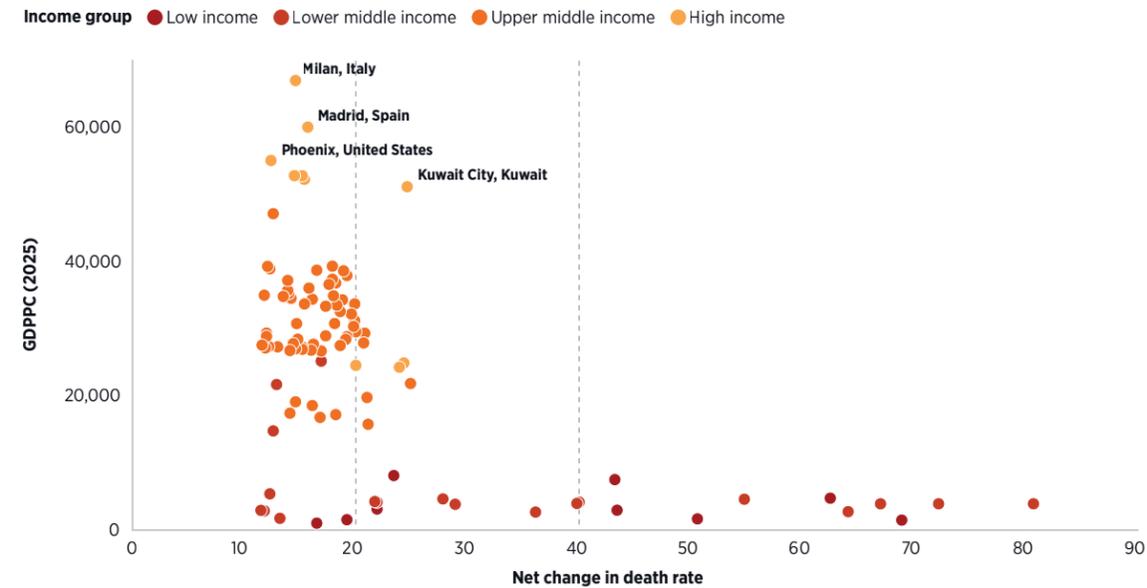
Outside of Pakistan, the data also shows cities in China are impacted—underscoring the impact on highly populated areas. Most of the cities shown on Figure 5 with changes in mortality rates between 10-20 deaths per 100,000 people reside in eastern China. The alignment of temperature-driven mortality with these highly populated areas will cause a significant rise in the number of temperature-related deaths by mid-century. Overall, 56 Chinese cities are projected to see an increase in temperature-related mortality exceeding 10 deaths per 100,000 with nearly 17,000 additional lives lost across those cities each year by 2050.

**Figure 4.** Change in region-level net mortality rates in low- and lower middle-income countries in 2050 compared to the 2001-2010 average due to climate change



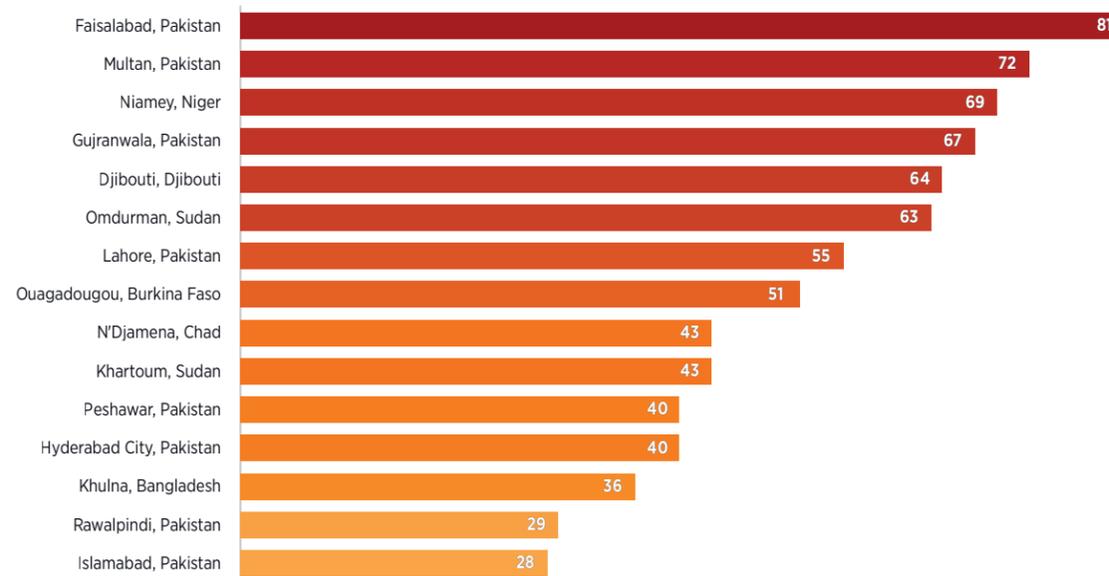
Note: Colored dots represent the change in net mortality rate for each region. Countries are listed in order of the maximum region-level net mortality rate changes within their boundaries, with the top 50 countries shown. Crosses represent the population-weighted mean for each country. Diamonds represent the death rates associated with the 10th largest cause of death in that country (WHO, 2024b).

**Figure 5.** Top 100 cities ranked by projected changes in net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average vs. 2025 GDP per capita (USD)



Note: The income categories of the countries in which the cities reside are shown in their respective colors.

**Figure 6.** Top 15 cities in low- and lower-middle income countries ranked by projected increases in net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average



### Variation by local climates

While some countries will experience significant increases in mortality across their entire territory, nations with diverse local climates and topographies will see some areas benefit while others will experience negative impacts—underscoring the need for targeted adaptation.

For example, the continental United States is projected to see a wide range of impacts, with the northern states and Rocky Mountains experiencing a decrease in deaths by 30-60 deaths per 100,000 and the southern tier experiencing an increase of approximately 10 deaths per 100,000.

This intra-country disparity is particularly important for those in lower-income countries deciding where to target their limited adaptation dollars, such as Bolivia. The mountainous regions of that South American nation, where it is generally cooler, fare significantly better than the more lowland parts of the country. Targeted interventions there would seek to address temperature-related mortality in the southeast, which is projected to experience an additional 30 deaths per 100,000—on par with the current death rate of diabetes—rather than La Paz, which will see 17 fewer deaths per 100,000. When this range of outcomes within a country is summarized as population-weighted averages (i.e., Figure 4, crosses), nine of the top 10 countries shown will have changes in temperature-driven mortality as one of their 10 leading causes of death.

### Adapting to an uncertain future

The projected mortality impacts estimate how outcomes might evolve, given the amount of climate change the world is likely on track for, compared to an alternate future with no climate change. However, there are many unknowns about the future, such as how quickly the population will grow, how fast technology will change, or how much the climate will warm in response to emissions. This research on the effects of future climate change explicitly does not attempt to forecast the future. Instead, the CIL meticulously models and reports these sources of uncertainty, which involves assigning probabilities to different possible outcomes and exploring various scenarios of possible future emissions and socioeconomic development.

Our report presents the central expected values (i.e., mean outcome) of a full probabilistic distribution for each region that accounts for those sources of uncertainty. When we look across that distribution—spanning futures that are richer, poorer, hotter, or cooler than the central estimate—the ranking of most-impacted countries and regions remains generally stable. The rankings shown throughout this report, based on projections in 2050 as we progress toward a world that is 3°C warmer at the end of the century, are also robust to alternate warming scenarios or target time periods. Whether calculated for 2050 or the end of the century (i.e., 2090), and whether the world is tracking cooler (i.e., 2°C) or warmer (i.e., 4°C) by the end of the century, the rankings do not significantly change. Through an adaptation funding lens, this matters. Directing resources to the most vulnerable regions prioritized in this report would avert substantial mortality impacts across a wide range of plausible futures.

Accounting for all modeled sources of uncertainty, the likelihood that the most negatively impacted countries (Figure 3) avoid net increases in temperature-related mortality is relatively small (<10%), as is the likelihood of a dire scenario in which mortality rates increase by double the central projection (10-25%). Overall, considering the tails of the projected mortality distribution certainly affects the magnitude of those projections, but in general, does not materially change the ranking of those projections and therefore their relative prioritization for adaptation interventions and funding.

# Regional spotlights

Global organizations need to understand where to prioritize their efforts and funding across the world. However, many organizations have a more targeted geographic focus and would benefit from a regional\* assessment of climate change's impact on mortality to help them prioritize the areas most in need. These summaries provide a snapshot of the projected changes in mortality for each continent and include countries of all income levels.

\*Regional definitions are consistent with those used by UN Statistics Division.

## Guide to Visualizations

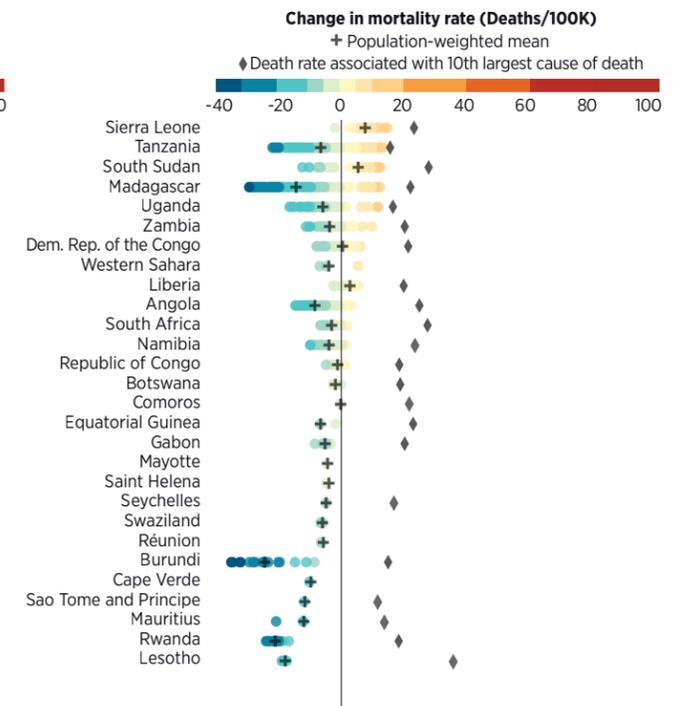
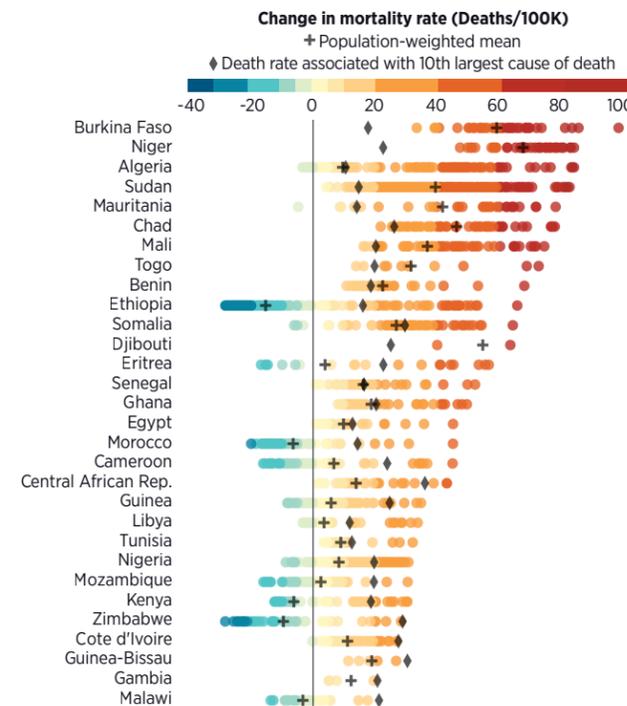
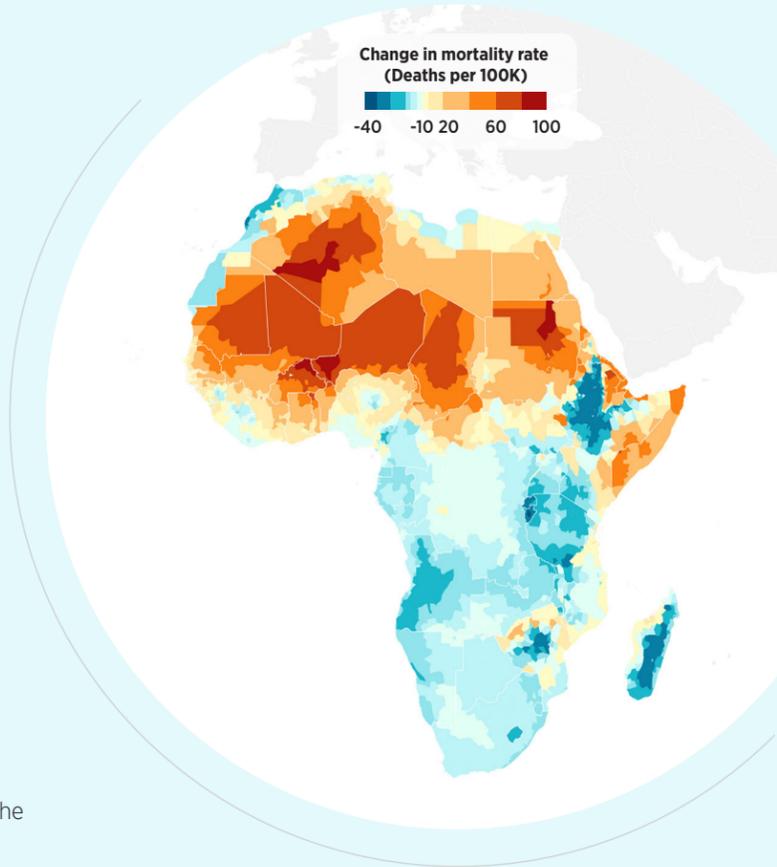
**Maps:** Change in region-level net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average. Positive values indicate a net increase in mortality rates. Negative values indicate a net decrease in mortality rates.

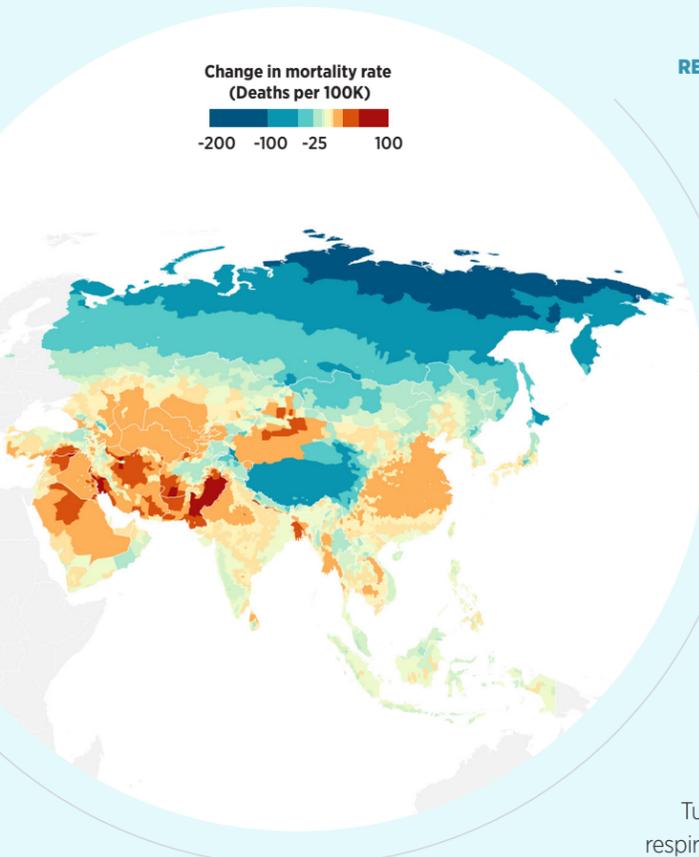
**Dot plots:** Change in region-level net mortality rates in 2050 compared to the 2001-2010 average. Countries are listed in order of the maximum region-level net mortality rate changes within their boundaries. Colored dots represent the change in net mortality rate for each region. Crosses represent the population-weighted mean for each country. Diamonds represent the death rates associated with the 10th largest cause of death in that country, where available. (WHO, 2024b).

## REGIONAL SPOTLIGHT

# Africa

CIL projections indicate significant net increases in temperature-related mortality across much of northern Africa. Twenty-six countries across the continent will experience increases in temperature-related deaths that are on par with other top killers in at least a portion of their territory. The most impacted areas in several of those countries, including Burkina Faso, Algeria, Niger, and Mauritania, will see new temperature-driven deaths exceeding that of stroke, which is one of the top causes of death across the globe. Many of the most impacted African cities reside in or just south of the Sahel, including Niamey (69 deaths per 100,000), Ouagadougou (51 deaths per 100,000), and Khartoum (43 deaths per 100,000). Outside of these areas, portions of the Horn of Africa will also experience some of the largest increases in temperature-related mortality, including Somalia, Djibouti, and localized areas in the lowlands of Ethiopia. We project that the temperate areas across much of southern Africa will experience more modest net changes in temperature-driven mortality, due, in part, to fewer cold-related deaths moderating the increase in the number of heat-related deaths.



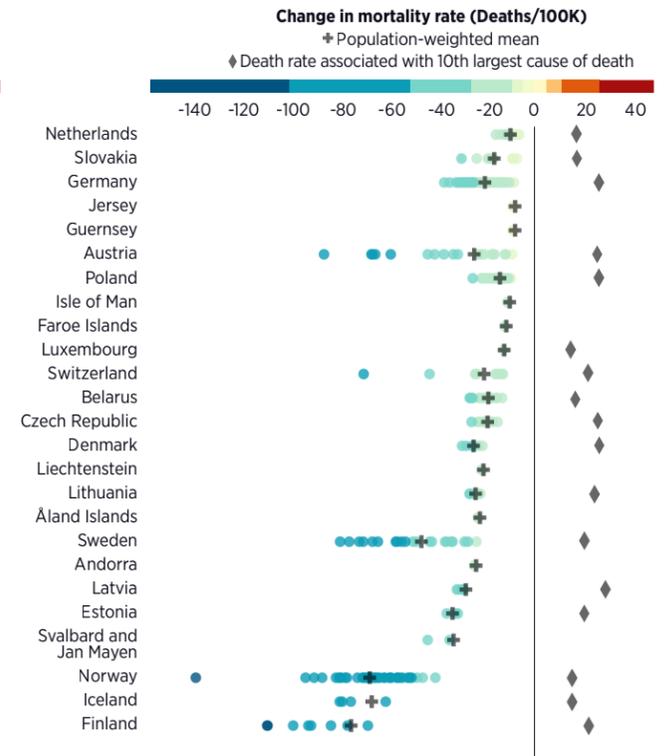
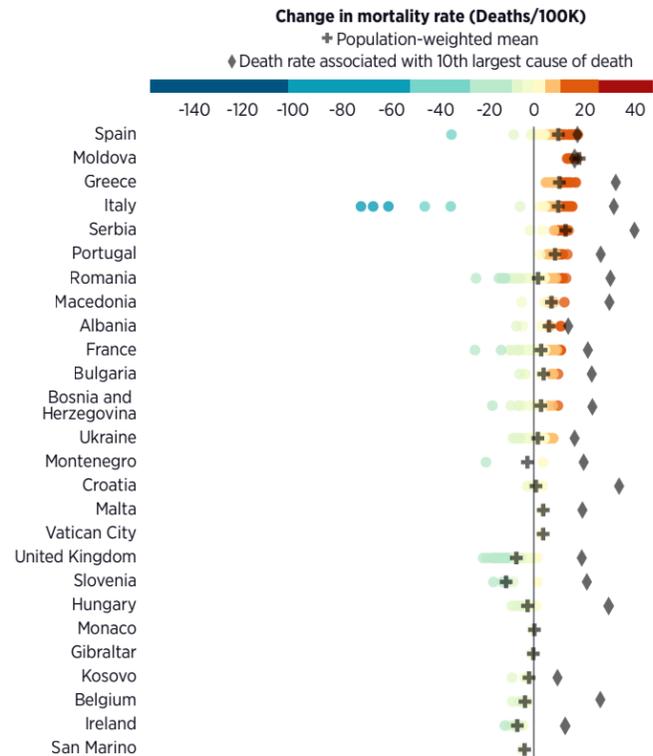
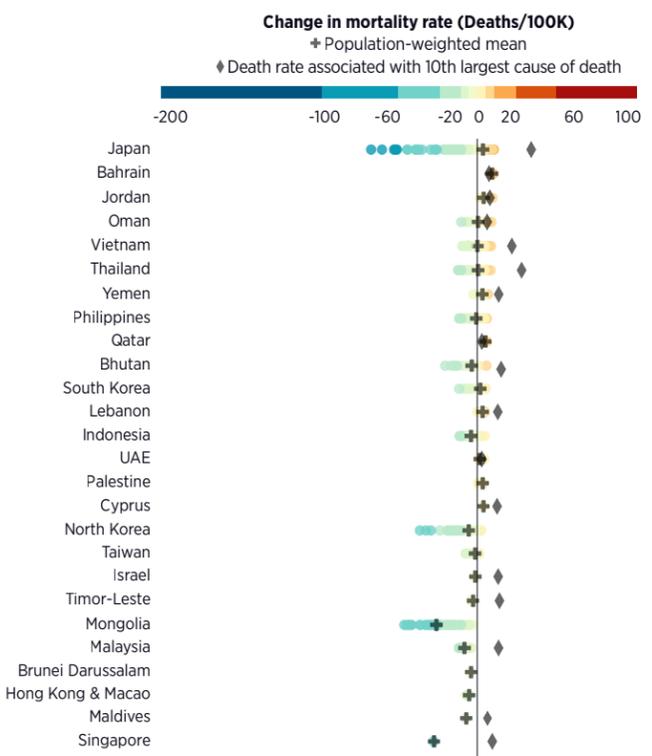
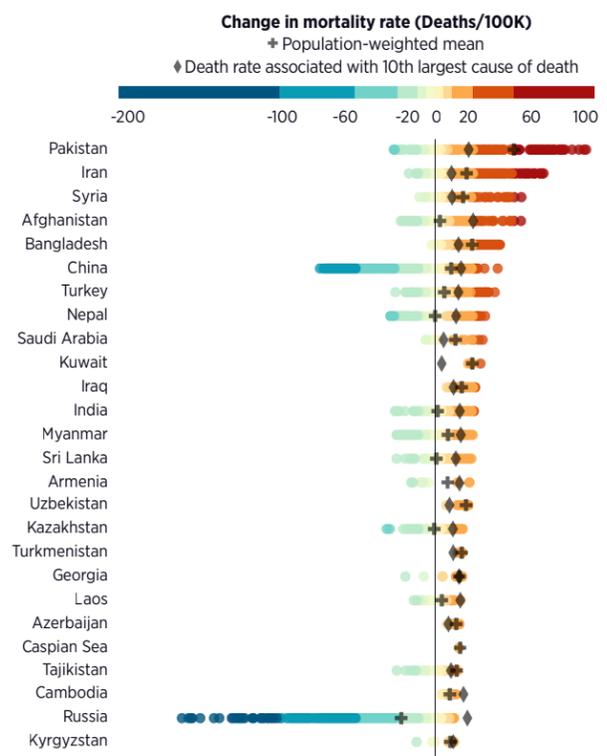
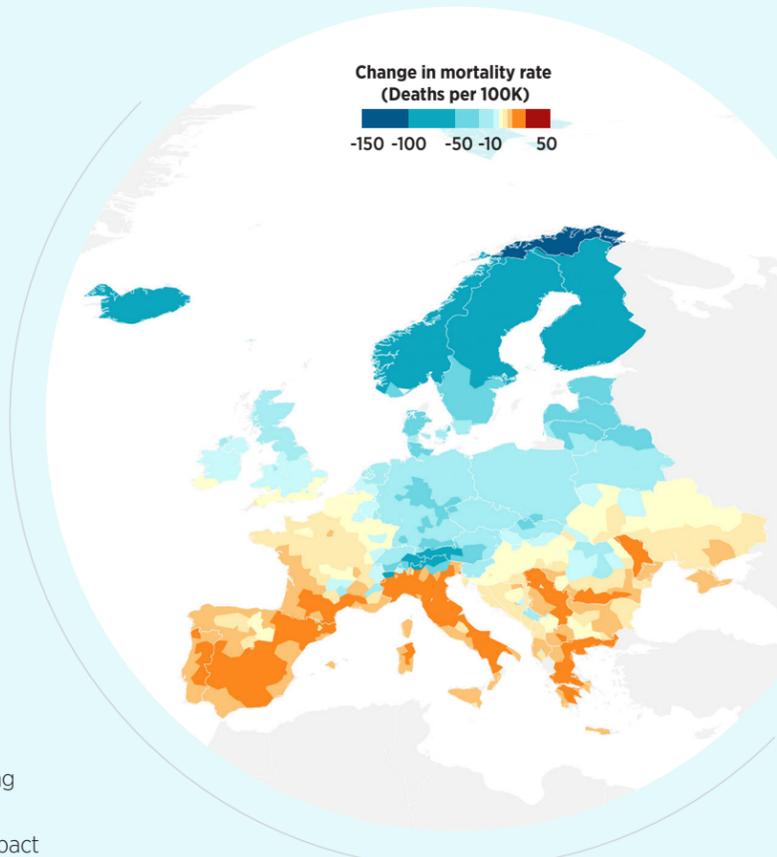


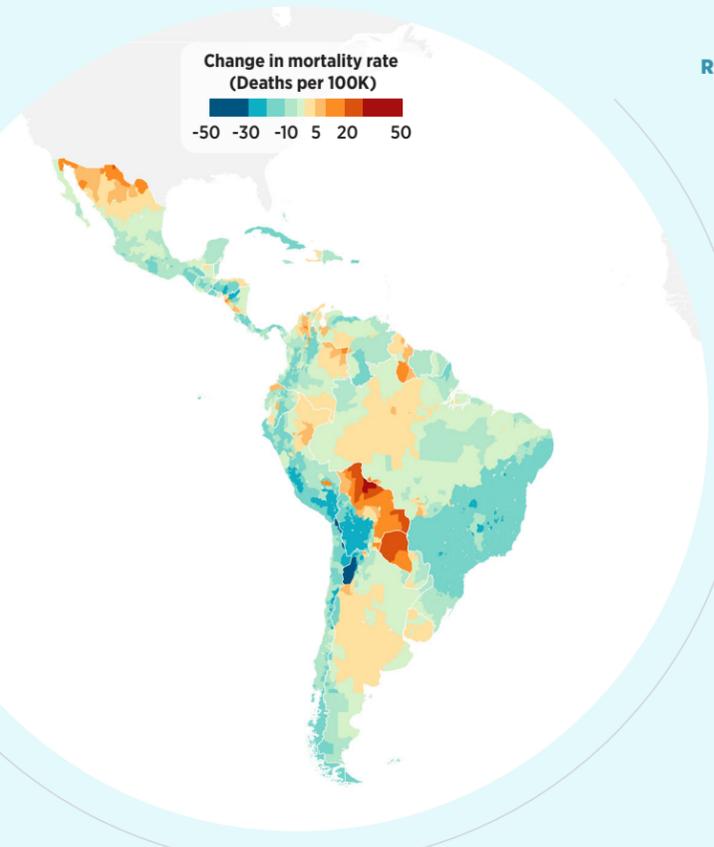
**REGIONAL SPOTLIGHT**  
**Asia**

The diverse climates and economies of Asian countries combine to drive a wide range of outcomes in our temperature-related mortality projections for the continent. Beyond the heavily impacted areas in southwest Asia already noted (e.g., Pakistan), we project a majority of the Middle East will experience significant increases in net mortality, including Kuwait (25 deaths per 100,000), Iran (21 deaths per 100,000), and Syria (19 deaths per 100,000). In contrast, the northern latitudes (e.g., Russia) and high-altitude areas (e.g., southwestern China, Mongolia) are projected to see temperature-related mortality rates significantly drop due to fewer cold-related deaths. CIL projections indicate that 95 cities across Asia will experience an increase in temperature-related mortality of at least 10 deaths per 100,000 with 56 of them residing in China. Additional deaths due to climate change in those heavily populated areas of China will be on par with the number of lives currently lost to both esophagus and colon cancer. Other countries with multiple cities that exceed the 10 deaths per 100,000 threshold include Pakistan (9), Japan (4), Iran (4), Bangladesh (3), and Saudi Arabia (3). Elsewhere, in Gaziantep, Turkey, the increase in mortality due to climate is on par with that of lower respiratory infections and in Khulna, Bangladesh, it exceeds the current death rate due to chronic obstructive pulmonary disease (COPD).

**REGIONAL SPOTLIGHT**  
**Europe**

We project that most European countries will have net decreases in mortality rates due to fewer cold-related deaths. This is particularly true across Scandinavia and central Europe. Across the southern tier of Europe, twelve countries are projected to have at least a portion of their territory experience net increases in temperature-related mortality exceeding 10 deaths per 100,000. In Spain, the number of additional temperature-related deaths will be on par with those from diabetes, but elsewhere, the change in the temperature-related mortality rate is less than that associated with the 10 largest causes of death in their respective countries. Seven cities across the southern tier are projected to have net increases in mortality rates exceeding 10 deaths per 100,000, with Madrid (16 deaths per 100,000), Florence (15 deaths per 100,000), Turin (15 deaths per 100,000), and Chisinau (15 deaths per 100,000) seeing the largest increase. These net impacts, however, underplay the fact that heat-related deaths will continue to be a threat across a broader portion of the continent. Like the devastating 2003 heat wave in France that took an estimated 15,000 lives, a warming climate will continue to drive seasonal extremes that impact human health at the same time as decreasing cold-related deaths.



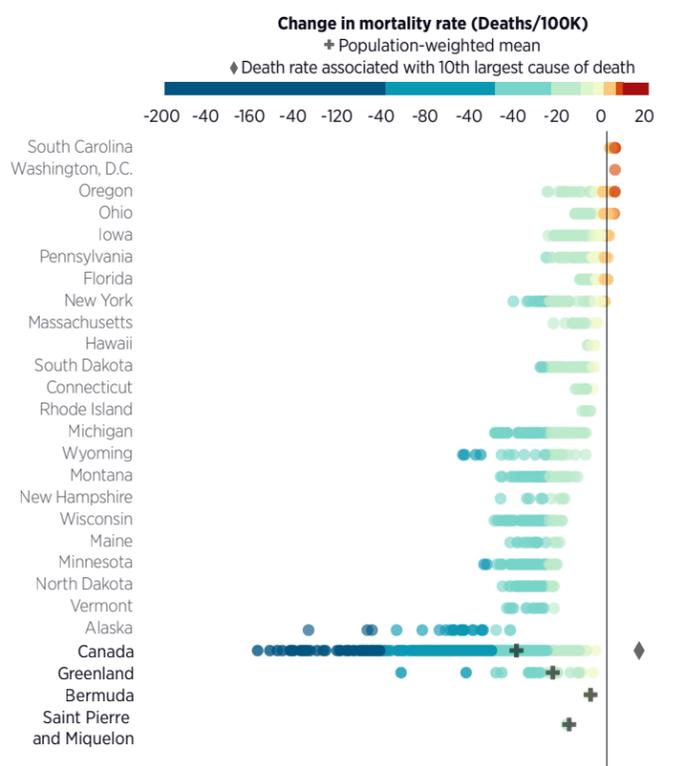
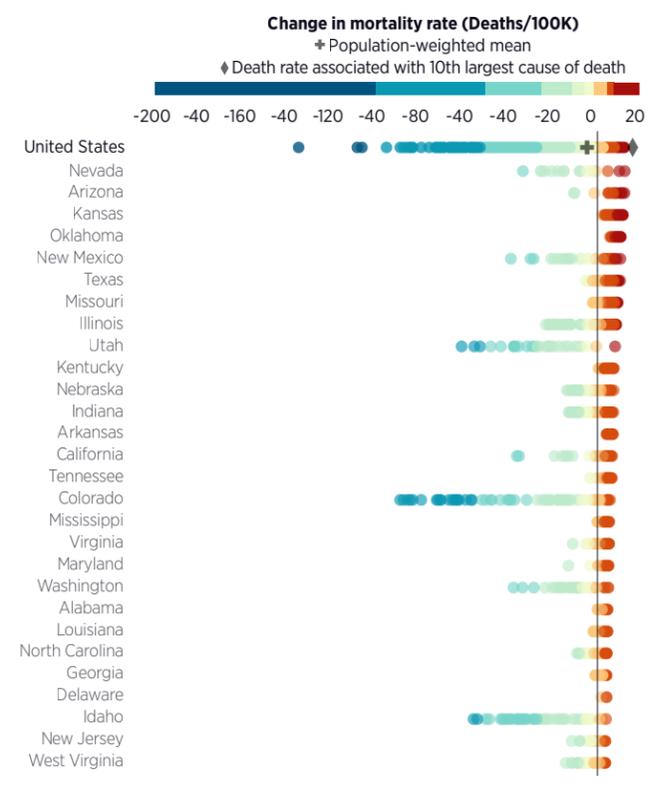
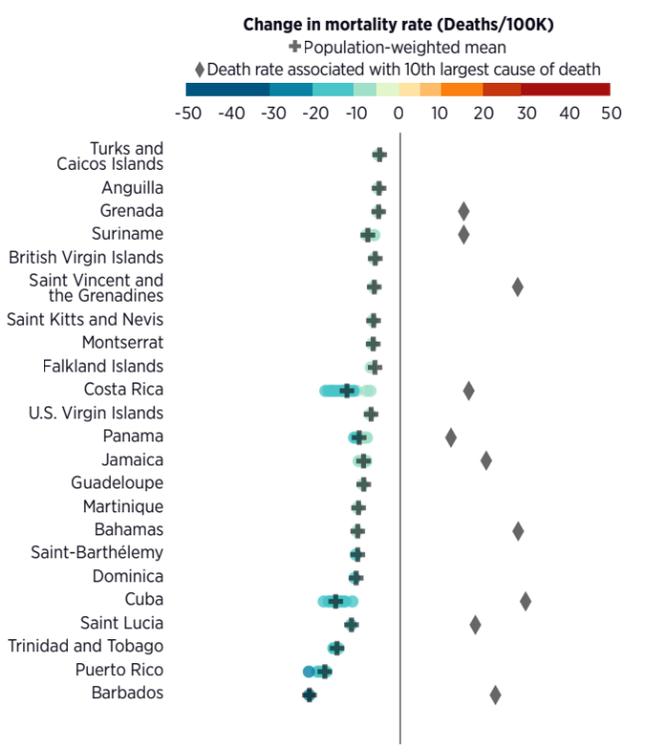
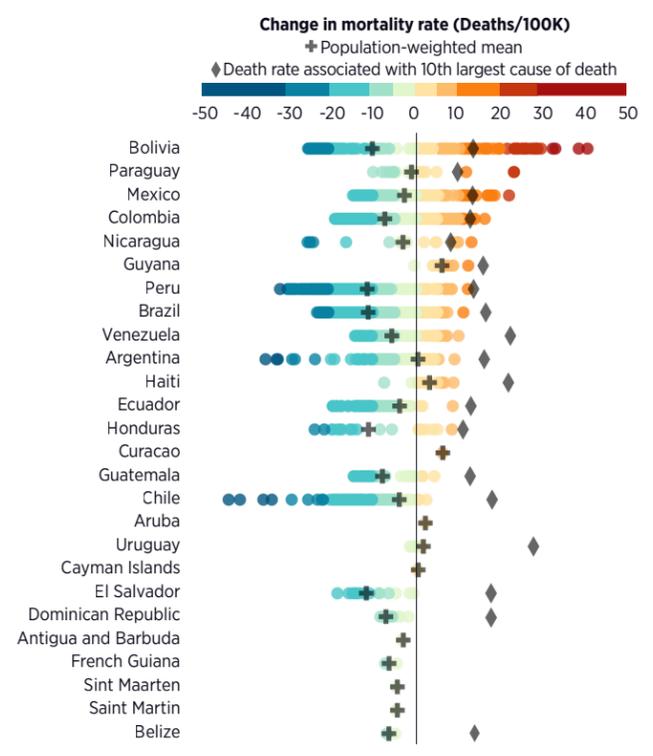
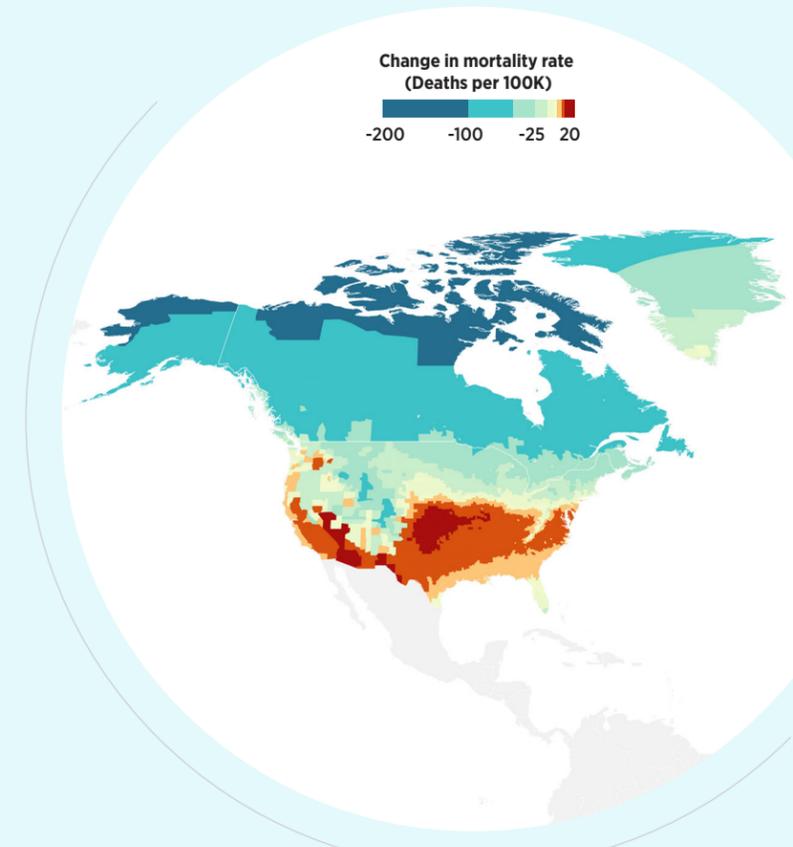


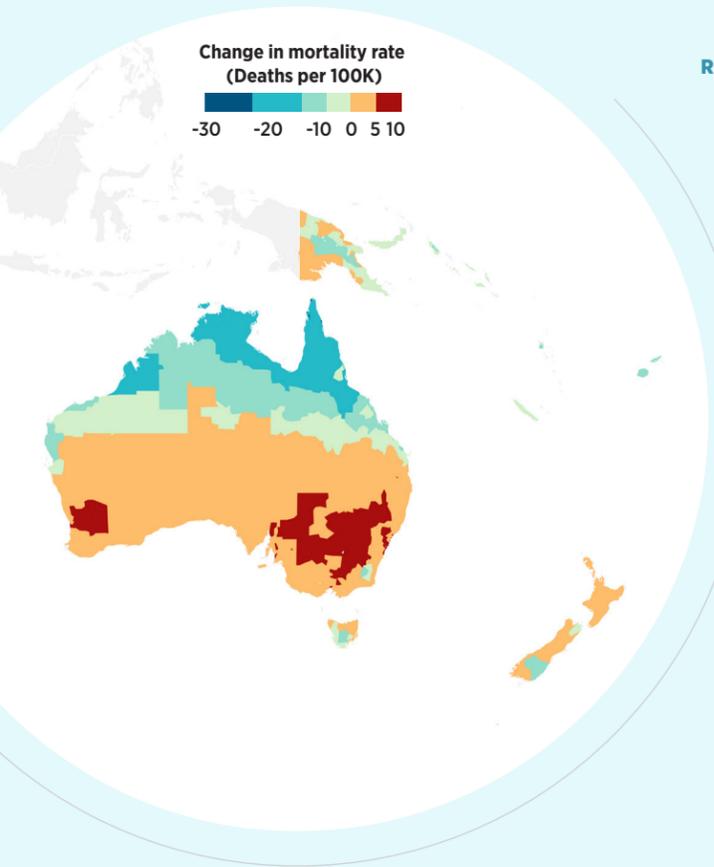
**REGIONAL SPOTLIGHT**  
**Latin America and The Caribbean**

CIL's temperature-related mortality projections indicate a wide range of outcomes across Latin America and the Caribbean. The most negatively impacted areas are concentrated in Bolivia, Paraguay, and northern Mexico, with those in Bolivia set to experience increases in mortality exceeding 30 deaths per 100,000. The magnitude of additional temperature-related deaths in these most impacted areas is similar to that of road injuries in Paraguay and cirrhosis of the liver in Mexico. Many of these areas are not densely populated, however; only one major city in the Latin American region is expected to see a significant increase in mortality (Juárez, Mexico; 21 deaths per 100,000). The high-altitude areas of the Andes and the Brazilian Plateau are projected to see significant decreases in net mortality rates due to fewer cold-related deaths.

**REGIONAL SPOTLIGHT**  
**North America**

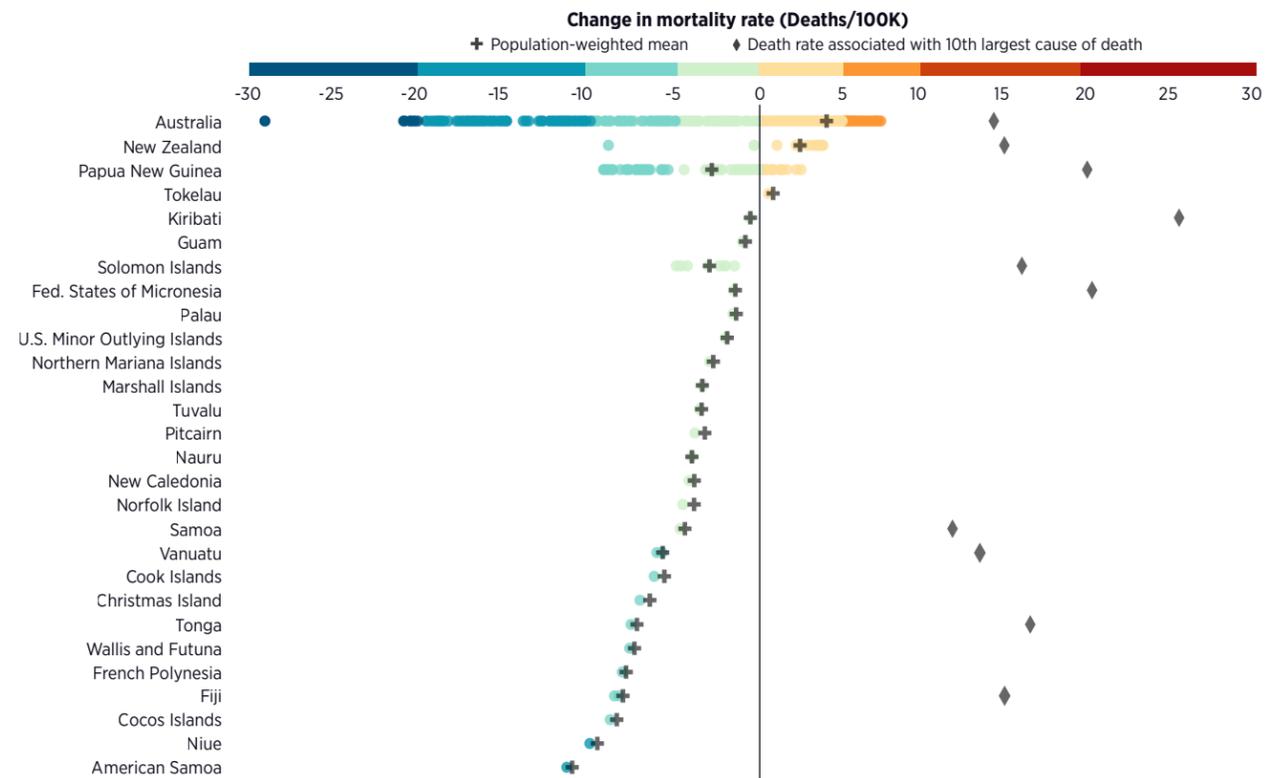
CIL projects that temperature-related mortality will significantly decrease across the vast majority of North America, including all of Canada. Despite this net benefit, the northern half of the United States will be exposed to an increase in extreme heat on a seasonal basis. Heatwaves like those in the Pacific Northwest (2021) and Chicago (1995), are projected to increase heat-related deaths while cold-related deaths decline in the same areas. Regions in the southwestern and central United States are expected to experience increases in net mortality rates exceeding 10 deaths per 100,000, including the cities of Las Vegas (15 deaths per 100,000) and Phoenix (12 deaths per 100,000), but those changes in mortality rates do not reach those of the 10 largest causes of death in the United States today.





## REGIONAL SPOTLIGHT Oceania

Australia is projected to see the greatest increase in temperature-related mortality across Oceania. We project portions of the southeast and southwest of the country will experience mortality changes exceeding 5 deaths per 100,000, including Sydney (7 deaths per 100,000) and Perth (5 deaths per 100,000). No areas in Australia are projected to see a change in mortality on par with current leading causes of death. Elsewhere in the region, including New Zealand, Papua New Guinea, and the Small Island Developing States of the Pacific, CIL projects modest changes in temperature-related mortality rates and, in most areas, decreasing temperature-related mortality rates.



## GLOBAL SPOTLIGHT Ranked Country Table

REGION	RATE	REGION	RATE
<b>Africa</b>		Tajikistan	15
Niger	68	Azerbaijan	14
Burkina Faso	60	Saudi Arabia	14
Djibouti	55	China	11
Chad	47	Kyrgyzstan	11
Mauritania	42	Cambodia	10
Sudan	40	Bahrain	10
Mali	37	Myanmar	9
Togo	32	Armenia	9
Somalia	27	Turkey	7
Benin	23	Qatar	5
Guinea-Bissau	19	Laos	5
Ghana	19	<b>Europe</b>	
Senegal	16	Moldova	19
Central African Republic	14	Serbia	13
Gambia	12	Greece	11
Cote d'Ivoire	11	Spain	10
Egypt	10	Italy	10
Algeria	10	Portugal	9
Tunisia	9	Macedonia	7
Nigeria	8	Albania	6
Sierra Leone	8	<b>Latin America and Caribbean</b>	
Cameroon	7	Curaçao	6
Guinea	6	Guyana	6
South Sudan	5	<b>North America</b>	
<b>Asia</b>		—	—
Pakistan	51	<b>Oceania</b>	
Kuwait	25	—	—
Bangladesh	24		
Iran	21		
Uzbekistan	21		
Syria	19		
Turkmenistan	18		
Iraq	18		
Georgia	16		

Note: Change in population-weighted country-level net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average organized by continent. Only countries with a net increase in mortality rate greater than 5 deaths per 100,000 are shown.

## Ranked City Table

REGION	RATE
<b>Asia</b>	
Faisalabad, Pakistan	81
Multan, Pakistan	72
Gujranwala, Pakistan	67
Lahore, Pakistan	55
Peshawar, Pakistan	40
Hyderabad City, Pakistan	40
Khulna, Bangladesh	36
Rawalpindi, Pakistan	29
Islamabad, Pakistan	28
Tehran, Iran	25
Kuwait City, Kuwait	25
Riyadh, Saudi Arabia	24
Ad Dammam, Saudi Arabia	24
Aleppo, Syria	23
Karachi, Pakistan	22
Dhaka, Bangladesh	22
Mosul, Iraq	21
Heze, China	21
Suzhou, China	21
Medina, Saudi Arabia	20
Zaozhuang, China	20
Jining, China	20
Handan, China	20
Tongshan, China	20
Jinan, China	20
Baoding, China	19
Tai'an, China	19
Shuyangzha, China	19
Shijiazhuang, China	19
Xianyang, China	19
Linyi, China	19
Lu'an, China	19
Zibo, China	18
Gaziantep, Turkey	18

REGION	RATE
Tbilisi, Georgia	18
Huainan, China	18
Shangqiu, China	18
Xi'an, China	18
Tianjin, China	18
Zhengzhou, China	18
Nanyang, China	17
Huaiyin, China	17
Tashkent, Uzbekistan	17
Ankang, China	17
Esfahan, Iran	17
Beijing, China	16
Xiangyang, China	16
Karaj, Iran	16
Weifang, China	16
Ashgabat, Turkmenistan	16
Luoyang, China	16
Xinyang, China	15
Yerevan, Armenia	15
Jingling, China	15
Mizhou, China	15
Huzhou, China	15
Xiantao, China	15
Wuxi, China	14
Ma'anshan, China	14
Sanzhou, China	14
Adana, Turkey	14
Changzhou, China	14
Tangshan, China	14
Hefei, China	14
Nanjing, China	14
Qingdao, China	13
Gaoping, China	13
Dushanbe, Tajikistan	13
Baku, Azerbaijan	13

REGION	RATE
Amritsar, India	13
Suzhou, China	12
Mandalay, Myanmar	12
Suining, China	12
Shanghai, China	12
Guiyang, China	12
Mianyang, China	12
Changde, China	12
Chittagong, Bangladesh	12
Wuhan, China	12
Yiyang, China	12
Kunming, China	11
Ningbo, China	11
Hangzhou, China	11
Jinhua, China	11
Shiraz, Iran	10
Chengdu, China	10
Nay Pyi Taw, Myanmar	10
Neijiang, China	10
Shangrao, China	10
Osaka, Japan	10
Luzhou, China	10
Kyoto, Japan	10
Ürümqi, China	10
Nagoya, Japan	10
Kobe, Japan	10
<b>Africa</b>	
Niamey, Niger	69
Djibouti, Djibouti	64
Omdurman, Sudan	63
Ouagadougou, Burkina Faso	51
N'Djamena, Chad	43
Khartoum, Sudan	43
Bamako, Mali	22

REGION	RATE
Mogadishu, Somalia	19
Lomé, Togo	16
Cotonou, Benin	13
Accra, Ghana	11
Giza, Egypt	11
Kumasi, Ghana	11
<b>Europe</b>	
Madrid, Spain	16
Florence, Italy	15
Turin, Italy	15
Chisinau, Moldova	15
Milan, Italy	15
Belgrade, Serbia	14
Rome, Italy	10
<b>Latin America &amp; Caribbean</b>	
Juárez, Mexico	21
<b>North America</b>	
Las Vegas, United States	15
Phoenix, United States	12
<b>Oceania</b>	
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City table: Change in net mortality rates (deaths per 100,000 people) in 2050 compared to the 2001-2010 average organized by continent. Only cities with a net increase in mortality rate greater than 10 deaths per 100,000 and current population exceeding 500,000 are shown.

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## About the Authors

**Emily Grover-Kopec** is a Director within the Energy and Climate practice at Rhodium Group and leads the firm's work with the Climate Impact Lab, which provides expertise on climate science, multi-disciplinary research software development, and the creation of products that bridge the Lab's research to decision makers. Prior to joining Rhodium Group, she spent more than a decade focusing on catastrophe modeling for the insurance industry at Risk Management Solutions (RMS), now a part of Moody's. Emily also brings experience from Columbia University's International Research Institute for Climate and Society (IRI), where her work concentrated on monitoring climate impacts and developing climate monitoring tools, particularly for the Global South. She has served as a member of the Climate-Related Financial Risk Advisory Committee for the U.S. Department of the Treasury and currently serves as a member of the Board of Directors for Insurance for Good. Emily holds a B.S. in Atmospheric, Oceanic, and Space Sciences from the University of Michigan and an M.S. in Meteorology from Penn State University.

**Tamma Carleton** is the Faculty Head of Research for the Climate Impact Lab (CIL) and an Assistant Professor in the Department of Agricultural and Resource Economics at University of California, Berkeley. Previously, Tamma was an Assistant Professor at the Bren School of Environmental Science & Management at the University of California, Santa Barbara (UCSB) and a postdoctoral scholar in the Kenneth C. Griffin Department of Economics at the University of Chicago. Tamma's research combines economics with data science, remote sensing, and climate science to improve quantitative understanding of how global environmental change influences and is shaped by economic development. Tamma worked with CIL while completing her PhD at the University of California, Berkeley, where she was also a U.S. Environmental Protection Agency STAR Fellow. A Rhodes Scholar, Tamma earned master's degrees at the University of Oxford and she has a BA in Economics from Lewis & Clark College in Portland, Oregon.

**Michael Greenstone** is the Milton Friedman Distinguished Service Professor in Economics at the University of Chicago. In addition, he serves as the founding director of the University's Institute for Climate and Sustainable Growth and the director of the interdisciplinary Energy Policy Institute at the University of Chicago. He was previously the director of the Becker Friedman Institute for Economics. During the Obama Administration, he served as the Chief Economist for the President's Council of Economic Advisers, where he proposed and then co-led the development of the United States Government's social cost of carbon. He is an elected member of the American Academy of Arts and Sciences, a fellow of the Econometric Society, a Carnegie Fellow (aka the "Brainy Award"), and a former editor of the *Journal of Political Economy*. Formerly, Greenstone was the 3M Professor of Environmental Economics at MIT and directed The Hamilton Project. Greenstone's research, which has influenced policy in the United States and globally, is focused on the global energy challenge that requires all societies to balance the needs for inexpensive and reliable energy, protection of the public's health from air pollution, and minimizing the damages from climate change. Greenstone received a Ph.D. in Economics from Princeton University and a B.A. in Economics with High Honors from Swarthmore College.

The authors appreciate the contributions of Elliot Grenier (University of Chicago) for his analytical support.

Part of the Energy Policy Institute at the University of Chicago (EPIC), the Climate Impact Lab's global network of economists, climate scientists, data engineers, and risk analysts are identifying where climate adaptations are most needed and what investments will deliver the greatest benefits to communities. This work builds off of a decade of research that projected the impacts of climate change globally and locally on mortality, agricultural productivity, labor supply, energy demand and coastal flooding risk. Published in the world's leading scientific and economics journals, the research formed the basis for the US Government's official estimate of the cost of climate change and has been used by the International Monetary Fund and Federal Reserve, private companies like Nike, Microsoft and Realtor.com, and the United Nations Development Programme.

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