Statement of Michael Greenstone

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Thank you, Chairman Whitehouse, Ranking Member Grassley, and members of the Committee for inviting me to speak today.

My name is Michael Greenstone, and I am the Milton Friedman Distinguished Service Professor in Economics and Director of the Becker Friedman Institute and Energy Policy Institute at the University of Chicago. I also serve as co-director of the Climate Impact Lab, a multi-disciplinary collaboration of researchers working to quantify the long-term impacts of climate change. My research focuses on estimating the costs and benefits of societies' energy and environmental choices.

I appreciate the opportunity to speak with you today about the projected health costs of climate change and the impacts of climate change on the broader economy.

Over the last year, the world has been experiencing record hot temperatures: Summer 2022 was the second hottest ever recorded in the Northern Hemisphere. A weather station in Death Valley, California, clocked a scorching 53°C (127°F) in September, one of the hottest temperatures ever observed on Earth. Officials from Delhi to Tokyo to Baghdad, cities where past heat waves have claimed hundreds of lives, are bracing for dangerously hot periods. And yet, this is nothing new. Year after year heat records are broken all over the world.

Temperature's toll on public health, particularly the toll from extreme temperatures, is likely to be one of the dominant costs of climate change. Thus, given our ability today to alter the path of temperature change through the release of greenhouse gases, understanding the relationships between temperature change, mortality, and the monetary costs of this mortality, is essential to determining appropriate responses to climate change. So, what impact will temperature have on public health, and how much will it cost? The paper, "Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits" that I authored with my colleagues at the Climate Impact Lab, and which was published in *The Quarterly Journal of Economics* last year, addresses these critical questions.

I want to emphasize from the outset one data challenge with the paper's results that is due to the state of climate science. This research produces local (e.g., at the U.S. county level) climate impact estimates and thus requires local projections of what will happen to temperatures in the future. Such climate projections are only available for two climate scenarios: RCP8.5 which is considered a "high-emissions scenario" and RCP4.5 which is considered a "moderate-emissions scenario." Given current trends and policies, the high-emissions pathway likely overstates the growth of emissions, while the moderate-emissions pathway likely understates it. Throughout the testimony I will present results using both pathways, but the true impacts of climate change from our current trajectory are likely to lie between the estimates based on these two emissions pathways.

In the remainder of my statement, I will make the following points:

1. To measure the impact of climate-driven temperature changes on mortality risk, my colleagues and I compiled the largest sub-national vital statistics database in the world, detailing 399 million deaths across 40 countries accounting for 38% of the global population. We divided the world into more than 24,000 regions that are each about the size of a U.S. county.

2. We found that the global mortality risk is projected to increase by 85 deaths per 100,000 people by 2100 under the high-emissions scenario in which average global temperatures increase by around 3.7°C (6.7°F) relative to 2001-2010 temperatures. This is greater than the current global mortality rate—66 deaths per 100,000 people—from all infectious and parasitic diseases combined (excluding COVID-19). Under the moderate-emissions scenario—which is expected to increase temperatures by 1.6°C (2.9°F)—the global mortality risk is projected to increase by 14 deaths per 100,000 people, comparable to the global mortality rate from diabetes (19 per 100,000). The mortality consequences will be the largest in places that today are hot and/or poor.

3. In the United States, and under the high-emissions scenario, the mortality risk is projected to increase by 10 deaths per 100,000, about on par with our current fatality rate from auto accidents. Many areas will experience mortality risks that are significantly higher, including areas represented by members of this committee, which I will detail. In contrast, some areas will benefit as the number of deadly cold days declines, but again on average mortality risk will increase. Although the average mortality risk in the United States under the moderate-emissions scenario is projected to be essentially unchanged, there remain substantial geographic differences in these impacts, with many areas expected to see sizable increases in mortality risk and others expected to see declines.

4. On our current emissions trajectory—which lies in-between these two representative scenarios—we can expect climate-induced mortality risk to be in-between the two estimates. In this regard, policy has the potential to deliver some of the most significant public health gains in human history. Bringing global emissions down to moderate levels—not even as low as the Paris Agreement's long-term targets—would reduce expected warming by around 2.1°C (3.8°F) at the end of the century and the attendant global mortality risk by 83% compared to the high-emissions pathway. As I highlighted above, under this moderate-emissions scenario, the total mortality risk due to climate-induced temperature changes would be eliminated in the United States.

5. This research is the basis for the new social cost of carbon estimates showing that the Trump and Obama administrations have underestimated the full social cost of carbon, in the former case dramatically so. As a part of a recent rulemaking, the Environmental Protection Agency (EPA) has proposed updating its estimate of the social cost of carbon to $190 from the Biden administration's interim value of $51. This revision is an accurate reflection of recent advances in the literature on climate change and its economic impacts and incorporates recommendations made by the National Academies of Science, Engineering, and Medicine in 2017 (U.S. EPA 2022). The advances include those detailed in this testimony.

1 Mortality Consequences of Climate Change

1.1 Research Design and Relationship between Temperatures and Mortality Rates

Before detailing our research findings about the relationship between mortality risk and climate change, let me first explain how we produced our results. The study uses mortality records to quantify how death rates around the world have been affected by observed climate-induced temperature changes. We do so by compiling the largest sub-national vital statistics database in the world, detailing 399 million deaths across 40 countries accounting for 38% of the global population. We combine these records with decades of detailed daily and local temperature observations.

The data reveal a U-shaped relationship where extreme cold and hot temperatures increase mortality rates, especially for the elderly. Further, the effects of extreme cold and hot temperatures are attenuated by both higher incomes and adaptation to local climate (e.g., robust heating systems in cold climates and cooling systems in hot climates).

We then use these estimates of the mortality-temperature relationship to generate projections of the future impacts of climate-induced temperature changes on mortality rates, dividing the world into 24,378 regions containing roughly 300,000 people each—about the size of a U.S. county. With a new technique to measure the total cost of adaptive behaviors and technologies, these projections capture the full mortality risk of climate-induced temperature changes. In other words, this is the first study to account for direct mortality impacts and both the benefits and costs of adaptation.

These estimates include three projections for future income and population growth and simulations from 33 climate models, allowing for an assessment of the uncertainty surrounding any particular projection. The full estimates also reflect statistical uncertainty related to the underlying economic and health data.

To reiterate a point made above, we obtain estimates of mortality impacts using two different trajectories of future greenhouse gas emissions. The first is a high-emissions scenario, where temperatures are projected to rise by around 3.7°C (6.7°F) by 2100 relative to 2001-2010 levels. The second is a more moderate-emissions scenario, where temperatures would rise by around 1.6°C (2.9°F). Given current trends and policies, the high-emissions pathway likely overstates the growth of emissions, while the moderate-emissions pathway likely understates it. Our current emissions trajectory lies in between these two scenarios. Ultimately, advances in technology, policy choices in countries around the world, and their interaction will determine the planet's emissions path.

1.2 Mortality Risk under Moderate and High-Emissions Scenarios

Under the high-emissions scenario (RCP8.5) our research finds that the full temperature-related global mortality risk is projected to rise by the equivalent of 85 deaths per 100,000 people in 2100, compared to a world with no warming above the 2000-2010 average. Under the moderate-emissions scenario (RCP4.5) this mortality risk is projected to increase by 14 deaths by 100,000 people. I say full mortality risk because our projections reflect changes in both the number of deaths and the money and time people will spend to protect themselves against high and low temperatures through adaptation.

As I noted in my opening, the projected impact of temperature on mortality at the end of the century under the high-emissions scenario is greater than the current death rate for all infectious and parasitic diseases (except COVID-19)—including tuberculosis, HIV, malaria, dengue, yellow fever, and diseases transmitted by ticks, mosquitoes, and parasites—combined: approximately 66 deaths per 100,000 globally (See Figure 1). It is smaller than, but comparable to, the overall cancer mortality rate, which is 121 deaths per 100,000 globally (World Health Organization 2020). Under the moderate-emissions scenario, the projected increase in mortality risk is comparable to the global diabetes mortality rate, which is around 19 deaths per 100,000.

An especially striking finding is that the damages from climate-induced temperature changes discussed above will be unevenly distributed both globally and within the United States, as Figure 2 and Figure 3 illustrate for the high-emissions and moderate-emissions scenarios, respectively. Globally, we find that the mortality risk of climate-induced temperature changes disproportionately falls on regions that are poorest and hottest today, exacerbating existing inequality.

For example, in Accra, Ghana, climate change is predicted to lead to approximately 100 more days a year with the day's average temperature above 32°C (90°F) under the high-emissions scenario. This increase raises the city's mortality rate by about 19%. The climate-induced temperature-related mortality risk at the end of the century there under this scenario is projected at roughly 160 additional deaths per 100,000 people. Under the moderate-emissions scenario, this figure is 35 additional deaths per 100,000 people.

In contrast, colder and relatively wealthier Oslo, Norway, is projected to see benefits equivalent to saving approximately 230 lives per 100,000 people under the high-emissions scenario, and 140 lives per 100,000 people under the moderate-emissions scenario. These differences reflect Oslo's means to adapt to additional warm days, as a wealthy nation, and the benefit that the population experiences as climate change reduces the number of deadly cold days. In fact, in high-income places such as Oslo, the mortality-related risks of climate-induced temperature changes are mainly damages to the economy because of increased adaptation costs. In contrast, in low-income places like Accra, the damages of climate-induced temperature changes are projected to be felt as significant increases in death rates on hot days.

Another feature of the global projections is that the distribution of benefits and costs is troubling from a geopolitical or international relations perspective. The places that are expected to benefit (e.g., Northern Canada and Russia) are relatively sparsely populated, while the locations that are projected to become much more lethal (e.g., India, Pakistan, and Sub-Saharan Africa) are densely populated and home to several billion people. It is not difficult to imagine the possibility of substantial migration from these newly relatively more dangerous locations to the newly relatively more desirable areas. This kind of climate-induced migration could be at a scale that political systems are unable to accommodate without disruption. The precise consequences are difficult to predict but highly negative ones cannot be dismissed. These costs are outside the analysis that I'm discussing today but would nevertheless be real.

Turning to the United States, it is projected to see its mortality risk rise by 10 deaths per 100,000 at the end of the century under the high-emissions scenario. This mortality risk is about on par with the current fatality rate from auto accidents in the U.S.—roughly 12 deaths per 100,000 (World Health Organization 2018). Under the moderate-emissions scenario, this mortality risk would decrease by 0.1 deaths per 100,000. Again, it is important to highlight here that our current trajectory lies in between these two standardized scenarios; on it, we should expect to see a mortality risk in between these two numbers.

Domestically, risk differs depending on where you live. Table 1 shows mortality risks for each state under each emissions scenario. I will list some county-level examples here.

In my hometown of Chicago, the mortality risk is projected to decrease by about 34 lives per 100,000 by 2100 under the high-emissions scenario, and 39 lives per 100,000 by 2100 under the moderate-emissions scenario. My city will see more hot days, and it will pay to adapt to them. But, it also typically sees a lot of extremely cold days. Over time, we will see fewer of those cold days, decreasing mortality risk during the winter and—combined with the additional adaptation measures—giving Chicago a net benefit.

Orange County, California (which is represented by Senator Padilla), on the other hand, does not have the chance to benefit from a reduction in cold days—there are few already. People there can pay to adapt to additional hot days, but it will not be enough to offset the loss of life. There, temperature-related mortality risk is projected to increase by 38 deaths for every 100,000 people under the high-emissions scenario and 20 deaths for every 100,000 people under the moderate-emissions scenario. The mortality risk under the high-emissions scenario is on par with the current U.S. mortality rate for Alzheimer's disease (37 deaths per 100,000; Kochanek et al. 2019).

Washington, D.C., is also projected to experience a higher mortality risk under either scenario—around 32 deaths per 100,000 by 2100 under the high-emissions scenario, and 13 deaths per 100,000 by 2100 under the moderate-emissions scenario. In Henrico County, Virginia (which is represented by Senators Warner and Kaine), there is a projected increase of about 35 deaths per 100,000 under the high-emissions scenario and 17 deaths per 100,000 under the moderate-emissions scenario. Caddo Parish, Louisana (which is represented by Senator Kennedy) is projected to face an increase of about 28 and 16 deaths per 100,000 under the high-emissions and moderate-emissions scenario, respectively; similarly, Johnson County, Kansas (which is represented by Senator Marshall) will see an increase of 31 and 11 deaths per 100,000 under the high-emissions and moderate-emissions scenario, respectively. In all of these cases, the mortality risk is comparable to the current U.S. mortality rate for diabetes (26 deaths per 100,000) and for the flu and pneumonia (17 deaths per 100,000; Kochanek et al. 2019).

In sum, both here in the United States and around the world climate-induced temperature changes will leave some regions as winners and others as losers. But the clear message from the data is that, under the high-emissions scenario, the United States and the world as a whole will lose on net. However, the data also reveal that the moderate-emissions scenario would dramatically lower the mortality costs of climate change. These findings highlight the value of policy that reduces emissions.

1.3 Policy has the Potential to Deliver High Returns

The level of greenhouse gas emissions is not a law of physics but rather reflects policy choices about restricting emissions and technical advances that can be accelerated by policy. It is therefore instructive to consider the benefits of different potential policies, one of which would be a policy moving us from a high-emissions path to a moderate-emissions (RCP4.5) path—reducing warming at the end of the century from 3.7°C to 1.6°C (or 6.7°F to 2.9°F). Given the high-emissions path (RCP8.5) likely overstates emissions growth, this evaluation will overstate the gains of moving from the current emissions pathway to the moderate-emissions path; still, we use it here as an illustrative example of the substantial health and mortality benefits from robust policy reducing emissions.

This illustrative reduction in warming, which still falls short of achieving the Paris Agreement's long-term targets, would lead to dramatically lower mortality risks compared to the high-emissions scenario. For example, the projected end of century total global mortality risk from climate-induced temperature change falls 84% relative to a scenario of continued high emissions (from 85 to 14 additional deaths per 100,000). Accra, Ghana would see its mortality risk sink from 160 deaths per 100,000 people to 35 deaths per 100,000 people.

In the United States, the increased mortality risk would be completely eliminated, with −0.1 deaths for every 100,000 people instead of 10 deaths per 100,000. Looking around the country, Chicago sees a slight improvement. But the real gains happen in higher-risk areas. Orange County reduces its temperature-related mortality risk from 38 deaths per 100,000 to 20 deaths. Washington, DC sees its mortality risk more than cut in half—from 33 deaths per 100,000 to 13. Similar decreases occur in Henrico County (35 deaths to 17 deaths), Caddo Parish (28 deaths to 16 deaths), and Johnson County (31 deaths to 11 deaths).

The bottom line is that this illustrative example demonstrates that policies reducing greenhouse gas emissions have the potential to bring some of the most significant public health gains in human history, both domestically and globally. Our example of policies moving from a high-emissions trajectory to a moderate-emissions trajectory would reduce global mortality risk by 71 deaths per 100,000, as shown in Figure 4. Using the same benchmarks as previously, this reduction is similar to eliminating all deaths from infectious and parasitic diseases other than COVID-19 (66 deaths per 100,000) and on a similar scale to eliminating all deaths from cancer (121 per 100,000).

2 Projected Climate Damages and the Social Cost of Carbon as a Guidepost

How can these reductions in emissions be achieved? A key instrument for any climate policy is an estimate of the social cost of carbon (SCC) that is based on a frontier understanding of climate science and economics. The SCC is the monetary cost of the damages, present and future, caused by the release of an additional ton of carbon dioxide into the atmosphere. Simply put, it reflects the cost of climate change—accounting for elevated mortality rates as well as the destruction of property from storms and floods, declining agricultural and labor productivity, and so forth.

The SCC is arguably the most important component of regulatory policy in this area because, by calculating the costs of climate change, the social cost of carbon allows for the calculation of the monetary benefits of regulations that reduce greenhouse gases. For example, if the value of the social cost of carbon was $51 as the Obama administration set it (and also equal to the Biden administration's interim value), a regulation that reduces carbon dioxide emissions by 10 tons would have societal benefits of $510. These benefits can then be compared to the costs that the regulation imposes to determine whether the regulation is on net socially desirable.

Since the establishment of the United States Government's SCC in 2010, it has been used to guide the design of more than 80 regulations. These regulations have resulted in more than $1 trillion of gross benefits (Nordhaus 2017).

Critically, the SCC can also be used to determine an efficient price for market-based policies for combating climate change, such as a carbon tax or cap-and-trade system. If set at the value of the SCC, these pricing approaches will ensure that we are pursuing policies where the benefits exceed the costs. A great appeal of these approaches is that they unleash market forces to uncover the least expensive ways to reduce emissions without requiring an *ex-ante* knowledge of which sector these reductions will come from, thereby minimizing costs to the economy.

Regardless of the policy approach used, a social cost of carbon based on the best available peer-reviewed research is a key ingredient in beneficial policy. To detail how we get there, it is important to first understand where the SCC came from and how it has evolved.

2.1 The History of the Social Cost of Carbon

The development of the SCC has a history that goes back to my time as the Chief Economist for President Obama's Council of Economic Advisors. In 2008, the 9th Circuit Court of Appeals ruled that the Department of Transportation needed to update its regulatory impact analysis for fuel economy rules with an estimate of the SCC.[1] The court directed that "while the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero." So, the Department of Energy, the Department of Transportation, and the EPA began to incorporate a variety of individually developed estimates of the SCC into their regulatory analyses. These estimates were derived from the academic literature and ranged from zero—which they were instructed by the court to no longer use—to $159 per metric ton of carbon dioxide emitted (U.S. Government Accountability Office 2020).

To improve consistency in the government's use of the SCC, I, along with Cass Sunstein, then the Administrator of the White House Office of Information and Regulatory Affairs and now a professor at Harvard, assembled and co-led an interagency working group to determine a single government-wide SCC. The team consisted of top economists, scientists, and lawyers from four other offices in the Executive Office of the President and six federal agencies, including the EPA and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury.

The process of developing the SCC took approximately a year and included an intense assessment of the best available peer-reviewed research and significant debate and discussion amongst the team of experts from across the federal government. It also included careful consideration of public comments on the interim values that agencies had been using and an interim value determined by the interagency group. Ultimately, the interagency working group determined a central estimate of $21 per metric ton. That estimate has since been revised to reflect updates of the models that underlie it and as of 2016 was about $51; I believe this is the basis for the Biden administration's choice of an interim value.

To ensure that the next SCC update keeps up with the latest available science and economics, in 2015 the Office of Management and Budget directed the National Academy of Sciences (NAS) to help in providing advice on approaches to future updates. In 2017, the NAS released its recommendations after a comprehensive assessment informed by ongoing public comments and peer-reviewed literature, for which I served as a reviewer. The NAS report identified important ways to take advantage of an improved understanding of the social and economic impacts of climate change. It proposed a new framework that strengthened the scientific

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[1] *Center for Biological Diversity v. National Highway Traffic Safety Administration* 2008.

basis of the calculation, provided greater transparency in the process, and improved the characterization of the uncertainties of the estimates.

In March 2017, President Trump's Executive Order 13783 disbanded the Interagency Working Group on Social Cost of Greenhouse Gases, withdrawing its official estimates of the SCC. In 2018, the EPA released a regulatory impact analysis for greenhouse gas emission guidelines that established a new SCC estimate between $1 and $7. To arrive at this number, the EPA made methodological changes that in my judgment cannot be justified by science or economics, and, in this respect, moved the SCC away from the frontier of understanding.

In the absence of federal leadership, I joined with Trevor Houser from Rhodium Group, Solomon Hsiang from the University of California, Berkeley, and Robert Kopp from Rutgers University to co-found a multi-disciplinary research institute, the Climate Impact Lab (CIL), in 2014. The CIL includes more than 30 climate scientists, economists, data engineers, and other experts. We are producing the world's first empirically derived estimate of the social cost of carbon that is in line with the latest evidence in climate science and economics.

2.2 A Frontier Approach to Estimating Climate Damages and the SCC

The CIL has combined an immense body of historical data on social, economic, and climate indicators with climate models to develop projections of the long-term impacts of climate change in five core sectors: human mortality (which I have summarized today), agricultural productivity, energy consumption, labor disutility, and coastal flooding. All these projections cover local regions across the globe.

These projections are monetized to determine the total costs of climate change and the social cost of carbon: the cost that emitting an additional ton of carbon imposes on current and future society. For instance, the monetization of the full mortality risk uses the EPA's value of a statistical life (VSL), which is then scaled across the globe using country-level incomes (Carleton et al. 2022).

Following the NAS guidelines, the CIL has developed a process to aggregate these sector-specific cost estimates. This process takes into account multiple dimensions of uncertainty, the ways in which people in the future will adapt to help in coping with climate change, and the implications of differences in damages across regions. Specifically, it factors in the existence of low-probability, high-impact temperature changes and the fact that poorer regions, for which damages have relatively larger welfare impacts, will face disproportionate climate damages.

The CIL's aggregation of climate damages leveraging NAS guidance leads to an estimated SCC of $190 per metric ton. The CIL SCC calculations uses socioeconomic and climate projections from Resources for the Future (RFF) (Rennert et al. 2022), which provides a single pathway taking into account some of the most up to date climate projections. (These projections are unfortunately not available at the local level.) As a basis of comparison, the full set of RFF projections resemble the moderate RCP4.5 emissions pathway when it is combined with a particular set of other socioeconomic assumptions.

This updated SCC estimate, based on frontier science and economics, is significantly higher than either President Trump's estimate of $7 per metric ton or President Obama's $51, as shown in Figure 5. A substantial portion of this difference comes from our updated understanding of mortality risk. This is especially striking because mortality risk only accounted for 4% of the Obama SCC of $51.[2]

Different assumptions can result in higher or lower SCCs, but our judgment is that the CIL assumptions are grounded in the latest scientific and economic knowledge. That said, the analysis used to derive our estimates has some important limitations—it does not account for geopolitical risk resulting from climate

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[2] Differences in the valuation of future damages also drive part of the gap between these SCCs; the EPA proposed $190 based on a 2% target discount rate, while the Obama and Trump administration's estimates used rates between 3% and 7%. Even with comparable discount rates, the CIL and EPA SCCs remain meaningfully higher than those used by previous administrations.

disruptions or migration as described above, trade-related responses to climate change are also excluded, and it does not include all possible sectors in which damages may occur. Overall, including such factors in our analysis is likely to result in an even higher estimate of the SCC.

3 Conclusion

Climate-induced temperature changes will have dramatic impacts on human life, with the high-emissions trajectory raising global mortality risk by 85 deaths for every 100,000 people by the end of the century, comparable to, or even greater than, the mortality impacts of all infectious and parasitic diseases today, outside of COVID-19. On this trajectory, the United States is projected to see its temperature-related mortality risk increase by 10 deaths for every 100,000 people by 2100, on par with the U.S. fatality rate from auto accidents today. Even on the moderate-emissions trajectory global mortality risk rises by 14 deaths for every 100,000 people, comparable to the global mortality impact of diabetes. Domestically, this trajectory would leave total mortality rates essentially unaffected, though this masks meaningful increases in some places and decreases in others. Thus, a robust climate policy that restricts emissions to a moderate trajectory or that even more stringently restricts emissions has the potential to deliver some of the greatest public health gains in human history.

Finally, a key guidepost to setting climate policy is a scientifically validated social cost of carbon, like the one that the Climate Impact Lab has constructed. This new research suggests that climate damages are about four times larger than was previously understood or reflected in United States policy. It is encouraging that the EPA's recently proposed revision of the social cost of carbon draws from the CIL estimate and in so doing aims to return it to the frontier of understanding.

Thank you for the opportunity to share this work with the Committee.

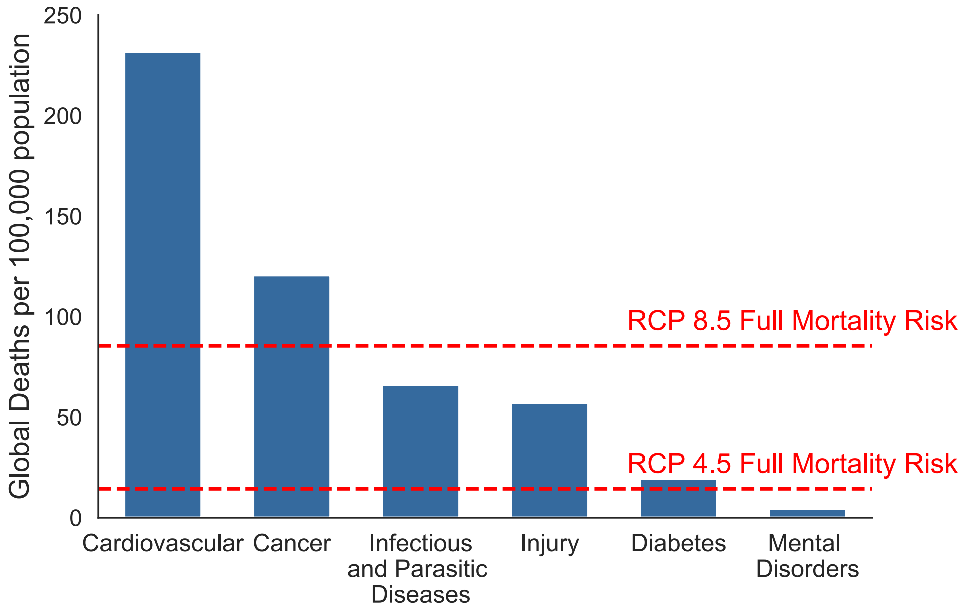
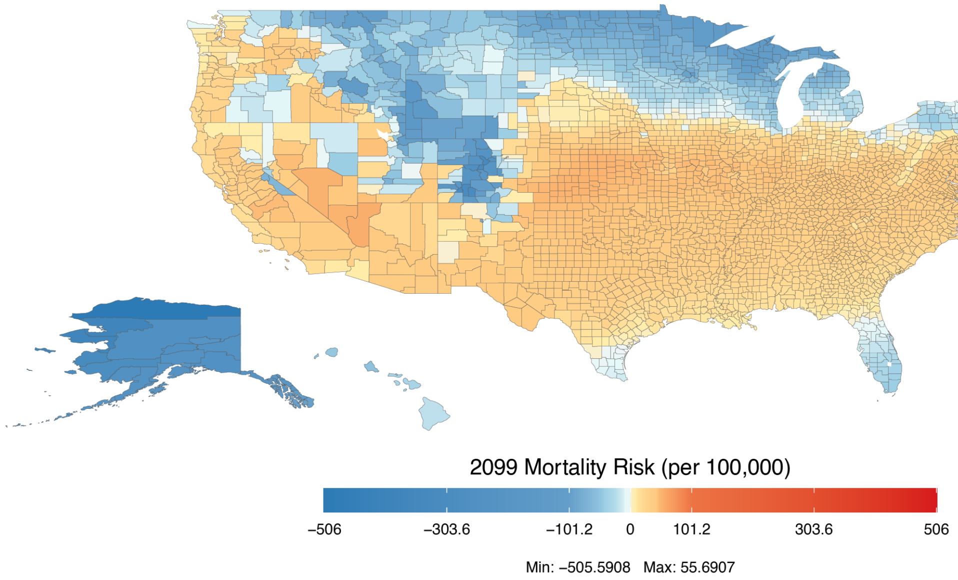
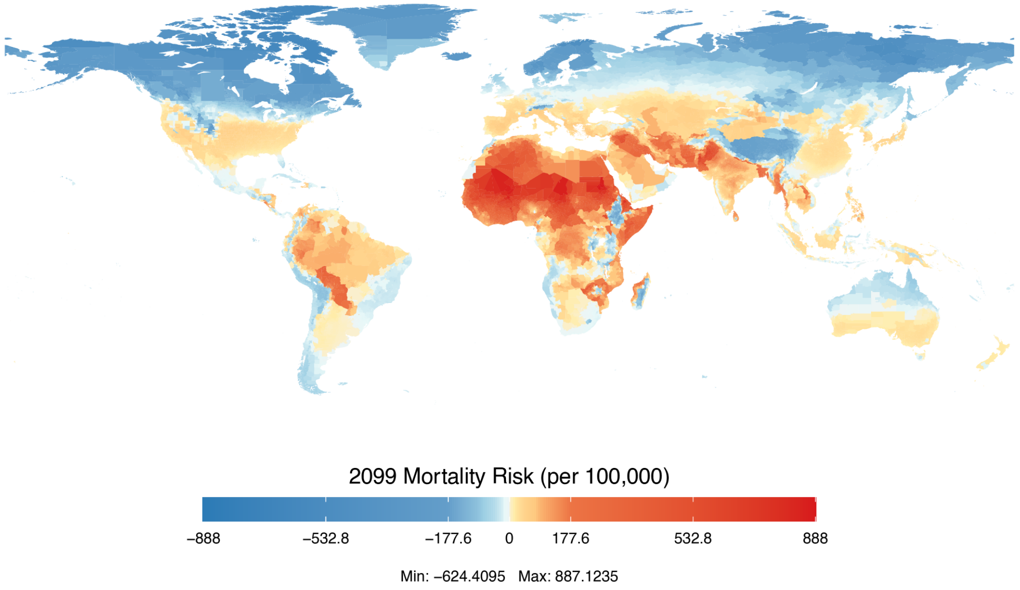


Figure 1: **The Mortality Impact of Climate Change in 2099 is Comparable to Contemporary Leading Causes of Death.** Projected mortality impacts of climate change (red) are calculated for the year 2099 under both the moderate and high-emissions scenarios (SSP3-RCP4.5 and SSP3-RCP8.5, respectively) and include changes in death rates in addition to adaptation costs measured in death equivalents. Blue bars indicate average mortality rates globally in 2019, with values from World Health Organization (2020).

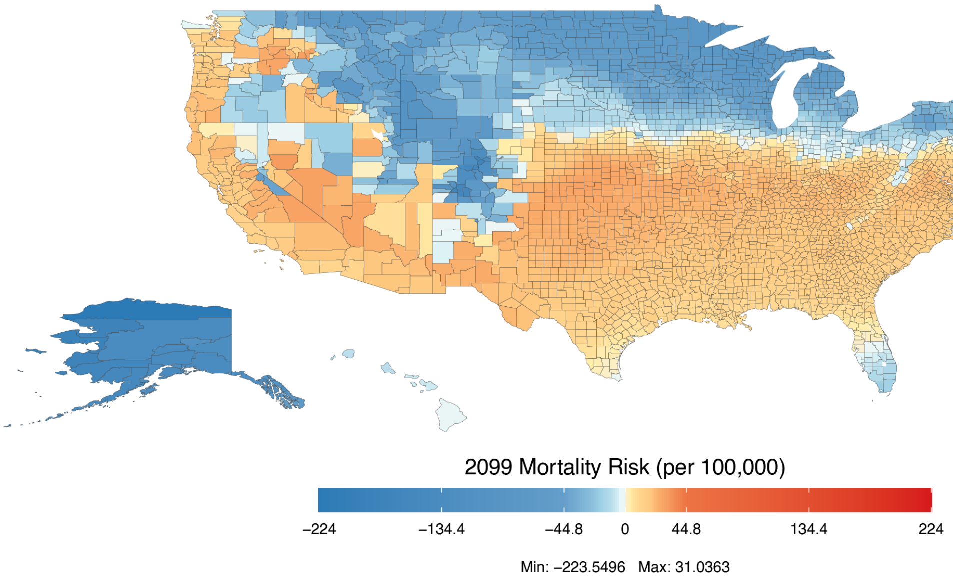


(a) RCP8.5 United States Spatial Distribution of Climate-Induced Mortality Risk at County Level

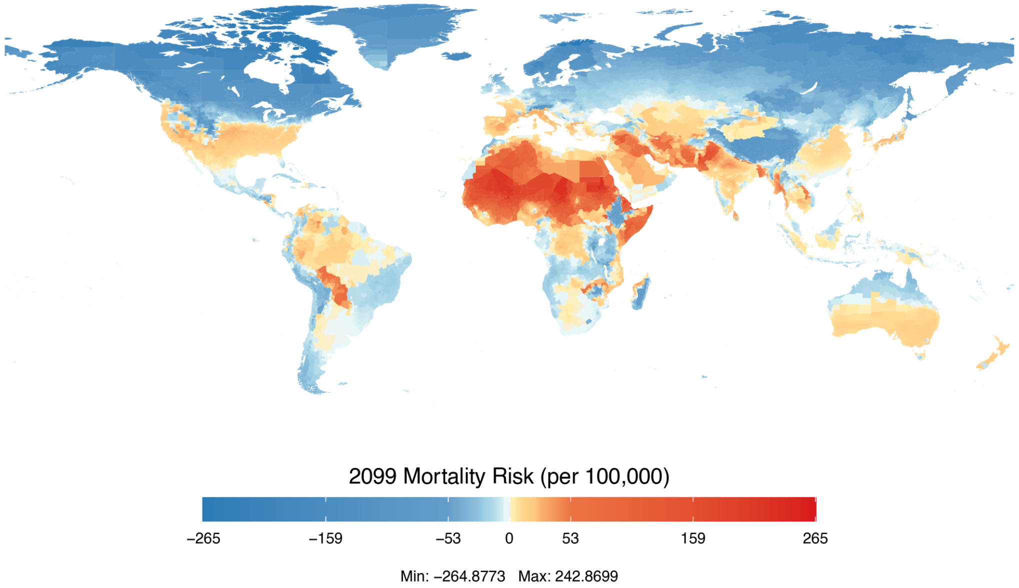


(b) RCP8.5 Global Spatial Distribution of Climate-Induced Mortality Risk at Impact Region Level

Figure 2: **High-Emissions Scenario (RCP8.5) Full Mortality Risk of Future Climate Change.** The maps indicate the full mortality risk of climate change, measured in units of deaths per 100,000 population, in the year 2099. Panel (a) displays risk results for the United States, while Panel (b) displays results for the world. Estimates come from a model accounting for both direct change in death rate as well as the costs and benefits of adaptation. The map shows the climate model weighted mean estimate across Monte Carlo simulations conducted on 33 climate models. All values shown refer to the RCP8.5 emissions scenario and the SSP3 socioeconomic scenario. Figure adapted from Carleton et al. (2022).



(a) RCP4.5 United States Spatial Distribution of Climate-Induced Mortality Risk at County Level



(b) RCP4.5 Global Spatial Distribution of Climate-Induced Mortality Risk at Impact Region Level

Figure 3: **Moderate-Emissions Scenario (RCP4.5) Full Mortality Risk of Future Climate Change.** The maps indicate the full mortality risk of climate change, measured in units of deaths per 100,000 population, in the year 2099. Panel (a) displays risk results for the United States, while Panel (b) displays results for the world. Estimates come from a model accounting for both direct change in death rate as well as the costs and benefits of adaptation. The map shows the climate model weighted mean estimate across Monte Carlo simulations conducted on 33 climate models. All values shown refer to the RCP8.5 emissions scenario and the SSP3 socioeconomic scenario. Figure adapted from Carleton et al. (2022).

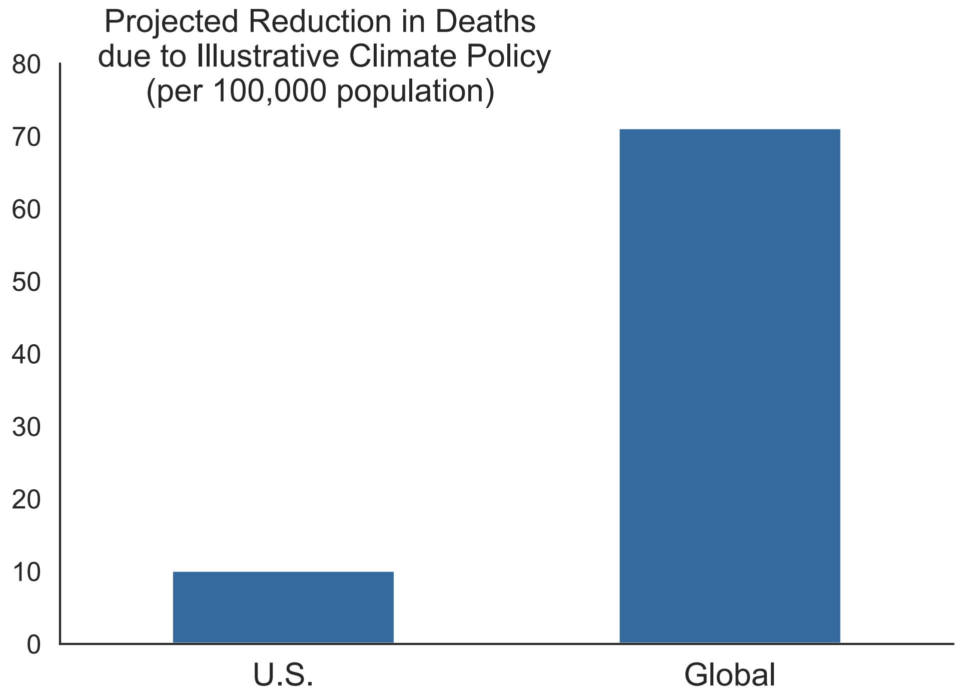


Figure 4: **Full Mortality Risk Avoided in 2099 Under Illustrative Climate Policy.** Illustrative climate policy is defined as a climate policy that aligns global emissions with the moderate-emissions scenario (RCP4.5) moving from the high-emissions scenario (RCP8.5). Hence, deaths avoided represent the difference between projected mortality impacts in 2099 under the high-emissions scenario (RCP8.5) and the moderate-emissions scenario (RCP4.5). Both include changes in death rates in addition to adaptation costs measured in death equivalents.

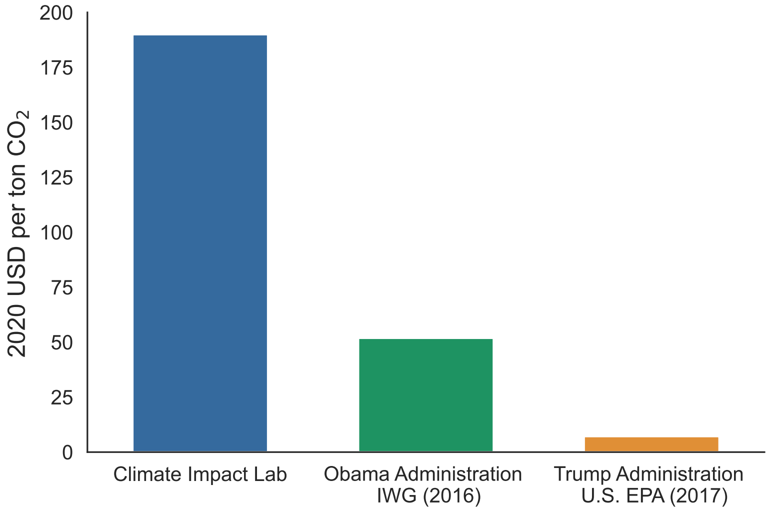


Figure 5: **Estimates of the Social Cost of Carbon (SCC).** The Climate Impact Lab (CIL) uses Data-driven Spatial Climate Impact Model (DSCIM) (Climate Impact Lab (CIL) 2022; Carleton et al. 2022; Rode et al. 2021) accounting for mortality, labor, coastal, agriculture, and energy sectors. Socioeconomic and emissions projections were developed by Resources for the Future (Rennert et al. 2022). Additionally, the CIL's SCC assumes Ramsey discounting with a 2% target and age-varying VSL. Obama administration and Trump administration estimates account for all sectors of climate change impacts and both assume a 3% discount rate and RCP8.5 climate projections. Trump administration SCC values include only damages within the United States, while all others shown reflect global damages.

Table 1: **End of Century Climate-Induced Full Mortality Risk by State.**

State	Mortality Risk Per 100,000	
	Moderate Emissions (SSP3-RCP4.5)	High Emissions (SSP3-RCP8.5)
Alabama	15.48	24.81
Alaska	−127.88	−217.22
Arizona	18.78	34.48
Arkansas	19.92	37.37
California	16.70	31.09
Colorado	−22.02	−24.72
Connecticut	−10.67	0.80
Delaware	13.63	32.34
District of Columbia	12.97	32.46
Florida	−3.43	−19.14
Georgia	16.84	26.76
Hawaii	−8.39	−45.36
Idaho	−3.74	1.25
Illinois	−23.76	−11.44
Indiana	−2.39	18.64
Iowa	−17.28	4.54
Kansas	20.34	41.68
Kentucky	16.47	35.08
Louisiana	11.28	17.10
Maine	−49.04	−58.95
Maryland	13.16	32.98
Massachusetts	−21.01	−15.18
Michigan	−36.39	−30.08
Minnesota	−65.95	−77.28
Mississippi	15.24	25.21
Missouri	15.59	37.38
Montana	−42.91	−48.65
Nebraska	−6.61	14.07
Nevada	17.25	37.13
New Hampshire	−37.30	−36.42
New Jersey	1.93	18.33
New Mexico	11.56	25.38
New York	−10.58	2.69
North Carolina	17.11	30.63
North Dakota	−61.83	−77.67
Ohio	−9.68	7.80
Oklahoma	21.97	41.17
Oregon	14.46	19.74
Pennsylvania	−3.73	14.06
Rhode Island	−9.94	−0.18
South Carolina	15.94	25.02
South Dakota	−29.62	−16.37
Tennessee	18.63	34.53
Texas	15.29	26.73
Utah	−9.00	−5.73
Vermont	−60.27	−70.44
Virginia	16.59	34.19
Washington	12.30	17.92
West Virginia	12.11	30.95
Wisconsin	−53.75	−56.37
Wyoming	−47.59	−60.69
United States	−0.08	10.05

Note: Projected mortality risk (per 100,000 people) from climate change in 2099 for each state under moderate emissions (RCP4.5) and high emissions (RCP8.5). These values include changes in death rate and adaptation costs converted to death equivalents, and both use the SSP3 socioeconomic scenario. States with bold names are those with Senators on this committee.

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